30/8/76

EFFECTS OF MAN ON THE VEGETATION IN THE NATIONAL PARKS OF SOUTH AUSTRALIA

by

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Thesis submitted for the degree of Doctor of Philosophy,
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PART I
Text and Appendices

APRIL, 1975

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SUMMARY.

The floristic and structural changes in native vegetation resulting from man's influence were given detailed examination in five South Australian Parks. The historical background of each park was investigated and recorded. The prevailing physical and climatic conditions were also documented. These factors were considered as possible determinants of the existing vegetation in the parks. Population studies were carried out on the premise that man has influenced the composition and structure of the native plant communities. The vegetation was studied using incidence data (analysed by association analysis) and density data. This thesis included the distribution maps of the species sampled, so providing hitherto unavailable information on their abundance and spatial patterns which is of value for park management. The results permit the clear delineation and segregation of those patterns determined by man's activities, from those induced by soil and topographic features. Further, the systematic surveys provide the basis for both time studies (if so desired by the park authorities) and biogeographic work on the species concerned. In the parks studied, the majority of the plant species were examined to gain optimal information from each survey.

Particular attention was given to the response of *Eucalyptus obliqua* dry sclerophyll forest to controlled burning, in autumn and spring, as the use of fire in management is receiving increasing attention in South Australia. An experiment was carried out in conjunction with the South Australian Department of Woods and Forests.

Summary (Cont.)

The variation in response of different species to the controlled burn emphasized the complexity of this community's reaction to such treatment. Further attention was given to the reaction of alien species to the controlled burning.

Although the problems of introduced plant species have been given particular attention in agricultural situations in Australia, in uncultivated areas studies on these alien species have been largely neglected so leading to an inadequacy of information. To bridge this gap in information, a pyric succession study was undertaken to determine the response of alien species following a wild fire. As with the other studies reported in this thesis the pyric successional situations have provided quantitative information which can be used as a basis for management decisions.

DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University. To the best of my knowledge and belief this thesis contains no material previously published or written by another person, except where due reference is made in the text.

Elizabeth Mary Heddle

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to the numerous people who have assisted me in many ways with this thesis :

..... to the National Parks Commission (now the National Parks and Wildlife Service, a Division of the Department of Environment and Conservation) who provided finance for the research work.

..... to my supervisor, Dr. R.T. Lange of the Botany Department for his assistance and guidance in sorting out practical and academic problems.

..... to Mr. R.G. Lyons (National Parks and Wildlife Service) and Dr. R.C. Shearer (Department of Environment and Conservation).

..... to the South Australian Department of Woods and Forests, in particular to Mr. D.R. Douglas, Mr. R.S. Bungey and Mr. A. Gray.

..... to the Bureau of Meteorology, the South Australian Department of Lands and the South Australian Department of Agriculture for information.

..... to Ian Noble and Trevor Mattiske for their assistance in the analytical side of the thesis.

..... to Timothy Fatchen for his helpful criticism of the research work and thesis.

..... to the staff of the Computing Centre of the University of Adelaide.

..... to Mrs. R.B. Heddle for her assistance in the field work and in the sorting of the herbarium material.

..... to the many helpers I have had in the field on various occasions.

Acknowledgements (Cont.)

My thanks go finally to the members of the Botany Department for their help over the last three years. The final presentation of the text is the careful work of Christine Evans, for whose accurate typing I am extremely grateful.

CHAPTER I

INTRODUCTION

This thesis relates to the influence of man on the native vegetation in the national parks of South Australia. Particular attention is given to the detailed changes in the composition and structure of plant communities. This aspect has been neglected in the past in Australia.

The end of the nineteenth century witnessed an increasing awareness of the need to conserve the flora and fauna of the world. This awareness was accompanied by the national parks movement which was initiated in the United States of America and gradually spread to other countries. Although at first the emphasis was on providing areas for recreational facilities and public enjoyment, the idea of conservation of the flora and fauna in such areas gradually gained momentum. In many countries this need to set aside and dedicate areas for the conservation of the flora and fauna has received only recent attention. For example, in South Australia all except one of the parks have been declared in the last two decades. Further the first examination of the position of wildlife conservation by the Commonwealth Government was in 1972 (Report from the House of Representatives Select Committee on Wildlife Conservation, 1972). The recent formation of South Australian Department of Environment and Conservation and its Division of the National Parks and Wildlife Service also reflects this increasing awareness for the need of the conservation of flora and fauna in South Australia.

The research discussed in this thesis investigates the influence of man in some South Australian parks.

In the past attention has been focused on descriptive accounts of degradation which has resulted from man's activities. These changes were recognised by earlier workers, e.g. Specht and Cleland, 1961; but this was in very broad terms only, and not in biological detail. In recent years there has been a growing awareness of the need to manage these local parks, and for this purpose detail is essential. Further, the need to acquire information for management purposes on the flora and fauna in these parks is well recognised. The "National Parks and Wildlife Act, 1972" outlines the basic control and management objectives for the parks in South Australia. Provision is made for management plans, however up to date no such plan has been finalized. This is due in part to the following reasons. Firstly, the majority of the parks have only recently been acquired. Secondly, there is no adequate information on which these plans can be based. In particular the history of the majority of areas dedicated is relatively unknown and this, combined with a lack of biological knowledge, prevents effective planning. The present research, a detailed examination of a selection of parks, provides a basis for future research and management decisions. The assessment of the adequacy of the parks, as regards the conservation of native plant and animal communities, has been largely subjective up to date. Despite many accounts of the parks in Australia there is still a lack of quantitative data on which management decisions can be made. It might be said that many authors and authorities point out the need for detailed information, but few set out to obtain it.

In this present research, recently developed statistical applications are used to establish the type and extent of vegetation pattern induced by man's activities as distinct from those due to "natural" influences. The research was guided by plain evidence that man's activities have been largely deleterious to the conservation of native plant communities.

It is well recognised that fire is a major influence in the national parks in Australia. The use of fire as a management tool has received increasing attention in recent years. Research was therefore undertaken to investigate the possible use of fire in the local parks. To this end a controlled burning experiment was undertaken in an *Eucalyptus obliqua* dry sclerophyll forest. Quantitative data was collected to determine the detailed effects of fire. The lack of data relating to alien plant species in a non-agricultural situation further poses difficulties to the national park authorities and other organizations. Particular attention was therefore given to the response of a selection of alien plant species to fire.

The thesis plan is as follows. Before specific research objectives are described a review of the literature is presented to place the research into a broad context. This review includes the history of the conservation movement and national parks system. A general discussion of the management problems faced in the South Australian Parks is also given, to place the selection of parks and research into perspective. Following these reviews the research follows two courses. The first is the examination of selected parks. The second is the selection of a specific influencing factor (fire). The sequential development of the study is outlined in Figure 1.1..

Figure 1.1.

Flow diagram showing sequential development of ideas in this thesis. Roman numerals indicate chapter headings.

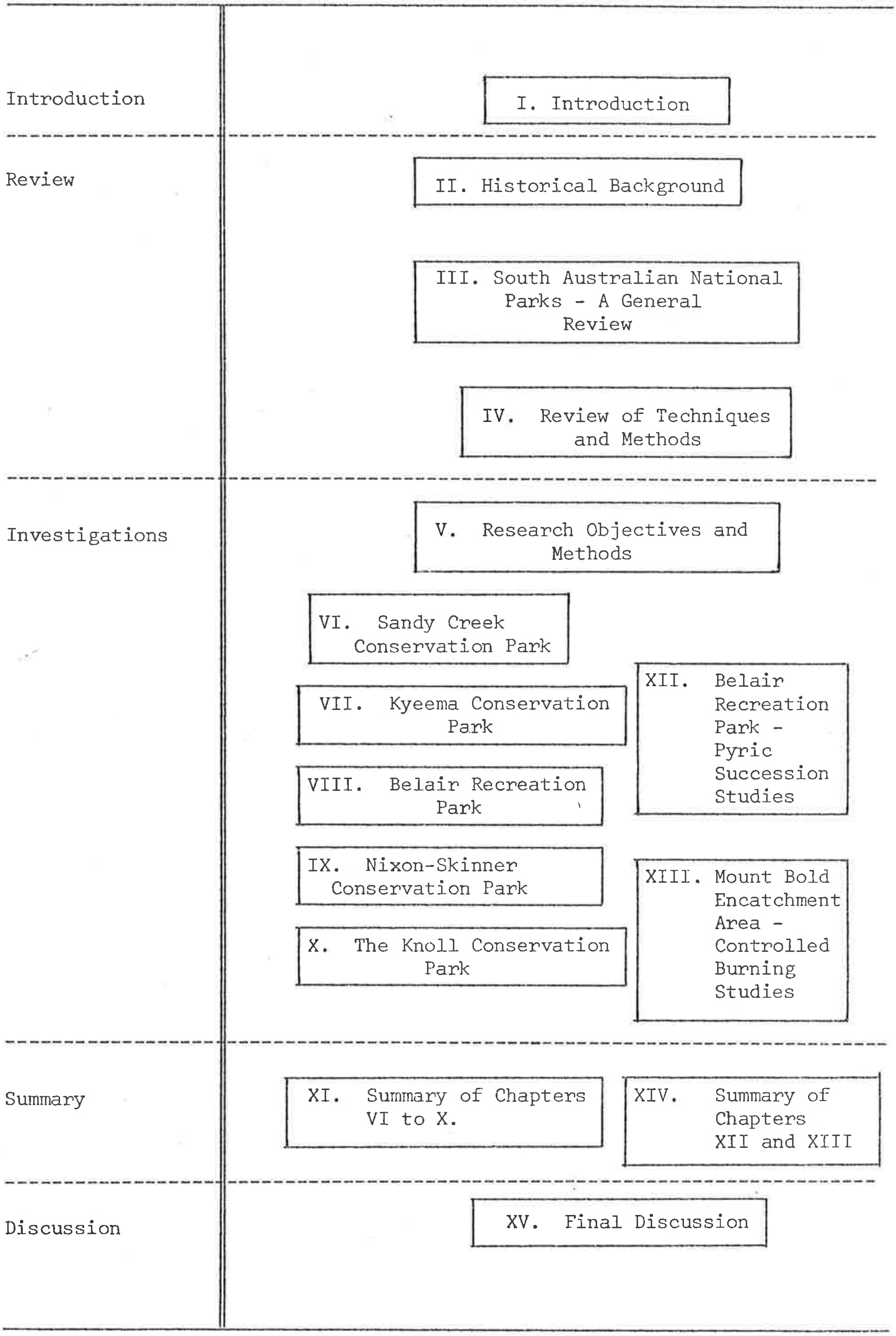
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Figure 1.1.

CHAPTER II

HISTORICAL BACKGROUND

2.1. Introduction

In one form or another man has occupied the earth for over a million years (Brace, 1970). For the last 10,000 years man has dominated the earth. The actual nature of the influence of man has been largely dependent on his cultural skills. As a gatherer and hunter, man recognised his dependence on other fauna and flora for survival. With the development of tools man acquired the ability that enabled him to better exploit his surroundings (Smith, 1972). The development of agriculture permitted greater human populations than were possible under the gatherer and hunter cultures. Populations of man fluctuated due to closer conditions and inadequate sanitation and hygiene.

The Industrial Revolution in Europe, about 300 years ago, with its associated improvements in hygiene, agriculture and medicine resulted in major population increases. During this time transformation of the environment gained momentum with the exploitation of animals and deforestation. In the last two centuries massive increases in the demands of the human population have increased man's destruction of the world's natural fauna and flora. Today very few areas remain uninfluenced by man. This destruction has been so rapid and extensive that it has changed man's attitude to his surroundings.

Over the last century there has been a growing proportion of the world's population that have recognised the need to preserve the remaining natural ecosystems.

The United States of America in the latter part of the nineteenth century recognised the need to conserve the landscape and fauna and flora of Yellowstone. In 1872 the formation of the Yellowstone National Park instigated a movement that has gained momentum in recent years. At the end of the last century there was a rapid succession of new parks declared throughout the world. These efforts have proved invaluable towards the conservation of many plants and animals.

The following two sections discuss the impact of man on the biota of Australia with particular attention to the situation in South Australia. Where relevant, overseas situations are referred to in the text. The three classical works of George Perkins Marsh (1802-82), an American diplomat and philologist provide a useful history of man's impact on the earth. In the preparation of "Man and Nature, or Physical Geography as Modified by Human Action" (1864) and the later editions of 1874 and 1885, he accumulated material from his own observations as well as from European countries. He was recognised not only for making a plea for conservation but also for providing the world with a deeper insight into the nature of man's impact on his surroundings.

There are also the two volumes of the International Symposium on "Man's Role in Changing the Face of the Earth", edited by W.L. Thomas, Jr. This collection of papers is comprehensive and provides a valuable lead into this subject.

2.2. Changes independent of man

It is important to recognise that a variety of natural forces are in operation and have not ceased since man appeared on the earth (Russell, 1956). The dominance of man is well recognised and not denied, but his own destiny along with that of the fauna and flora of the world is also dependent on natural forces. These include geological and climatical changes taking place over long periods, as well as catastrophic events such as floods, droughts, earth-quakes and volcanic eruptions. Such changes are major determinants of succession and evolution. Early writers recognised the importance of natural forces in influencing the environment. For example Hippocrates in his writings "On Airs, Waters, and Places" refers to their influence (Hippocrates, Trans. Adams, 1952). Russell also provides a discussion of the environmental changes that are independent of man (Russell, 1956).

In Australia the flora and fauna have been influenced by such geological and climatical changes. Browne (1958) gives an account of the geological history of Australia.

Historical Background (Cont.)

As Australia is an island continent, it must have received a large component of its flora and fauna from land connections in the past. The relationships of Australia to other land masses are reviewed by Keast (1959) and Darlington (1968). Postulated land connections are discussed as possible determinants of the fauna and flora of Australia. From late pre-Cambrian time till the end of the Mesozoic Era deposition took place chiefly in four great basins. The sea flowed for differing lengths of time in these geosynclinal troughs. These events along with the elevation of the Mount Lofty and Flinders Ranges and the Olary Ridge were among the more important changes affecting South Australia (Browne, 1958), in determining the fauna and flora (Keast, 1959).

Crocker (1959) discussed the influence of past climatic changes on the Australian vegetation. He recognised the marked changes in the distribution of plants since the Tertiary era. Paleobotanical evidence indicated that the climate was warm and humid during the lower Tertiary. Mesic genera (e.g. *Nothofagus, Cinnamomum* and *Ficus*) were inter-mingled with the xeric genera well represented in today's flora, e.g. *Eucalyptus, Acacia* and *Banksia*, (Crocker, 1959 ; Crocker and Wood, 1947). Little is known of the flora of the Upper Tertiary. During the Pleistocene the continent of Australia was thought to alternate between "wet" and "dry".

The arid belt correspondingly shifted south and north (Keble, 1947). The prominent aspect of the Australian flora is that it is xeric over the bulk of the continent and that it lacks extensive tracts of deciduous types. Also only small numbers of softwood and conifers occur (Keast, 1959). The recent aridity in Australia has been reflected in the flora and fauna. The "giant animals" which were prominent in the fauna during the Tertiary disappeared with the onset of aridity and the arrival of aboriginal man. (Tindale, 1959). Such animals included the giant marsupials, Diprotodon (a hippotomuslike animal), Thylacoleo (the marsupial lion) and Palorchestes (a giant kangaroo) see Hills (1959). The catastrophic events have varied in their extent and severity.

2.3. Changes dependent on man

The influence of man on his environment has long been recognised. Plato in his Critias reconstructed the pre-history of Attica. He suggested that human history was, in part, the history of environmental changes induced by natural catastrophes and human activities (Plato, Trans. Jowett, 1952). Mencius, a chinese philosopher, described the decrease in trees on the mountains as being a result of the use of axes and grazing of goats and cattle. Further he outlined the difficulties associated in determining natural from cultural landscapes (Mencius, 1933).

The classical authors placed emphasis mainly on the study of origins and changes in human society. As a result, these initial observations of the influence of man on the environment were not extended. The idea that man was the highest creature and that nature was present for his sake was expressed in the ancient Egyptian creation myth (Frankfort, 1951). This claim by man to the dominance of the flora and fauna of the earth has led to unlimited and ruthless exploitation. The religious and ethical standards encouraged this dominance over other living things. For example, Genesis, Chapter 1, verse 26.

> *"And God said, Let us make man in our image, after our likeness: and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth."*

Probably the turning point in the recognition by man of his powers to change nature resulted from the cutting of trees and the exploitation and slaughtering of animals. These activities were by no means restricted to man's survival needs. They included the killing of animals for pleasure, entertainment and sport.

Plato and other classical writers clearly illustrated the destructive effects of clearing. Recent evidence from pollen analyses have clarified the process of pre-historic land-clearing.

For example, Godwin (1944) found evidence of a decline which was attributed to clearing, in the tree species and a rise in grasslands at Hockham Mere, Norfolk, at about 3000 B.C. The clearing of woods continued throughout historical times. The development of agriculture and the need for fuel and building materials necessitated this increase in cleared areas (Darby, 1952). Darby in 1956 reviewed the clearance of woodlands in Europe from classical times. An earlier account along similar lines is that of Marsh (1864).

The exploitation of animals has occurred in most sections of the earth. The large decreases in the sable, *Martes zibellina,* slaughtered in Siberia for fur and the near extinction of the American bison are two examples to illustrate this point (Guggisberg, 1970). Similarly, man has killed large numbers of animals for their furs, feathers, ivory tusks, perfumes, hides, oils and food; over and above that needed for subsistence. Writers have provided invaluable insights into the exploitation of animals in Australia and overseas (Calaby, 1963; Marshall, 1966; Guggisberg, 1970). In addition, the publication of the present status of many of these species in the Red Data Book of the International Union for the Conservation of Nature (I.U.C.N.) has further emphasized the severity of the situation. (1966). There is a constant need to update such lists and records.

In recent centuries man has also become a significant geological agent as a result of mining and industrial activities.

Historical Background (Cont.)

For example Sherlock (1922) discusses man as a geological force in England.

The recent settlement of Europeans in Australia, in 1788, initiated changes almost as drastic as the earlier climatic oscillations (Keast, 1959). The clearing of forests, extensive burning, the introduction of grazing ungulates and the wholesale colonization by exotic plants and animals led to vast areas of Australia being altered by man (Keast, 1959). Cleland (1957) thought that the aborigines had not caused marked changes in Australia. This point is disputed by others who think that aboriginal man did play a significant part (Tindale, 1959; Merrilees, 1968; Jones, 1968; Mulvaney, 1969). Mulvaney in "The Prehistory of Australia" (1969) points to three major factors that were relevant to the aborigines. First the possible selective hunting of animal species as a result of their methods. Second the consequences of accidental or deliberate firing of the vegetation. Thirdly the introduction of the Aboriginal dog or dingo.

The vast changes that occurred as a result of European man's occupation can be seen in most parts of Australia. The degree of ring-barking and clearing of trees varies in different communities. In the woodland communities clearing was primarily to increase pasture for grazing lumber and firewood.

The recent review of the Australian forests and the clearing of extensive areas for the woodchip industry and intensive forestry gives an indication of the demands man is still placing on the forests of Australia (Routley and Routley, 1973). The side effects of forest deterioration are severe erosion, loss of top soil and nutrients and the introduction of diseases and alien species. The introduction of softwoods and conifers (which are deficient in Australian forests) has left few areas intact.

A recent threat to the Australian native vegetation is the root-rot disease, *Phytophthora cinnamomi.* In southern areas of Australia this fungus has led to the destruction of native species in the *Eucalyptus* forests. The alteration of the environment of many forest areas has led to its explosive spread (Routley and Routley, 1973). The Western Australian Department of Forestry believes that mineral exploration has assisted in the spread of this disease which threatens the jarrah forests (A.C.F. Viewpoint Series No. 6, 1971).

Another problem faced in Australia is the introduction of alien plant and animal species. The African and Mediter-anean plant species pose a particular threat to the native plant communities. Livestock, seeds and alien plants entered the country either by design or accident. The great influence man had in altering the world distribution of vegetation was recognised in the early nineteenth century by the German botanist, Schleiden. He stressed the ability of man to distribute weeds or "rubbish plants". The weeds - "mark the track which Man has proudly traversed throughout the earth"

(Schleiden, 1848).

Many of these introduced plant species were well adapted to the disturbed areas with modified environments. Moore discusses the influence of sheep on the grasslands of Australia (1959). The once widespread kangaroo grass, *Themeda australis,* a summer-growing perennial, has gradually been replaced along with other native grasses by introduced annuals. Grazing combined with the application of fertilizers has favoured the growth of introduced grasses and legumes. The work carried out by Specht in the Ninety-Mile Plain clearly indicates that the introduced plant species are favoured by the application of fertilizers (Specht, 1963). The introduction of alien plant species in South Australia was recognised by earlier workers including Cleland (1928). He commented on the largely alien flora on the Adelaide plains.

The introduction of rabbits by European man brought marked changes to the vegetation of Australia. The extent of the ecological consequences of its introduction cannot be given with any precision. The success of this animal in destroying the vegetation is well recognised (Ratcliffe, 1959). Similarly, the introduction of sheep and cattle brought marked changes (Moore, 1959).

In recent years the human population has placed greater demands on increasing mining activities. In Australia particular attention has been given to the mining activities in the coastal areas (Coaldrake, 1972).

Since European man's arrival in Australia, less than two centuries ago, he has left few areas uninfluenced as a result of his agricultural, pastoral, forestry and mining activities.

2.4. Nature Conservation and the National Park Movement

For thousands of years man has given protection to animals that he needed for food and sport. In recent centuries he has also recognised the need to conserve not only the animals but the habitat as a whole.

Because there are so many areas of conservation, it is not surprising that the definition of the word, "conservation" varies a great deal between authors and countries. In fact conservation is such a broad term that its meaning ranges from total preservation (non-use) to wisely managed complete use of resources. Herfindahl (1961) reviews some of the definitions and emphasizes the following - "conservation is the use of natural resources for the greatest good of the greatest number for the longest time." Nicholson's definition of nature conservation is more pragmatic - "nature conservation means undertaking research, experiment or management aiming directly or indirectly to influence soils or water or vegetation or animal life" (1956). In a field where definitions vary so widely with the pre-occupations of their authors, it is best to refer to recognised authorities, for example Dasmann (1968), for generally acceptable interpretations.

Figure 2.1.

South Australian National Parks

- the total number and area of parks.

SOUTH AUSTRALIAN
National Parks

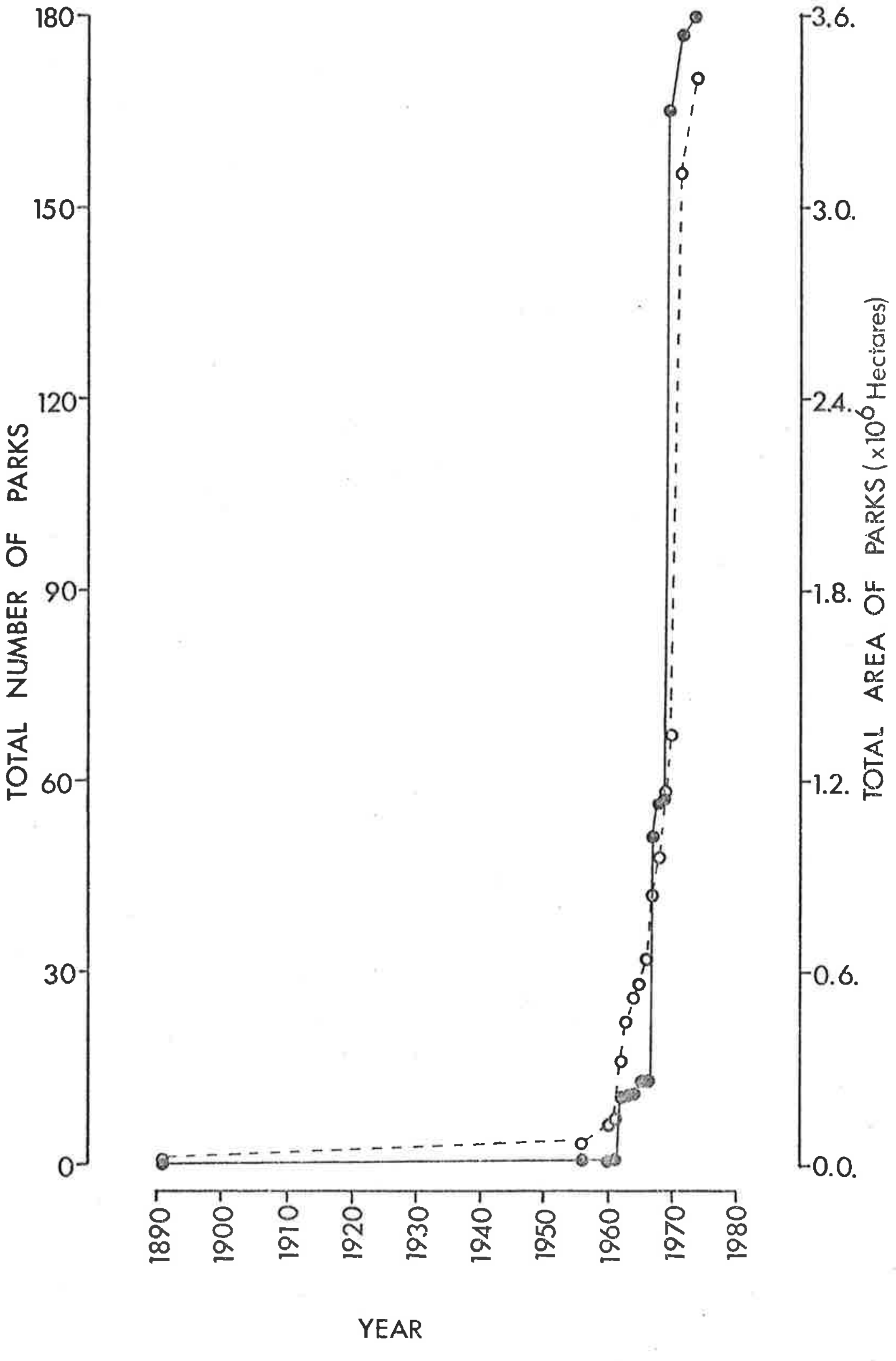


Figure 2.1.

As there are many definitions of conservation it is hardly surprising that there has been little uniformity of terminology in relation to national parks. A national park in the United States or Canada, for example, is chiefly designed for human recreation. In Africa generally its chief purpose is for the preservation of wildlife.

The national park movement was instigated by a group of Americans who recognised the need to conserve the Yellowstone area, as they could foresee that man would deface and irrevocably spoil this area. As a result a bill declaring Yellowstone a national park, was signed by President Grant in 1872. Other countries were soon to follow America in setting aside areas for the conservation of their flora and fauna. Amongst the first to create national parks were Canada, New Zealand and Australia. The twentieth century witnessed a rapid increase in the number of national parks dedicated. For example, the recent rapid increase in national parks in South Australia is illustrated in Fig. 2.1.. Only over the last decade has there been a significant increase in the number of parks in South Australia. Similarly with the total area dedicated in this state, see Fig. 2.1.. During the early decades of conservation, the choice of sites was restricted in the main to areas of scenic beauty.

Game reserves have existed since antiquity. The old custom of royalty and nobility, of preserving wild animals for entertainment and sport, had long been known in many regions of the world.

For example the Karpf Game Sanctuary was created in the Swiss Canton of Glaurus in 1548 and has provided a sanctuary for alpine wildlife for over 400 years (Guggisberg, 1970). There were also early attempts to save animal species threatened by extinction. For example the Kings of Poland did their utmost to try to save the aurochs near Warsaw. In 1627, the last auroch was found dead. On the other hand reserves have succeeded in protecting many animals. In Russia wildlife reserves have provided protection for the Caucasian and Siberian ibex and snow leopards (Guggisberg, 1970). Similarly Guggisberg discussed the protection of an antelope, the blesbok, which was once approaching extinction in Africa. Several parks there have seen a recovery in its numbers. In recent years the activities of man has hastened the disappearance of many animal species. In Australia, the mallee fowl in parts of New South Wales, despite efforts of the park system, has been threatened by man's introduction of the sheep and rabbit (Frith, 1962).

The Sabie Game Reserve was declared in 1898. This area in Africa was later renamed as the Kruger National Park. This park provides an example where tourism and the conservation of animals co-exist. It extends two hundred miles, from the Limpopo River in the north to the Crocodile in the south, with an average width of forty miles. The success of this park has in the main been due to the strict regulations that apply to it. The greater paradox of national parks is that, whereas for their existence they depend on tourists to create public interest in the preservation of wildlife, the plants and animals depend for their preservation on being unmolested.

As the idea of wildlife conservation spread, the necessity for international co-operation became obvious. Although conventions had been held in many countries the formation of international organisations furthered the cause of conservation. In 1928 the International Office for the Protection of Nature was established in Brussels. In 1948 an international conference at Fontainebleau founded the International Union for the Conservation of Nature and Natural Resources. This organisation promotes nature conservation from a scientific point of view and places emphasis on education (Boyle, 1959). The formation of the World Wildlife Fund in Zurich in Switzerland in 1961 has also been a significant step forward in the conservation of nature. Among other international programs is the world survey of protected areas-natural and man-influenced - being undertaken by the Section on Terrestial Communities (CT) of the International Biological Program (Webb et. al., 1973). Nevertheless, a great deal still needs to be done in relation to the conservation of the fauna and flora of the earth. The recent upsurge in interest and work in this field since the second world war has given hope for many threatened species.

2.5. National Parks in Australia

By comparison with Great Britain, Europe and North America Australia has only recently been subject to the activities of European man.

Potentially, Australia was in a prime position for the conservation of natural communities. Initially, although there was a rapid upsurge in concern for the conservation of natural resources, the natural communities reserved within Australia were those generally considered to have no or little value for agriculture, forestry or pastoral activities. The land was selected mainly on the basis of tourist appeal (Webb et. al., 1973). This led to an inadequate coverage of certain ecosystems.

In 1961 and 1963, Specht and Cleland reviewed the plant communities and plant species found in South Australia's National Parks and Nature Reserves. Later Frankenberg (1971) reviewed nature conservation in Victoria. Up to this time little attention had been given to selecting areas on the basis of their faunal features. The recent report by the Australian Academy of Science in 1968 and the Report from the House of Representatives of the Select Committee on Wildlife Conservation (1972) both clearly point to the inadequacies in the conservation of Australia's natural communities. These reports indicate the lack of and/or the poor representation of the wetlands, swamps, rainforests, coastal and marine areas.

The rapid agricultural and pastoral development in Australia over the last twenty years has left few areas undeveloped or uninfluenced by man.

Table 2.1.

The Park and Reserve Position in Australia (at 30 June, 1972)

This table is based on Appendix IV of the Report from the House of Representatives Select Committee on Wildlife Conservation, 1972.

The reserves have been divided into Groups A,B,C and D to try to indicate broadly comparable classes throughout Australia. The chief criteria used for the classification are objectives, control, and security of tenure. Although the importance of management is recognised it is too complex a matter to use as a criteria. The criteria used for each class is as follows:

A. Public reserve. Objective is maintenance of the natural state for wildlife and flora conservation; conditions and opportunities for recreation, science and education; control is by central conservation organisations, any change in the status or security of tenure of reserves requires consent of Parliament.

B. As with A but the status or security of tenure of the reserves can be changed by the Minister or Department responsible for them.

C. Public reserve, sanctuary or Aboriginal reserve controlled or partly controlled by government or local government body other than those concerned with wildlife conservation.

D. Reserves or sanctuaries on private land.

Table 2.1. (Cont.)

State/ Territory	Type of Park or Reserve	Number of Units	AREA (hectares)	Percentage of State/Territory
New South Wales	A. 1. National and State Parks	31	1,140,530.6	1.42
	2. Nature Reserves	84	235,398.2	0.29
	3. Game Reserves	2	2,505.9	0.00
	4. Flora Reserves (on Crown Land) (Forestry Act)	16	5,340.3	0.01
	TOTAL	133	1,383,775.0	1.73
	B. Forest Preserves	88	8,028.3	0.01
	D. 1. Game Reserves (Private land)	20	125,903.3	0.16
	2. Wildlife Refuges (Private land)	299	1,274,908.5	1.59
Victoria	A. National Parks	24	205,280.5	0.90
	B. 1. Wildlife Reserves	35	52,905.7	0.23
	2. Areas set aside under S. 50 of Forestry Act.	100	36,914.6	0.16

Table 2.1. (Cont.)

State/ Territory	Type of Park or Reserve	Number of Units	AREA (hectares)	Percentage of State/ Territory
Victoria (Cont'd)	C. Sanctuaries on public land (except those in other categories already included)	70	42,754.4	0.19
Queensland	A. National Parks	284	1,037,322.9	0.60
	B. 1. Fauna Reserves	2	29,939.3	0.02
	2. Other Fauna Sanctuaries under sole control of the Department of Primary Industry	3	8,732.1	0.01
	3. Fisheries Habitat Reserves	12	28,328.6	0.02
	C. 1. Sanctuaries on Public Land (except in other categories)	94	260,038.4	0.15
	2. All Islands	Not known	Not known	-
	3. State Forests	459	3,123,257.8	1.81
	D. 1. Sanctuaries on Private Land	191	2,240,894.8	1.30
	2. Sancturaries - Atherton Tablelands, Brisbane, Nambour-Gympie, Toowoomba districts (complex tenure)	4	2,286,694.9	1.32

Table 2.1. (Cont.)

State/ Territory	Type of Park or Reserve	Number of Units	AREA (hectares)	Percentage of State/Territory
Western Australia	A. 1. 'A' Reserves vested in National Parks Board of W.A.	Mixed tenure see below	1,379,707.8	0.55
	2. 'A' Reserves vested in Western Australia Wildlife Authority and Minister of Fisheries and Fauna	65	3,826,198.7 (plus 3 unsurveyed groups of islands	1.51
	TOTAL	65	5,205,906.5	2.06
	B. 1. Other Reserves vested in National Parks Board of W.A.		81,174.0	0.03
	Total number of areas controlled by National Parks Board	56	-	-
	2. Other reserves vested in Western Australia Wildlife Authority and Minister of Fisheries and Fauna.	182	708,407.9	0.28
	C. Other fauna sanctuaries (dual control with other bodies)	157	542,728.9 (includes 17 'A' class reserves)	0.21

Table 2.1. (Cont'd.)

State/ Territory	Type of Park or Reserve	Number of Units	AREA (hectares)	Percentage of State/Territory
South Australia	A. 1. National Parks 2. Conservation Parks 3. Recreation Parks 4. Game Reserves	8 126 15 6	177,854.3 3,370,862.0 2,904.5 13,447.2	0.18 3.42 - 0.01
	TOTAL	155	3,564,663.3	3.62
	B. 1. Natural Forest Reserves 2. Aquatic Reserves	7 6	1,496.6 1,748.3	- -
	C. Sanctuaries on Public Land (except other categories)	See below	122,938.9	0.12
	D. Sanctuaries on Private Land Total number of Sanctuaries	See below 145	764,123.8	0.78
Tasmania	A. State Reserves	85	425,108.1	6.22

Table 2.1. (Cont.)

State/ Territory	Type of Park or Reserve	Number of Units	AREA (hectares)	Percentage of State/Territory
Tasmania (Cont.)	C. Conservation Areas on Public Land (including some minor private areas)	56	509,214.1	7.45
	D. Conservation Areas on Private Land (including some minor public areas)	18	5.238.0	0.08
Northern Territory	A. 1. Reserves under control of N.T. Reserves Board	38	230.271.1	0.17
	2. Sanctuaries under control of Chief Inspector of Wildlife	2	3,944,637.8	2.93
	TOTAL	40	4,174,908.9	3.10
	C. 1. Sanctuaries under control of Director of Wildlife	3	568,514.8	0.42
	2. Wildlife Protected Areas with in Aboriginal Reserves	14	27,832,382.4	20.65

Table 2.1. (Cont.)

State/ Territory	Type of Park or Reserve	Number of Units	AREA (hectares)	Percentage of State/Territory
North. Terr. (Cont'd.)	D. Wildlife Protected Areas on Private Land	5	15,565.4	0.01
Aust. Capital Territory	B. Public Parks and Recreation Reserves	3	14,196.7	5.84
AUSTRALIA	TOTAL GROUP A		15,996,965.2	2.08

In South Australia the post World War II development on Kangaroo Island and in the south-east have resulted in the recent clearing of scrub and natural communities. The areas acquired without the consideration of their faunal features have since proved invaluable in the conservation of nature in Australia. Man's influence on the vegetation in our National Parks initially was seen in his choice of areas to be dedicated.

There is a great deal of variation existing in definition, objectives, nomenclature, administration, selection procedures and security of tenure, which all pose additional problems to any comparison of parks within Australia (Report from the House of Representatives Select Committee on Wildlife Conservation, 1972; Specht et. al., 1974). Table 2.1. presents the position of parks and reserves in Australia at June 30th, 1972. This table indicates clearly the variation in types of parks existing in the states.

A minimum of five per cent of the land is suggested by the International Union for the Conservation of Nature and Natural Resources as the area that needs to be set aside as secure National Parks and Reserves. The percentage of dedicated land is well below this figure in all states except Tasmania, see Table 2.2..

Not only the different natural communities should be represented but also the quantity of each should be considered.

Table 2.2.

National Parks and Reserves of Australia
(as at 30th June, 1972)

This table is based on figures from the Report from the House of Representatives Select Committee on Wildlife Conservation, 1972.

State or Territory	AREA (hectares)	Percentage of State/Territory
New South Wales	1,383,775.0	1.7
Victoria	205,280.5	0.9
Queensland	1,037,322.9	0.6
Western Australia	5,205,906.5	2.0
South Australia	3,564,663.3	3.6
Tasmania	425,108.1	6.2
Northern Territory	4,174,908.9	3.1
Australian Capital Territory	Nil	Nil
TOTAL:	15,996,965.2	2.1

The determination of the minimum area required for conservation of an ecosystem is largely subjective until long-term ecological studies have been made on an ecosystem. Mosley (1968) considers that areas greater than 4000 hectares have a relatively good chance of conserving the fauna. Overseas this minimal area is larger. In the U.S.S.R. the recommended minimal area is 10,000 hectares (Pryde, 1972). This area was based on the National Parks System in the United States of America where the majority of the areas are above this size. For example Yellowstone National Park, the first National Park, covers 895,672.42 hectares (Story, 1959).

The need for habitat preservation is well recognised. Difficulties arise in the national parks where species of animals can never find sanctuary in parks as their migratory habits and/or needs for large areas are not met. Main and Yadav (1971) have estimated areas larger than 20,000 hectares may be necessary to conserve the diversity of macropods representative of a region. Similar arguments apply to plant species. Although such species as *Eucalyptus obliqua* and other tree species are widespread, their associated species are usually more restricted in range and have lower tolerance of environmental variations. Therefore large areas provide better possibilities for the conservation of the environment for these other species.

The tendency for the distribution of native species to contract has been evident for a long time.

Historical Background (Cont.)

The parks and reserves are surrounded and separated by areas developed by man for agricultural, pastoral, forestry and mining activities (to name but a few). As a result the importance of size of a park and the adequacy of buffered areas should be major determining factors in the viability of plant and animal communities. The increasing demands being placed on the parks by man has added additional threats. Whether the parks are adequate for the conservation of the flora and fauna is difficult to ascertain. However attempts have been made in recent years under the auspices of the Conservation of Terrestial Communities project of the International Biological Program, which have been fully described by Nicholson (1968). Specht's recent publication (1974) provides a detailed account and review of the plant communities and their status in Australian National Parks. This list is already out of date but it still provides a base line for government authorities to maintain a record of the plant communities.

Recent publications in Australia have indicated that there is a growing awareness of the national parks (Morecombe, 1969; Serventy, 1969). Assessment of the parks and reserves in Australia has been made by several groups including the Australian Academy of Science (1965 and 1968), Webb, Whitelock and Brereton (1969), Morecombe (1969) and Specht (1974).

The aim to dedicate reserves for particular species has been attempted overseas as well as in Australia.

Spring Gully Conservation Park in South Australia provides an area for the preservation of *Eucalyptus macrorhyncha*. This species is restricted in its distribution in South Australia to the area around Clare (Boomsma, 1949). Similarly the purpose for the formation of Calectasia Conservation Park was for the preservation of *Calectasia cyanea* (Specht, 1974).

Two reserves in New South Wales, Round Hill and Pulletop were established for the purpose of providing for the conservation of the mallee fowl. Frith (1962) found that sheep and rabbits were the main cause of the decrease in the numbers of this species. The mallee fowl are now found in low numbers in these reserves. Fortunately they are also found in larger numbers in areas in Victoria and Western Australia.

The main difficulty in the conservation of particular species is that so little is known of their requirements for survival. This lack of information on the distribution and characteristics of many plants and animals has led to difficulties in conservation considerations. The systematic ecological surveys required as a basis are not available (Webb et. al., 1973).

The management of reserves is probably the most difficult problem facing the groups concerned with governing them. The lack of information again is reflected as management decisions are usually based on inadequate information.

Nicholson (1956) discusses management problems in parks overseas. The experience from the United States of America indicates that the laissez-faire attitude is not always the most desirable. The White Pine was successfully saved from the White Pine Blister Rust in the Great Smokies by refusing to adopt a laissez-faire approach (Nicholson, 1956). Unfortunately the American Chestnut suffered a different fate and has been virtually exterminated as a forest tree.

It is desirable for individual parks to have their individual plan of management. Due to the recent formation of many of the Australian authorities such plans are lacking for the majority of parks. Obviously the management of the area is dependent on its individual characteristics and objectives. For example a park dedicated for the preservation of a particular plant species would be expected to be managed differently to one designed to cater for the recreational needs of man.

Broadly speaking management problems in Australia include "culling" of animal species from excessive populations, control of weeds and pests, grazing of domesticated animals, the role of fire, the use of herbicides or other chemicals, revegetation and the role of public recreation (Gabrielson, 1956; A.C.F. Viewpoint Series, No. 4., 1969; A.C.F. Viewpoint Series, No. 5., 1970; Costin and Frith, 1971; A.C.F. Occasional Publication, No. 8., 1972).

If a laissez-faire approach is the basic policy this should not be applied blindly but should be regarded as an experiment requiring monitoring (Ovington, 1956). The designation of areas within national parks, e.g. wilderness areas (non-use), as adopted overseas needs reviewing for possible application to the Australian National Parks. Hopefully, wise management practices and associated ecological studies will reduce the areas needed to be rehabilitated in later years. Basically the lack of information in Australia on which management procedures and decisions can be made necessitates seeking the experience of overseas countries.

The objectives of management not only differ from one state to another but they also differ within a given state with time. A review of the South Australian Act for National Parks clearly indicates the change in attitudes to park management over the last eighty or so years. I quote "The National Park Act, 1891", Section 5.

> "The Commissioners ..... may set apart such portions as they shall think fit for the conservation of water, for the purposes of sports and games, for landscape gardening, for temporary platforms along the railway line, for enclosures for birds or animals, and any other purpose for public enjoyment they may think fit, and may make all necessary roads, ways, and paths, and erect pavilions, rotundas,

lodges, summer-houses, fences, and all buildings they may consider necessary for the purposes of the said Park, and may plant trees, shrubs, and flowers, and sell and remove stone and bark, dead and serviceable timber, and also sell and exchange specimens of plants and animals .....".

The objectives of the "National Parks Act, 1966" were similar but slightly enlarged and more clearly defined, see Division II, Section 15 (1) (b). and Division II, 17 (1), (a) to (j) inclusive.

The recent "National Parks and Wildlife Act, 1972" has very clear objectives of management and management plans (Part III, Div. V.). I quote the "National Parks Act, 1972", Part III, Div.V., 37 (a) to (i) inclusive.

"37. The Minister, the Permanent Head and the Director shall have regard to the following objectives in managing reserves: -

(a) the preservation and management of wildlife;

(b) the preservation of historic sites, objects and structures of historic or scientific interest within reserves;

(c) the preservation of features of geographical, natural or scenic interest;

(d) the destruction of dangerous weeds and the eradication or control of noxious weeds and exotic plants;

(e) the control of vermin and exotic animals;

(f) the control and eradication of disease and injurious affection of animals and vegetation;

(g) the prevention of bush fires and other hazards;

(h) the encouragement of public use and enjoyment of reserves and education in, and a proper understanding and recognition of, their purpose and significance;

and (i) generally the promotion of the public interest."

This review of the acts gives a clear indication of the changes in attitude from the first act to cover the management of Belair Recreation Park to that covering the current parks in South Australia. The division of the parks into four categories, National Parks, Conservation Parks, Game Reserves and Recreation Parks has led to clarification of the park system in South Australia. A list of the parks in South Australia appears in Appendix I. Although there is provision in the act for the preparation of management plans for individual parks, the lack of information poses difficulties in carrying out such plans. Hopefully in the future efforts will be made to bridge this gap.

Throughout history man has changed his attitude to his natural surroundings. The increasing demands he has placed on the natural communities has led to the recognition of the need for conservation. The national parks throughout the world have in part met this need for conservation through the protection of many plant and animal species. The problems associated with the conservation of native plant and animal species in the park system have been outlined. The research objectives are discussed in the following chapter. This historical background provides a general context, so placing my research into perspective.

CHAPTER III

THE NATIONAL PARKS OF SOUTH AUSTRALIA - A GENERAL REVIEW

3.1. Introduction.

This chapter gives a general review of the national parks in South Australia so as to provide a general background on which the research approaches and selection of parks were based.

All but one of the national parks in South Australia have been dedicated in the last two decades. Prior to the dedication some of the parks had been subject to the activities of man. These activities included clearing, grazing, cultivation and firing. Many of these influences are still present in the parks today. In this chapter the major influences are considered. The choice of situations studied can then be placed in perspective.

Despite the division of parks into four categories, i.e. National Parks, Recreational Parks, Conservation Parks and Game Reserves, the influences of man are similar in all of these areas. Where applicable, reference will be made to observations in the parks during the course of research. The main influences are sub-divided and will be discussed separately in the following sections.

3.2. Influence of ~~Man.~~ Person

Dixon (1892) recognized the influence of man on the vegetation in South Australia. These early influences were due to the indirect effect of settlement by the introduction of foreign plants as well as the effect of grazing on indigenous fodder plants.

3.2. Influence of Man (Cont.)

The early influences of man were largely due to legislature. In Australia, farmers were allowed to select the richest and most fertile areas for grazing purposes. These grazing activities resulted in a change of species from native, perennial grasses to introduced annuals (Dixon, 1892; Moore, 1966).

Man's cultivation of the land despoiled the native vegetation as a result of clearing and repeated ploughings. On the whole one could conclude that cultivation results in the destruction of native plant species. As the more fertile areas were the first to be occupied by man the species endemic in the se localities were the most likely to become extinct. Further, these settlers are recognized as causing extensive conflagrations. Although fire was used by the aborigines, the number of fires increased markedly with the arrival of the Europeans. This increased frequency of fires along with the extensive grazing by sheep left few areas of native vegetation undisturbed. The poverty of the soils in Australia in part protected many areas from this initial impact of man after settlement. It was only with the improvements in fertilizers and agricultural practices that many of these areas were developed.

These influences of man are seen in the national parks of South Australia. Few parks have not been cleared or logged for firewood, building materials (for houses or fences) and railway sleepers. Examples of clearing and logging practices can be found in Belair Recreation Park, Innes National Park, Mount Remarkable National Park, Flinders Ranges National Park, Kyeema Conservation Park and Sandy Creek Conservation Park. This logging was selective, e.g. the suitability of *Callitris* sp. for building purposes was well recognized by the early settlers.

Previous workers have studied in detail the impact of man on the vegetation both in Australia and overseas (Willard and Marr, 1970 and 1971; Ovington et. al., 1972). In the local parks his influence varies from the physical disturbance of soils (e.g. by tracks or dams) to widespread changes in the composition and structure of the vegetation. In all parks visited, man has had some influence, however, the effect of his presence varies in intensity and extent.

The following sections expand the more important influences that man has had in national parks.

3.3. Influence of Fire.

Fire is among the major features of the Australian plant communities (A.C.F. Viewpoint Series No., 1970). The majority of fires in the parks arise from the activities of man. The increasing populations of man have been accompanied by an increasing incidence of fire. This factor is of particular interest in many of the local parks due to the risk to human life and adjacent private land-holdings. In view of the increase in fire incidence, in such parks as Cleland Conservation Park and Belair Recreation Park, particular attention was given to their influence. The recent interest in using fire as a management tool has placed greater emphasis on the need to study its effects. A brief review is given in this section of the effects of fire on the vegetation and on its occurrence in local parks.

The south-eastern area of Australia is recognized as being the most fire hazardous part of Australia (Gabel, 1969). In the main the fires that occurred prior to European settlement in Australia have been attributed to lightning and the burning practices of aborigines (Pryor, 1939; Gill and Ashton, 1968). After white settlement there was a rapid increase in the number of fires as has been seen also in the local parks.

Fire has played an important part in determining the vegetation in Australia (Howitt, 1890; Gilbert, 1963). Gilbert suggested that the greater part of the forest vegetation of south-eastern Australia at some time has been subject to severe or intermittent fires. In recent decades the behaviour of fire has been described in terms of different parameters (Byram, 1959). Due to the large number of variables that must be considered in the interaction of fire and vegetation, difficulties have arisen in predicting what effects the fire will have on the plant community. These variables include the nature of the fire (Westcott and Cleary, 1950; Webb, 1968; Westman and Anderson, 1970), the vegetation (Petrie, 1925; Francis, 1951, Specht and Rayson, 1957; Jackson, 1968; Mutch, 1970), the climate (Petrie, 1925; Went et. al., 1952; Jackson, 1968; Webb, 1968), the soil (Jackson, 1968), and biotic factors (Howitt, 1890; Jacobs, 1955; Cremer and Mount, 1965).

The importance of fire as a determining factor in the sclerophyll forests is well recognized (Gilbert, 1959; Cremer, 1960; Cochrane, 1963). The vegetation must also determine the fire frequency in that fires are dependent on the accumulation of litter and fuel. Many of the observations up to date have been descriptive. Only in recent years has the need to collect quantitative information been recognized.

The actual nature of the fire is important as even the so called "resistant" eucalypts are unable to withstand frequent firing (Harris, 1959). "Resistant" species are those that have evolved the ability to resume their form and function (Cremer, 1962). This point is particularly applicable to the situation in the parks where increasing frequency of fires is resulting in marked changes to the vegetation. The ability of many Australian shrubs to regenerate from rootstocks and other vegetative parts, as well as from seedlings is well recognized (Petrie, 1925; Cleland, 1940; Specht and Rayson, 1957; and McArthur, 1968). A similar response was found in the vegetation in California (Hellmers et. al., 1955; Specht, 1969). Such adaptions are illustrated by the eucalypts which are capable of forming adventitious shoots from the stems (Wood, 1937; Cleland, 1940, 1958). The regeneration of the species from seeds is often enhanced by the impact of fire (Cleland, 1940; Went et. al., 1952). Among the Australian species that are known to rely on fire to increase the release of seed are the species of *Hakea* and members of the family, Myrtaceae (Cleland, 1958; Cremer, 1965).

This ability of native plant species to regenerate and establish after fires has encouraged the foresters to consider fire as a management tool. However, if fires become too frequent the regeneration is reduced and might ultimately have destructive effects on the vegetation (Pritchard, 1951;

Harris, 1959). One of the major difficulties associated with the use of fire is the lack of information.

Total protection of the parks from fire is obviously dangerous in light of the results of the previous workers in both Australia and America (Chapman, 1947; Weaver, 1955; Gabel, 1969). The other alternative is to take advantage of the evolved adaptive mechanisms of the Australian flora to survive occasional fires. This can be carried out by employing controlled burning. Initially there was strong opposition to the idea of control burning (Chapman, 1947). However there has been a change in ideas in recent years as there has been a gradual accumulation of the knowledge of their effects (Heislers,1971; Houston, 1971). Some of the disadvantages of using controlled burning are discussed by Little, (1953). Controlled burning apparently reduces the accumulation of fuel and would be particularly suitable in reducing the risk of conflagration in the local parks, so minimizing the damage to adjacent properties. One of the major criticisms of the use of controlled burning has been due to the fact that firing has been undertaken without an adequate information basis. This lack of information is particularly applicable to South Australia where no detailed quantitative data has been collected.

3.4. Influence of Fertilizers.

The importance of soil as a determining factor of the vegetation in Australia is well recognized. (Billing, 1950; Beadle, 1953 and 1954; Coaldrake, 1961; Connor and Wilson, 1968).

3 .4. Influence of Fertilizers (Cont.)

For example, in the Mount Lofty Ranges the heath understorey is found on the more infertile soils (Specht, Brownell and Hewitt, 1961). The low fertility levels of Australian soils is well recognized and until recent developments in fertilizers this limited the spread of agricultural activities. Wild (1958) surveyed the phosphate content of Australian soils. Other workers in Australia have since studied the low fertility of the soils (Burvill, 1965; Grundon, 1972). This lower fertility is recognized as a determinant of the vegetation in Australia (Groves, 1965; Grundon, 1972). The dependency of soil on the vegetation was also pointed out by Major (1951).

The experiment in the Ninety-Mile Plains of South Australia clearly indicated that the application of fertilizers affected both the composition and growth of the vegetation (Specht, 1963). The fertile soils supported a herbaceous understorey consisting of introduced plant species. Similar results were obtained in the area in 1972. However, the wind drift of agricultural fertilizers had resulted in increases in introduced species in all the fertilizer plots established by Specht (Heddle and Specht, 1975). These results are particularly important in determining the vegetation in the smaller national parks as well as on the verges of the larger parks.

In the other states of Australia and overseas, nutritional experiments have been carried out to study the effect of fertilizer application (Connor and Wilson, 1968; Bradshaw, 1968; Rorison, 1970; Harper, 1970).

Harper (1970) discusses the major nutritional experiments in England. The results of these studies all demonstrate that both the controlled variation in nutrient supply and the regulation of the activity of grazing animals could change the composition of the grasslands at will. Similar experiments in Australia involving the application of fertilizers, have resulted in similar conclusions. (Connor and Wilson, 1968).

The influence of fertilizers in the parks of South Australia is in the main localized. However, the results of the work undertaken in the south-east suggest that the vegetation in smaller parks will be markedly affected by wind drift of agricultural fertilizers (Heddle and Specht, 1975).

3.5. Influence of Grazing.

The recent settlement of Australia has enabled changes resulting from the grazing to be followed with some certainty (Moore, 1966). The indigenous marsupial populations in all probability placed lower grazing pressures on the vegetation than the introduced domestic animals. Whatever the situation, the introduction of domestic animals has resulted in marked changes in the vegetation. The most important of these animals were sheep and cattle. Their grazing has modified the vegetation markedly in most sections of Australia.

The presence of introduced animals in many of the parks, either by accident or by intention, has resulted in marked changes in the vegetation. Several parks have been grazed in the past or are currently being actively grazed. Work carried out overseas has indicated that grazing markedly affects the vegetation.

3.5. Influence of Grazing. (Cont.)

Gillham (1955) studies the effect of grazing on vegetation onto Pembrokeshire Islands. The resulting zonation of plants around rabbit warrens clearly exemplifies the modifying effect this animal has on the vegetation. Harper (1969) provides a further summary of grazing and predation experiments in England. In 1970, he pointed out that by regulating the activity of grazing animals it was possible to change the composition of the vegetation. Studies in Scotland indicated that the resulting changes are not limited to grazing but also include the tearing action of the soil surface leading to localized soil erosion (Ritchie and Mather, 1971).

In Australia large numbers of workers have stressed the importance of introduced animals as determinants of the vegetation. The manipulation of plant communities by grazing has been discussed by Williams (1968). He delineates those species encouraged by grazing as distinct from those that are favoured by the exclusion of grazing. The exposure of soils to erosion as a result of grazing has been discussed in the Snowy Mountains of Australia (Crook, 1972). These results support those of overseas workers.

Within the park situation there has been a growing awareness of the need to review the grazing by native animals (Darling, 1964; Stone, 1965). The protection provided in these parts has led to inbalances in the existing populations of animals leading to the need to control their numbers. The native animals in South Australia have only posed problems during periods of water stress. Under these conditions, the native animals roam to adjacent properties and compete with domestic for water. The position of grazing in the national parks, by both native and introduced animals, has not been studied to any extent in Australia.

3.6. Other Influences.

The choice and size of parks by man is also important. Main and Yadav (1971) have stressed the size of parks required to conserve the macropods in Australia. There is no doubt that the parks cannot be considered in isolation. As a result the nature of adjacent properties becomes an important consideration (Raup, 1964). The selection of the areas to be dedicated is also important (Stone, 1965). In many cases the choice has been restricted to areas that have been of less interest to others (Wielgolaski, 1971). The lack of interest is usually due to the areas being unsuitable for private exploitation.

Another major influence is the management of the park (Ovington, 1964; Houston, 1971; Owen, 1972; Green, 1972). Until recently the need to manage the parks on a scientific basis was not recognised. In recent years the growing awareness of the need to place the management decisions on a more exact basis has led to more detailed examinations being undertaken (Gabrielson, 1956; Duffey, 1974). Cragg (1968) suggests that this scientific basis is not enough, but that it must be integrated with social and cultural studies. Further, workers have recognized that one of the most critical needs of environmental management is the ability to predict the impact of man's activities (Jenkins and Bedford, 1973).

3.6. Other Influences (Cont.)

One of the major influences of man is the choice of areas and also whether this choice is adequate for both the conservation of native plant species and communities. Dring and Fost (1971) gave a clear account of a study undertaken in England to modify management policies so as to provide for the adequate operation of *Ranunculus ophioglossifolius*. The consideration of both species and plant formations in South Australia has received attention by Specht and Cleland (1961, 1963). As the majority of the parks in South Australia are limited in size the conservation of many of the plant species and/or communities may be difficult. Experience overseas has shown that there is a growing awareness for the need to document and follow both species as well as communities of plants and animals (Corner, 1968).

Other influences include clearing and the alteration of drainage patterns by man (Dixon, 1892; Crocker, 1944; Crook, 1972). In many instances this not only leads to local changes but also widespread alteration in the hydrology of the parks (Greenway and Vesey-Fitzgerald, 1969).

3.7. Summary.

In summary, the activities of man in parks have been discussed. The majority of the parks (regardless of their type) in South Australia have been influenced by one or more of these factors. On the basis of overseas work and observations,the situations studied were considered to typify those in other parks in this state.

Obviously, the number and area of parks is too extensive to be adequately covered in this research, therefore, the choice of situations to be studied was restricted. On the basis of my own observations the impact of man was apparent in all of the parks I visited in the course of the research, however, the nature and extent of this influence varies from one park to the next. It is valid to say that the presence of man has led to marked deleterious changes in both the composition and structure of the vegetation. Further, if the conservation of the plant species and communities is to be attained then the influence of man must be carefully reviewed and monitored in the South Australian Parks.

CHAPTER IV

REVIEW OF TECHNIQUES AND METHODS

In Chapter V, research aims are discussed in detail, but in brief they are to examine a series of South Australian situations so as to reveal and expose the particular ways in which the influences of man and his activities are influencing the vegetation in the parks. This information is an essential requisite for the development of sound management plans.

To achieve these aims, a well chosen series of observational approaches and techniques had to be selected from the wide variety offered in the ecological literature. This present chapter gives a general review of the literature from which techniques were selected, and outlines the approaches adopted for the collection and analysis of data in the situations confronted in this present research.

At the beginning of the century ecologists used descriptive and subjective assessments to recognise the patterns they observed in plant communities. In recent years the emphasis has changed from a qualitative to a quantitative approach and this has been accompanied by the development and application of a variety of statistical methods both in data collection and analysis, e.g. Goodall (1953, 1954) and Williams and Lambert (1959). These relatively objective approaches have arisen from the need to place ecology on a more exact basis. Where these more objective methods have been applied to specific ecological situations they have improved the amount of information and insight gained, e.g. Williams and Lambert (1960). Although many of the objective sampling and analysis techniques have been applied to small areas (Ivemey-Cook and Proctor, 1966; Moore et. al., 1970) they are also applicable to larger areas, e.g. Noy-Meir (1971).

A variety of workers have provided reviews of statistical plant ecology (Lambert and Dale, 1964; Greig-Smith, 1964; Kershaw, 1964; Pielou, 1969; Goodall, 1970; Patten, 1971; Jeffers, 1972). A very recent development has been systems ecology and simulation as reviewed in Patten (1971). These two techniques have led to the possibility of predicting and perhaps designing and controlling ecosystems (Patten, 1971). Sneath and Sokal (1973) discuss the use in plant ecology and biogeography of the very recent developments in methods which also are applicable in many instances to numerical taxonomy. The application of statistical methods has three main functions (Goodall, 1970). The first of these is to reduce a complex mass of data to a simpler form for easier examination and interpretation. Secondly its function is to indicate the optimum choice of research method. Thirdly it is to test hypotheses by the application of statistical methods.

Before detailed survey work can be undertaken in an area, it is necessary to know what species are present, their general distribution and their relative abundance. In addition a general account of the area and its prevailing environmental conditions are required. The latter includes such information as climatic and geological conditions. The first step is therefore to undertake a general examination of the area. The second is to investigate the floristic composition of the area and in doing so familiarise oneself with the flora present. The third is to describe the structure of the vegetation as a basis for ecological work.

The type of data that could be collected must be reviewed and the most suitable chosen for the particular investigation. To this end a brief review of the different types of data will be discussed. The abundance of the plant species can be measured in a variety of ways. The assignment of frequencies to the plant species in an area developed from a subjective approach (i.e. a plant was classified as being rare or common) to one using defined classes (i.e. a plant occurring in 20-40 per cent of the number of sampling units). The latter is the percentage frequency, i.e. the percentage of samples in which each species has been found. This second method was developed by Raunkiaer (1934). Hope-Simpson (1940) investigated the causes of error in the assessment of the frequency value. These causes included the human factor as well as the time of year at which the recordings were taken. The personal error is related to the familiarity of the worker with the vegetation type, the conspicuousness of different species and the mental state of the observer (Greig-Smith, 1964). These factors are minimized by independent workers. Braun-Blanquet's system of rating is considered to be a better defined approach (1927).

Quantitative assessments include the measurements of density (the number of individual per unit area), cover (the proportion of ground occupied by the perpendicular projection on to it by the aerial parts of individual plants), frequency (the chance of finding a plant in a given area) and biomass (the weight of plant in a given area). The various aspects of these measurements are discussed in Greig-Smith (1964) and Kershaw (1973). The gathering of suitable data and the choice of sampling techniques is important if the maximum amount of information is to be gained from the area.

The vegetation may also be followed by its structure. The structure of the vegetation is defined by three components, the vertical arrangement, the horizontal arrangement and the abundance of the species. The method of description of stratification (vertical arrangement) by the use of profile diagrams is due to Davis and Richards (1933-4). This method was included and expanded in northern Australia by Christian and Perry (1953) by a simultaneous approach including the stratification of vegetation, abundance and spatial distribution of species in large-scale surveys.

Mapping techniques (to illustrate horizontal distributions) are laborious and time consuming. However these methods prove useful for the placement of permanent quadrats and time succession studies (Watt, 1962). If it is desirable to follow the spatial distribution of a species or group of species maps provide the most suitable method.

The decision on the type of data to be collected depends on a variety of factors. The choice depends on the number of species to be followed, the number of quadrats, the size of the area and the size of the quadrats. That is, it is a matter of striking a balance between the limits of the experiment and time considerations.

The other major decision is the choice of a sampling system. Sampling can be undertaken either by selecting sites considered to be typical of an area, or by placing samples randomly, or by placing them systematically. The first is inappropriate for a quantitative approach as the observer may be biased in the choice of the study area. The choice is therefore limited to the more objective methods. Greig-Smith (1964) and Kershaw (1973) both provide accounts of the advantages and disadvantages of these two methods of sampling. The other important considerations are the numbers and size of the sampling unit.

If a selection of species is to be followed, a particular sampling method or size of sampling unit may be unsuitable for different plant species, due to the species' different habits and distributions.

A variety of workers have emphasized the importance of sampling a plant community in order to obtain the maximum amount of information from one set of samples. Also the choice of the analytical test is of prime importance. In all ecological work there is a certain error involved in any field observation and measurement. The application of statistical methods tests whether the observed differences are in fact real or a result of the sampling system or a chance event. It is impractical to record quantitative measurements for all plant species in the whole area. Thus only samples of the area are studied and tested. A variety of statistical tests are discussed in Sokal and Rohlf (1969), Bailey (1959) and Kershaw (1973).

If the relative spatial distribution of the sampling units is recorded along with the vegetational details, the possibilities of pattern interpretation become greater. Most studies of pattern are limited to testing whether the distribution of individual plant species can be regarded as random, regular or aggregated. A detailed review of these studies can be found in Goodall (1970).

The causes of pattern may be related to a variety of factors. For example, the distribution of a particular plant species in a defined area may be related to a particular soil, geological, topographic feature, or to the incidence of another species. Many papers in the literature of plant ecology demonstrate these sorts of correlations. The causes of inter-specific correlation are as various as those of spatial pattern for individual plant species.

The commonest cause is the mutual response to varying environmental conditions. Also there may be a direct inter-relation between selected species so influencing their correlation (e.g. allelopathic effects). The association between species based on joint presence is usually distinguished from correlations, in which the quantities present are taken into account. In general investigators have shown correlations between species without attempting to elucidate the cause of relationship.

The correlation of species with particular environmental variables has more potential as a tool for the explanation of plant distributions. The other practical value of correlation studies is the establishment of indicator species. Further species which tend to be constantly associated leads to the idea of a group or, more specifically, ecological groups. Godron (1967) indicates that ecological groups may overlap in their environmental requirements. In particular, a less demanding group may often overlap with a more demanding group. The classification and ordination of the vegetation is of prime importance as it leads to simplification and coding of data and may allow the objective description of ecological groups. Classification attempts to arrange stands into discrete classes. The members of such classes have in common a number of characteristics setting them apart from members of other classes. Ordination accepts the overlap and that there is a continuum in vegetation.

An early example of objective classification can be found in Goodall (1953). He used presence and absence data from random quadrats in testing for the association between species. His classification procedure was based on the formation of groups of stands by elimination of association.

This technique depended on positive associations, negative associations being ignored. Williams and Lambert (1959, 1960) and Williams and Lance (1958) have examined critically the problems of classification of stands when only presence and absence data are available. The technique of association analysis is based on the significance of chi-squared values generated from contingency tables between pairs of species regarding their incidence in quadrats. This technique has produced subdivisions expected from previous knowledge of the area but has also exposed differences, previously overlooked, which are capable of ecological interpretation. However the size of the sampling unit is of great importance in interpreting the results (Kershaw, 1961). For example if the sampling unit is too small species tend to be negatively associated with each other. This is simply due to the physical inability of species to occupy the same area. One of the main advantages of this method is that it can handle large numbers of units (whether species, stands or quadrats). Williams and Lambert (1961) suggested the use of simultaneous normal and inverse analysis, i.e. clusters of both quadrats and species. Although this approach has advantages for certain applications it has weaknesses. These are discussed by Lange, Stenhouse and Offler (1965), Lange (1966), and Welbourn and Lange (1967).

A number of comparisons have been made in recent ecological literature between different techniques for this sort of vegetation analysis. Particular attention has been placed on the comparison of clustering methods and those employing information statistics (Lambert and Williams, 1966; Williams, Lambert and Lance, 1966; Webb et. al. 1967; Orloci, 1968a, 1968b, 1969).

Because of the continuous nature of the variation of most vegetation, ordination methods have often been used in preference to clustering techniques. The early ordination techniques (e.g. the vegetation of Wisconsin, see Curtis, 1959) have gradually been replaced by various types of factor analysis (Austin and Orloci, 1966; Ivimey-Cook and Proctor, 1967; Whittaker, 1972). However when working with large areas of vegetation the preference of most workers is to use the clustering techniques.

This chapter has given a brief review of the literature of the techniques and methods in plant ecology. Because of the wide range of approaches with which one can study vegetation the following chapter discusses the research techniques and methods adopted in this research work.

CHAPTER V

RESEARCH OBJECTIVES AND METHODS

Chapter II and III have indicated that the flora and fauna of the world are threatened by the influence of man. Despite man's relatively recent realization of the need to conserve his surroundings, there is still a great deal of damage being done to the native plant and animal communities. In South Australia, the dedication of national parks has led to the possibility of conserving sections of the flora and fauna from further damage by man. The diminishing areas of native vegetation has placed greater emphasis on the need to describe and assess the vegetation in those areas already set aside.

The management of parks involves great problems and these are confused further by the inadequacy of present knowledge. This inadequacy is hindering decisions in the management of the national parks. It is essential that a more exact basis of information is made available for future management than can be provided by descriptive ecology. To this end the collection of quantitative data is of utmost importance if man is to conserve the remnants of the relatively uninfluenced native vegetation. With analytical studies it will not only be possible to elucidate his influence on the plant communities but also to identify plant indicators of such influence. Such information would predictably alleviate those influences if they are harmful to the native plant communities. In addition by adequate initial collection of data it would be feasible to undertake long term monitoring of any changes in the vegetation so helping in decisions of management.

Five parks were selected to follow the impact of man as reflected in the composition and structure of the vegetation. The choice of parks was made on the basis of several factors including the history of man's influence, the nature of the vegetation, the size of the park and the nature of the influences. The selection of the parks was biased. In South Australia, the large number of parks and varieties of vegetation in them were weighed against the familiarity of local vegetation. In addition the two long term pyric succession studies were undertaken in similar vegetation to that in the local parks. This enabled comparisons to be made between the broad surveys and the localised pyric succession studies.

The object in selecting five parks was to find the extent and nature of the changes in the vegetation that reflected man's influence. To this end it was necessary to distinguish between those patterns in the vegetation that were related to natural forces (e.g. soils and aspect) and those that resulted from man's activities. The influences in these parks were compared and discussed with reference to other parks in South Australia.

The other object of the research was to follow the pyric succession of the plant species after the advent of both a wild fire and controlled fires. In light of the large number of fires in many of our local parks, the Bushfire Research Council of South Australia has recommended the use of controlled burning in the parks for protective purposes to the surrounding properties. They carried out a control burn on a strip of land in Cleland Conservation Park. The object of the first of these pyric succession studies was to investigate the response of selected plant species to a wild fire.

This research was carried out in a section of Pittosporum Valley in Belair Recreation Park. Particular attention was given to the aggressive alien species, *Senecio pterophorus*.

Controlled burning has been recommended as a possible management tool in our local parks. However up to date no quantitative data is available in South Australia on the effect this treatment would have on the local vegetation. To this end a monitoring experiment was undertaken for two and a half years in the Mount Bold Encatchment Area to follow the effect of controlled burning (in spring and autumn) on a selection of native and alien plant species. This experiment would provide data as well as descriptive accounts of the impact of such burning treatments.

The research methods can be basically divided into two sections. Firstly those methods which are concerned with the broad-scale vegetation surveys in the five parks (Sandy Creek Conservation Park, Kyeema Conservation Park, Belair Recreation Park, Nixon-Skinner Conservation Park and the Knoll Conservation Park). Secondly those methods which are used in the pyric succession studies.

Several points were taken into consideration in deciding upon an appropriate analytical method for the first section. The vegetation of the parks was followed by binary data for all species present at the time of the survey. Although the results for the annual species recorded varied with the season, their inclusion enabled a better coverage of the vegetation. The choice to collect presence-absence data for all the plant species was based on the consideration of time involved in collecting quantitative data such as density measurements.

The large number of species combined with the large number of sampling units made the choice of binary data the most efficient for the analysis of the vegetation. Where density results were included they were mainly limited to the more frequent shrubs and tree species (i.e. where the individual plant was easily distinguished). The distribution data of the soils for the parks were taken from previous documentations and converted into binary data. They were then included in the analysis. Similarly the topographic features were recorded in the surveys and included in the binary data, i.e. aspect and ridges.

As the majority of the field sampling was to be recorded single-handed and as the studies involved extensive areas, the simplest method was chosen. The simple method of systematic sampling was chosen instead of the more time consuming random sampling. Also it was desirable to map the spatial distributions of all plant species for pattern interpretation and for future reference. The incidence data was subjected to an association analysis and the inter-relations visually presented in constellation diagrams. The association analysis of all pair-wise combinations of the plant species, soils and topographic features were undertaken with the use of a program written by I.R. Noble * for the CDC 6400 Computer at the University of Adelaide.

This program calculates an association matrix between all combinations of species (or soils or topographic features) using binary data and a chi-squared test.

* I.R. Noble: formerly Botany Department, University of Adelaide, now Research School of Biological Sciences, A.N.U., Canberra, A.C.T.

The chi-squared test is either with Yates Correction or when necessary with Fishers Exact Test (two-tailed, not assumed symmetrical). Results are presented in array in the form of probability scores of the chi-squared values. All chi-squared values greater than 10.83 (i.e. with a probability value of less than or equal to 0.001) were included in the results. The program also calculates whether an association is positive or negative. For further details of the association analysis and chi-squared test see Sokal and Rohlf (1969).

The approach taken was to distinguish between groupings of plant species associated with natural forces (soils or aspect) and then plant inter-relations. The plant inter-relations were then discussed in light of possible causal factors including the influence of man in the particular area.

Incidence was therefore the prime parameter used to identify plant distribution patterns and plant groups. Density was included in several instances to clarify and expand the situation further. In several parks localised areas also were studied to establish a base-line for future comparison.

The data was collected on a pre-defined grid at regular intervals. This provided the opportunity for later comparison and replication if desired by the park authorities. The actual interval between quadrats and traverses depended on several factors including the size of the park and/or time considerations.

The two pyric succession studies were carried out to gather quantitative data on the changes after a wild fire and after the controlled burns. Density was the main parameter measured in both cases.

However in the controlled burning experiment percentage cover and biomass measurements were also collected. The results for selected species were analysed by testing the significance between means with a t-test, with variances not assumed equal by using a program written by T. Mattiske*. The mean and standard deviations were calculated at the different time intervals. The results for the different time intervals were tested with each other. The results were graphically presented by using a plotting program written by T. Mattiske*. The large variation in the vegetation at the Mount Bold Encatchment Area restricted analyses to time studies.

The following chapters comprise the original work of this thesis.

* T. Mattiske: formerly with Control Data Australia, now Amax Exploration (Aust.) Inc., Perth, W.A.

CHAPTER VI

SANDY CREEK CONSERVATION PARK

6.1. Introduction.

Sandy Creek Conservation Park (Hundred of Barossa, Section 72, 317 and 319) is located approximately 42 kilometres north of Adelaide. The park lies between Gawler and Lyndoch at the southern end of the Barossa Valley (Fig.6.1.).

In 1965, Section 72 was dedicated as a Wildlife Reserve within the meaning of the National Parks and Wildlife Reserves Act, 1891 - 1960. The reserve was controlled and managed by the Commissioners of the National Parks and Wildlife Reserves. In 1966, the park was renamed and declared as Sandy Creek National Park under the Provision of the 2nd Schedule of the National Park Act, 1966. In 1967 the adjacent sections 317 and 319 were added to enlarge the area of the park to 104 hectares. Sandy Creek National Park was later proclaimed to be a conservation park under the control of the National Parks and Wildlife Act, 1972.

6.2. Historical Background.

Over a hundred years have elapsed since settlement began in the Barossa District (Northcote, Russell and Wells, 1954). The majority of the region has long been cleared and developed for agricultural purposes. In comparison Sandy Creek Conservation Park consists of an area relatively undisturbed and undeveloped.

Figure 6.1.

Location of Sandy Creek Conservation Park

(▲ indicates the location)

SANDY CREEK CONSERVATION PARK

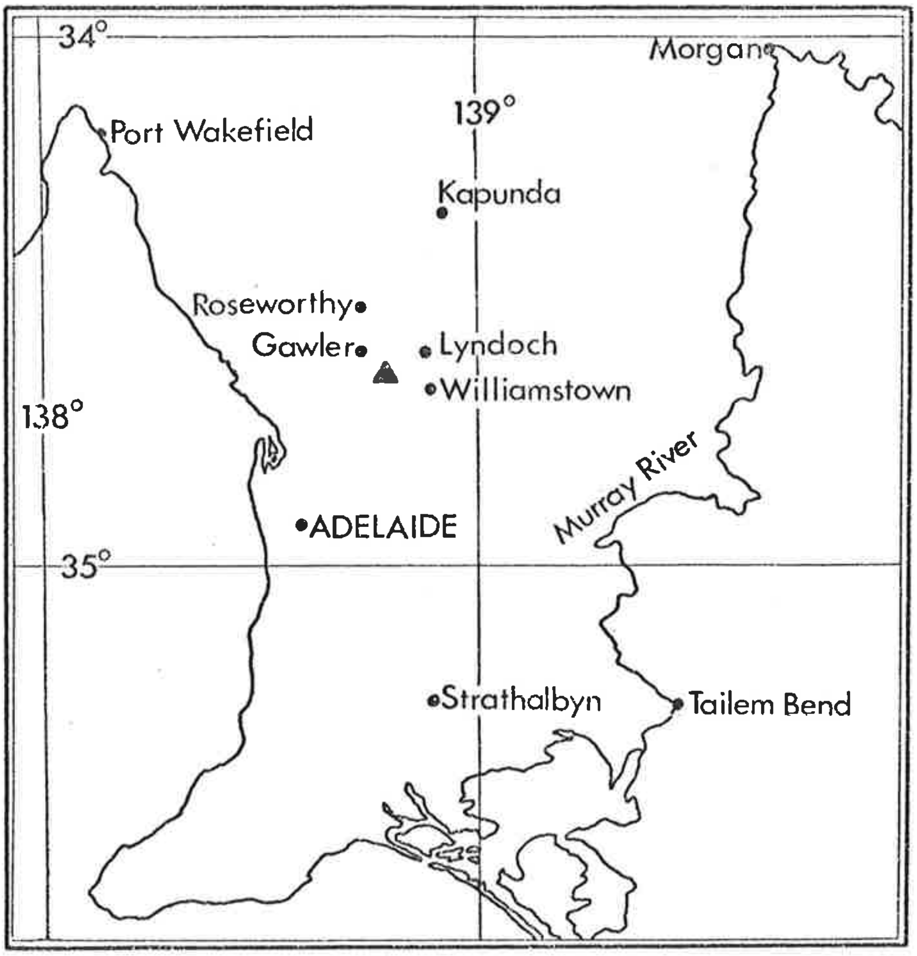


Figure 6.1.

Sandy Creek Conservation Park typifies many of our local parks in that sections have been subject to the past activities of man. These activities have included the cultivation of vines, logging, clearing and grazing of domesticated animals. The park is surrounded on most sides by land currently being used for a range of agricultural purposes including grazing of domesticated animals as well as the cultivation of orchards, crops and vineyards.

The northern and southern sections of the central area of the park were once ploughed and vineyards cultivated. In 1965 these vines were abandoned and in the main have been left in the two areas. In 1967, attempts were made at pulling and heaping the vines in portion of the northern area. This disturbance of the soil surface appears to have favoured the regeneration of some native species.

In 1970, the native pine, *Callitris preissii,* was logged for the construction of fences. The suitability of the native pine for fencing and building purposes has reduced the number of this species in the Barossa District. Evidence of the logging of native pine in Sandy Creek Conservation Park can be seen in the northern area near the access road to the park. In addition, the logging of *Eucalyptus odorata* in the north-western corner of the park has been carried out in the past. The construction of fences along the northern edge resulted in further clearing and encouraged the establishment of several introduced plants including *Senecio pterophorus* (South African daisy) and *Cynara cardunculus* (Artichoke).

6.2. Historical Background (Cont.)

Although some efforts have been made to maintain fencing, I would estimate that sixty per cent of the fences of the park are inadequate for the purposes of keeping domestic animals out of the area and native ones in the park. In the south-western corner the only evidence of the edge of the park is the occasional surveyor's peg. With inadequate fencing and the attitude of local farmers, it is not surprising that sheep, cattle and horses all have been seen or reported in the park. Due to the loose surface of the sandy soil over the majority of the park the presence of the animals has caused a large amount of erosion. This is particularly marked along the tracks over the sand dunes where the soil surface has been removed and the roots of the trees and shrubs have become exposed. The successful practice of laying wire-mesh on the sandy tracks at Kelvin Powrie Conservation Park in the south-east has not been undertaken at Sandy Creek Conservation Park.

In the northern area where the vines have been uprooted there are apparently only small numbers of rabbits, but these appear to have stunted the growth of *Callitris preissii* seedlings. Kangaroos also have been sighted but appear to be present in low numbers. In the parks of the south-east of South Australia, the farmers do not take kindly to the kangaroos but in this area they do. This is probably due to the infrequent occurrence of extremely dry conditions which, in the south-east, encourages the kangaroos to roam and compete with domestic animals for water (pers. comm., D. Scammell and R.S. Haynes).

Despite the recently installed sign posts on the main access tracks into the park, vehicles still reach the central area of the park. The disturbance due to vehicles in the northern access area of the park is severe with complete removal of the vegetation. The presence of convenient parking spots has led to the damage and removal of shrubs in this area. Although sites are not provided, barbecues are held there. Littering of rubbish including used explosive shells, old furniture, bottles, paper and plastic containers is also a problem.

The South Australian Ornithologists Society and the National Fitness Council of South Australia both have shown a great deal of interest in the park.

6.3. Climate.

The climate of Sandy Creek Conservation Park consists of cool, wet winters and hot, dry summers. Rainfall and temperature data for Kapunda and Roseworthy Agricultural College appear in Table 6.1. A comparison of the rainfall for Kapunda to the north-east and Roseworthy College (near Roseworthy) to the north-west, illustrates the decrease in rainfall from east to west across the area. As Sandy Creek Conservation Park lies roughly half way between the two places these data give an indication of the climate in the park (Fig 6.1.). The majority of annual rainfall (more than 75 per cent) is in the months April to October inclusive.

Table 6.1.

Rainfall and temperature recording for Kapunda and Roseworthy Agricultural College (taken from the records of the Bureau of Meteorology, Adelaide)

		No. of Years	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
Kapunda	Mean Rainfall (mm)	113	21	21	23	39	57	59	59	62	54	46	30	26	497
	Median Rainfall (mm)	113	16	14	17	31	46	55	58	61	50	44	24	19	500
	Rain Days	113	4	4	4	8	11	14	15	15	12	10	6	6	119
	Av. Max. Temp. °C	74	29.7	29.4	26.6	21.5	17.5	14.2	13.4	15	17.8	21.3	25.2	28.1	21.6
	Av. Min. Temp. °C	74	14.5	14.7	12.7	10.1	7.9	6.2	5.3	5.8	6.9	8.8	11.2	13.3	9.8
	Mean Temp. °C	74	22.1	22.1	19.7	15.8	12.7	10.2	9.3	10.4	12.3	15.1	18.2	20.7	15.7
	Extreme Max. Temp. °C	74	45.4	43.9	42.4	37.9	33.9	25.6	22.8	27.5	37.4	38.3	42.3	43.3	
	Extreme Min. Temp. °C	74	4.4	4.4	2.8	1.7	0.7	2.8	3.3	1.7	1.7	0.6	1.6	3.3	
Rose. Agr. College	Mean Rainfall (mm)	88	21	20	19	38	49	55	49	53	45	41	27	24	441
	Median rainfall (mm)	88	12	10	15	30	42	48	44	51	43	40	22	22	442
	Rain Days	88	4	3	4	8	11	13	14	15	11	10	6	5	106
	Av. Max. Temp. °C	64	29.8	29.5	27.3	22.8	18.7	15.7	14.8	16.1	18.8	22.1	25.3	27.8	22.4
	Av. Min. Temp. °C	64	15.1	15.3	13.4	10.9	8.8	6.7	5.9	6.1	7	8.9	11.4	13.4	10.2
	Mean Temp. °C	64	22.5	22.4	20.3	16.9	13.7	11.2	10.3	11.1	12.9	15.5	18.3	20.6	16.3
	Extreme Max. Temp. °C	64	46.4	44.7	43.1	37.8	32.8	26.4	23.7	36.5	34.7	41.8	45.3	45.4	
	Extreme Min. Temp. °C	64	5.2	5.6	4.2	1.1	0.5	1.9	2.2	2	1.1	1.1	0.0	2.9	

6.3. Climate (Cont.)

Trumble, 1948, in a study of rainfall, evaporation and drought frequency in South Australia showed that the mean effective rainfall season for this area varies from 7.6 months for Kapunda to 8.3 months for Williamstown (located south-east of Sandy Creek Conservation Park).

Temperature conditions in the Barossa District have been discussed by Northcote, Russell and Wells (1954) and Northcote and de Mooy (1957). One of the important features is the low mean temperature of less than twelve degrees Celsius for June, July and August. This means a substantial check to plant growth during these three months. The effective growing season is therefore divided into two parts, autumn and spring.

6.4. Physiography and Drainage.

The dominant features of the area are the low undulating hills and plains dissected by creek valleys. The elevation of the park is two hundred and twenty metres above sea-level. (Geological Survey of South Australia, Gawler Sheet, 1953). Two major sand dunes run in an east-west direction and merge into one dune at eastern edge of the park. A smaller dune runs in an east-west direction in the south-western corner of the park. (fig.6.2.).

Main drainage consists of a small tributary of Sandy Creek on the southern edge of the park. (Fig. 6.2.).

Figure 6.2.

The main features of Sandy Creek Conservation Park. (Scale 1 cm = 100 metres)

————	Sand ridge
--------	Watercourse
	Abandoned vineyards
	Intensive study area
A	Access road to park
H	Hut
W	Waterhole

SANDY CREEK CONSERVATION PARK

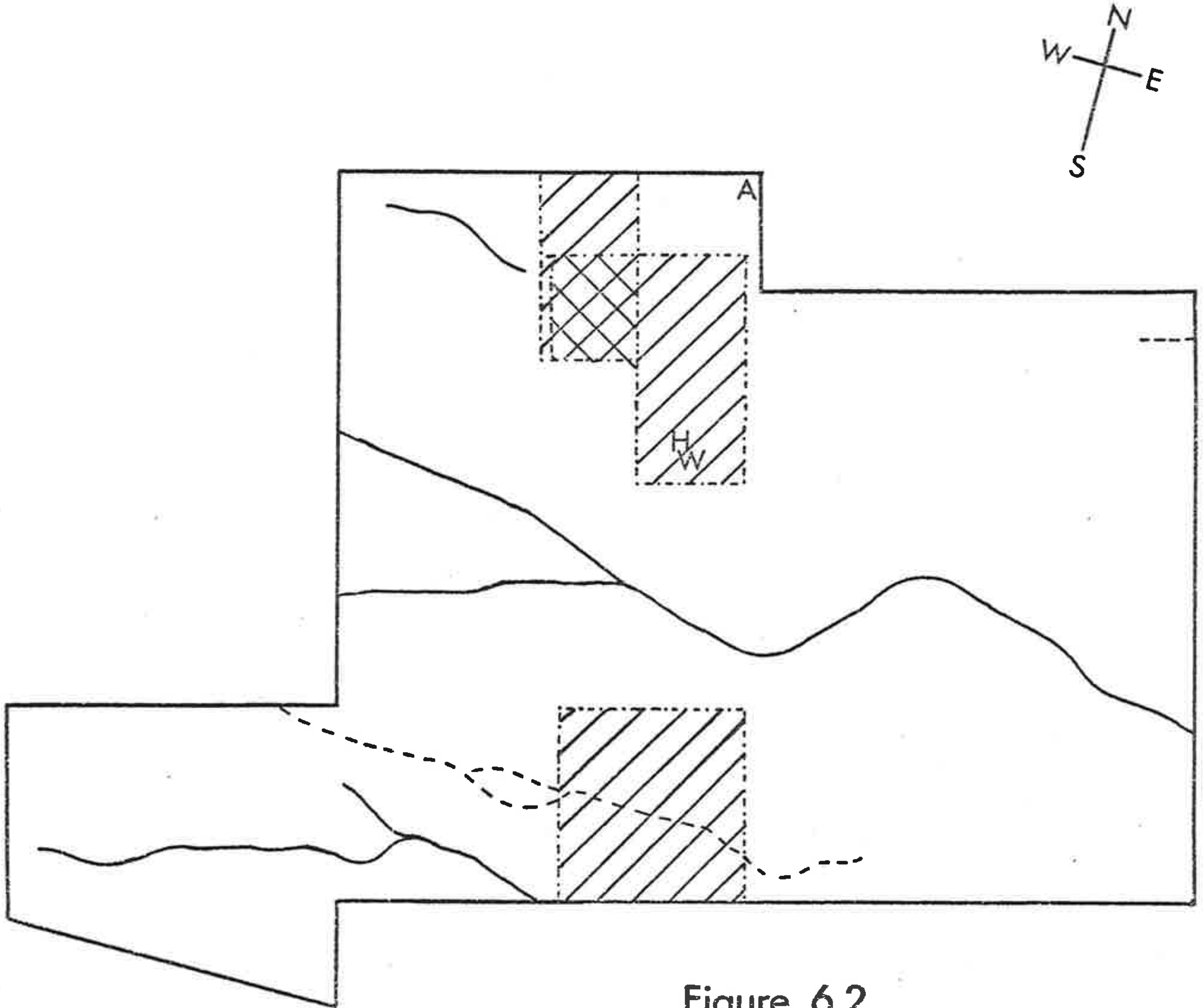


Figure 6.2.

6.4. Physiography and Drainage (Cont.)

Sandy Creek runs along the south-western border of the park and then follows a northerly course to join the North Para River downstream from Rosedale on the western edge of the Barossa Valley. A small creek flows out of the north-eastern edge of the park. Other drainage-influences include a water-hole near a hut in the centre of the park.

6.5. Geology and Soils.

Two broad groups of parent material from which the soils were formed were recognised in Sandy Creek Conservation Park (Northcote, 1959). The large range of soils and fertility levels is characteristic of the Barossa District (Northcote, Russell and Wells, 1954; Northcote and De Mooy, 1957; Wells, 1959). The soils developed from the tertiary deposits are markedly the most impoverished, see Tables 6.2 and 6.3.: The major soil groups in Table 6.2. are those described by Stephens in the early fifties (Stephens, 1953).

Analytical data on the key horizons for the soils found at Sandy Creek Conservation Park are extracted from Northcote, 1959, see Table 6.3. For the purposes of investigating the factor of soil as a possible determinant of the vegetation these data are considered to be adequate for this area.

The Dale-Altona Association soils in the north-western corner of the park cover only a small section (Volume II, Map 6.23.).

Table 6.2.
Parent Materials of the soils of Sandy Creek Conservation Park (Northcote, 1959)

Parent Material	Soil Groups, Soil Families, Micro-associations
Tertiary (?) deposits and/or material influenced by lateritic weathering.	Solods - Willamba, Long and Incrassata. Solodized solonetz-Warpoo.
Proterozoic rocks - Torrensian series. Phyllitic slates and associates.	Grey brown soils of heavy texture-Altona. Dale family with Altona micro-association.

The Dale soil family of moderately shallow red-brown earths cover the low-rounded hill found in the north-western section of the park. Parent materials are dominantly Proterozoic phyllitic slates and alluvial-colluvial deposits derived from them. The loam surface soils are restricted to the upper twenty-five centimetres of the profile. The red-brown clay subsoils (the subsoils contain free calcium carbonate) which overlay large amounts of calcium carbonate, cover a layer of weathered slates. The soils occur in a complex with the Altona micro-association.

The Warpoo family of soils are sandy, strongly solodized solonetz occupying a small section on the northern edge of the park (Volume II, Map 6.24.). The soils have bleached subsurface

Table 6.3.

Analytical Data for Key Horizons - Data extracted from Northcote (1959)

Soil	Horizon	Depth (in.)	pH	Clay (%)	Total* Phosphorous (%)	Total* Potassium (%)	Exchangeable Cations										
							TOT.	Ca		Mg		K		Na		H	
							A	A	B	A	B	A	B	A	B	A	B
Solods Willamba family	A_1	0-2½	6.2	3	0.006	0.04	9.7	4.6	48	1.0	10	0.1	1	0.1	1	3.9	40
	B_1	41-51	6.6	19	n.d.	n.d.	7.6	2.7	36	3.0	39	0.1	2	0.4	6	1.3	17
	B-C	61-70	7.2	31													
Incassata family	A_1	0-3½	6.4	1	0.003	0.02	3.1	1.4	45	0.2	7	0.06	2	0.02	1	1.4	45
	B_1	35-40	6.2	24	0.004	0.17	10.9	2.3	21	3.9	36	0.12	1	1.2	11	3.4	31
Long family	B_1	26-34	6.5	14	0.005	0.16	6.1	2.2	36	1.9	31	0.17	3	0.56	9	1.3	21
Solodized solonetz	A_1	0-3½	7.2	3	0.011	0.06	11.4	7.5	66	1.3	11	0.3	2	0.05	1	2.3	20
Warpoo family	B_1	19-28	5.9	58	0.008	0.5	20.9	5.9	28	5.5	26	0.6	3	1.4	7	7.5	36
Red-brown earths Dale family	B_1	9-15	8.1	55	0.022	0.9	32.4	21.8	67	5.1	16	1.3	4	0.3	1	3.9	12

* Soluble in boiling hydrochloric acid.

A = m. equiv./100 g. of soil ; B = percentage composition of exchangeable cations.

n.d. = Not determined.

horizons immediately above the clay subsoil (containing free calcium carbonate) and an accumulation of calcium carbonate in the deeper subsoils. These soils are subject to drought and sometimes salinity problems.

The other three soil families do not contain free calcium carbonate in their subsoils and all consist of deep sandy soils with a pronounced bleached subsurface horizon. The low fertility levels of these three soil families has led to the lack of agricultural development of the majority of the area of Sandy Creek Conservation Park.

The Willamba family soils which cover by far the major area of the park have developed on Tertiary deposits with sandy horizons varying in depth from fifteen centimetres to two metres. The major sand dunes in the Sandy Creek Conservation Park consist of this soil type (Volume II, Map 6.24.). Their fertility levels are particularly low and the soils tend to be subject to drought conditions.

The Incrassata family soils cover only a small area of the park in the relatively low-lying situations on Tertiary deposits near the margins of the Willamba family soils (Volume II, Map 6.23 and Map 6.24.) and are subject to severe seasonal waterlogging.

Long family soils are similar to the Incrassata family soils in their parent materials but they tend to be better drained.

The Long family soils only cover a small area of the park. (Volume II, Map 6.23.).

6.6. Vegetation.

The low woodland formation found at Sandy Creek Conservation Park is dominated by a range of species of *Eucalyptus, Callitris preissii* and the occasional *Casuarina stricta*. The trees are in the range of five to ten metres tall with an open cover. The understorey depends on the soil type and varies from a herbaceous one to dense sclerophyllous shrubs. The vegetation in the park tends to reflect the large range of soil types. The cultivated areas are almost void of trees with only the occasional shrub of *Acacia calamifolia, Acacia pycnantha* and *Astroloma conostephioides*.

The disturbed areas, as a result of the presence of vineyards, support a range of introduced species including *Oxalis pes-caprae, Medicago polymorpha* and *Echium lycopsis*.

Chrysanthemoides monilifera which grows in a thicket adjacent to the hut, is the only introduced shrub that is present in significant numbers in this area. This species has been in the district since the fifties and is now well established in some areas.

6.6. Vegetation (Cont.)

The various determinants of vegetation pattern were investigated and discussed in view of the activities of man.

6.7. Research Objectives.

Sandy Creek Conservation Park offered several advantages for research. First it provided a park that had been subjected to a range of man's activities. Second it provided an area with a sandy soil in contrast with the other parks surveyed which all had heavy textured loam to clay soils. I therefore studied the vegetation of the area to investigate the floristic and structural components of the plant communities in this park, with particular attention being placed on causal factors of the distribution of the plant communities. The approach can be summarized by the following: -

a) To carry out a reconnaissance of the park to gain a general description of the area.

b) To construct a floristic list as a basis for the identification of plant species.

c) To study the plant communities by surveying the species present throughout the park.

d) To follow some species that appear to be of particular interest in that they reflect man's activities and/or are of interest in the inter-relationships present within the plant communities.

6.7. Research Objectives (Cont.)

e) To study a localized area in the northern section of the park by measuring the densities and heights of the native species in order to follow the regeneration of a disturbed area.

f) To review the soil and physiographic features of the area as possible determinants of the distribution of plant species.

6.8. Research Methods.

Reconnaissance and the collection of species were carried out on several occasions. The necessity to collect at a series of different times was due to the different flowering dates of the plant species present. The floristic list presented in Appendix II is complete as far as possible.

In order to study the vegetation of the park the survey was necessarily extensive rather than intensive. The vegetation was surveyed by using a systematic location of three hundred and sixty nine quadrats at fifty metre intervals (measured by pacing) along traverses seventy five metres apart running at a compass bearing of one hundred and sixty five degrees. The first traverse was along the fence running on a course of one hundred and sixty five degrees from the north-western corner of the park along the major part of the western edge. The quadrats were circular in shape with a radius of five metres.

6.8. Research Methods (Cont.)

At the edges of the park quadrats only included the semi-circular section within the park. The presence-absence data collected for Sandy Creek Conservation Park enabled the distribution maps of the species to be constructed with the assistance of the University of Adelaide CDC 6400 computer (Volume II, Maps 6.1. to Map 6.22. inclusive). In addition an association analysis was carried out on the binary data to study the inter-relations between plant species, soils and topography in the park. These results are discussed in the following section of this chapter.

The density and heights of all native plant species in an area of the northern abandoned vineyards of the park were measured.

6.9. Results.

6.9.1. Introduction.

The floristic list appears in Appendix II. The distribution maps of the plant species and soil groups appear in Volume II, Appendix III, Maps 6.1. to 6.24. inclusive. The frequency of species in Sandy Creek Conservation Park are recorded in Table 6.4. The inter-relationships of plants with soils, physiographic features and other plants will be discussed separately in sections 6.9.2., 6.9.3., and 6.9.4. respectively. The results for the density of the re-establishing plant species on the area in the northern abandoned vineyards will be discussed in Section 6.9.5.

Table 6.4.

The plant species sampled at Sandy Creek Conservation Park with the percentage of total samples in which they occur. Introduced species are prefixed by an asterisk.

Species	Frequency
* *Vulpia myuros*	84.0
* *Hypochoeris glabra*	83.7
Astroloma conostephioides	80.2
Moss spp.	70.5
Millotia tenuifolia	58.3
Chemaescilla corymbosa	57.5
Drosera whittakeri	53.7
Calytrix tetragona	53.7
Baeckea behrii	53.4
Drosera auriculata	52.8
Eucalyptus fasciculosa	49.3
* *Avena fatua*	48.8
* *Aira caryophyllea*	45.0
Schoenus maschalinus	42.0
Callitris preissii	42.0
Crassula colorata	38.8
Calandrinia neesiana	38.8
Hibbertia virgata	38.5
Centrolepis strigosa	38.2
Haloragis spp.	27.6
* *Briza maxima*	26.8
Cynodon dactylon	26.8
Actinobole uliginosum	26.6
* *Trifolium arvense*	26.3
Podotheca angustifolia	25.7
* *Asparagus asparagoides*	24.4
* *Anagallis arvensis var. carrula*	24.1
* *Arctotheca calendula*	24.1
Hibbertia stricta	23.3
Dodonaea viscosa	22.5
* *Chrysanthemoides monilifera*	22.2
* *Bromus madritensis*	20.6
Acacia calamifolia	20.3
Banksia marginata	18.7
Calocephalus drummondii	17.6
* *Medicago polymorpha*	16.8
* *Echium lycopsis*	16.5
* *Oxalis pes-caprae*	14.9
Lepidosperma laterale	14.9
Helipterum laeve	14.1
Casuarina stricta	13.3
Xanthorrhoea semiplana	11.1

Table 6.4 (Cont.)

	Species	Frequency
*	*Erodium botrys*	9.2
	Hybanthus floribundus	8.9
	Grevillea lavandulacea	8.9
	Danthonia spp.	7.6
	Dianella revoluta	7.3
*	*Briza minor*	6.8
	Dillwynia hispida	6.2
	Acacia pycnantha	5.7
	Leucopogon cordifolius	5.4
	Eucalyptus odorata	4.9
	Callistemon macropunctatus	4.9
	Stipa aristiglumis	4.6
*	*Rumex angiocarpus*	4.1
	Pimelea stricta	3.8
*	*Ehrharta calycina*	3.8
	Lomandra dura	2.2
	Acacia rotundifolia	2.2
	Helichrysum bilobum	1.6
	Correa pulchella	1.6
	Astroloma humifusum	1.4
	Kunzea pomifera	1.4
	Senecio quadridentatus	1.1
	Spyridium sp.	0.3

6.9.2. The soil-plant relationships.

a) The Dale family soils are poorly represented in Sandy Creek Conservation park occurring in less than five per cent of the area. Therefore, any deductions drawn from the following results must be treated with caution. It is noteworthy that the group of plants associated with *Eucalyptus odorata* are positively associated with this soil type (Fig. 6.3. (a).). This group of plants includes such species as *Acacia pycnantha, Acacia rotundifolia, Helichrysum bilobum, Pimelea stricta, Stipa aristiglumis* and the introduced plant *Arctotheca calendula.* The importance of the soil type as the determinant of this group of species can be seen on the southern edge of the *Eucalyptus odorata* where there is a marked change in vegetation to an open woodland of *Eucalyptus fasciculosa* within twenty metres. The incidence of this group which is associated with the Dale-Altona association soil indicates that on an area basis this group of plants is poorly represented in Sandy Creek Conservation Park.

b) The Warpoo family of soils is restricted in area but has several positive associations with plant species. *Calytrix tetragona,* an abundant shrub (Table 6.4.) along with the native annual, *Millotia tenuifolia,* show positive association with this and the Willamba soil family (Fig. 6.3. (b).). Their range of tolerance of soil conditions is therefore high compared with *Hibbertia stricta, Briza minor* and the species of *Danthonia* which are restricted to the soils of the Warpoo family. *Trifolium arvense* on the other hand is dissociated with this soil type and prefers the drained soils of the Long family of soils.

Figure 6.3.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Sandy Creek Conservation Park.

(a) Node of species associated with Dale soil family

(b) Node of species associated with Warpoo soil family

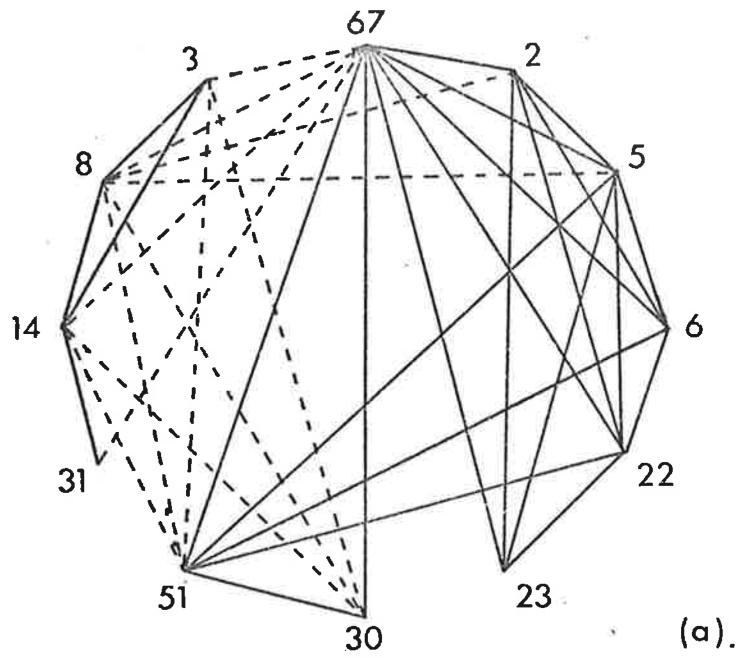
________ indicates association, positive association

- - - - - indicates dissociation, negative association

* indicates an introduced species

(2)		*Eucalyptus fasciculosa*
(3)		*Eucalyptus odorata*
(5)		*Acacia pycnantha*
(6)		*Acacia rotundifolia*
(7)		*Calytrix tetragona*
(8)		*Baeckea behrii*
(11)		*Hibbertia stricta*
(14)		*Astroloma conostephioides*
(22)		*Helichrysum bilobum*
(23)		*Pimelea stricta*
(30)	*	*Arctotheca calendula*
(31)	*	*Hypochoeris glabra*
(46)	*	*Briza minor*
(51)		*Stipa aristiglumis*
(53)		*Danthonia* spp.
(57)	*	*Trifolium arvense*
(59)	*	*Millotia tenuifolia*
(67)		Dale soil family
(71)		Warpoo soil family

SANDY CREEK CONSERVATION PARK



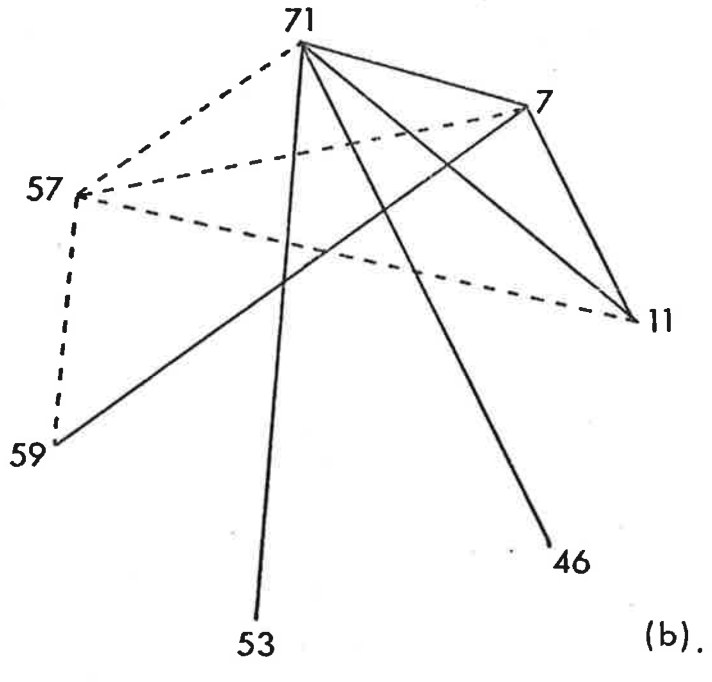


Figure 6.3.

c) A group of introduced species are associated with the Long family of soils (Fig. 6.4. (a).). *Callistemon macropunctatus* which grows in the well-drained creek-beds and valleys of the park is the exception. The large number of species dissociated with this soil type are those that prefer deep sandy soils of a low fertility level.

d) The Willamba soil family covers the majority of the park and supports the *Eucalyptus fasciculosa* association (Fig. 6.4. (b).). Selected species of this node are dissociated with the well drained Long family soils. These species include *Calytrix tetragona, Baeckea behrii, Hibbertia virgata* and *Banksia marginata*. The majority of herbaceous and introduced plants are dissociated with this soil type. The exception is the introduced creeper *Asparagus asparagoides*.

e) The Incrassata soil family appears in only a small section of the park and is of little significance as a determinant of vegetation. *Leucopogon cordifolius*, a sclerophyllous undershrub is associated with this soil (Fig. 6.5. (a).).

The soils are an important factor in determining the distribution of plant species. The two soil families, Dale and Willamba, clearly deliniate the two groups of plants as will be discussed in section 6.9.4.

Figure 6.4.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Sandy Creek Conservation Park.

(a) Node of species associated with the Long soil family

(b) Node of species associated with the Willamba soil family

________ indicates association, positive association

-------- indicates dissociation, negative association

* indicates an introduced species.

(1) *Callitris preissii*

(2) *Eucalyptus odorata*

(7) *Calytrix tetragona*

(8) *Baeckea behrii*

(12) *Hibbertia virgata*

(14) *Astroloma conostephioides*

(16) *Callistemon macropunctatus*

(18) *Banksia marginata*

(27) * *Avena fatua*

(29) * *Echium lycopsis*

(31) * *Hypochoeris glabra*

(32) * *Asparagus asparagoides*

(35) * *Oxalis pes-caprae*

(39) *Chamaescilla corymbosa*

(40) Moss spp.

(49) * *Aira caryophyllea*

(51) *Stipa aristiglumis*

(57) * *Trifolium arvense*

(58) * *Medicago polymorpha*

(59) *Millotia tenuifolia*

(63) *Drosera whittakeri*

(64) *Drosera auriculata*

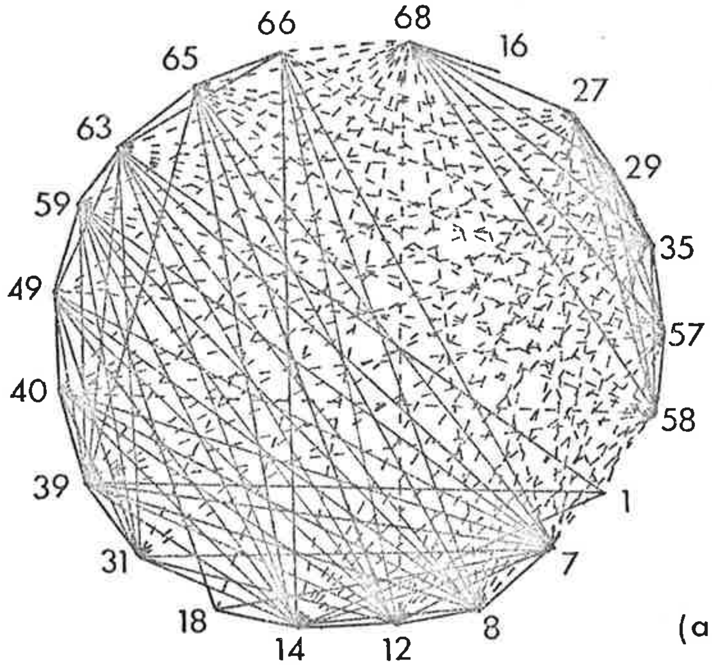
(65) *Centrolepis strigosa*

(66) *Calandrinia neesiana*

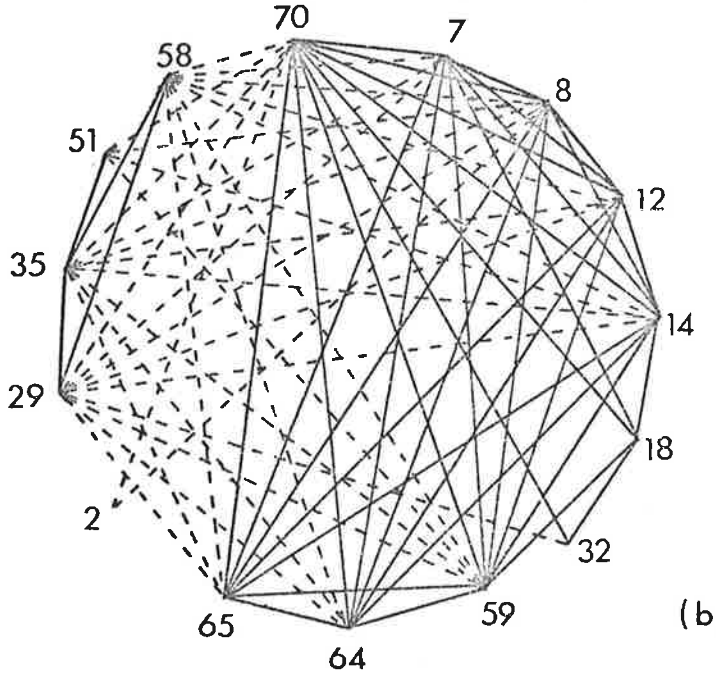
(68) Long soil family

(70) Willamba soil family

SANDY CREEK CONSERVATION PARK



(a).



(b).

Figure 6.4.

Figure 6.5.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Sandy Creek Conservation Park.

(a) Node of species associated with Incrassata soil family.

(b) Node of species associated with the northerly aspect.

(c) Node of species associated with the southerly aspect.

———— indicates association, positive association

- - - - - - indicates dissociation, negative association

* indicates an introduced species.

(11) *Hibbertia stricta*

(18) *Banksia marginata*

(24) *Leucopogon cordifolius*

(32) * *Asparagus asparagoides*

(42) *Dillwynia hispida*

(49) * *Aira caryophyllea*

(69) Incrassata soil family

(73) Northerly facing aspect

(74) Southerly facing aspect

SANDY CREEK CONSERVATION PARK

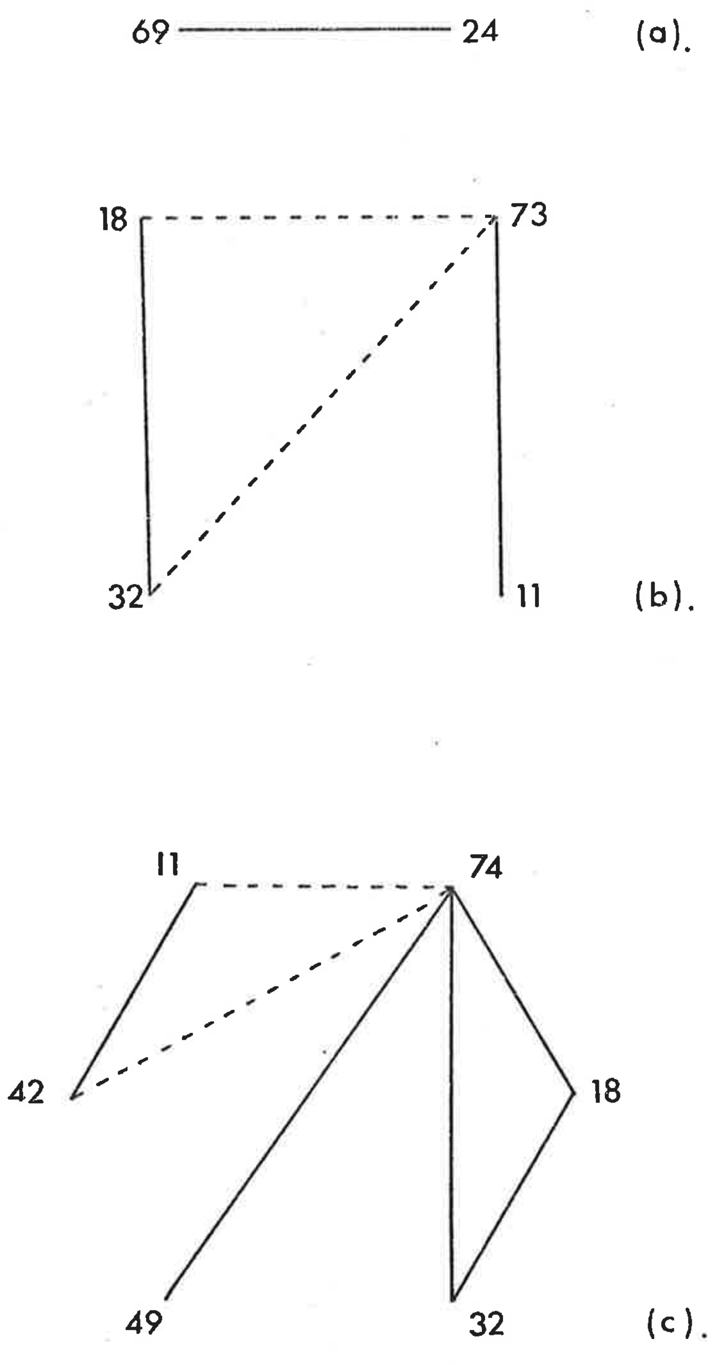


Figure 6.5.

6.9.3. Plant-topography relationships.

The physiographic features included are the northerly and southerly aspects, sand ridges, valleys and creek beds.

(a) Northerly aspect.

There are only a few species significantly associated with the northerly aspect. (Fig. 6.5. (b).).

Hibbertia stricta is positively associated while *Banksia marginata* and *Asparagus asparagoides* are dissociated.

(b) Southerly aspect.

The results as predicted show a reverse trend to those discussed for the northerly aspect. *Hibbertia strica* and *Dillwynia hispida* are dissociated while *Banksia marginata, Asparagus asparagoides* and *Aira caryophyllea* are associated with this southerly aspect. (Fig. 6.5. (c).).

(c) Sand ridges.

This appears to be a relatively significant factor in determining the distribution of plant species. (Fig. 6.6. (a).). *Millotia tenuifolia,* a native annual, is associated with the sand ridge.

(d) Creek beds.

Callistemon macropunctatus although it appears in less than five per cent of the quadrat shows a strong association with creek beds. In sections of the southern end of the park the thickets of *Callistemon macropunctatus* are so dense that they are impenetrable. (Fig. 6.6. (b).).

Figure 6.6.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Sandy Creek Conservation Park.

(a) Node of species associated with the sand ridge.

(b) Node of species associated with the creek-bed.

(c) Node of species associated with the valleys.

________ indicates association, positive association

\- - - - - indicates dissociation, negative association

* indicates an introduced species

(16)		*Callistemon macropunctatus*
(32)	*	*Asparagus asparagoides*
(47)	*	*Vulpia myuros*
(59)		*Millotia tenuifolia*
(65)		*Centrolepis strigosa*
(66)		*Calandrinia neesiana*
(72)		Sand ridge
(75)		Creek-bed
(76)		Valley

SANDY CREEK CONSERVATION PARK

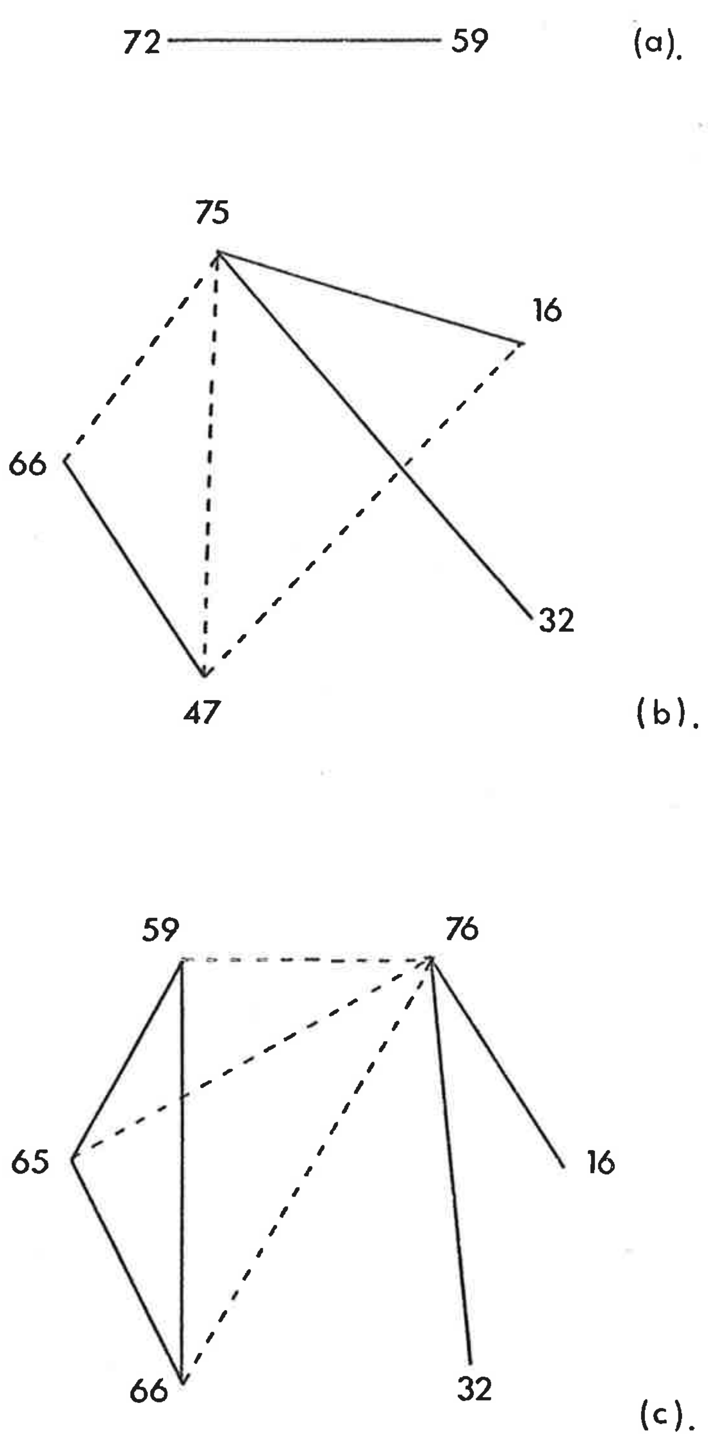


Figure 6.6.

(d) (Cont.)

Asparagus asparagoides also positively associated with the creek beds, in parts completely covers other species in the area. *Calandrinia neesiana* and *Vulpia myuros* are dissociated with the creek beds.

(e) Valleys.

The results are similar to those for the creek beds and include the species *Millotia tenuifolia* as being dissociated with the valleys.

Selected species illustrate significant associations with a range of topographic features.

6.9.4. Plant species inter-relations.

The positive associations of plant species for Sandy Creek Conservation Park appear in Fig. 6.7.. Dissociations were not included in the figure but will be discussed in the text.

The grouping of plants consists basically of three sub-groups, all of which are inter-related by one or more associations. The group with the large number of species includes those species associated with *Eucalyptus fasciculosa* and a range of sclerophyllous shrubs including *Baeckia behrii, Astroloma conostephioides* and the two species of *Hibbertia, Hibbertia virgata* and *Hibbertia stricta*. Due to the time of survey it was possible to include a range of annual species. *Millotia tenuifolia, Podotheca angustifolia, Calocephalus drummondii* and *Calandrinia neesiana* being examples of the native annuals. The majority of the species in

Figure 6.7.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Sandy Creek Conservation Park

__________ indicates association, positive association

* indicates an introduced species

(1) *Callitris preissii*
(2) *Eucalyptus odorata*
(3) *Eucalyptus fasciculosa*
(4) *Acacia calamifolia*
(5) *Acacia pycnantha*
(6) *Acacia rotundifolia*
(7) *Calytrix tetragona*
(8) *Baeckea behrii*
(9) *Dodonaea viscosa*
(10) *Casuarina stricta*
(11) *Hibbertia stricta*
(12) *Hibbertia virgata*
(13) *Grevillea lavandulacea*
(14) *Astroloma conostephioides*
(16) *Callistemon macropunctatus*
(18) *Banksia marginata*
(19) *Xanthorrhoea semiplana*
(21) *Dianella revoluta*
(22) *Helichrysum bilobum*
(23) *Pimelea stricta*
(25) *Correa pulchella*
(26) *Hybanthus floribundus*
(27) * *Avena fatua*
(28) * *Erodium botrys*
(29) * *Echium lycopsis*
(30) * *Arctotheca calendula*
(31) * *Hypochoeris glabra*
(32) * *Asparagus asparagoides*
(35) * *Oxalis pes-caprae*
(36) *Lepidosperma laterale*
(38) * *Rumex angiocarpus*
(39) *Chamescilla corymbosa*
(40) Moss spp.
(41) *Haloragis* spp.
(42) *Dillwynia hispida*
(44) *Helipterum laeve*
(45) * *Briza maxima*
(46) * *Briza minor*
(47) * *Vulpia myuros*
(48) *Cynodon dactylon*
(49) * *Aira caryophyllea*
(50) * *Ehrharta calycina*
(51) *Stipa aristiglumis*
(52) * *Bromus madritensis*
(53) *Danthonia* spp.
(54) *Schoenus maschalinus*
(55) *Crassula colorata*
(56) *Actinobole uliginosum*
(57) * *Trifolium arvense*
(58) * *Medicago polymorpha*
(59) *Millotia tenuifolia*
(60) *Podotheca angustifolia*
(61) * *Anagallis arvensis*
(62) *Calocephalus drummondii*
(63) *Drosera whittakeri*
(64) *Drosera auriculata*
(65) *Centrolepis strigosa*
(66) *Calandrinia neesiana*

SANDY CREEK CONSERVATION PARK

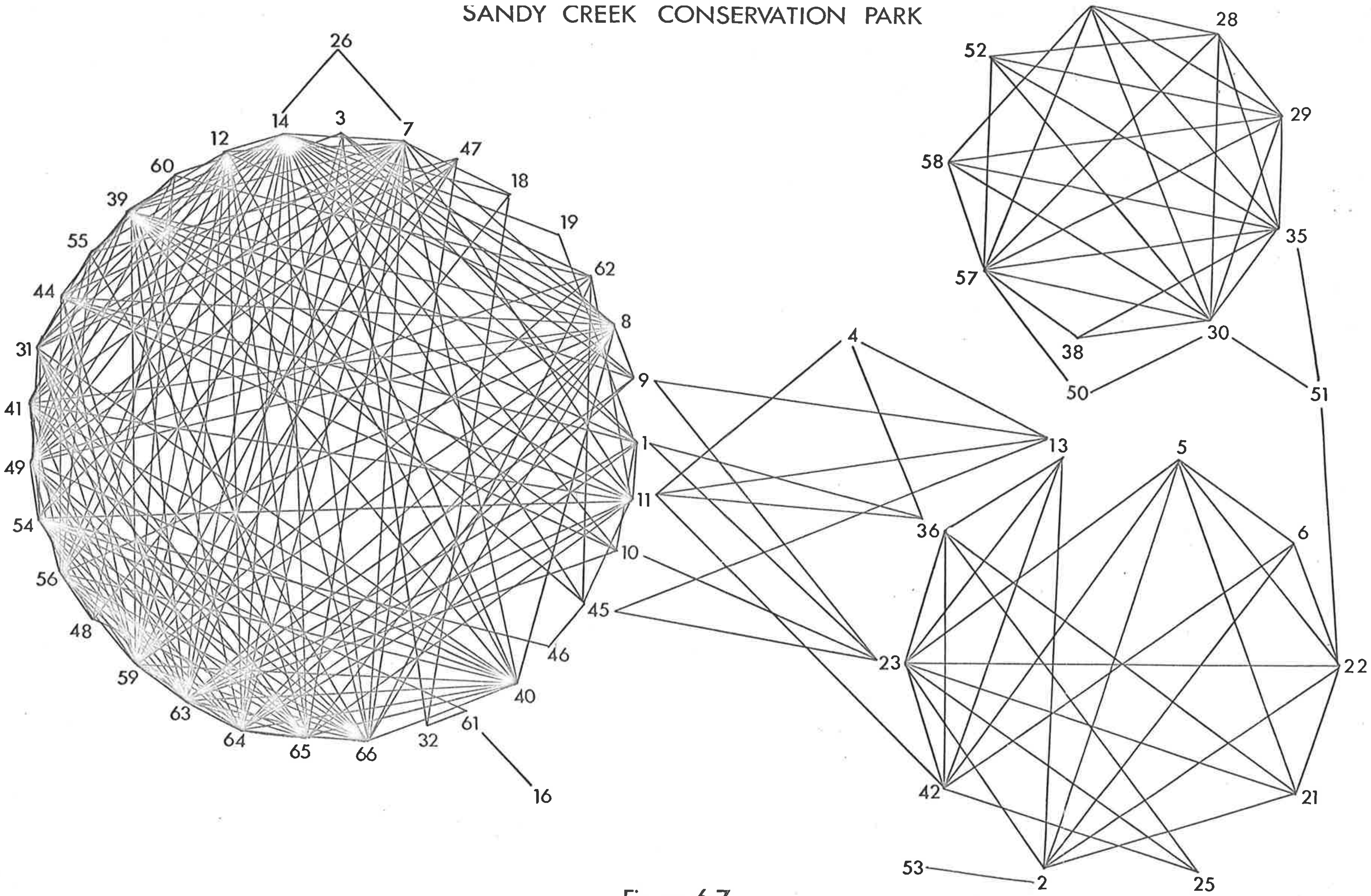


Figure 6.7.

this first sub-group are native. The introduced grasses associated with this particular group of plants are *Briza maxima, Briza minor, Vulpia myuros* and *Aira caryophyllea.* Other introduced plants associated with this group are *Hypochoeris glabra* (annual composite), *Asparagus asparagoides* (creeper), and *Anagallis arvensis.* The soil-plant relationships discussed in 6.9.2. illustrate that this group of plants is associated with the sandy soil with low fertility levels.

The second and smaller sub-group of plants which is linked with the first group just discussed, consists of those native plants associated with *Eucalyptus odorata.* These species have low frequencies and appear in the main, to be confined to the heavier Dale-Altona soil family in the north-western corner of the park. The linking species associated with the two groups of plants, *Acacia calamifolia, Callitris preissii, Dodonaea viscosa, Casuarina stricta, Hibbertia stricta, Grevillea lavandulacea, Pimelia stricta, Lepidosperma laterale* and *Briza maxima* show a larger tolerance of soil conditions than the other members of the two groups.

There is a small number of species of the first sub-group that is dissociated with the second sub-group. For example, *Eucalyptus odorata* is dissociated with *Baeckia behrii* at Chi-squared greater or equal to a value of and probability of less than 0.001. At this probability level *Grevillea lavandulacea, Dianella revoluta, Pimelia stricta* and *Correa pulchella,* all are dissociated with *Vulpia myuros,* the very frequent, introduced grass.

The third sub-group of plants consists of introduced species and is strongly dissociated with the first two groups except for the link with the second smaller group via the native grass, *Stipa aristiglumis*. This group of plants is confined to those areas disturbed by man in the south and north where vines have been cultivated in the past and to the south-western corner where there is no fence to the edge of the park. This is clearly seen by looking at distribution maps of the species comprising this group. *Oxalis pes-caprae, Erodium botrys, Trifolium arvense* and *Medicago polymorpha* typify the distribution pattern of this group.

The activities of man are reflected in the distribution of this group of introduced species. It is noteworthy to observe the presence of these plants along the edges of the park. In some instances the plants of this group are spreading into the park from the disturbed areas and the edges of the park. The results from the studies in this park reflect the importance of the activities of man not only as a determining factor within the park, but by his influence on the nature of the vegetation of adjacent land-holdings. As Sandy Creek Conservation Park is surrounded on all borders (except the central western edge) by pastoral and agricultural activities this "border effect" appears to be an important factor in management considerations.

6.9.5. Intensive-study area.

This section of abandoned vineyards was located in the north-central area of the park (Fig. 6.2.).

The vineyards were abandoned in 1965. The densities of the native plant species were measured and the results are presented in Maps 6.25. to 6.29. inclusive.

The ground cover consists of *Cynodon dactylon, Echium lycopsis, Trifolium arvense* and *Medicago polymorpha*. *Callitris preissii* was present in low numbers in the southern section of this area. The growth of this species was stunted by the rabbits in this locality. On several occasions others had made successful trappings of rabbits in this section of the park.

Other species present in low numbers included *Acacia pycnantha, Hibbertia virgata, Baeckea behrii, Calytrix tetragona, Astroloma humifusum* and *Leucopogon cordifolius*. These species appear in the southern section of the area. This is to be expected as the intensive-study area on the west and south boundaries is surrounded by native plant communities. The heights for *Callitris preissii* and the other native plant species present in low numbers are recorded in Table 6.5.. The heights for *Acacia calamifolia* and *Astroloma conostephioides* are presented in Fig. 6.8.. These two species were present in large numbers.

Acacia pycnantha appears to be dying off in this area. The majority of the plants are tall. In comparison *Callitris preissii, Baeckea behrii, Leucopogon cordifolius* and *Calytrix tetragona* have a range of plant heights. *Astroloma humifusum* and *Hibbertia virgata* have only several plants present.

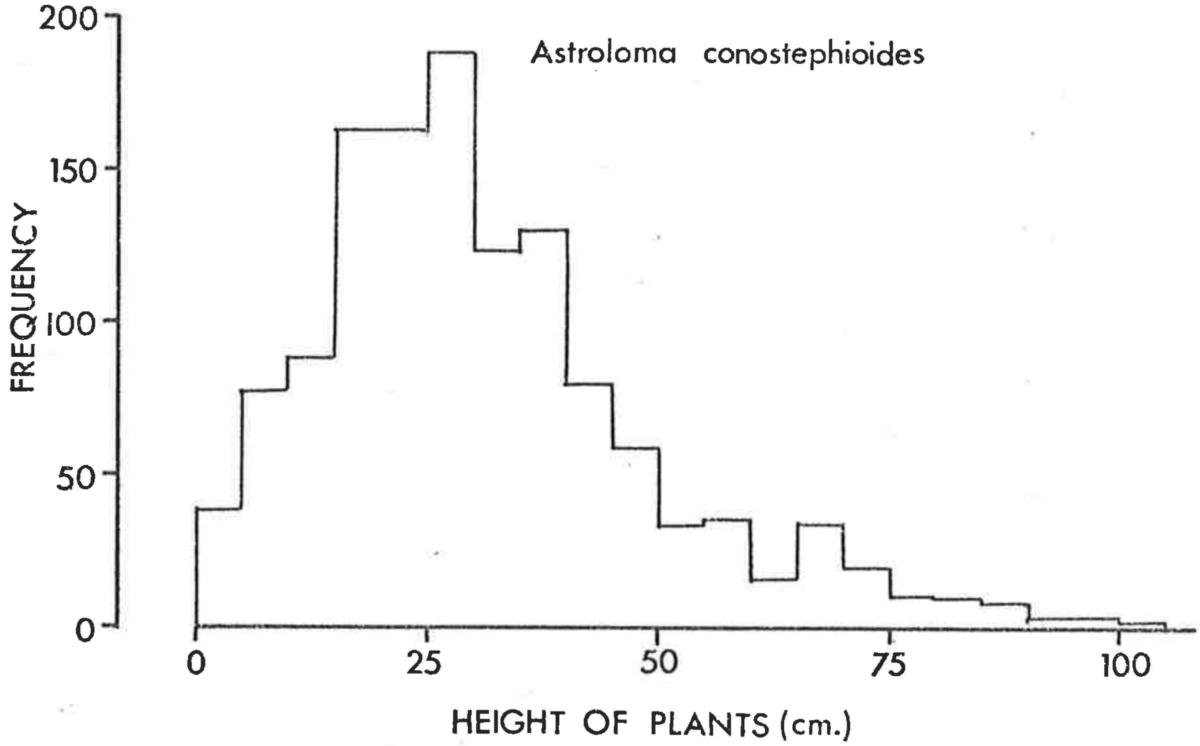
Figure 6.8.

The histogram for the distribution of heights of *Astroloma conostephioides* and *Acacia calamifolia* in the intensive-study area at Sandy Creek Conservation Park.

Astroloma conostephioides
Mean height = 33.0 centimetres

Acacia calamifolia
Mean height = 261.4 centimetres

Figure 6.8.
SANDY CREEK CONSERVATION PARK



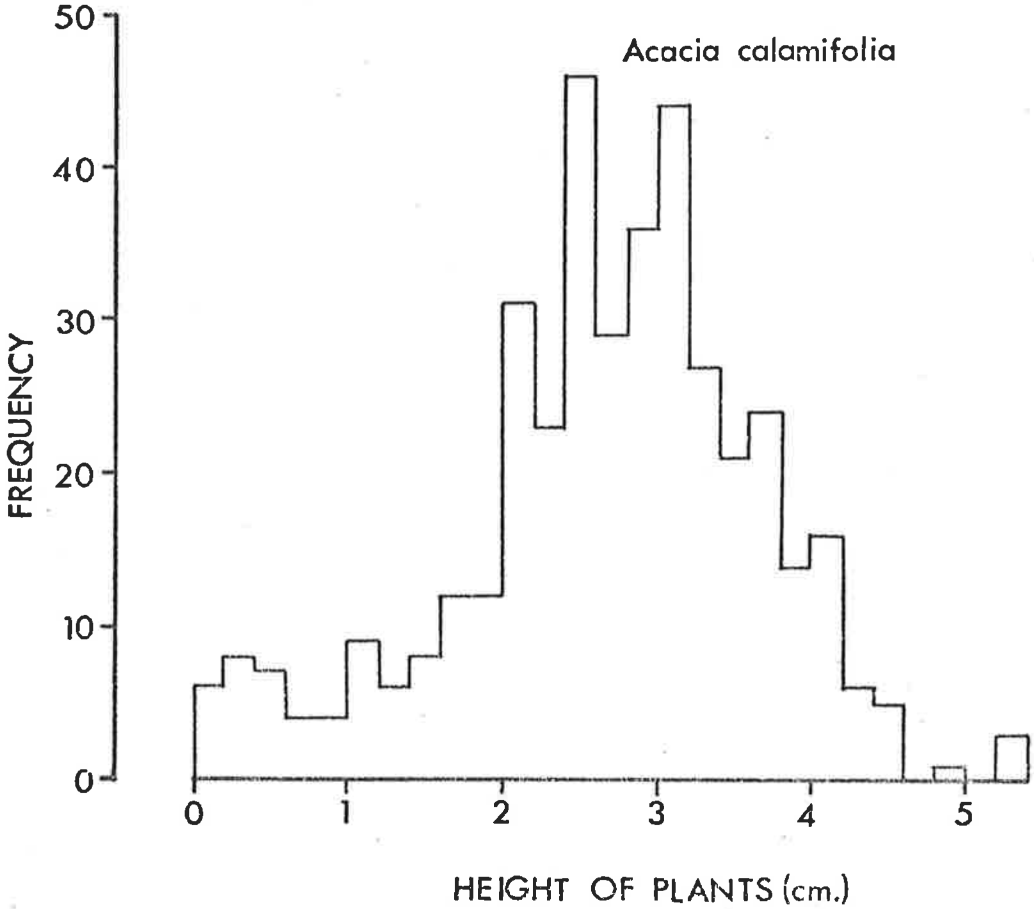


Table 6.5.

The heights of the native plant species in the intensive study area in Sandy Creek Conservation Park (Heights in centimetres)

Species	Heights	Total Height	Total No. of Plants	Ave. Height
Callitris preissii	2, 5, 7, 9, 10, 12, 15, 20, 20, 23, 24, 25, 27, 30, 33, 35, 38, 40, 40, 70, 175.	660	21	31.4
Acacia pycnantha	18, 160, 400, 450, 480, 480, 540.	2528	7	361.1
Baeckea behrii	2, 15, 20, 50, 80, 90, 190, 280, 300, 320, 330, 340.	2017	12	168.1
Leucopogon cordifolius	4, 4, 4, 5, 5, 7, 15, 19, 30, 35, 35, 38, 45, 70.	316	14	22.6
Calytrix tetragona	5, 5, 5, 8, 10, 10, 10, 10, 10, 15, 15, 35, 40, 40, 60, 60, 70, 75, 75, 80, 80, 85.	803	22	36.5
Hibbertia virgata	70, 80.	150	2	75.0

Acacia calamifolia is present in large numbers. It is noteworthy to subjectively compare the numbers of this species, *Acacia calamifolia* in this intensively studied area with the numbers in the adjacent areas. In the area studied the vines had been uprooted in contrast to the area east of this section where they were simply abandoned. In this latter area both *Acacia calamifolia* and *Astroloma conostephioides* were present in lower numbers. The disturbance of the soil by removing the vines has encouraged the establishment of the native plants. This point is of interest if it be desirable to re-establish the native species in the abandoned vineyard area. Further research is required into the feasibility of extending this study into the remaining abandoned vineyards.

It is of interest to note the distribution pattern of *Astroloma conostephioides* and *Acacia calamifolia* (Maps 6.26., 6.28.). The species appear to be spreading north-westward from larger numbers in the south and south-western edges. The plants of the two species are not of uniform size suggesting different ages of individual plants. Plants of *Astroloma conostephioides* range in height from only a few centimetres to over a metre, see Fig. 6.8.. Similarly, *Acacia calamifolia* shows a range in heights, see Fig. 6.8.. These results provide the basis for successional studies in the re-establishment of the disturbed areas in this park.

6.10. Summary.

The impact of man on the vegetation in Sandy Creek Conservation Park is clear from the results.

6.10. Summary (Cont.)

The distribution maps of the alien plant species illustrate the main areas of impact. The majority of the alien plant species are grouped together and occur in those areas that man has cleared or cultivated. In addition the introduced plant species have spread from adjacent properties into the park to give a "border effect". The soils and topographic features are also clearly important determinants of the vegetation.

Eucalyptus odorata and associated species occur in a small area in the north-western corner of the park. This group of plants is poorly represented in this park. Other plant species that occur in low numbers include *Conospermum patens, Kunzea pomifera, Lepidosperma carphoides* and *Hakea rostrata* (only one plant of *Hakea rostrata* was found at Sandy Creek Conservation Park). The rare occurrence of many of these species are important considerations if their conservation is desirable.

The shrub species, *Chrysanthemoides monilifera* is also of interest as it has spread into the undeveloped areas in the centre of Sandy Creek Conservation Park. This species is present in relatively large numbers and therefore poses a threat to the native plant species.

The presence of sheep, rabbits and horses in this park needs to be reviewed.

The establishment of native species in the abandoned vineyard is of interest. This regrowth could be encouraged by further uprooting of the vineyards in both the northern and southern areas.

6.10. Summary (Cont.)

By undertaking such a program the vegetation, in these areas disturbed by man, could approach the other undeveloped areas in structure and composition.

CHAPTER VII

KYEEMA CONSERVATION PARK

7.1. Introduction

Kyeema Conservation Park (Hundred of Kuitpo, Section 92,522,688,850,302,682 and 683) is located approximately 40 kilometres south of Adelaide. The park lies south of Meadows and north-east of Myponga (Fig. 7.1.).

In 1964, Section 92, 522, 688 and 850, were dedicated as a Wildlife Reserve within the meaning of the National Parks and Wildlife Reserves Act, 1891-1960. The reserve, of 278.8 hectares, was controlled and managed by the Commissioners of the National Parks and Wildlife Reserves. In 1966, the park was renamed and declared as Kyeema National Park under the second schedule of the National Parks Act, 1966. In 1967, Section 302 was added to the National Park to enlarge its area to 348.9 hectares. Kyeema National Park was later proclaimed to be a conservation park under the control of the National Parks and Wildlife Act, 1972. In 1973 an additional area (Section 682 and 683) was added to enlarge the park to the current area of 373.5 hectares.

7.2. Historical Background

The majority of the region has long been cleared for agricultural, pastoral and forestry activities. In contrast a large section of Kyeema Conservation Park remains relatively undisturbed.

Figure 7.1.

Location of Kyeema Conservation Park

(▲ indicates the location)

KYEEMA CONSERVATION PARK

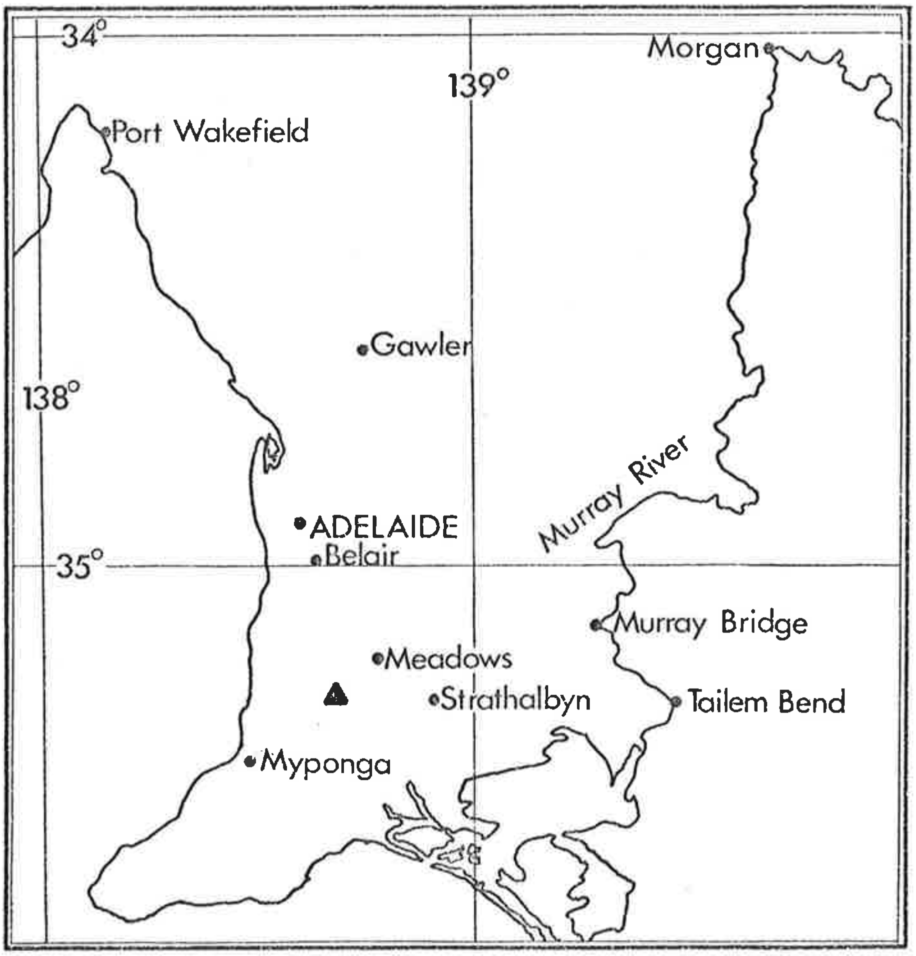


Figure 7.1.

Kyeema Conservation Park (Cont.)

Kyeema Conservation Park typifies many of our local parks in that sections have been subjected to grazing by domesticated animals. The western, south-eastern and south-central edges of the park have been cleared and are currently leased for cattle grazing. This park therefore provides the opportunity to compare the vegetation in grazed and cleared areas with that found in the relatively undisturbed parts.

To the north the park is surrounded in the main by a forest of *Pinus radiata* (The Kuitpo Forest Reserve of the South Australian Woods and Forest Department). Recent observers suggest that *Pinus radiata* is spreading from forest areas into adjacent areas of native vegetation in the south-east of South Australia. This park provides an ideal study area to investigate the influence of the proximity of these *Pinus radiata* forests on the vegetation found within this park.

The remainder of the park is surrounded by pastoral lands. The southern limit of the park is the Willunga-Ashbourne Road. The Kyeema Prison Camp in the western portion of the park is now a National Fitness Council Camp. The camp is used at regular intervals, by youth groups in the main, throughout the year.

The occurrence of blackberries (*Rubus* spp. *aff. fruticosus)* along the creek beds on the southern border was reported in 1965. This species is still present in patches along these creek beds.

South African daisy, *Senecio pterophorus,* was pulled up in 1969 near the hut (which is no longer present) in the south-eastern corner of the park. South African daisy is still present in low numbers. Although this species is present in the valleys and gullies it does not appear to be spreading. The other introduced plant species include gorse, *Ulex europaeus,* which is spreading in the south-central and western fringes of the cleared areas.

The fences constructed in the western part of the park between the cattle paddocks and the central area are in the main adequate for restricting the access of animals into the central area. The fences on the eastern fringe of the central area of native vegetation are inadequate for keeping cattle out of this section of the park. In the remainder of the park the majority of the fences, where they are installed, are adequate. The southern section of the park supports dense thickets of native vegetation which are impenetrable. For example the thicket of *Casuarina striata* on the southern edge is very dense. The skeleton of a cow in a grove of *Eucalyptus cosmophylla* only yards from a fence indicates the unsuccessful attempt this cow had in trying to penetrate the scrub. The creek beds, which support thickets of *Melaleuca decussata* on their fringes, also have *Gahnia trifida* (the cutting grass) and blackberries in their beds. Thus the creek beds are a natural barrier to all but the smallest of animals. As a result the park users, including motor-bike riders and walkers have been restricted in the main to the cleared areas and tracks.

The appearance of alien species appears to be restricted to the gullies, creeks, valleys and cleared areas. It is of interest to note that some native plant species are growing in the grazed paddocks. For example *Isopogon ceratophyllus, Astroloma humifusum* and *Xanthorrhoea semiplana* extend into the grazed areas and are inter-mingled with such alien species as *Ulex europaeus, Rubus* spp. *aff. fruticosus* and the occasional plant of *Hypericum perforatum.* Kangaroos and rabbits are apparently present in low numbers.

The main tracks are shown in Fig. 7.2.. Any vandalism or littering has been restricted to the edges of the tracks. Efforts in the past by the park authorities with the installation of chains and locked gates have discouraged most vehicles except the motor cyclist who still takes advantage of the tracks in the park. Beehives have also been installed on the edges and in the central area.

7.3. Climate

Official climatic data for Kuitpo were not available. However rainfall observations were made at Meadows and at the Kuitpo Forest Headquarters, see Table 7.1..

The marked seasonal variations in rainfall are clear from these results. The measurements for Kuitpo Forest are a little misleading with regard to the high rainfall for the month of January. This can be explained by the lack of data.

Figure 7.2.

The main features of Kyeema Conservation Park.

(a) Kyeema Conservation Park.

(Scale 1 cm. = 300 metres)

....	Watercourse
- - - -	Tracks
	Grazed areas (currently)
	Intensive-study area
H	Hut
D	Dam

(b) Intensive-study area.

(Scale 1 cm. = 60 metres)

·—·—·	Fences
	Grazed areas (currently)

KYEEMA CONSERVATION PARK

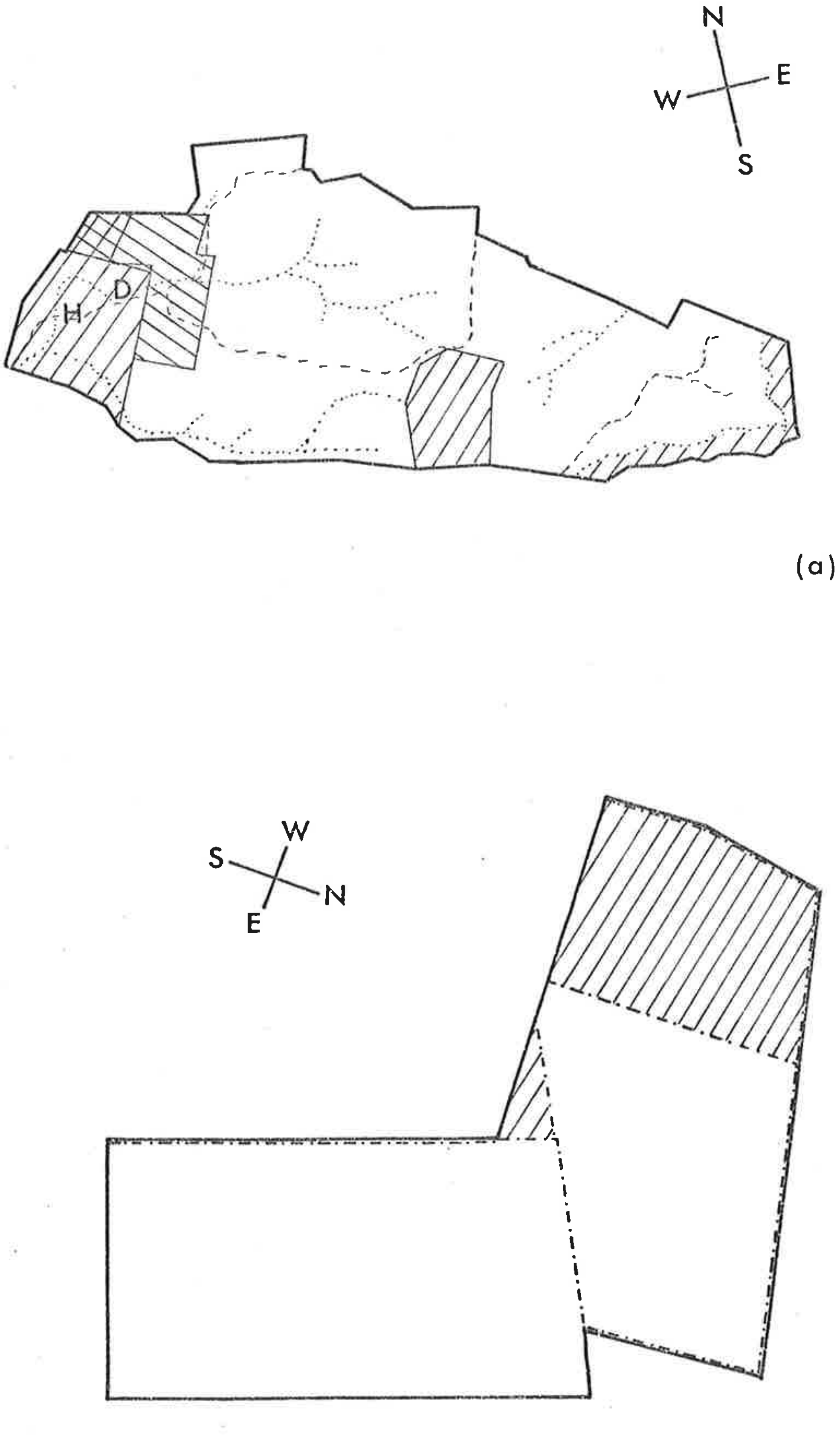


Figure 7.2.

Table 7.1.

Rainfall recordings for Meadows & Kuitpo Forest

(taken from the records of the Bureau of Meteorology, Adelaide).

Meadows -	No.of Yrs.	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
Mean Rainfall (mm.)	77	28	29	35	74	103	126	120	113	101	77	48	37	891
Kuitpo Forest -														
Mean Rainfall (mm.)	4	51	32	30	127	102	81	102	157	99	66	33	38	918

No temperature records were kept for Meadows or Kuitpo Forest. However from observing the Myponga and Stirling figures, in Table 9.1. and Table 10.1., an indication of the temperature range can be gathered. The climate therefore consisted of cold, wet winters and hot, dry summers. Trumble (1948) discussed the temperatures in this region. The effective growing period is reduced to five months, consisting of two periods with a non-growing period intervening (Trumble, 1948).

7.4. Physiography and Drainage

The main physiographic features of the area are the broad Meadows Creek Valley with numerous tributaries, the smaller Blackfellows Creek Valley, and the intensively dissected, steep-sided, flat-topped remnants of the ancient peneplain (Taylor and O'Donnell, 1932).

The ancient peneplain once covered the whole area.

Blackfellows Creek runs in a west-east direction and drains the eastern edge of the park. The tributaries of Meadows Creek run in a east-west direction and drain the western edge of the park (Fig. 7.2.). The park consists of steep-sided valleys and flat-topped ridges in the central area. At the western and eastern edges of the park the valleys are broader.

7.5. Geology and soils

The distribution maps of the three soil types found in Kyeema Conservation Park appear in Volume II, Appendix IV, Map 7.38. The soils for this area were extracted from Taylor and O'Donnell (1932). The geological features of this district have also been described by several authors (Teale, 1918; Sprigg, 1945; Rix and Hutton, 1953). For the parent materials and the soils found at Kyeema Conservation Park, see Table 7.2..

Table 7.2.

Parent Materials of the soils of Kyeema Conservation Park (Rix and Hutton, 1953).

Parent Materials	Soil Groups
Sedentary on Pre-Cambrian sandstones and quartzites	Burbrook sandy loam soils.
Truncated relict laterite on Pre-Cambrian quartzites and sandstones.	Kuitpo gravelly sandy loam soils.
Transported material	Myponga sandy soils.

The three soil types found in the park are the following (descriptions from Taylor and O'Donnell, 1932).

Burbrook sandy loam	- Grey sand or sandy loam over buff loam or friable clay over rock (schist and quartzite). Frequently stony and shallow soil.
Kuitpo gravelly sandy loam (lateritic)	- Grey to yellow sandy loam, with varying content of ironstone gravel over yellow friable clay with ironstone gravel.
Myponga sand	- A deep podsolized grey to white sand overlying yellow sand over sandstone. A distinct typical coffee brown layer is often present between 30-60 inches.

These soils are described in more detail by Taylor and O'Donnell (1932) and Rix and Hutton (1953). Analytical data on the soils are provided in Rix and Hutton (1953).

7.6. Vegetation

The open forest of the eucalyptus, *Eucalyptus obliqua, Eucalyptus fasciculosa* and *Eucalyptus cosmophylla* are found in the majority of the park. *Eucalyptus cosmophylla* and *Eucalyptus baxteri* replace *Eucalyptus obliqua* in dominance in sections of the park. *Eucalyptus baxteri* is restricted in the main to the south-central area, that is on top of the flat-topped ridge. The sclerophyllous understorey consists of *Xanthorrhoea semiplana, Banksia marginata, Acacia myrtifolia, Daviesia virgata, Platylobium obtusangulum, Lepidosperma semiteres* and species of the genera *Hakea, Pultenaea* and *Hibbertia.*

Kyeema Conservation Park (Cont.)

The creek beds support dense thickets of *Leptospermum juniperinum, Melaleuca decussata* and *Gahnia trifida*. In the broader valleys *Eucalyptus leucoxylon* is present with few shrubs due to past clearing. In parts of the grazed western edge of the park, *Pteridium esculentum* becomes prominent in the lower stratum.

The cleared and grazed areas support a pasture of grasses and various legumes. The majority of these plant species are introduced.

7.7. Research Objectives

Kyeema Conservation Park offered several advantages for research. It provided a park that had been subjected to a range of man's activities. The vegetation of the park was also comparable with that in section of Belair Recreation Park, Nixon-Skinner Conservation Park and the Knoll Conservation Park. The presence of cattle in the park made it possible to study the influence that man has had on the vegetation through the introduction of these animals. The recent construction of fences between the western and central areas enabled an intensive-study to be undertaken to compare the vegetation either side of this fence.

The causal factors of the distribution of the plant communities in the park and in the intensive-study area were investigated. The location of the latter is illustrated in Figure 7.2..

The approach taken can be summarized as follows -

a. To carry out a reconnaissance of the park to gain a general description of the area.

b. To construct a floristic list as a basis for the identification of plant species.

c. To study the plant communities by surveying the species present throughout the park.

d. To follow some species that appear to be of particular interest in that they reflect man's activities and/or are of interest in the inter-relationships present within the plant communities.

e. To study a localised area in the western section of the park.

f. To review the soil and physiographic features of the area as possible determinants of the distribution of plant species.

7.8. Research Methods

Reconnaissance and the collection of plants were carried out on several occasions. The floristic list presented in Appendix II is complete as far as practical.

The vegetation was surveyed using a systematic location of two hundred and eighty-one quadrats at one hundred and ten metre intervals (measured by pacing) along traverses one hundred and fifteen metres apart, running at a compass bearing of three hundred and sixty degrees. The first quadrat was located in the most westerly corner of the park.

The quadrats were circular in shape with a radius of five metres. The presence-absence data collected for Kyeema Conservation Park enabled the distribution maps of the species to be constructed. An association analysis was carried out on the binary data to study the inter-relations between plant species, soils and topography in the park. These results are discussed in the following section of the chapter.

The intensive study area was located in the western corner of the park. (Fig. 7.2.). The presence/absence data for this area was collected by a grid of five hundred and forty-eight quadrats at twenty metres intervals located on two series of traverses. The quadrats were circular with a five metre radius. First there are twenty-two traverses at a compass bearing of ninety degrees and second fifteen traverses at a compass bearing of one hundred and eight degrees. All the parallel traverses were twenty metres apart. An association analysis was carried out on the binary data collected.

7.9. Results

7.9.1. Introduction

The floristic list appears in Appendix II. The distribution maps of the plant species and soil groups appear in Volume II, Appendix IV, Maps 7.1. to 7.38. inclusive. The frequency of the plant species in Kyeema Conservation Park appear in Table 7.3.. the inter-relationships of plants with soils, physiographic features and other plants will be

Table 7.3.

The plant species sampled at Kyeema Conservation Park with the percentage of total samples in which they occur. Introduced species are prefixed by an asterisk.

Species	Frequency
Lepidosperma semiteres	79.4
Haloragis tetragyna	77.9
Tetratheca pilosa	73.3
Platylobium obtusangulum	72.2
Hibbertia stricta	61.9
Acacia myrtifolia	61.6
Cassytha glabella	61.2
Xanthorrhoea semiplana	58.4
Eucalyptus obliqua	56.6
Isopogon ceratophyllus	54.8
Leptospermum myrsinoides	52.0
Hakea ulicina	51.6
Hibbertia sericea	50.2
Pultenaea daphnoides	50.2
Eucalyptus cosmophylla	48.4
Hakea rostrata	48.4
Pultenaea involucrata	47.7
Acrotriche serrulata	43.4
Banksia marginata	37.0
Daviesia virgata	35.2
Epacris impressa	32.0
Moss spp.	32.0
Hibbertia exutiacies	28.8
Poa laevis	27.4
Hakea rugosa	25.6
Leucopogon concurvus	25.3
Eucalyptus fasciculosa	23.5
* *Fumaria muralis*	21.0
Goodenia primulacea	20.6
Casuarina striata	19.6

	Species	Frequency
	Leptospermum juniperinum	19.6
	Lomandra dura	19.6
*	*Holcus lanatus*	19.2
	Olearia tubuliflora	18.9
	Leucopogon virgatus	18.1
	Spyridium parvifolium	17.4
*	*Hypochoeris radicata*	17.1
	Astroloma humifusum	16.7
	Dianella revoluta	16.0
	Ixodia achillaeoides	15.7
	Schoenus sp.	15.7
	Kangaroo dung	15.7
	Danthonia spp. (*Danthonia geniculata* and *Danthonia setacea*)	15.3
	Danthonia spp. (*Danthonia clelandii* and *Danthonia caespitosa*)	15.3
	Daviesia ulicifolia	14.9
*	*Trifolium repens*	14.9
	Microlaena stipoides	14.6
	Acacia verticillata	14.2
	Eucalyptus baxteri	13.5
	Goodenia ovata	13.5
	Astroloma conostephioides	13.2
*	*Rumex angiocarpus*	12.8
	Pteridium esculentum	12.8
	Persoonia juniperina	11.0
	Gompholobium ecostatum	11.0
	Pultenaea largiflorens	9.6
	Lomandra sororia	9.3
	Stipa spp.	8.9
*	*Plantago lanceolata*	8.9
*	*Vulpia* spp.	8.5
*	*Phalaris minor*	8.2
	Arthropodium fimbriatum	7.8
	Burchardia umbellata	7.5

Table 7.3. (Cont.)

	Species	Frequency
	Billardiera sericophora	7.1
*	*Aira caryophyllea*	7.1
	Viola hederacea	6.8
	Acaena anserinifolia	6.8
*	*Trifolium fragiferum*	6.0
*	*Lolium perenne*	5.3
	Exocarpus cupressiformis	5.0
	Stylidium graminifolium	5.0
*	*Arctotheca calendula*	5.0
	Daviesia brevifolia	3.9
	Helichrysum baxteri	3.9
*	*Cynosurus echinatus*	3.6
	Pimelia glauca	3.2
*	*Senecio pterophorus*	3.2
	Melaleuca decussata	3.2
	Pimelia octophylla	2.8
*	*Briza maxima*	2.8
*	*Oxalis pes-caprae*	2.8
	Acaena ovina	2.5
	Gahnia trifida	2.5
	Machaerina gunnii	2.5
	Lythrum hyssopifolia	2.5
*	*Onopordum acanthium*	2.5
	Pimelia spathulata	2.1
*	*Briza minor*	2.1
*	*Centaurium minus*	2.1
	Grevillea lavandulacea	1.8
	Juncus polyanthemos	1.8
	Hypericum gramineum	1.8
	Pinus radiata	1.8
	Eucalyptus leucoxylon	1.4
*	*Ulex europaeus*	1.4
	Senecio quadridentatus	1.4
	Bursaria spinosa	1.4

7.3. (Cont.)

Species	Frequency
* *Trifolium campestre*	1.1
* *Rosa rubiginosa*	1.1
Deyeuxia quadriseta	1.1
Eucalyptus rubida	0.7
Tricoryne elatior	0.7
* *Bromus* spp.	0.7
Acacia retinodes	0.4
Leptospermum pubescens	0.4
* *Trifolium angustifolium*	0.4
* *Trifolium micranthum*	0.4
* *Dactylis glomerata*	0.4
Drosera spp.	0.4
* *Hypericum perforatum*	0.4
* *Erodium botrys*	0.4

discussed separately in sections 7.9.2., 7.9.3. and 7.9.4. respectively. The distribution maps for the plant species found in Kyeema Conservation Park will also be discussed in 7.9.4..

The distribution maps of the plant species in the intensive area appear in Volume II, Appendix IV, Maps 7.39. to 7.97. inclusive. These results will be discussed in section 7.9.5..

7.9.2. The soil-plant relationships

(a). The Burbrook sandy loam soils are restricted to the edges of the park, see Volume II, Appendix IV, Map. 7.38.. The results of the association analysis appear in Fig. 7.3. (a)..

Acaena anserinifolia, a perennial herb, is associated with this soil. On the other hand there are a number of native species negatively associated with this soil. These species include *Eucalyptus cosmophylla*, *Daviesia virgata*, *Isopogon ceratophyllus*, *Hakea rugosa*, *Hakea ulicina*, *Lepidosperma semiteres*, *Haloragis tetragyna* and *Cassytha glabella*.

(b). The Kuitpo gravelly sandy loam soils cover by far the biggest area of the park, see Volume II, Appendix IV, Map 7.38.. The associated plant species are the reverse of those for the Burbrook sandy loam soils. The only addition is the introduced perennial composite, *Hypochoeris radicata*.

Figure 7.3.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Kyeema Conservation Park.

(a) Node of species associated with the Burbrook sandy loam soil.

(b) Node of species associated with the Kuitpo gravelly sandy loam soil.

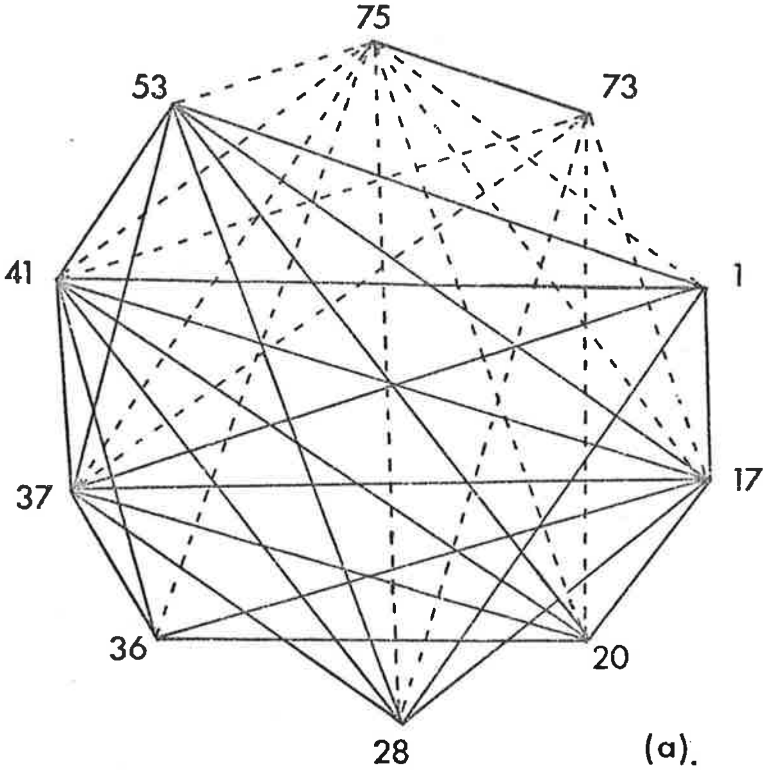
_____ indicates association, positive association.

----- indicates dissociation, negative association.

* indicates an introduced species.

(1) *Eucalyptus cosmophylla*
(17) *Cassytha glabella*
(20) *Daviesia virgata*
(28) *Isopogon ceratophyllus*
(36) *Hakea rugosa*
(37) *Hakea ulicina*
(41) *Lepidosperma semiteres*
(53) *Haloragis tetragyna*
(73) *Acaena anserinifolia*
(75) Burbrook sandy loam soil
(76) Kuitpo gravelly sandy loam soil
(78) Valley
(82) * *Hypochoeris radicata*

KYEEMA CONSERVATION PARK



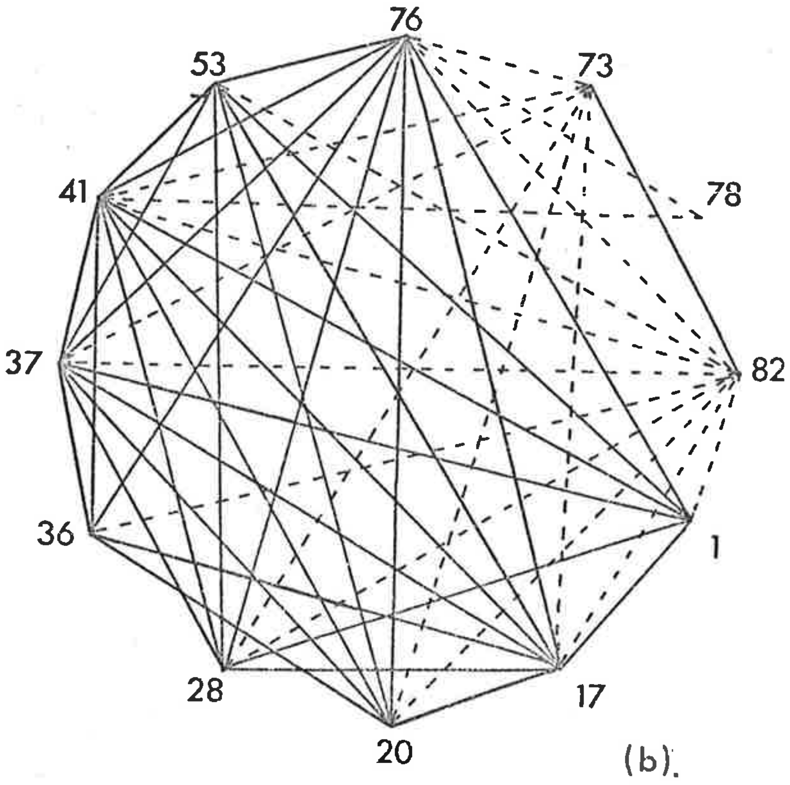


Figure 7.3.

This species is positively associated with *Acaena anserinifolia* but negatively associated with the Kuitpo gravelly sandy loam soils and the group of native plant species.

(c). The Myponga sandy soils are restricted to the western corner of the park and do not play a significant part in determining the vegetation within the park.

Two of the soils therefore appear to be important in determining the distribution of plant species.

7.9.3. Plant-Topographic Relationships

The physiographic features included were the northerly aspect, the southerly aspect, ridges and valleys.

(a). Northerly aspect.

The only plant species significantly associated with this aspect is the cup gum, *Eucalyptus cosmophylla* (Fig. 7.4. (a).).

(b). Southerly aspect.

The two native species *Eucalyptus obliqua* and *Haloragis tetragyna* are associated with this aspect (Fig. 7.4. (b).).

(c). Ridge.

The only significant result is that *Leptospermum juniperinum* (a shrub which is restricted to creek beds and valleys) is dissociated with the ridges (Fig. 7.4. (c).).

Figure 7.4.

Nodes of associates species at $\chi^2 \geqslant 10.83$ in Kyeema Conservation Park.

(a) Node of species associated with the northerly aspect.
(b) Node of species associated with the southerly aspect.
(c) Node of species associated with the ridge.

——— indicates association, positive association
- - - indicates dissociation, negative association
* indicates an introduced species

(1) *Eucalyptus cosmophylla*
(3) *Eucalyptus obliqua*
(42) *Leptospermum juniperinum*
(53) *Haloragis tetragyna*
(81) Northerly aspect
(88) Southerly aspect
(90) Ridge

KYEEMA CONSERVATION PARK

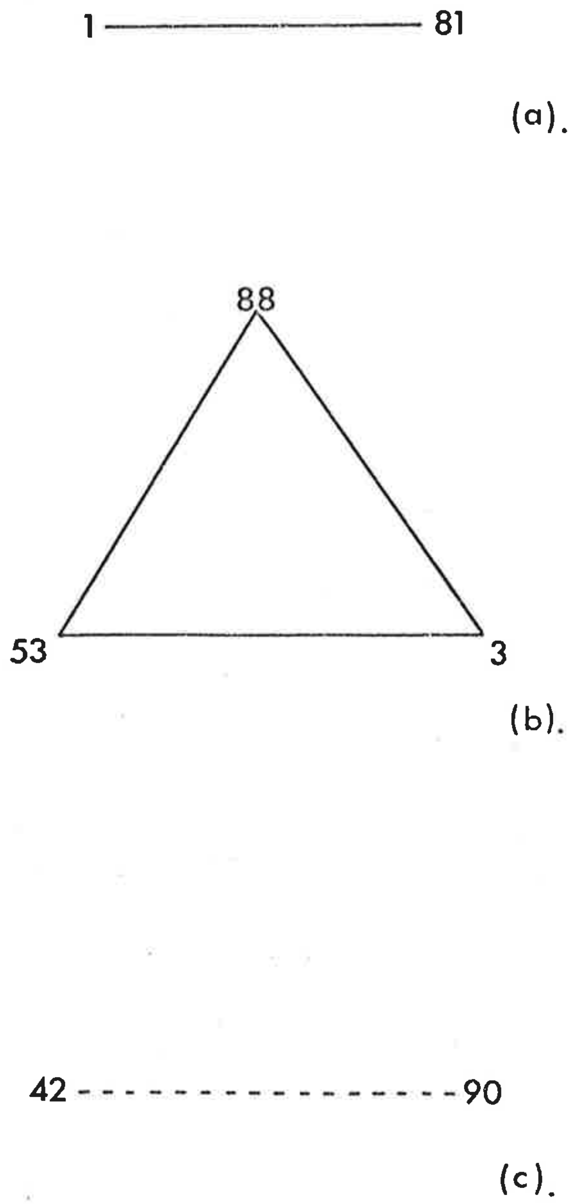


Figure 7.4.

Kyeema Conservation Park (Cont.)

(d). Valleys.

The only plant species significantly associated with the valleys is *Goodenia ovata*. The Burbrook sandy loam soils and the cleared areas are also associated with this physiographic feature. A range of native plant species are negatively associated with the valleys. The soil group, Kuitpo gravelly sandy loam, is also dissociated with this feature (Fig. 7.5. (a).).

7.9.4. Plant Species Inter-relations

The plants associated with kangaroo dung and cleared areas are given in Fig. 7.5. (b). and Fig. 7.6.. First the presence of kangaroo dung is significantly associated with the three introduced plant species, *Trifolium repens*, *Holcus lanatus* and *Phalaris minor*. On the other hand the kangaroo dung is dissociated with the native perennial, *Lepidosperma semiteres*.

The plants associated with the cleared areas were all introduced plant species except for the species of *Danthonia*, *Lythrum hyssopifolia* and *Machaerina gunnii*. On the other hand the species that are dissociated with this feature are all native. Such species include *Eucalyptus obliqua*, *Eucalyptus cosmophylla* and *Eucalyptus fasciculosa* and associated plant species (Fig. 7.6.).

The majority of the native plants are frequent (Table 7.3.). On the other hand the alien species are restricted, in the main, to the cleared and grazed areas and are therefore

Figure 7.5.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Kyeema Conservation Park.

(a) Node of species associated with the valley.

(b) Node of species associated with kangaroo dung.

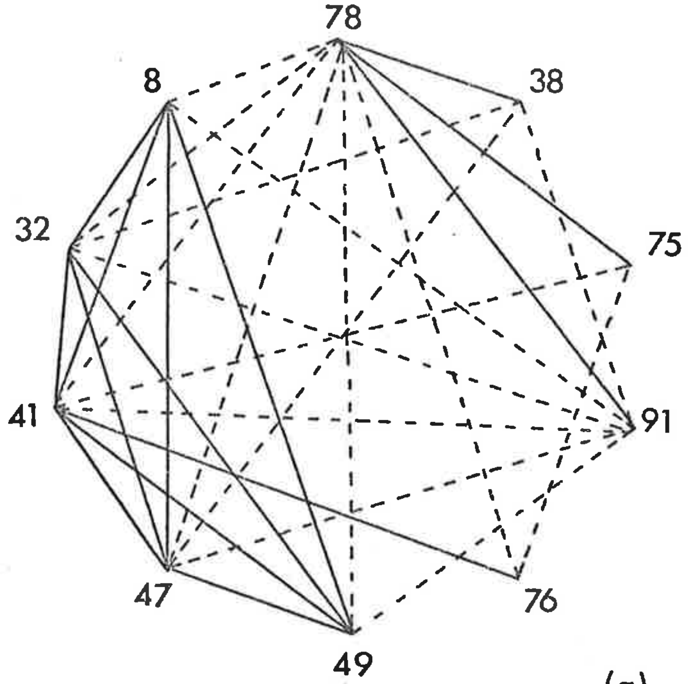
________ indicates association, positive association

\- - - - indicates dissociation, negative association

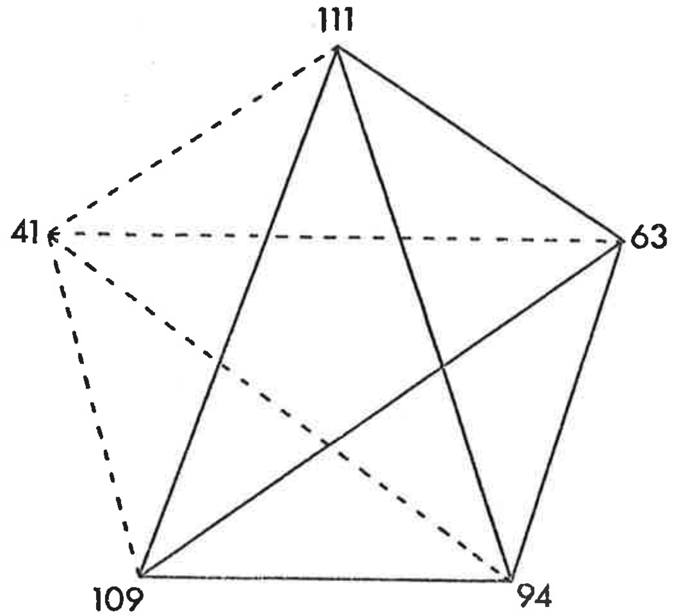
* indicates an introduced species

(8) *Acacia myrtifolia*
(32) *Hibbertia stricta*
(38) *Goodenia ovata*
(41) *Lepidosperma semiteres*
(47) *Platylobium obtusangulum*
(49) *Tetratheca pilosa*
(63) * *Trifolium repens*
(75) Burbrook sandy loam soil
(76) Kuitpo gravelly sandy loam soil
(78) Valley
(91) Cleared area
(94) * *Holcus lanatus*
(109) * *Phalaris minor*
(111) Kangaroo dung

KYEEMA CONSERVATION PARK



(a).



(b).

Figure 7.5.

Figure 7.6.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Kyeema Conservation Park.

Nodes of species associated with the cleared areas.

______ indicates association, positive association

- - - - indicates dissociation, negative association

* indicates an introduced species

(1)	*Eucalyptus cosmophylla*
(2)	*Eucalyptus fasciculosa*
(3)	*Eucalyptus obliqua*
(8)	*Acacia myrtifolia*
(14)	*Banksia marginata*
(17)	*Cassytha glabella*
(19)	*Pultenaea involucrata*
(20)	*Daviesia virgata*
(26)	*Xanthorrhoea semiplana*
(28)	*Isopogon ceratophyllus*
(32)	*Hibbertia stricta*
(33)	*Hibbertia exutiacies*
(34)	*Hibbertia sericea*
(35)	*Hakea rostrata*
(36)	*Hakea rugosa*
(37)	*Hakea ulicina*
(38)	*Goodenia ovata*
(40)	*Epacris impressa*
(41)	*Lepidosperma semiteres*
(43)	*Leptospermum myrsinoides*
(45)	*Lomandra dura*
(47)	*Platylobium obtusangulum*
(49)	*Tetratheca pilosa*
(53)	*Haloragis tetragyna*
(54)	*Pultenaea daphnoides*
(58) *	*Rumex angiocarpus*
(63) *	*Trifolium repens*
(72)	*Acrotriche serrulata*
(78)	Valley
(82)*	*Hypochoeris radicata*
(84)*	*Plantago lanceolata*
(91)	Cleared area
(93)*	*Arctotheca calendula*
(94)*	*Holcus lanatus*
(96)	*Machaerina gunnii*
(99)	*Dianella revoluta*
(100)*	*Aira caryophyllea*
(102)	*Danthonia* spp. (*Danthonia geniculata* & *Danthonia setacea*)
(103)	*Danthonia* spp. (*Danthonia clelandii* & *Danthonia caespitosa*)
(104)*	*Lolium perenne*
(105)*	*Vulpia* spp.
(109)*	*Phalaris minor*
(114)	*Lythrum hyssopifolia*
(115)*	*Onopordum acanthium*
(116)*	*Cynosurus echinatus*
(122)*	*Trifolium fragiferum*

KYEEMA CONSERVATION PARK

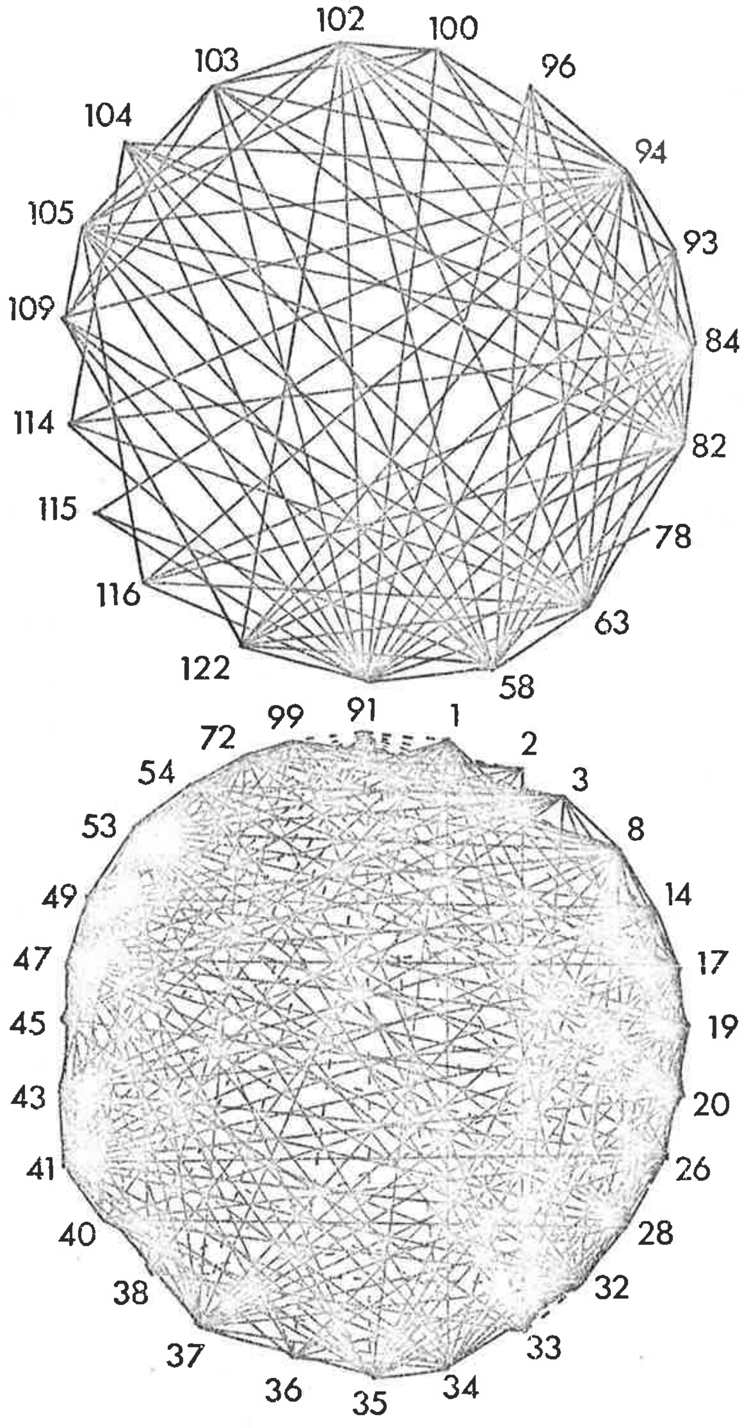


Figure 7.6.

less frequent in occurrence in the park as a whole. Nevertheless many of the plants that are infrequent are still important to consider. For example, *Pinus radiata* is present in less than two per cent of the quadrats but is still important in that it is able to establish in undisturbed areas. Similarly several native plant species are rare, e.g. *Leptospermum pubescens, Acacia retinodes* and the species of *Pimelea*.

The plant species inter-relations are illustrated in Fig. 7.7.. The vegetation of the park consists of two groups. These groups are linked by several mutual species. However the dissociations between these two groups (diss-ociations were not included as their inclusion would add little to the diagram) indicate that they are distinct groups of plants. The first group, the larger of the two, consists of two inter-related groups. That is those species associated with *Eucalyptus cosmophylla* and those associated with *Eucalyptus obliqua* and *Eucalyptus fasciculosa*. These two sub-groups are linked by a large number of species. All the species in this first group are native except for *Fumaria muralis* and South African daisy, *Senecio pterophorus*.

On the other hand the smaller group associated with such introduced species as *Holcus lanatus* and *Trifolium repens* are all alien except for a few native species. These species are *Machaerina gunnii, Lythrum hyssopifolia, Acaena anserinifolia, Senecio quadridentatus, Microlaena stipoides* and the species of *Danthonia*.

KYEEMA CONSERVATION PARK

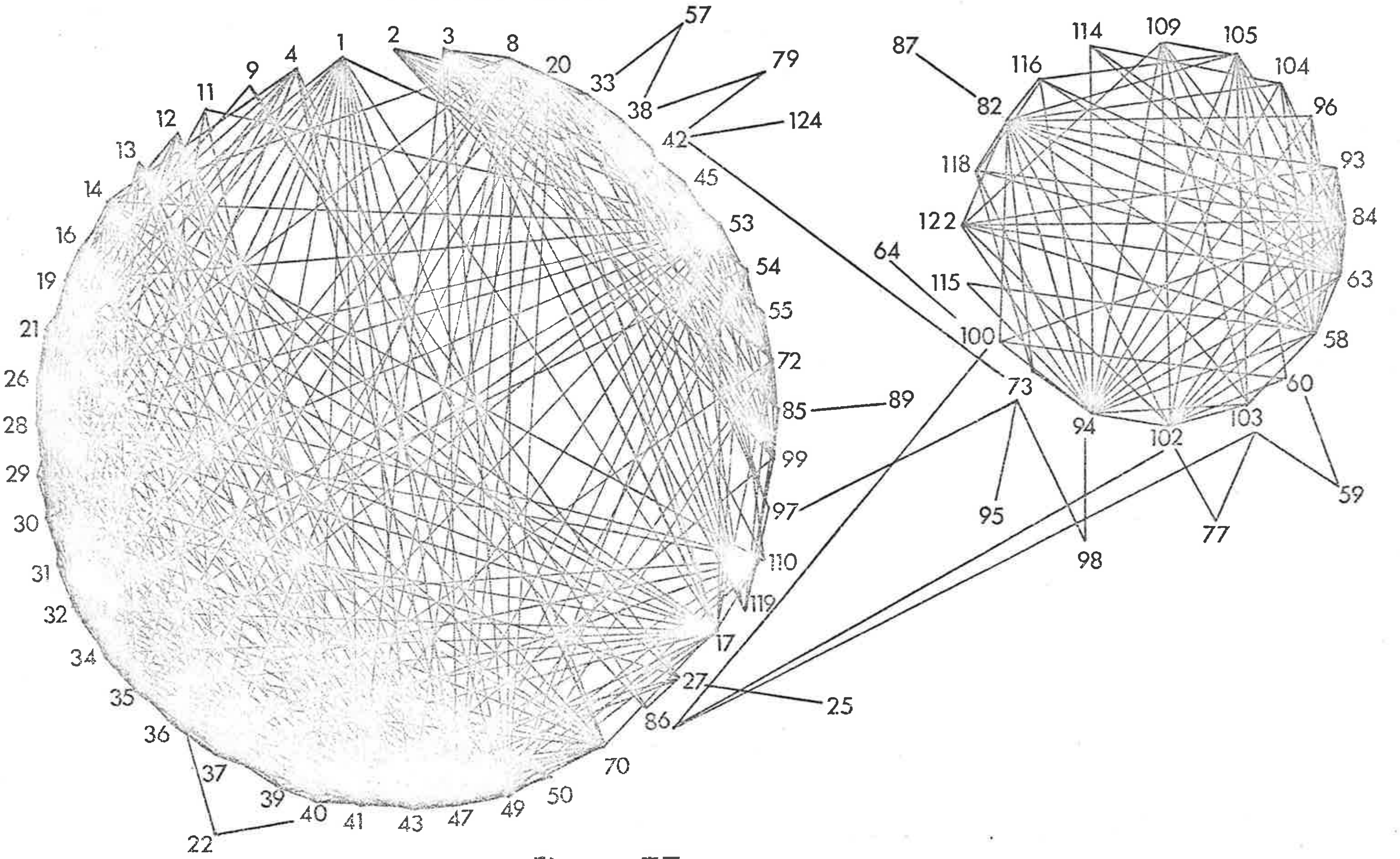


Figure 7.7.

It is notetworthy that the majority of alien species are significantly associated. Only the occasional alien species appear to have been able to establish in the areas of native vegetation, for example *Senecio pterophorus*.

The distribution maps of the plant species in Kyeema Conservation Park appear in Volume II, Appendix IV, Map 7.1. to 7.37. inclusive. The linking species like *Pteridium esculentum*, *Leptospermum juniperinum* and the species of *Schoenus* all have maps that show scattered patterns of distribution.

The plant species of the first larger group include plant species that are restricted, in the main, to the relatively undisturbed area in the central section of the park. These plant species do not grow in general in the cleared and grazed areas of the park, i.e. the western, south-central and eastern sections. A large number of plant species show this distribution pattern. For example, *Lepidosperma semiteres*, *Xanthorrhoea semiplana*, *Casuarina striata*, *Isopogon ceratophyllus* and species of the three genera *Hakea*, *Pultenaea* and *Eucalyptus*. It is noteworthy that the distribution maps of *Xanthorrhoea semiplana* and *Isopogon ceratophyllus* illustrate that these species occur in the cleared and grazed areas. Figure 7.2. shows the approximate position of the cleared and grazed areas. *Eucalyptus baxteri* is restricted in distribution to the south-central section of the park.

This area corresponds with the top of the ridge. Other species of interest include those native species that are present in restricted areas and/or appear in a low number of the quadrats in the central area. These native species include *Persoonia juniperinum, Acacia verticillata, Gompholobium ecostatum, Daviesia brevifolia, Spyridium parvifolium* and the species of *Pimelea*.

This species belonging to the second smaller group of plants (Fig. 7.7.) illustrate similar distributions in that they are restricted to the western, south-central and eastern corners of the park. For example *Microlaena stipoides, Holcus lanatus, Lolium perenne, Rumex angiocarpus, Trifolium fragiferum, Trifolium repens, Arctotheca calendula, Hypochoeris radicata* and the species of *Danthonia*. All these species have a similar distribution.

7.9.5. Intensive-Study Area - Plant Distribution

The distribution of plant species in the intensive study area appear in Volume II, Appendix IV, Maps 7.39. to 7.97. inclusive. An association analysis was carried out on the results. However the resulting figure did not provide any additional information. The alien and native plant species formed one node. This would be expected in that the intensive area studied only covers a small area. Therefore all discussions are based on the distribution maps of the plant species.

The location of the currently grazed areas can be seen in Fig. 7.2.. The majority of introduced plants are well established in the grazed areas, the edge of the grazed paddocks and the cleared valley. For example *Aira caryophyllea, Avena barbata, Cynosurus echinatus, Briza maxima, Briza minor, Dactylis glomerata, Vulpia* spp., *Plantago lanceolata, Arctotheca calendula* and the species of *Trifolium* and *Hypochoeris*. There are also native plants that show a similar pattern of distribution. These include *Machaerina gunnii, Cyperus tenellus, Centrolepsis aristata* and *Scirpus antarcticus*.

On the other hand the majority of the native plants in this localised area do not grow in the grazed paddocks. *Eucalyptus obliqua, Banksia marginata, Acacia myrtifolia, Gompholobium ecostatum, Daviesia virgata, Daviesia ulicifolia* and the species of *Hakea, Pultenaea* are among these many native plant species that are restricted in distribution to the areas not currently grazed. The interesting species to observe are the alien species that are intermingled with the native species and vice-versa. *Isopogon ceratophyllus* and *Lepidosperma semiteres* are two of the native species that have been able to persist in the grazed paddocks. *Plantago lanceolata* and *Oxalis pes-caprae* are among the alien species that extend in the distributions into the currently ungrazed areas.

Pinus radiata is scattered and illustrates no particular pattern in its distribution. *Ulex europaeus* grows along the fences on the edges of the grazed paddocks.

The other plant species of interest are *Goodenia ovata* and *Leptospermum juniperinum* which are restricted to the creeks and valleys.

7.10. Summary

The influence of man in Kyeema Conservation Park is reflected in the vegetation. The distinct groups of plant species give clear evidence of his influence. First the native species which are restricted, in the main, to the central steep-sided gullies and rocky flat top-ridges. Second the introduced species which dominate the cleared and grazed valleys. Man's introduction of the cattle and introduced plant species has clearly changed the vegetation of the park.

The few introduced plant species that have established in the central area include *Rubus* spp. *aff. fruticosus, Senecio pterophorus* and *Ulex europaeus.* Although these plant species are present in relatively low numbers in comparison with other parks in the Adelaide Hills their presence should be carefully monitored. The introduced grasses, legumes and composites in the cleared areas have replaced the majority of the original plant species found in these areas.

The results from the intensive-study area provides a basis for later work. Selected native species have persisted on the edges of the grazed and cleared areas. These species are of particular interest.

Such species include *Isopogon ceratophyllus, Lepidosperma semiteres, Xanthorrhoea semiplana* and the species of *Hibbertia*. On the other hand several introduced species appear in the area not currently grazed. This intermingling of species on the fringes of the central area of the park resembles the "border effect" discussed in the previous chapter.

The vegetation has also been determined by the soils, aspect and other topographic features within the park. The rare occurrence of many native species, e.g. *Leptospermum pubescens, Acacia retinodes* and species of *Pimelea,* questions the adequacy of this park for the conservation of these species.

CHAPTER VIII

BELAIR RECREATION PARK

8.1. Introduction.

Belair Recreation Park (Hundred of Adelaide, Section 675) is located ten kilometres south-east of Adelaide (Fig. 8.1.).

In 1891, the passing of the National Park Act was a turning point in the history of this state. The area of eight hundred and nine hectares declared at Belair was primarily set aside for recreational purposes. The park was under the control of the Commissioners of the National Park. In 1955 the Act was amended to include the control of other reserves.

In the six years preceeding its declaration as a National Park in 1966 the park was increased in area (by the addition of Section 606, 514 and 496). In 1967, a further section was added to enlarge it to its present area of eight hundred and thirty-five hectares. At various times areas of the park were resumed so in fact the park has not changed a great deal in area since it was first declared. Belair National Park was later proclaimed to be a recreation park under the control of the National Parks and Wildlife Act, 1972.

8.2. Historical Background.

Belair Recreation Park prior to its dedication as a park was known as the Government Farm. Pitt (1939) and Cleland (1964) provide historical accounts of this area. Pitt and Cleland both clearly indicate that the Government Farm in the nineteenth century was used for a variety of man's activities.

Figure 8.1.

Location of Belair Recreation Park

(▲ indicates the location)

BELAIR RECREATION PARK

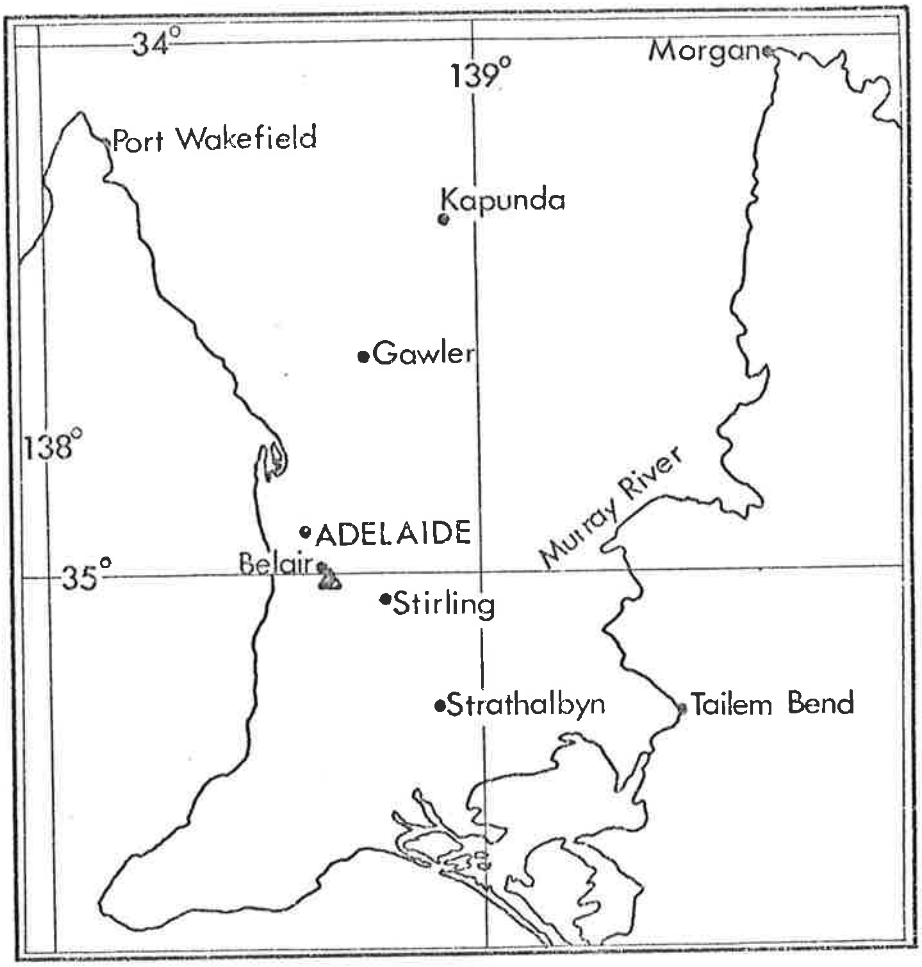


Figure 8.1.

8.2. Historical Background (Cont.)

Such activities included the grazing of animals, cultivation of vegetables, collection of firewood and hunting of opossums.

The Native Fauna and Flora Protection Committee of the Field Naturalist's Section of the Royal Society of South Australia came into existence in 1888, and a resolution by Samuel Dixon was passed ".....that Government Farm be declared a public park....." (Cleland, 1964). After several years the National Park Act was finally approved. The powers of the Commissioners as scheduled in this act have already been discussed in Chapter II, section 5.

In 1955, the National Park Act was amended to include the control of the dedicated Wildlife Reserves. Since early times the park was developed for the recreational needs of the population of Adelaide. The recreational facilities provided included tennis courts, ovals, pavilions and public amenities. Even though this park was dedicated primarily for recreational purposes many sections still provide areas left relatively undisturbed by man. For example the area in the north-east of the park still provides areas of native vegetation which have had little disturbance from man. The planting of many shrubs and trees in the valleys has altered the plant communities. The planted species have spread in some patches, e.g. *Crataegus monogyna* (Hawthorn) and species of *Populus*. This idea of planting introduced species was also carried out in other local parks, e.g. Morialta Conservation Park.

In recent years the population of Adelaide has placed increasing demands on this park.

8.2. Historical background (Cont.)

As a result of the large number of vehicles, denudation has resulted with marked destruction of the vegetation. There has also been a marked decrease in the ground cover in many areas as a result of the network of tracks through the park.

The increase in fires as a result of vandalism or accidental outbreaks has affected the plant communities. A number of alien species have been encouraged by these fires. This has led to the growth of alien species in large sections of the park. For example, *Senecio pterophorus*, South African daisy is well adapted to the conditions created by the advent of a fire. As a result this plant has spread throughout most of the park. Attempts have been made to hand pull this weed but such efforts need to be carried out on a very large scale if they are to prove successful. Another weed that is present in large numbers is *Chrysanthemoides monilifera* which dominates the shrub layer in the north-western section of the park. This plant is also a serious problem in Morialta Conservation Park.

The grazing of animals in the park has resulted in the majority of the ground layer being altered to include large numbers of introduced grasses. In fact the remaining areas of native grasses appear to have become patchy and localised in their distribution. The presence of introduced animals also pose problems, e.g. rabbits, sheep, feral cats and wild dogs. The fences in the park are inadequate for keeping native animals in the park and for keeping introduced animals out. The inaccessibility of many areas leads to problems in management of animals.

8.3. Climate.

The rainfall and temperature recordings for Belair "Kalyra" are given in Table 8.1.. The marked seasonal variation in rainfall and temperature is clear from these results. The climate consists of cold, wet winters and hot, dry summers. The rainfall in the Adelaide Hills increases with altitude, while the temperature decreases with altitude thus leading to a longer effective growing period for plants.

There is a slight variation between the rainfall and temperature at Stirling (Table 10.1.) and Belair "Kalyra". It is colder and wetter at Stirling.

8.4. Physiography and Drainage.

Belair Recreation Park varies in elevation from two hundred and fifty metres to four hundred and ninety metres above sea-level. The headquarters of Workanda and Minno Creek run in an east-west direction and both then join the Sturt Creek further downstream (Fig. 8.2.).

The park consists of deeply dissected, steep-sided valleys in the eastern part of the park. The valleys in the western edge are broader and flatter in comparison. The ridges run in an east-west direction.

8.5. Geology and Soils.

The geology and soils for the Mount Lofty Ranges have been described by previous workers (Sprigg, 1945; Specht, 1964). In Belair the four soil types are; Lateritic Podsol, Skeletal Quartzite and Podsol, Grey Brown Podsol and Grey Brown Podsol (Lower nutrient status) (Specht, 1964).

Figure 8.2.

The main features of Belair Recreation Park

(Scale 1 cm. = 250 metres)

Railway line	Oval
Watercourse	Intensive-study area
Waterfall	Bitumen road
Dam	Golf course

BELAIR RECREATION PARK

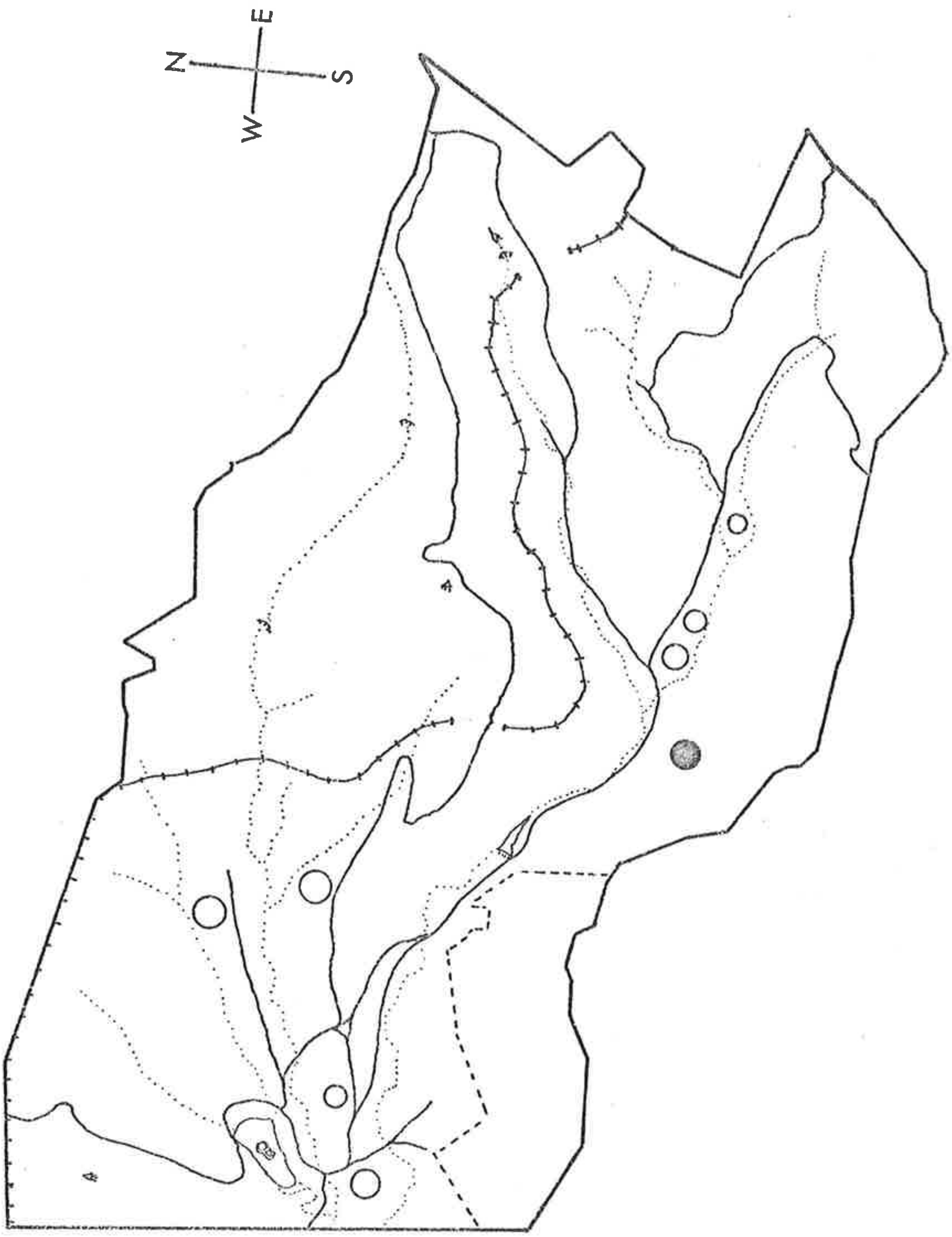


Figure 8.2.

Table 8.1.

Rainfall and temperature recordings for Belair "Kalyra"

(taken from the records of the Bureau of Meteorology, Adelaide)

	No. of Yrs	J	F	M	A	M	J	J	A	S	O	N	D	Year
Mean Rainfall (mm)	80	24	27	30	63	100	108	99	91	75	61	42	35	755
Median Rainfall (mm).	80	18	15	22	53	90	97	98	82	70	60	33	28	747
Rain days	80	3	4	4	9	13	14	16	15	12	10	7	5	111
Av. Max. Temp. °C	26	26.7	26.8	24.6	20.3	16.4	13.4	12.7	13.7	16.4	19.5	22.5	24.6	19.8
Av. Min. Temp. °C	26	14.8	15.4	14.4	12.1	10.0	7.8	7.1	7.3	8.5	9.9	11.7	13.4	11.0
Mean Temp. °C.	26	20.7	21.1	19.5	16.2	13.2	10.6	9.9	10.5	12.5	14.7	17.1	19.0	15.4
Extreme Max. Temp. °C	26	44.1	41.7	40.1	33.3	29.4	20.8	23.6	25	33.2	36.7	41.3	42.8	
Extreme Min Temp. °C	26	6.7	4.3	4.7	4.2	3.3	1.7	1.2	-2.3	0.0	1.7	3.7	5.7	

8.5. Geology and Soils (Cont.)

The following descriptions of the soils are extracted from Specht (1964).

The Lateritic Podsol soils formerly covered a large proportion of the area prior to block-faulting. The soil which consists of a sandy surface soil overlying a clay sub-soil is restricted to two patches in the western edge of the park. This soil which has been completely eroded is acid and very low in available nutrients.

The other soils have been developed under the present prevailing conditions. The Skeletal Quartzite soils were formed from weathered siliceous rocks and are rocky as the soil is eroded down into the gullies. It is low in nutrients and is also acid. These soils are restricted to the southern edge of the park.

The two Grey Brown Podsol soils are formed from weathered, argillaceous rocks. Despite weathering, the soil materials accumulate over the majority of the ridges. They are acid and relatively fertile. The colour ascribed depends on the sub-soil. The better leached soils have a lower nutrient status.

8.6. Vegetation.

The vegetation of this area has been described previously. (Specht and Perry, 1948; Specht and Cleland, 1961, 1963; Specht, 1964).

Belair Recreation Park consists of a variety of plant communities. The open forest of *Eucalyptus obliqua* and *Eucalyptus fasciculosa* (with a heath understorey) covers the majority of the eastern and north-eastern sections of the park. The open scrub of *Eucalyptus cosmophylla* (with a heath understorey) is restricted to the southern fringe. The woodlands which have a grass understorey cover by far the largest area in the park. *Eucalyptus camaldulensis,* the red gum, grows in the valleys throughout the park. *Eucalyptus leucoxylon* and *Eucalyptus viminalis* cover the central area and parts of the southern edge of the park. *Eucalyptus odorata* on the other hand is restricted to the western edge.

The large number of alien species throughout the park has led to management problems. For example, the dense thicket of the two shrubs, *Senecio pterophorus* and *Chrysanthemoides monilifera* have made many areas inaccessible in the advent of a fire. The majority of creek beds no longer support native plants. The vegetation over vast sections of the park have been altered by man. As a result only selected, usually relatively inaccessible areas have a flora approaching that present prior to European settlement.

8.7. Research Objectives.

Belair Recreation Park offered several advantages for research. The presence of man in this park for over a century would predictably have led to marked changes in the vegetation. The introduction of animals and plants would also have led to changes in the vegetation. The obvious removal of vegetation as a result of vehicular traffic and the activities of horses is evident in most sections of the park.

8.7. Research Objectives (Cont.)

The vegetation would predictably reflect man's influence through the introduction of animals and plants, clearing of the scrub for firewood and recreational needs, firing of the park (accidental and deliberate), planting of alien species and the influence of management policies.

Research was therefore carried out in Belair Recreation Park with the following objectives -

a) To carry out a reconnaissance of the park to gain a general description of the area.

b) To construct a floristic list as a basis for the identification of plant species.

c) To study the plant communities by surveying the species present in the park.

d) To follow some species that appear to be of particular interest in that they reflect man's activities and/or are of interest in the inter-relationships present within the plant communities.

e) To review the soil and physiographic features of the area as possible determinants of the distribution of plant species.

f) To measure the densities of the major species in the park.

8.8. Research Methods.

The reconnaissance and the collection of plant species were carried out on several occasions.

8.8. Research Methods (Cont.)

The necessity to collect at a series of times was due to the different flowering dates of the plant species present. A floristic list was compiled.

The vegetation was surveyed by using a systematic location of four hundred and sixty-two quadrats at one hundred metre intervals (measured by pacing) along traverses two hundred metres apart running at a compass bearing of one hundred and sixty-five degrees. The first traverse was along the western fence of the park. The quadrats were circular in shape with a radius of five metres. The presence-absence data collected for Belair Recreation Park enabled the distribution maps of the plant species to be constructed with the assistance of the Adelaide University CDC 6400 computer. In addition an association analysis was carried out on all binary data collected to study the inter-relations between plant species, soils and topography in the park. The density measurements were recorded at the same time and were also plotted in the results.

8.9. Results.

8.9.1. Introduction.

The floristic list appears in Appendix II. The distribution maps of the plant species and soil groups appear in Volume II, Appendix V, Maps 8.1. to 8.74. inclusive. The frequency of plant species in Belair Recreation Park are recorded in Table 8.2.. The inter-relationships of plants with soils, physiographic features and other plants will be discussed separately in sections 8.9.2., 8.9.3. and 8.9.4. respectively.

Table 8.2.

The plant species sampled at Belair Recreation Park. The percentage of total samples in which they occur (frequency). Introduced species are prefixed by an asterisk.

	Species	Frequency
	Caesia vittata	64.7
	Acacia pycnantha	58.9
*	*Briza maxima*	54.1
*	*Allium triquetrum*	47.4
*	*Hypericum perforatum*	42.6
	Moss spp.	39.2
*	*Senecio pterophorus*	39.0
	Hibbertia exutiacies	34.4
	Eucalyptus obliqua	33.8
	Eucalyptus leucoxylon	32.9
	Pultenaea spp.	30.3
*	*Chrysanthemoides monilifera*	29.4
	Acaena spp.	27.3
	Acrotriche fasciculiflora	27.1
*	*Oxalis* spp.	26.8
	Haloragis tetragyna	25.5
	Eucalyptus odorata	23.6
	Pultenaea daphnoides	20.3
*	*Plantago lanceolata*	20.1
*	*Oxalis pes-caprae*	19.0
*	*Sparaxis* sp.	19.0
	Tetratheca pilosa	16.5
	Geranium pilosum	15.2
	Eucalyptus fasciculosa	14.9
*	*Aira caryophyllea*	14.5
	Dianella revoluta	13.9
	Poa laevis	12.8
	Microlaena stipoides	12.6
	Eucalyptus viminalis	12.1

Table 8.2. (Cont.)

	Species	Frequency
	Hibbertia sericea	11.9
	Exocarpus cupressiformis	11.5
	Pteridium esculentum	11.5
	Themeda australis	11.5
*	*Hypochoeris* spp.	11.3
*	*Olea europaea*	10.6
	Pultenaea largiflorens	10.6
	Scaevola albida	10.6
	Eucalyptus camaldulensis	10.2
	Olearia tubuliflora	9.3
	Hibbertia stricta	9.1
	Cheilanthes tenuifolia	8.9
	Drosera whittakeri	8.9
	Oxalis corniculata	8.9
	Thysanotus dichotomus	7.8
	Astroloma humifusum	7.4
	Acacia myrtifolia	7.1
	Lissanthe strigosa	6.1
	Lepidosperma semiteres	6.1
	Acacia melanoxylon	5.8
	Acrotriche serrulata	5.8
	Dodonaea viscosa	5.6
	Leptospermum myrsinoides	5.6
	Pinus halepensis	5.4
	Ixodia achillaeoides	5.4
*	*Holcus lanatus*	5.4
	Lomandra effusa	5.4
*	*Rosa rubiginosa*	5.2
*	*Trifolium* spp.	5.2
*	*Rubus* spp. *aff. fruticosus*	5.0
*	*Vulpia* spp.	5.0
	Stipa spp.	5.0
*	*Pittosporum undulatum*	4.8

Table 8.2. (Cont.)

	Species	Frequency
	Ranunculus lappaceus	4.8
	Brunonia australis	4.1
	Bursaria spinosa	3.7
	Pimelea glauca	3.7
	Xanthorrhoea semiplana	3.5
	Species of orchids	3.5
*	*Trifolium angustifolium*	3.5
	Hardenbergia violacea	3.2
	Hakea rugosa	3.0
*	*Silybum marianum*	3.0
	Goodenia primulacea	3.0
	Bulbinopsis bulbosa	3.0
*	*Crataegus monogyna*	2.6
	Acacia longifolia	2.6
	Casuarina striata	2.6
	Banksia marginata	2.4
*	*Trifolium fragiferum*	2.4
*	*Cynosurus echinatus*	2.4
*	*Echium lycopsis*	2.2
	Acacia rotundifolia	1.9
	Daviesia ulicifolia	1.9
	Grevillea lavandulacea	1.9
*	*Rumex angiocarpus*	1.9
	Calytrix tetragona	1.7
	Lagenifera stipitata	1.7
*	*Vinca major*	1.7
*	*Fumaria muralis*	1.7
	Eucalyptus cladocalyx	1.5
	Acacia armata	1.5
	Daviesia virgata	1.5
	Leptospermum juniperinum	1.5
	Hypericum japonicum	1.5
	Cassytha glabella	1.5
	Epacris impressa	2.6

Table 8.2. (Cont.)

	Species	Frequency
*	*Rhamnus alaternus*	1.3
	Hakea ulicina	1.3
	Adiantum aethiopicum	1.3
	Astroloma conostephioides	1.3
	Pinus radiata	1.1
	Casuarina stricta	1.1
	Eucalyptus cosmophylla	0.9
	Callistemon sp.	0.9
	Lepidosperma carphoides	0.9
*	*Genista maderensis*	0.9
*	*Ulex europaeus*	0.9
*	*Phalaris canariensis*	0.9
*	*Vicia sativa*	0.9
	Isopogon ceratophyllus	0.6
*	*Onopordum acanthium*	0.6
	Billardiera sericophora	0.6
	Eucalyptus ficifolia	0.4
	Araucaria spp.	0.4
	Melaleuca decussata	0.4
	Callitris sp.	0.4
*	*Inula graveolens*	0.4
	Pimelea humilis	0.4
	Ficus macrophylla	0.2
*	*Erica lusitanica*	0.2

8.9.1. Introduction (Cont.)

The distribution maps of the plant species will also be discussed in 8.9.4.. The results for the density measurements in Belair Recreation Park are discussed in section 8.9.5.

8.9.2. Soil-plant relationships.

The soil distribution maps for Belair Recreation Park appear in Volume II, Appendix V, Maps 8.73 and 8.74.. The results of the association analysis appear in Fig. 8.3. and Fig. 8.4..

(a) The Grey Brown Podsol soils cover the majority of the western edge of the park. The native and naturalised species associated with this soil group are *Eucalyptus camaldulensis, Eucalyptus odorata, Pinus halepensis, Pultenaea largiflorens, Hibbertia stricta, Dodonaea viscosa* and *Caesia vittata*. The alien species associated with this soil group are *Olea europaea, Rosa rubiginosa, Chrysanthemoides monilifera, Sparaxis* sp. and *Plantago lanceolata*. This group of plants in the main is dissociated with the larger group associated with the Grey Brown Podsol soils with a lower nutrient status. A few plant species from this group (associated with the Grey Podsol soils) are associated with *Acacia pycnantha* and species of *Pultenaea*. *Acacia pycnantha* and *Pultenaea* spp. are associated also with those plant species associated with the lower nutrient status Grey Brown Podsol soils (Fig. 8.3.).

(b) The Grey Brown Podsol soils (lower nutrient status) cover the greater part of the eastern edge of the park. There are a large number of plant species associated with this soil type (Fig. 8.3.).

Figure 8.3.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Belair Recreation Park. Nodes of species associated with the Grey Brown Podsol and Grey Brown Podsol (lower nutrient status) soil groups.

__________ indicates association, positive association

\- - - - - indicates dissociation, negative association

* indicates an introduced species

(1) *Eucalyptus fasciculosa*
(2) *Eucalyptus camaldulensis*
(3) *Eucalyptus obliqua*
(4) *Eucalyptus leucoxylon*
(6) *Eucalyptus odorata*
(7) *Pinus halepensis*
(8) * *Olea europaea*
(9) * *Rosa rubiginosa*
(10) *Ixodia achillaeoides*
(11) * *Chrysanthemoides monilifera*
(12) * *Senecio pterophorus*
(13) *Acacia pycnantha*
(14) *Acacia myrtifolia*
(16) *Dodonaea viscosa*
(17) *Exocarpus cupressiformis*
(18) *Pultenaea daphnoides*
(20) *Pultenaea largiflorens*
(22) *Pultenaea* spp.
(23) *Hibbertia stricta*
(24) *Hibbertia exutiacies*
(26) *Tetratheca pilosa*
(28) *Acrotriche fasciculiflora*
(32) *Scaevola albida*
(33) *Pteridium esculentum*
(36) *Thysanotus dichotomus*
(39) Moss spp.
(40) *Haloragis tetragyna*
(43) *Oxalis corniculata*
(47) *Caesia vittata*
(48) * *Sparaxis* sp.
(49) *Geranium pilosum*
(50) * *Plantago lanceolata*
(55) *Poa laevis*
(58) *Acaena* spp.
(59) * *Aira caryophyllea*
(62) Grey Brown Podsol
(63) Grey Brown Podsol (lower nutrient status)
(111) * *Vulpia* spp.

BELAIR RECREATION PARK

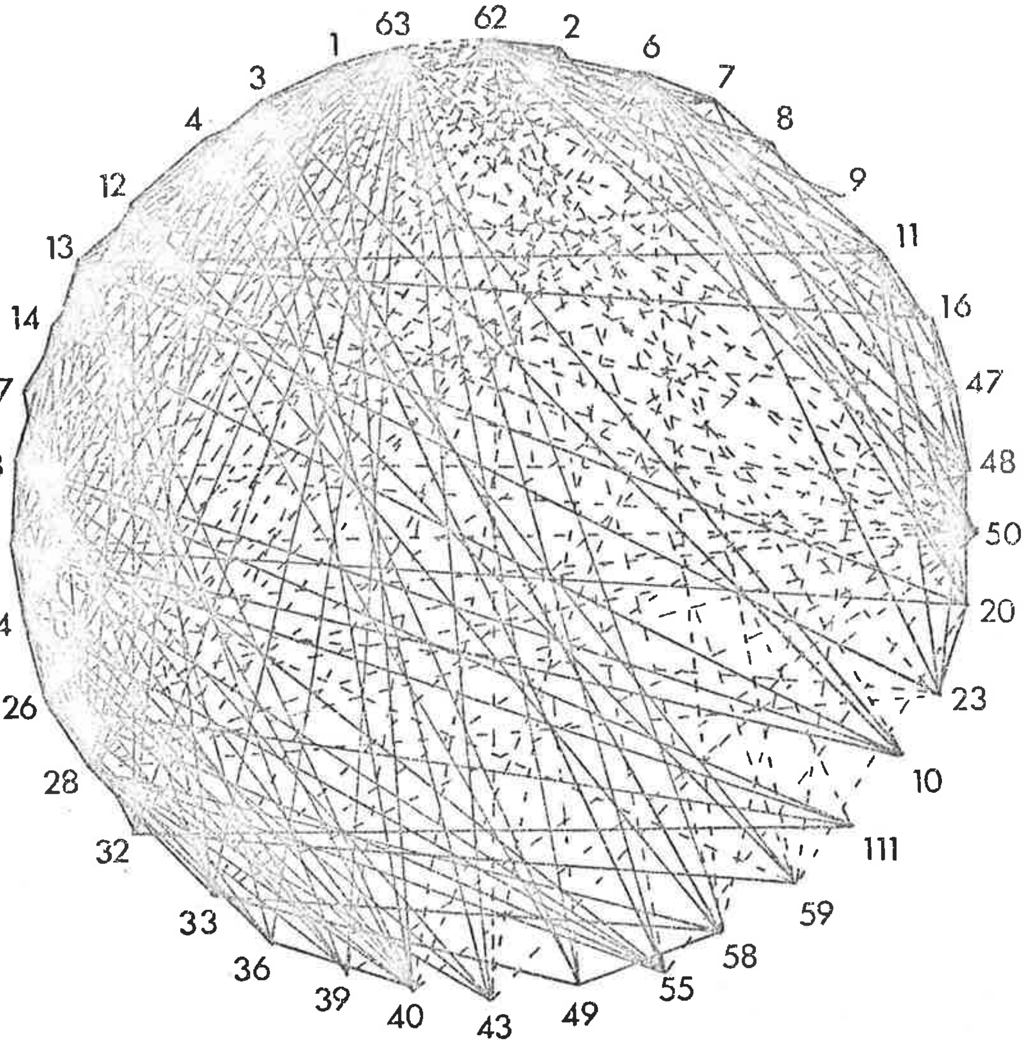


Figure 8.3.

8.9.2. Soil-plant relationships (Cont.)

(b) Cont.

The majority of these plants are native and include *Eucalyptus fasciculosa, Eucalyptus obliqua, Eucalyptus leucoxylon, Acacia myrtifolia, Pultenaea daphnoides, Hibbertia exutiacies, Tetratheca pilosa, Acrotriche fasciculiflora, Ixodia achillaeoides, Poa laevis* and species of Moss.

The alien plant species associated with this soil group include *Senecio pterophorus* and *Aira caryophyllea*. The majority of the species associated with this soil group are significantly dissociated with those species associated with the Grey Brown Podsol soils. The lower nutrient status of the soils is significant in determining the distribution of plant species. *Acacia pycnantha* has the ability to tolerate a larger range of nutrient levels in the soil.

(c) The Skeletal Quartzite and Podsol soils are restricted in distribution to two patches on the southern edge of Belair Recreation Park.

Eucalyptus viminalis, Ixodia achillaeoides, Scaevola albida and the introduced species *Aira caryophyllea* are associated with this soil group. On the other hand *Eucalyptus odorata, Caesia vittata* and the introduced species *Allium triquetrum* are significantly dissociated with this soil type (Fig. 8.4. (a).).

(d) The Lateritic Podsol soils are restricted in distribution to two patches in the western edge of the Park. *Eucalyptus odorata, Caesia vittata* and *Themeda australis* (kangaroo grass) are all positively associated with this soil group. *Eucalyptus obliqua* and the introduced shrub species, *Senecio pterophorus,*

Figure 8.4.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Belair Recreation Park.

(a) Node of species associated with the Skeletal Quartzite Podsols.

(b) Node of species associated with the Lateritic Podsols.

________ indicates association, positive association

- - - - - indicates dissociation, negative association

* indicates an introduced species

(3) *Eucalyptus obliqua*

(5) *Eucalyptus viminalis*

(6) *Eucalyptus odorata*

(10) *Ixodia achillaeoides*

(12) * *Senecio pterophorus*

(32) *Scaevola albida*

(46) * *Allium triquetrum*

(47) *Caesia vittata*

(52) *Themeda australis*

(59) * *Aira caryophyllea*

(64) Skeletal Quartzite Podsols

(65) Lateritic Podsols

BELAIR RECREATION PARK

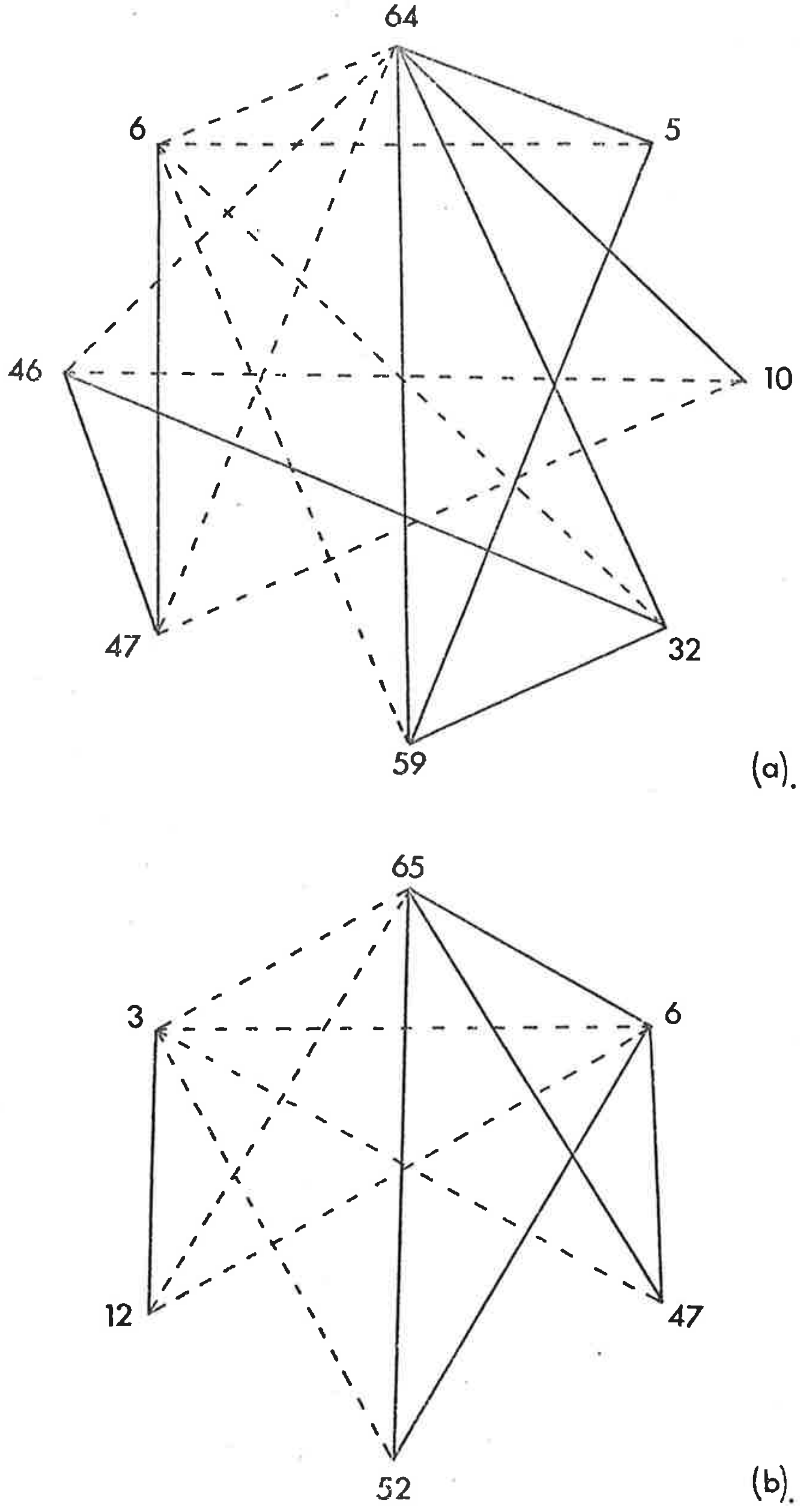


Figure 8.4.

8.9.2. Soil-plant relationships (Cont.)

(d) Cont.

are significantly dissociated with this soil (Fig. 8.4. (b).).

The soils all are important in determining the vegetation found in Belair Recreation Park.

8.9.3. Plant-Topographic relationships

The topographic features studied included southerly aspect, northerly aspect, creek beds, valleys and ridges (Fig. 8.5. (a), (b); Fig. 8.6. (a), (b), (c).).

(a) Southerly aspect.

The species associated with this aspect are *Eucalyptus obliqua, Acrotriche fasciculiflora, Pteridium esculentum, Poa laevis, Acaena* spp.. No significant dissociation were found in the association analysis (Fig. 8.5. (a).).

(b) Northerly aspect.

The species associated with this aspect are *Eucalyptus leucoxylon* and *Scaevola albida*. *Rosa rubiginosa* is dissociated with this aspect (Fig. 8.5. (b).).

(c) Creek beds.

The only species significantly associated with this topographic feature is blackberry, *Rubus* spp. *aff. fruticosus* (Fig. 8.6.(a).).

(d) Valleys.

The introduced perennial grass, *Holcus lanatus* (Yorkshire Fog) is significantly associated with the valleys (Fig. 8.6. (b).).

Figure 8.5.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Belair Recreation Park.

(a) Node of species associated with the southerly aspect.

(b) Node of species associated with the northerly aspect.

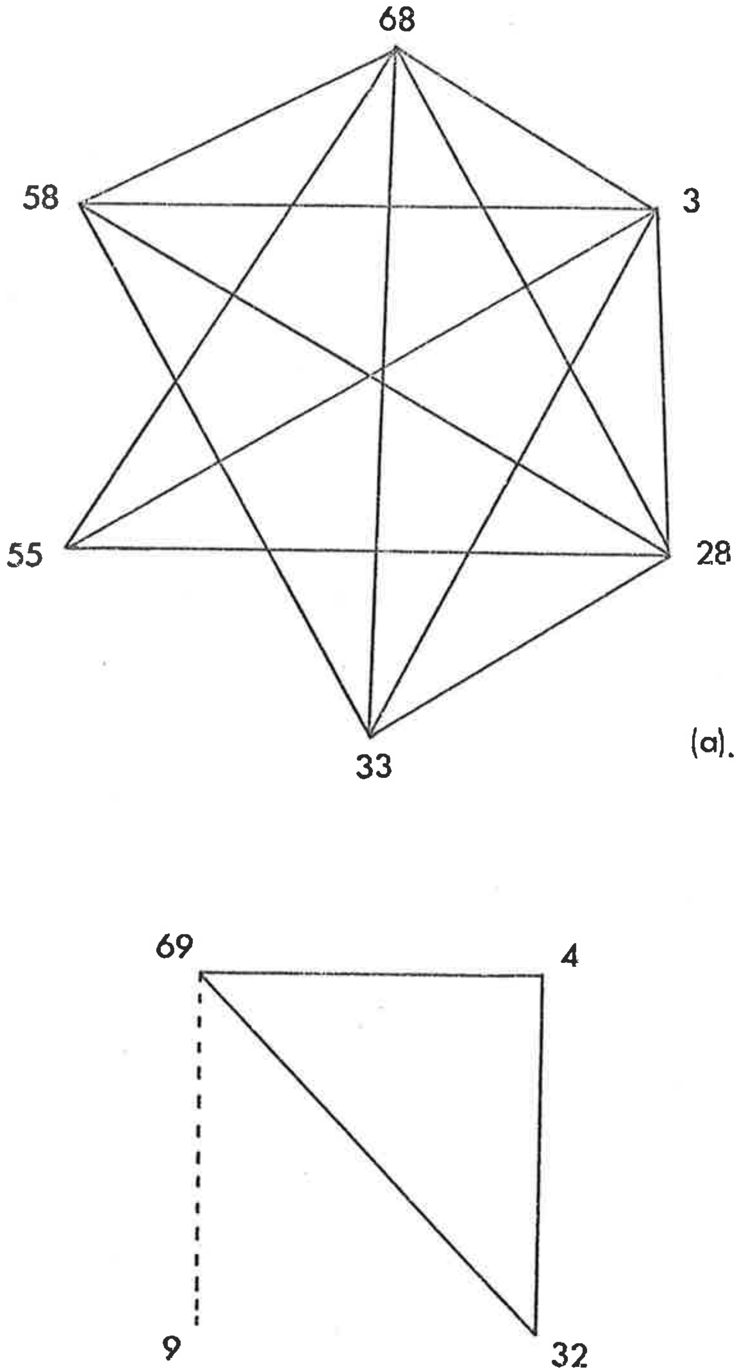
________ indicates association, positive association

\- - - - - indicates dissociation, negative association

* indicates an introduced species

(3) *Eucalyptus obliqua*
(4) *Eucalyptus leucoxylon*
(9) * *Rosa rubiginosa*
(28) *Acrotriche fasciculiflora*
(32) *Scaevola albida*
(33) *Pteridium esculentum*
(55) *Poa laevis*
(58) *Acaena* spp.
(68) Southerly aspect
(69) Northerly aspect

BELAIR RECREATION PARK



(a).

(b).

Figure 8.5.

Figure 8.6.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Belair Recreation Park.

(a) Node of species associated with creek-beds.

(b) Node of species associated with valleys.

(c) Node of species associated with ridges.

(d) Node of species associated with recently burnt areas (trunks of trees and ground still charred).

_______ indicates association, positive association.

- - - - indicates dissociation, negative association.

* indicates an introduced species.

(4) *Eucalyptus leucoxylon*
(11) * *Chrysanthemoides monilifera*
(12) * *Senecio pterophorus*
(13) *Acacia pycnantha*
(22) *Pultenaea* spp.
(32) *Scaevola albida*
(41) * *Trifolium* spp.
(42) * *Oxalis pes-caprae*
(46) * *Allium triquetrum*
(49) *Geranium pilosum*
(58) *Acaena* spp.
(59) * *Aira caryophyllea*
(60) * *Holcus lanatus*
(66) Burnt areas
(72) Ridges
(73) Creek-beds
(74) Valleys
(110) * *Rubus* spp. *aff. fruticosus*

BELAIR RECREATION PARK

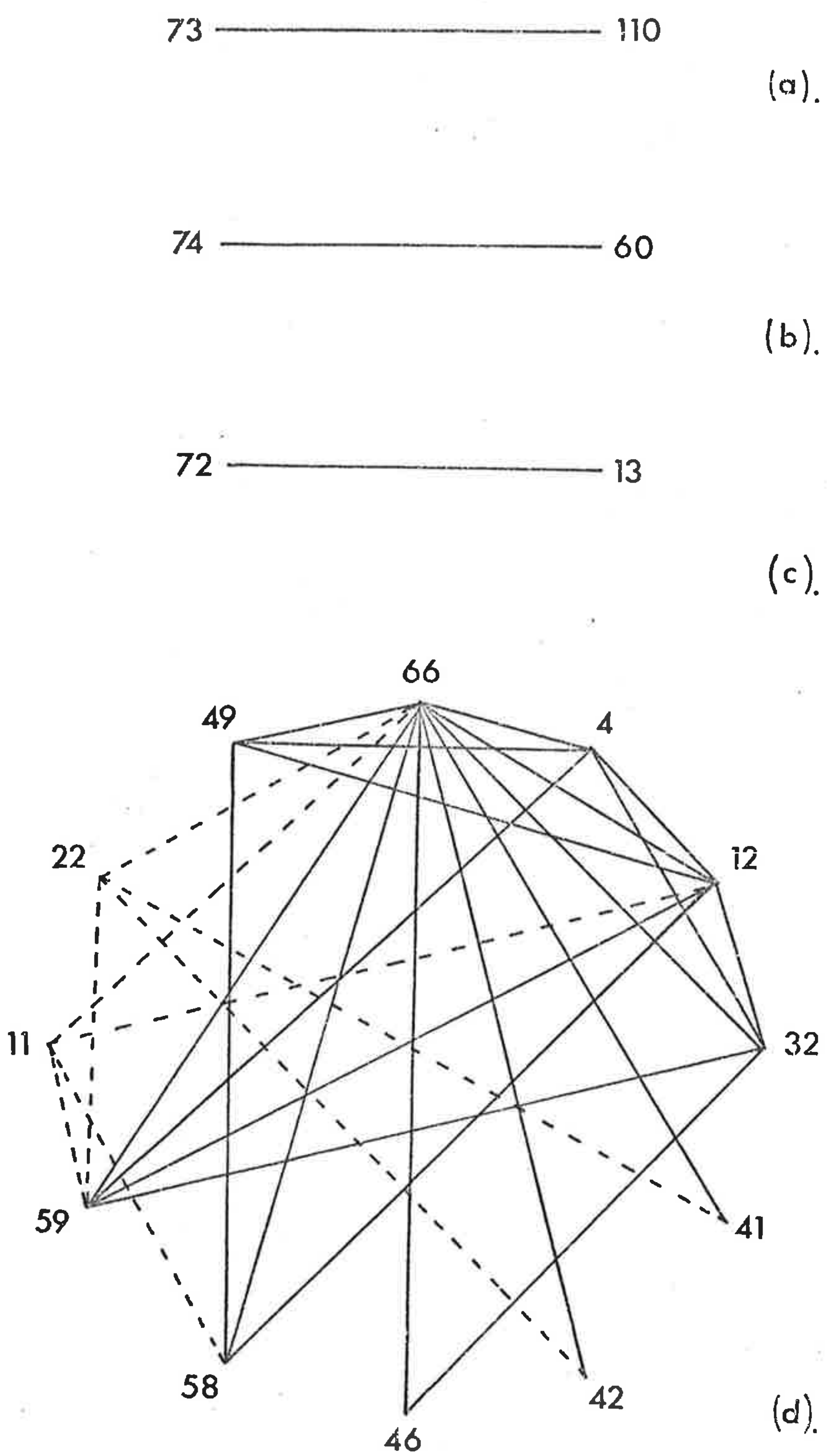


Figure 8.6.

8.9.3. Plant-Topographic relationships (Cont.)

(e) Ridges.

The only plant species positively associated with the ridges is *Acacia pycnantha* (Fig. 8.6.(c).).

The topographic features appear to be significant in determining the distribution of some of the plant species found in Belair Recreation Park.

8.9.4. Plant Species Inter-relations.

The plant distribution maps appear in Volume II, Appendix V, Maps 8.1. to 8.72. inclusive. The results of the association analysis of the plant species followed appear in Fig. 8.7.. Dissociations were not included in this figure but will be discussed in the text.

The recently burnt section of the park in the north-central area of the park (immediately east of the railway line) was included in the binary data. A number of plant species were positively associated with this burnt area. These included *Eucalyptus leucoxylon, Scaevola albida* and species of *Acaena* as well as a range of introduced species including *Allium triquetrum, Senecio pterophorus, Oxalis pes-caprae* and species of *Trifolium*. *Chrysanthemoides monilifera* and the species of *Pultenaea* were dissociated with this burnt area (Fig. 8.6.(d).).

The results of the association analysis are presented in Fig. 8.7.. The results clearly indicate that the plant species form one large inter-connected group and three small groups.

Figure 8.7.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in Belair Recreation Park

——— indicates association, positive association

* indicates an introduced species

(4) *Eucalyptus fasciculosa*
(5) *Eucalyptus camaldulensis*
(6) *Eucalyptus obliqua*
(7) *Eucalyptus leucoxylon*
(8) *Eucalyptus viminalis*
(9) *Eucalyptus odorata*
(10) *Pinus halepensis*
(13) * *Pittosporum undulatum*
(14) * *Crataegus monogyna*
(15) * *Olea europaea*
(17) * *Rosa rubiginosa*
(18) * *Rubus* spp. *aff. fruticosus*
(19) *Ixodia achillaeoides*
(20) * *Chrysanthemoides monilifera*
(21) * *Senecio pterophorus*
(22) *Acacia longifolia*
(23) *Acacia pycnantha*
(24) *Acacia myrtifolia*
(25) *Acacia obliqua*
(26) *Acacia armata*
(27) *Acacia melanoxylon*
(30) *Hakea rugosa*
(34) *Casuarina striata*
(35) *Dodonaea viscosa*
(36) *Xanthorrhoea semiplana*
(37) *Callistemon* sp.
(38) *Adiantum aethiopicum*
(40) *Exocarpus cupressiformis*
(41) *Banksia marginata*
(42) *Pultenaea daphnoides*
(44) *Daviesia virgata*

(45) *Daviesia ulicifolia*
(46) *Calytrix tetragona*
(47) *Olearia tubuliflora*
(48) *Pultenaea largiflorens*
(50) *Leptospermum myrsinoides*
(51) *Pultenaea* spp.
(52) *Hibbertia stricta*
(53) *Hibbertia exutiacies*
(54) *Hibbertia sericea*
(55) *Tetratheca pilosa*
(57) *Astroloma conostephioides*
(58) *Grevillea lavandulacea*
(59) *Astroloma humifusum*
(60) *Acrotriche fasciculiflora*
(61) *Acrotriche serrulata*
(62) *Lissanthe strigosa*
(65) *Lepidosperma semiteres*
(67) *Scaevola albida*
(68) *Goodenia primulacea*
(69) *Pimelia glauca*
(70) * *Genista maderensis*
(71) *Brunonia australis*
(73) *Pteridium esculentum*
(74) * *Hypericum perforatum*
(75) *Hypericum japonicum*
(76) *Dianella revoluta*
(77) *Thysanotus dichotomus*
(78) *Cheilanthes tenuifolia*
(79) *Drosera* sp.
(80) Moss sp.
(81) *Haloragis tetragyna*

(83) * *Trifolium* spp.
(84) * *Oxalis pes-caprae*
(85) *Oxalis corniculata*
(86) * *Oxalis* spp.
(87) * *Hypochoeris* spp.
(89) * *Allium triquetrum*
(91) *Caesia vittata*
(92) * *Sparaxis* sp.
(94) *Geranium pilosum*
(95) * *Plantago lanceolata*
(96) * *Cynosurus echinatus*
(97) * *Briza maxima*
(98) *Themeda australis*
(100) * *Vulpia* spp.
(101) Species of grasses
(102) *Microlaena stipoides*
(103) *Poa laevis*
(104) *Stipa* spp.
(105) Bare soil
(106) Leaf litter
(107) *Acaena* spp.
(108) * *Rumex angiocarpus*
(109) *Cassytha glabella*
(110) * *Vinca major*
(111) Species of orchids
(113) * *Aira caryophyllea*
(114) * *Silybum marianum*
(117) * *Holcus lanatus*
(118) * *Fumaria muralis*
(121) * *Trifolium angustifolium*
(124) *Lomandra effusa*

BELAIR
RECREATION PARK

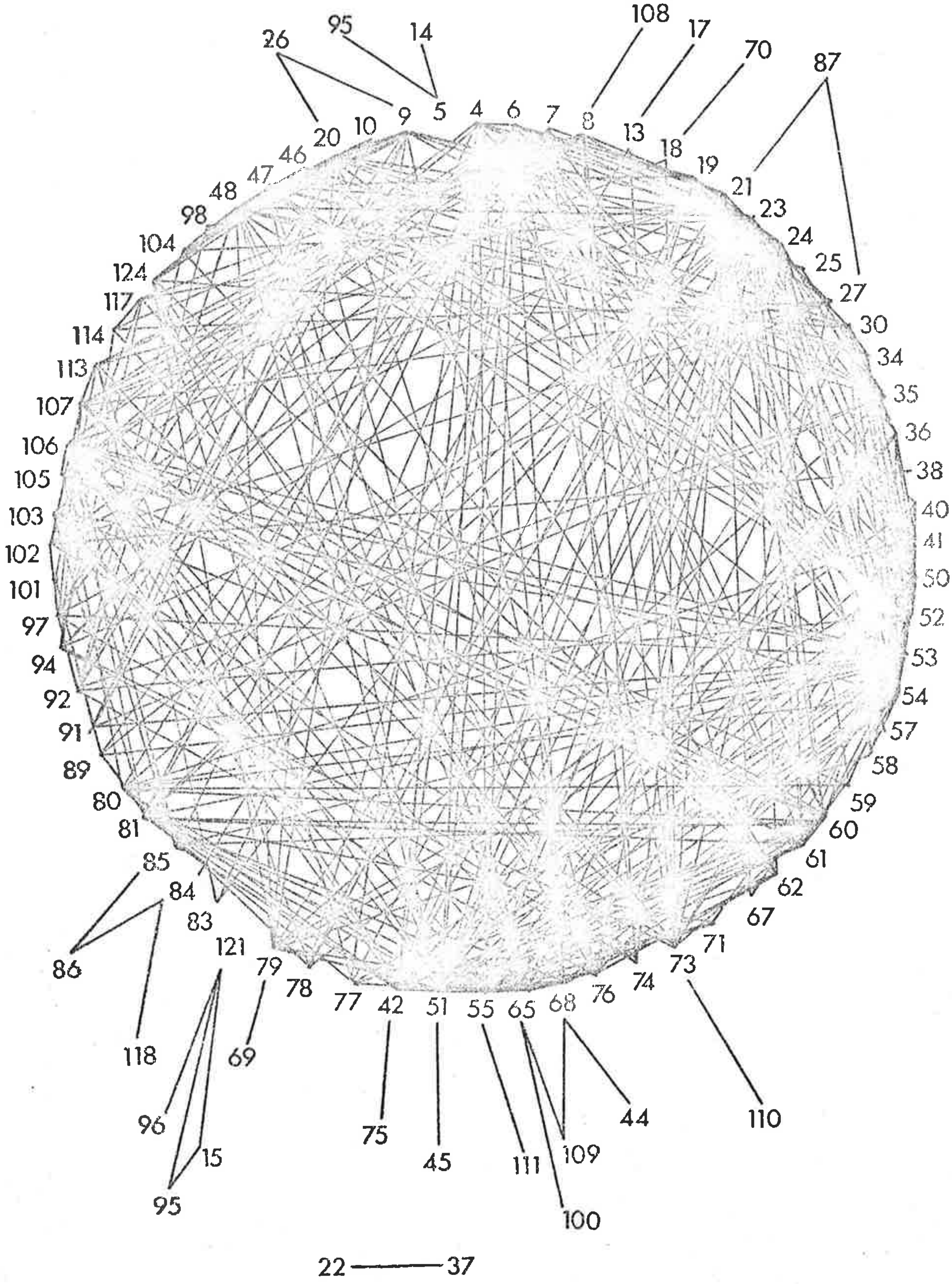


Figure 8.7.

The first large group consists of both native and alien plant species. So the discussion of this group does not become exhaustive the review of the results will be restricted to the eucalypts and some of the alien species.

First the three small groups of plants are as follows, first, *Acacia longifolia* is associated with the species of *Callistemon*. The second group of plants consists of alien species associated with each other, i.e.*Olea europaea, Plantago lanceolata, Cynosurus echinatus* and *Trifolium angustifolium*. The third group is associated with *Eucalyptus camaldulensis*.

Eucalyptus camaldulensis is associated with the two introduced species *Crataegus monogyna* (Hawthorn) and *Plantago lanceolata* (Fig. 8.7.). On the other hand this species is dissociated with *Eucalyptus obliqua* and its associated species, e.g. *Acrotriche fasciculiflora, Pultenaea daphnoides, Hibbertia exutiacies* and *Haloragis tetragyna*.

Eucalyptus obliqua is associated with a range of native species and the introduced plant species, *Senecio pterophorus* (Fig. 8.7.). It is dissociated with a range of native and alien species. These native species include *Eucalyptus camaldulensis, Eucalyptus odorata, Caesia vittata* and *Themeda australis*. The alien species dissociated with *Eucalyptus obliqua* include *Olea europaea, Chrysanthemoides monilifera, Oxalis pes-caprae* and *Plantago lanceolata*.

Eucalyptus fasciculosa, unlike *Eucalyptus camaldulensis* is positively associated with *Eucalyptus obliqua* and its associated species. Similarly it is dissociated with *Oxalis pes-caprae* and *Plantago lanceolata*.

Eucalyptus odorata is also associated with a large range of native and alien species (Fig. 8.7.). This species is dissociated with a variety of native plants including *Eucalyptus obliqua, Eucalyptus leucoxylon, Eucalyptus viminalis* and many of their associated plant species. *Eucalyptus odorata* is also dissociated with the alien species *Senecio pterophorus* and *Aira caryophyllea.*

Eucalyptus viminalis and *Eucalyptus leucoxylon* have similar plant species inter-relations. For example, they both are dissociated with *Eucalyptus odorata* and both are associated with *Senecio pterophorus, Hypericum perforatum* (St. John's Wort), *Geranium pilosum,* and *Aira caryophyllea.* They both still have species that are not in common, e.g. *Trifolium* spp. are associated with *Eucalyptus leucoxylon* but not with *Eucalyptus viminalis.*

Blackberries *(Rubus* spp. *aff. fruticosus)* are associated with *Genista maderensis, Pteridium esculentum* and *Acaena* spp.. The olive *(Olea europaea)* is positively associated with *Plantago lanceolata* and *Trifolium angustifolium,* while it is dissociated with *Eucalyptus obliqua, Pultenaea* spp., *Hibbertia exutiacies* and *Haloragis tetragyna.*

Senecio pterophorus is associated with a variety of native and alien plant species. Reference to its association with *Eucalyptus obliqua, Eucalyptus leucoxylon* and *Eucalyptus viminalis* has already been discussed. It is also associated with such species as *Acrotriche fasciculiflora, Scaevola albida, Pteridium esculentum, Cheilanthes tenuifolia, Microlaena stipoides, Hypericum perforatum, Holcus lanatus* and *Aira caryophyllea.*

The latter three are among the alien species that are associated with *Senecio pterophorus*. The species dissociated with this plant include *Eucalyptus odorata, Pultenaea largiflorens, Dianella revoluta* and *Chrysanthemoides monilifera*. This species is particularly interesting as it is capable of establishing in areas of native vegetation. Where it occurs in large numbers the native shrubs are present in only small numbers. This aggressive weed is among the major problems in the Adelaide Hills.

Chrysanthemoides monilifera is another widespread weed in the park. This species is associated with *Eucalyptus odorata* and its associates. It is dissociated with *Eucalyptus obliqua. Senecio pterophorus, Pultenaea daphnoides, Acrotriche fasciculiflora, Pteridium esculentum, Oxalis* spp. and *Aira caryophyllea*. *Chrysanthemoides monilifera* has long been established in the area and has become by far the dominant shrub in the western edge of the park.

Hypericum perforatum is positively associated with *Eucalyptus leucoxylon, Eucalyptus viminalis, Senecio pterophorus, Geranium pilosum, Briza maxima, Acaena* spp. and *Aira caryophyllea*, i.e. species that are similarly associated with *Senecio pterophorus*. On the other hand *Hypericum perforatum* is dissociated with *Acacia myrtifolia, Hakea rugosa, Pultenaea largiflorens, Leptospermum myrsinoides, Hibbertia sericea, Lepidosperma semiteres* and *Dianella revoluta*.

The other alien species of interest is *Oxalis pes-caprae* (sour-sob). This plant is associated with the two introduced species, *Pittosporum undulatum* and *Fumaria muralis*. It is dissociated with a range of native species which are *Eucalyptus*

8.9.4. Plant species inter-relations (Cont.)

fasciculosa, *Eucalyptus obliqua*, *Acacia pycnantha*, *Pultenaea daphnoides*, *Olearia tubuliflora*, *Hibbertia exutiacies*, *Tetratheca pilosa* and *Haloragis tetragyna*. This species is interesting in that it is associated with alien species and dissociated with native plants.

The rare occurrence of many of the native plant species is reflected in the distribution maps and the frequency results. *Grevillea lavandulacea*, *Xanthorrhoea semiplana*, *Daviesia virgata*, *Daviesia ulicifolia*, *Calytrix tetragona* and *Epacris impressa* are among the many native species that are restricted in distributions. In contrast, many of the alien species are present in large numbers and are widespread in their distribution. e.g. *Briza maxima*, *Hypericum perforatum* and *Senecio pterophorus*. This dominance by alien species in Belair Recreation Park is reflected in the vegetation. In many areas the understorey has been replaced completely by introduced plants. *Briza maxima*, *Allium triquetrum* and *Acacia pycnantha* all are widely distributed and are able to tolerate a large range of conditions.

On the other hand, other distribution patterns of plant species closely reflect their determining factors, i.e. soil and topography. These plant species include *Eucalyptus odorata*, *Eucalyptus obliqua* and the species of *Hibbertia*. The species associated with particular soils and topographic features have already been discussed in earlier sections.

Other plant species are restricted to the fringes of the park, e.g. *Echium lycopsis* is restricted to the south-west corner (the golf course) and a cleared area in the south-east corner.

8.9.4. Plant species inter-relations (Cont.)

Similarly, *Pinus halepensis* and *Pinus radiata* are restricted to the western fringe of the park. Many of the native species are restricted to the relatively inaccessible north-eastern corner and eastern edge of the park. e.g. *Juncus caespiticius, Bossiaea prostrata, Kennedia prostrata, Leucopogon virgatus* and *Goodenia primulacea.*

It is also of note to observe the pattern of distribution of *Asparagus asparagoides, Asclepias rotundifolia* and *Silybum marianum.* These three introduced species follow the railway line in their distribution. Other plant species follow the creek beds and valleys, as already discussed.

The noteworthy points in reviewing these distribution maps is that not all the plant species are related in their distribution to soils or topographic features. Many of the distributions have been influenced by man. In fact, the vegetation has been altered so much by the introduction of alien species that few areas are devoid of introduced plants. The rare occurrence of many of the native plant species is of particular concern if the conservation of the flora is amongst the management objectives for this particular park in South Australia. The planting of alien species in many of the valleys has resulted in marked changes in these areas.
Obviously, for most species of weeds, the control measures undertaken in the past have been inadequate.

8.9.5. Discussion of the Density Maps

The density maps appear in Volume II, Appendix V, Maps 8.75. to 8.93 inclusive.

Pteridium esculentum, Pultenaea daphnoides, Acrotriche fasciculiflora, Eucalyptus obliqua and *Eucalyptus fasciculosa* are all restricted to the eastern edge of the park. They all avoid the bottom of the valleys. *Hibbertia exutiacies* and *Hibbertia sericea* have similar patterns of distribution, but they extend further west in the northern section of the park. All these native plant species have similar distribution patterns.

On the other hand *Eucalyptus odorata, Pultenaea largiflorens, Dodonaea viscosa* and *Hibbertia stricta* are in the main restricted to the western end of the Belair Recreation Park.

Exocarpus cupressiformis occurs in large numbers in the eastern end of the park and gradually decreases in numbers towards the western end of the park. *Acacia pycnantha* is widespread in the park but tends to avoid open areas or valleys, e.g. the valleys in the south-eastern corner of the park.

Eucalyptus leucoxylon and *Hypericum perforatum* are both widespread and tend to grow in the valleys. *Eucalyptus camaldulensis* and *Eucalyptus viminalis* are both restricted to the valleys and slightly undulating areas in the southern and/or western edges of the park.

The two weeds *Senecio pterophorus* and *Chrysanthemoides monilifera* are present in large numbers in Belair Recreation Park. They differ in that *Senecio pterophorus* is mainly in the eastern and central sections while *Chrysanthemoides monilifera* is restricted to the western edge and valleys of the park.

8.9.5. Discussion of the Density Maps (Cont.)

The majority of the density maps indicate the decrease of and/or absence of native plant species in the valleys which have been cleared for man's recreational needs and in the open areas in the west (e.g. the golf course). This often leads to marked changes in the densities over short distances.

In most instances the higher densities are confined in areas not intensively used by man. These areas include the steep-sided valleys and inaccessible gullies. Those areas covered in dense underscrub (e.g. the thicket of *Chrysanthemoides monilifera* in the north-western corner) are also avoided by most of the public. The sharp boundaries of the density results reflect these influences of man.

8.10. Summary.

The presence of man in Belair Recreation Park is clearly reflected by the structure and floristics of the vegetation. Although the soils and topographic features clearly are important, the major determinant of the vegetation is man.

The vast changes brought about by man through the history of the park have led to limited areas of vegetation resembling that found prior to European settlement. The long lasting effects of management decisions is seen clearly in the vegetation e.g. the poplar stands which have spread uncontrolled. Similarly, the uncontrolled spread of alien species such as *Senecio pterophorus*. The laissez-faire approach adopted in many sections of the park has seen slightly weed-infested areas turn into monocultures of uncontrollable weed infestations.

This park should be taken as a guide line for other parks in this state. If it be desirable to control, if not eradicate, all aggressive alien species efforts should be undertaken on large scales. The possibility of adopting management procedures such as mowing and/or grazing should be considered in this park. At the present time many of the areas that could be used for recreation are useless e.g. Pittosporum Valley has so dense a cover of *Senecio pterophorus* that large areas of this valley are impenetrable and not used for recreational activities.

The increasing denudation of areas, particularly in the western section of the park, could be controlled by adopting schemes used overseas e.g. restricted access of vehicles. The ever increasing use of private vehicles is placing greater pressures on this park. As a result the vegetation is receding further from the roads and tracks. Efforts have been made in Para Wirra Recreation Park with the installation of logs, to prevent access of the vehicles.

The impact of horses in the northern sections of the park has increased in recent years. Efforts should be made to develop trails for the horses so that the damage to the surroundings is minimised.

Further, where the native plant species still persist in large numbers, access should be limited. This park does provide the possibility of zoning as encouraged by other park authorities.

Belair Recreation Park provides an ideal opportunity for the authorities to observe the impact of man on the vegetation in our parks.

8.10. Summary. (Cont.)

It may seem an extreme case as man has had a long history of influence. However, the ever increasing demands being placed on such areas as Para Wirra Recreation Park, Innes National Park and the Flinders Ranges National Park emphasise the need to review man's influence on the existing native fauna and flora in the parks of South Australia.

CHAPTER IX

NIXON-SKINNER CONSERVATION PARK

9.1. Introduction

Nixon-Skinner Conservation Park (Hundred of Myponga, Section 245) was originally donated, in 1956, by the relatives of Mrs. L.E. Page who had occupied adjacent land. Nixon-Skinner Wildlife Reserve, as it was then known, was the second park to be dedicated in South Australia and was under the control and management of the National Parks and Wildlife Act, 1891 - 1960. In 1967 the park was dedicated as the Nixon-Skinner National Parks Reserve under the control and management of the National Parks Act of 1966. In 1972 with the introduction of the National Parks and Wildlife Act the park was renamed as a conservation park.

Nixon-Skinner Conservation Park lies fifty seven kilometres south-west of Adelaide and covers an area of eight hectares.

9.2. Historical Background

The Nixon-Skinner Conservation Park is comparable in size with the Knoll Conservation Park, see Chapter X. Although this park is some distance from Kyeema Conservation Park and Adelaide the vegetation has features in common with most areas already discussed in the last three chapters. The park is located on the main road between Myponga and Yankalilla and is adjacent to the Myponga Reservoir, which

9.2. Historical Background (Cont.)

was opened in 1962 (Fig. 9.1.). To the south and west the park is surrounded by pasture while in the north and west it borders the reservoir. The park itself is bordered by a bitumen road on the western and northern fringes. This road separates the park from the reservoir.

In 1968 efforts were made to restrict the lighting of fires and dropping of litter within the reserve proper by the installation of rubbish bins and barbecues on the edges of the roads. Littering had encouraged the introduction of alien species including the occasional apple seedling, *Malus sylvestris* spp. *mitis*..

The park shows no evidence of recent grazing and only the northern and eastern edges have fences. The effluent and water that washes off the pasture under the main Myponga-Yankalilla road appears to have encouraged the growth of a range of introduced grasses and weeds in the south-western corner of the park.

9.3. Climate

Nixon-Skinner Conservation Park lies only five kilometres south-west of the township of Myponga so the data in Table 9.1. illustrates the prevailing climatic conditions. The temperature and rainfall figures follow a similar pattern to those of other areas in the Mount Lofty Ranges with cold, wet winters and hot, dry summers. The temperatures are slightly less than those at Belair due to the south-westerly winds bringing cooler conditions further south.

Figure 9.1.

Location of Nixon-Skinner Conservation Park

(▲ indicates the location).

NIXON - SKINNER CONSERVATION PARK

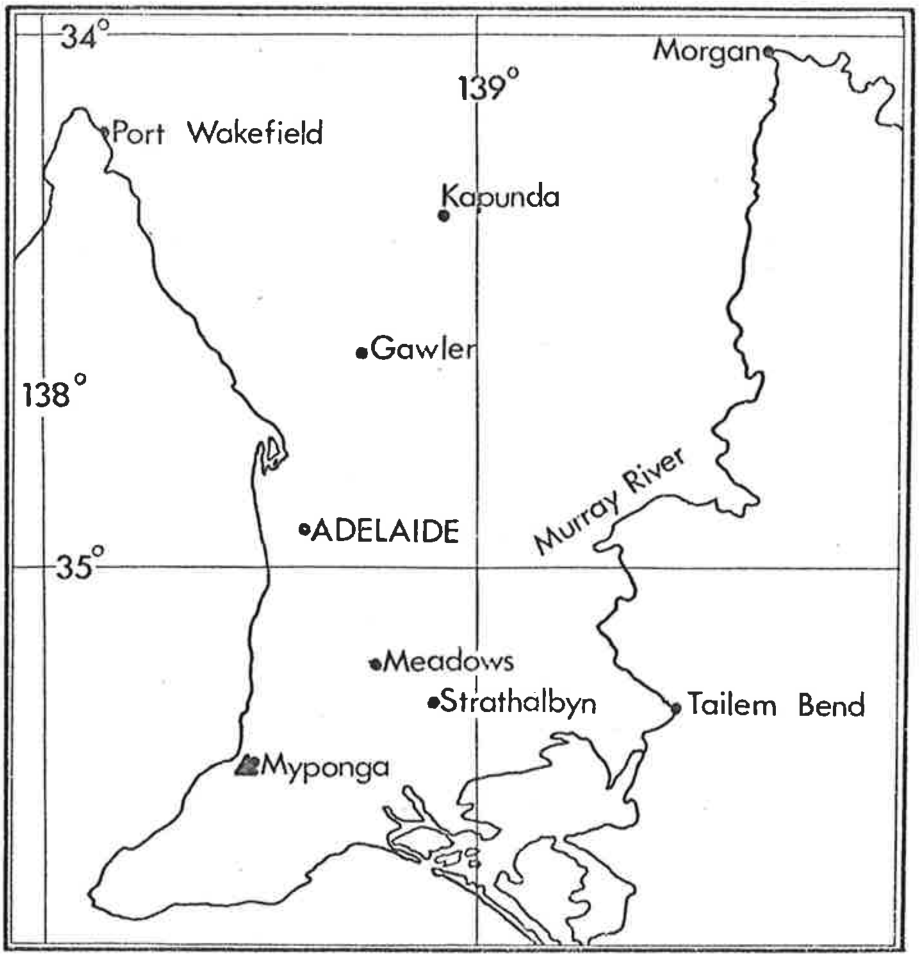


Figure 9.1.

Table 9.1.

Rainfall and Temperature recordings for Myponga (taken from the records of the Bureau of Meteorology, Adelaide)

	No. Yrs.	J	F	M	A	M	J	J	A	S	O	N	D	Year
Mean Rainfall (mm.).	59	23	30	23	59	97	109	113	96	81	59	39	31	760
Median Rainfall (mm.).	59	14	18	16	47	89	96	101	97	79	56	28	25	762
Rain Days	59	4	4	4	9	15	16	17	16	13	11	8	6	130
Ave. Max. Temp. ^{o}C	12	27	25.7	23.9	20.3	15.9	13.8	12.4	13.5	15.9	18.6	21.7	23.7	19.4
Ave. Min. Temp. ^{o}C	12	11.7	11.7	9.8	7.6	6.6	5.0	4.3	4.7	5.4	7.0	8.3	9.9	7.7
Mean Temp. ^{o}C	12	19.3	18.7	16.9	13.9	11.3	9.4	8.3	9.1	10.7	12.8	15.0	16.8	13.5
Extreme Max. Temp. ^{o}C	12	40.6	38.9	36.7	35	25	22.2	18.9	21.3	28.9	31.7	39.1	38.9	
Extreme Min. Temp. ^{o}C	12	2.2	3.3	0.4	-2.5	-2.8	-5.0	-5.5	-3.6	-1.3	-1.5	-1.1	0.0	

9.3. Climate (Cont.)

The rainfall on the other hand is similar to that recorded at Belair "Kalyra" (Table 8.1.).

9.4. Physiography and Drainage

The area around Myponga consists of undulating hills and broad valleys. Nixon-Skinner Conservation Park lies essentially on the slope of a hill but is within itself slightly undulating. The central area of the park is elevated compared with the south-west and eastern edges. Drainage of the area on the western edge has been interrupted as a result of the bitumen road running along the two sides of the park. The run-off from the adjacent pastures runs under the Myponga-Yankalilla road via a drain and into the south-western edge and tends to become a swamp in the wetter months of the year (Fig. 9.2.). The northern area of the park drains into the reservoir.

9.5. Geology and Soils

The geology and soils of the Fleurieu Peninsula have been summarized by Boomsma (1948). The variety of past geological events on the Fleurieu Peninsula are reflected in the diversity of soils with marked changes over relatively short distances. Boomsma (1948) concluded that the morphologies of the soil profiles and soils of the County of Hindmarsh are similar to those of the Hundred of Kuitpo (Taylor and O'Donnell 1932).

Figure 9.2.

The main features of Nixon-Skinner Conservation Park. (Scale 1 cm = 30 metres).

D	Location of Drain
B	Barbecue sites
-·-·-·-·-	Track
....	Extent of swampy area
-------	Creek-bed

NIXON-SKINNER CONSERVATION PARK

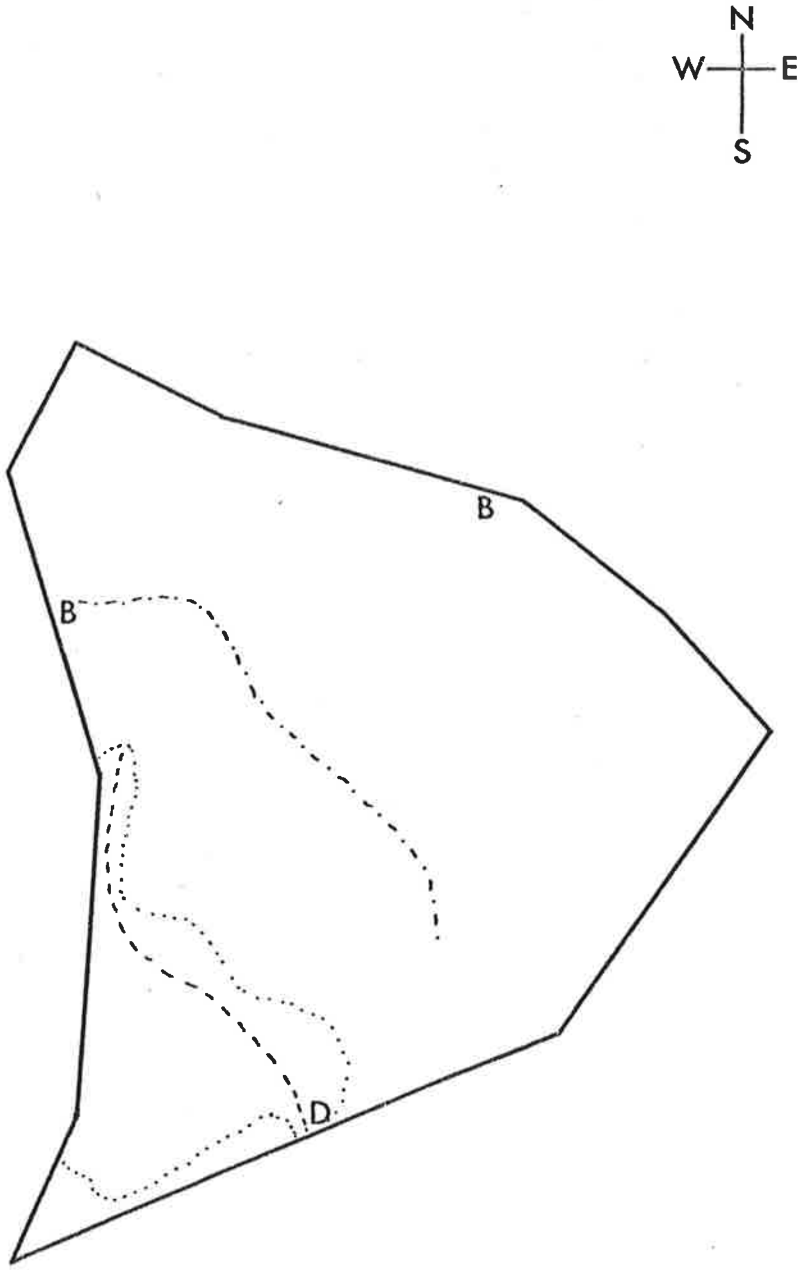


Figure 9.2.

9 .5. Geology and Soils (Cont.)

The lateritic loam soils found in the major part of the park are similar to the Kuitpo gravelly sandy loam found at Kyeema Conservation Park, while the podsol A soil found in the south-western corner of the park resembles the Myponga sand described by Taylor (1932). The two soils of Nixon-Skinner Conservation Park and their geological origin are given in Table 9.2.

Table 9.2.

The geological and soil features of Nixon-Skinner Conservation Park (taken from the thesis of Boomsma, 1948)

Geological Epoch	Rock Type	Soil Group
Pliocene	Laterite	Lateritic loam
Permian sands	Sandstone grits	Podsol A

9 .6. Vegetation

The floristics of the Mount Lofty Ranges have been described already by many authors (Wood, 1930; Adamson and Osborn, 1924; Boomsma, 1948; Specht and Perry, 1948; Specht and Cleland, 1963). Extensive lists of plant species found in the Mount Lofty Ranges appear in: "Plants of the Mount Lofty Ranges" by Cleland and Goldsack, 1964 and Specht, 1972.

The northern and central area of Nixon-Skinner Conservation Park supported a *Eucalyptus obliqua* association. The southern section of the park supported a *Eucalyptus leucoxylon* association.

9.6. Vegetation (Cont.)

There is a large variety of undershrubs and ground-cover shrubs.

The location and size of this park and the similarity in vegetation with areas of Kyeema Conservation Park led to the possibility of comparing such a small area with the large Kyeema Conservation Park.

The alien species that are present in the park appear to be confined to the borders of the area and the old vehicular track through the centre of the park (Fig. 9.2.). The swampy area in the south-western corner also appear to support a large number of alien species including *Briza maxima*, *Zantedeschia aethiopica* (Arum Lily), *Phalaris minor* and *Freesia refracta*.

9.7. Research Objectives

The enormous difficulties associated with the conservation and management of small areas is one of the problems faced by the local National Parks and Wildlife authorities. The past activities in this park are relatively minor compared with the intensity and extent of those discussed in the three previous chapters. If size and nature of adjacent land-holdings are significant in determining the vegetation of a park, one would predict that the vegetation of this park of eight hectares surrounded by pastures and reservoir would reflect these influences. Therefore, the importance of the two factors was given particular attention in the research carried out in this park.

9.7. Research Objectives (Cont.)

The research objectives for Nixon-Skinner Conservation Park were the following -

a. to carry out a reconnaissance of the area.

b. to construct a floristic list for plant identification.

c. to survey the presence and absence of plant species in the park.

d. to review the soil and climatic conditions as possible vegetation determinants.

e. to compare the results with those of other National Parks in the Adelaide Hills.

f. to develop comparisons reflecting on the possible significance of park size and its surroundings as possible determinants of the vegetation.

9.8. Research Methods

The area was observed and collections of plant species were made on several occasions. The vegetation was surveyed by collecting presence-absence data on a systematic grid of quadrats throughout the park. The presence of all species were recorded in quadrats of radius five metres at twenty-five metre intervals along traverses twenty-five metres apart on a compass bearing of three-hundred and fifty-two degrees.

An association analysis was carried out on the binary data to study the inter-relations between the plants. The soils were also included in the binary data.

9.9. Results

9.9.1. Introduction

The floristic list of plant species recorded at Nixon-Skinner Conservation Park appears in Appendix II. The soils are discussed as possible determinants of the distribution and structure of the plant communities in Section 9.9.2.. The soil distribution maps appear in Volume II, Appendix VI, Map 9.39.. The plant-topographic relationships are discussed in section 9.9.3..

The frequencies of the species sampled in the park are shown in Table 9.3.. The distribution maps of the majority of the species appear in Volume II, Appendix VI, Maps 9.1. to 9.38. inclusive. The plant inter-relations are discussed in section 9.9.4.. The distribution maps and species of particular interest are discussed in section 9.9.5..

9.9.2. The soil-plant relationships

The two soil types appear to be significant as factors determining the distribution of plant species and the resulting structure of the plant communities. Figure 9.3. clearly illustrates the importance of the soils as determinants of the vegetation in Nixon-Skinner Conservation Park.

The Podsol A soils found in the south-western corner are associated with the native species including *Eucalyptus leucoxylon, Melaleuca decussata, Leptospermum juniperinum,*

Figure 9.3.

Nodes of associated species with the soil types at $\chi^2 \geqslant 10.83$ in Nixon-Skinner Conservation Park.

__________ indicates association, positive association

---------- indicates dissociation, negative association

* indicates an introduced species

(1) *Eucalyptus obliqua*
(2) *Eucalyptus leucoxylon*
(3) *Eucalyptus fasciculosa*
(5) *Melaleuca decussata*
(6) *Leptospermum juniperinum*
(7) *Leptospermum myrsinoides*
(9) *Acacia myrtifolia*
(10) *Acacia spinescens*
(14) *Xanthorrhoea semiplana*
(17) *Leucopogon virgatus*
(20) *Hibbertia stricta*
(21) *Astroloma conostephioides*
(25) *Platylobium obtusangulum*
(26) *Lepidosperma semiteres*
(27) *Lepidosperma carphoides*
(28) *Lepidosperma laterale*
(29) *Isopogon ceratophyllus*
(31) *Tetratheca pilosa*
(36) *Calytrix tetragona*
(39) *Goodenia primulacea*
(44) * *Asparagus asparagoides*
(45) *Drosera whittakeri*
(46) *Drosera planchonii*
(51) *Billardiera sericophora*
(55) * *Oxalis pes-caprae*
(58) * *Vicia sativa*
(59) *Geranium pilosum*
(64) *Hydrocotyle callicarpa*
(74) * *Rumex obtusifolius*
(83) *Helichrysum scorpioides*
(84) *Brunonia australis*
(88) *Haloragis tetragyna*
(97) * *Freesia refracta*
(99) *Chamaescilla corymbosa*
(105) * *Briza maxima*
(109) * *Holcus lanatus*
(119) * *Cynosurus echinatus*
(122) Lateritic loam soils
(123) Podsol A soils

NIXON-SKINNER CONSERVATION PARK

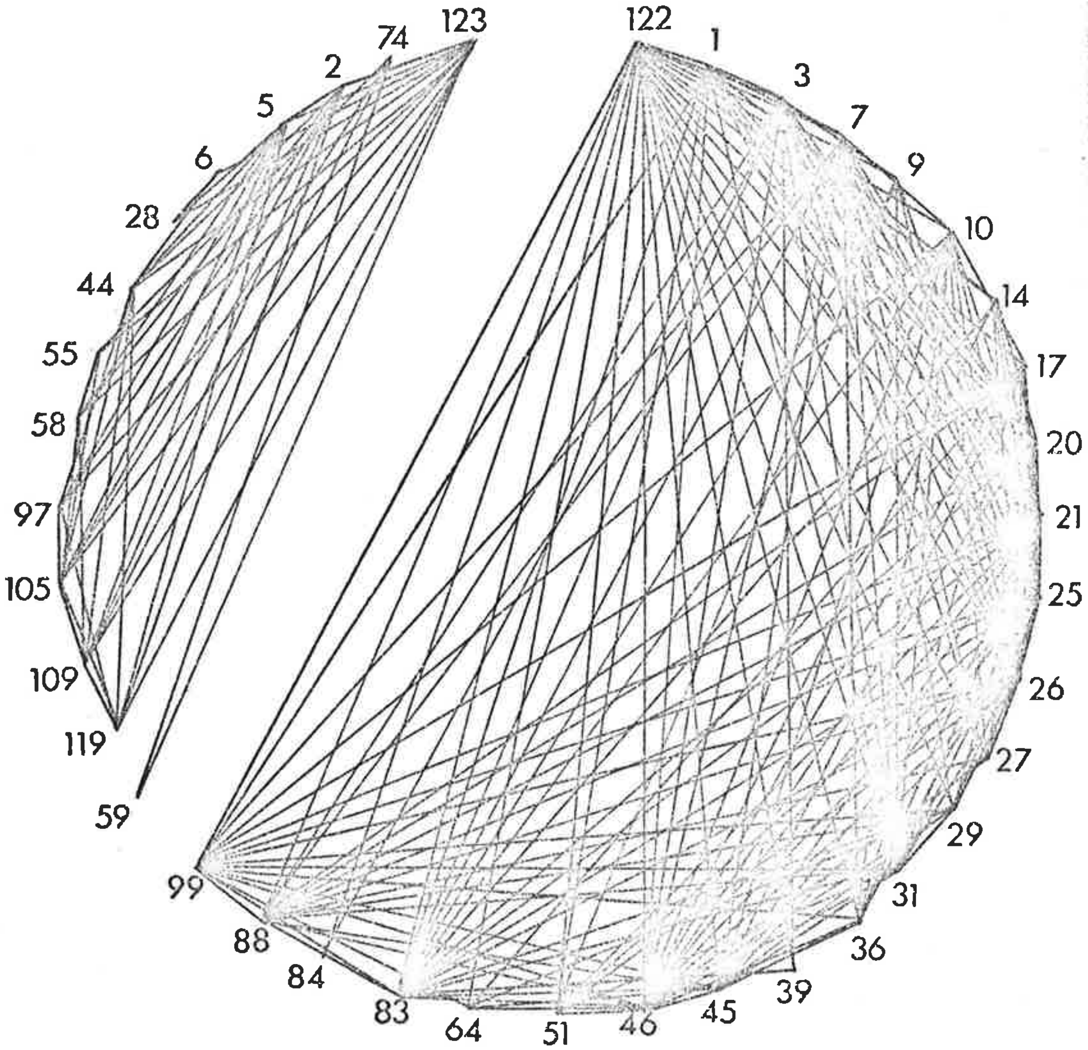


Figure 9.3.

Table 9.3.

The plant species sampled at Nixon-Skinner Conservation Park. The percentage of total samples in which they occur (Frequency). Introduced species are prefixed by an asterisk.

Species	Frequency
Hibbertia stricta	90.5
Acacia pycnantha	85.4
Astroloma conostephioides	82.5
Platylobium obtusangulum	81.8
Lepidosperma semiteres	81.8
Haloragis tetragyna	78.8
Leptospermum myrsinoides	75.2
Eucalyptus obliqua	73.7
Xanthorrhoea semiplana	73.7
Drosera planchonii	70.1
Cassytha glabella	69.3
Drosera auriculata	68.6
Helichrysum scorpioides	68.6
Olearia tubuliflora	68.6
Hakea rostrata	66.4
Chaemascilla corymbosa	63.5
Tetratheca pilosa	62.0
Moss spp.	61.3
Eucalyptus fasciculosa	60.6
* *Lophochloa phleoides*	59.9
Leucopogon virgatus	58.4
Billardiera sericophora	58.4
Lepidosperma carphoides	54.0
Calytrix tetragona	53.3
Hypericum gramineum	52.6
Drosera whittakeri	48.2
Hypolaena fastigiata	46.7

Table 9.3. (Cont.)

	Species	Frequency
	Stipa pubescens	45.9
	Acacia spinescens	45.3
	Viola hederacea	45.3
	Isopogon ceratophyllus	43.8
	Acacia myrtifolia	40.1
	Acianthus caudatus	35.8
	Microlaena stipoides	35.8
	Stylidium graminifolium	35.0
	Casuarina muelleriana	33.6
	Lomandra dura	33.6
	Thysanotus dichotomus	32.8
*	*Briza maxima*	32.8
*	*Juncus capitatus*	31.4
	Centrolepis aristata	30.7
	Xanthosia pusilla	30.7
	Hydrocotyle callicarpa	29.9
	Cassytha pubescens	29.9
	Neurachne alopecuroidea	29.2
	Grevillea lavandulacea	27.7
	Acianthus reniformis	27.7
	Daviesia ulicifolia	27.0
	Goodenia primulacea	27.0
	Banksia marginata	26.3
	Centrolepis strigosa	25.5
	Astroloma humifusum	24.8
	Trachymene cyanopetala	24.1
	Brunonia australis	23.4
	Dianella revoluta	21.9
	Schoenus tenuissimus	21.2
	Pimelea glauca	20.4
	Acrotriche serrulata	19.7
*	*Aira caryophyllea*	18.9
	Lepidosperma laterale	18.2

Table 9.3. (Cont.)

Species	Frequency
Machaerina gunnii	18.2
* *Chasmanthe aethiopica*	18.2
Melaleuca decussata	17.5
Thysanotus patersonii	16.8
Caesia vittata	14.6
* *Asparagus asparagoides*	13.9
* *Freesia refracta*	13.9
* *Ehrharta longiflora*	13.9
* *Oxalis pes-caprae*	12.4
Poa laevis	12.4
Danthonia semiannularis	12.4
Eucalyptus leucoxylon	11.7
Hakea ulicina	11.7
Cryptandra tomentosa	11.7
* *Plantago lanceolata*	10.2
Acaena anserinifolia	10.2
Leptospermum juniperinum	9.5
* *Holcus lanatus*	9.5
* *Poa annua*	9.5
Pterostylis sp.	8.0
Haloragis teucrioides	8.0
* *Cynosurus echinatus*	8.0
Hakea rugosa	7.3
Casuarina stricta	7.3
* *Rumex obtusifolius*	7.3
Hypoxis glabella	7.3
Dillwynia hispida	6.6
* *Vicia sativa*	6.6
Juncus pallidus	5.8
Geranium pilosum	5.8
Lomandra fibrata	5.8
* *Medicago polymorpha*	5.1
* *Fumaria muralis*	5.1

Table 9.3. (Cont.)

Species	Frequency
Exocarpus cupressiformis	5.1
Haloragis elata	4.4
* *Bromus diandrus*	4.4
* *Oxalis incarnata*	3.6
* *Zantedeschia aethiopica*	3.6
* *Phalaris minor*	3.6
Pimelea stricta	2.9
Kennedia prostrata	2.9
Oxalis corniculata	2.2
* *Stellaria media*	2.2
* *Homeria miniata*	2.2
Themeda australis	2.2
Eucalyptus ovata	2.2
Cynodon dactylon	1.5
* *Paspalum dilatatum*	1.5
Eucalyptus camaldulensis	0.7

9.9.2. The soil-plant relationships (Cont.)

Lepidosperma laterale and *Geranium pilosum*. *Melaleuca decussata* and *Leptospermum juniperinum* both grow in damp situations in hollows and creek-beds in the Adelaide Hills. The other plants associated with this soil type are all alien species. The negative association results, for these two soil types, are not presented in this diagram. The two groups of plants associated with the two respective soils are dissociated with each other. For purposes of simplifying this figure, these results were not included.

The lateritic loam soils found in the northern area are strongly associated with the species of the *Eucalyptus obliqua* association of plants. In addition, no alien species were significantly associated with this soil group.

The soils appear to be an important determinant of the vegetation in this park.

9.9.3. Plant-topographic relationships

These were not investigated in any detail as the park could be divided into only two basic regions, the swampy south-western area and the undulating northern area. As these two are comparable to the soil types in distribution the results would be predictably equivalent to those for the soils in Figure 9.3.

9.9.3. Plant-topographic relationships (Cont.)

Therefore the swampy area is associated with the Podsol A soil and the undulating area in the north with the lateritic loam soil and their associated plant species.

9.9.4. Plant Species Inter-relations

The results appear in Figure 9.4.. There are clearly two groups of positive associates in Nixon-Skinner Conservation Park and these two groups are mutually exclusive and independent of each other. The dissociations reinforce this situation but are not included in illustrating the results because they would complicate the diagram without adding a great deal of information. The majority of plants in the first group are negatively associated with plants in the second group.

The first group of plants consists of those species in the *Eucalyptus obliqua* association. All of the species in this node with the exception of the one annual grass species, *Lophochloa phleoides*, are native. On the other hand the second smaller node of plant species consists of mainly alien species. *Eucalyptus leucoxylon*, *Banksia marginata*, *Melaleuca decussata*, *Leptospermum juniperinum* and *Hakea rugosa* are the main native shrubs in the second group of plant species.

The two groups resemble those seen in Figure 9.3.. The large number of alien species in the south-western areaclearly can be seen to be associated with *Eucalyptus leucoxylon* and associated species.

Figure 9.4.

Nodes of associated species at $\chi^2 > 10.83$ in Nixon-Skinner Conservation Park

——— indicates association, positive association

* indicates an introduced species

(1) *Eucalyptus obliqua*
(2) *Eucalyptus leucoxylon*
(3) *Eucalyptus fasciculosa*
(4) *Banksia marginata*
(5) *Melaleuca decussata*
(6) *Leptospermum juniperinum*
(7) *Leptospermum myrsinoides*
(9) *Acacia myrtifolia*
(10) *Acacia spinescens*
(11) *Hakea rugosa*
(12) *Hakea rostrata*
(13) *Hakea ulicina*
(14) *Xanthorrhoea semiplana*
(16) *Casuarina muelleriana*
(17) *Leucopogon virgatus*
(20) *Hibbertia stricta*
(21) *Astroloma conostephioides*
(25) *Platylobium obtusangulum*
(26) *Lepidosperma semiteres*
(27) *Lepidosperma carphoides*
(28) *Lepidosperma laterale*
(29) *Isopogon ceratophyllus*
(30) *Cryptandra tomentosa*
(31) *Tetratheca pilosa*
(33) *Olearia tubuliflora*
(35) *Daviesia ulicifolia*
(36) *Calytrix tetragona*
(39) *Goodenia primulacea*
(41) *Machaerina gunnii*
(43) *Juncus pallidus*
(44) * *Asparagus asparagoides*
(45) *Drosera whittakeri*
(46) *Drosera planchonii*
(47) *Drosera auriculata*
(48) * *Plantago lanceolata*
(49) *Viola hederacea*
(50) *Stylidium graminifolium*
(51) *Billardiera sericophora*
(52) *Hypolaena fastigiata*
(53) *Trachymene cyanopetala*
(55) * *Oxalis pes-caprae*
(57) * *Oxalis incarnata*
(58) * *Vicia sativa*
(59) *Geranium pilosum*
(61) *Schoenus tenuissimus*
(62) *Centrolepis aristata*
(63) *Centrolepis strigosa*
(64) *Hydrocotyle callicarpa*
(65) *Xanthosia pusilla*
(74) * *Rumex obtusifolius*
(75) *Acaena anserinifolia*
(79) * *Medicago polymorpha*
(82) *Hypericum gramineum*
(83) *Helichrysum scorpioides*
(84) *Brunonia australis*
(88) *Haloragis tetragyna*
(91) *Cassytha pubescens*
(97) * *Freesia refracta*
(99) *Chamaescilla corymbosa*
(100) * *Chasmanthe aethiopica*
(104) *Hypoxis glabella*
(105) * *Briza maxima*
(106) * *Ehrharta longiflora*
(107) *Stipa pubescens*
(108) * *Lophochloa phleoides*
(109) * *Holcus lanatus*
(110) * *Phalaris minor*
(115) *Neurachne alopecuroidea*
(119) * *Cynosurus echinatus*
(121) * *Bromus diandrus*

NIXON-SKINNER CONSERVATION PARK

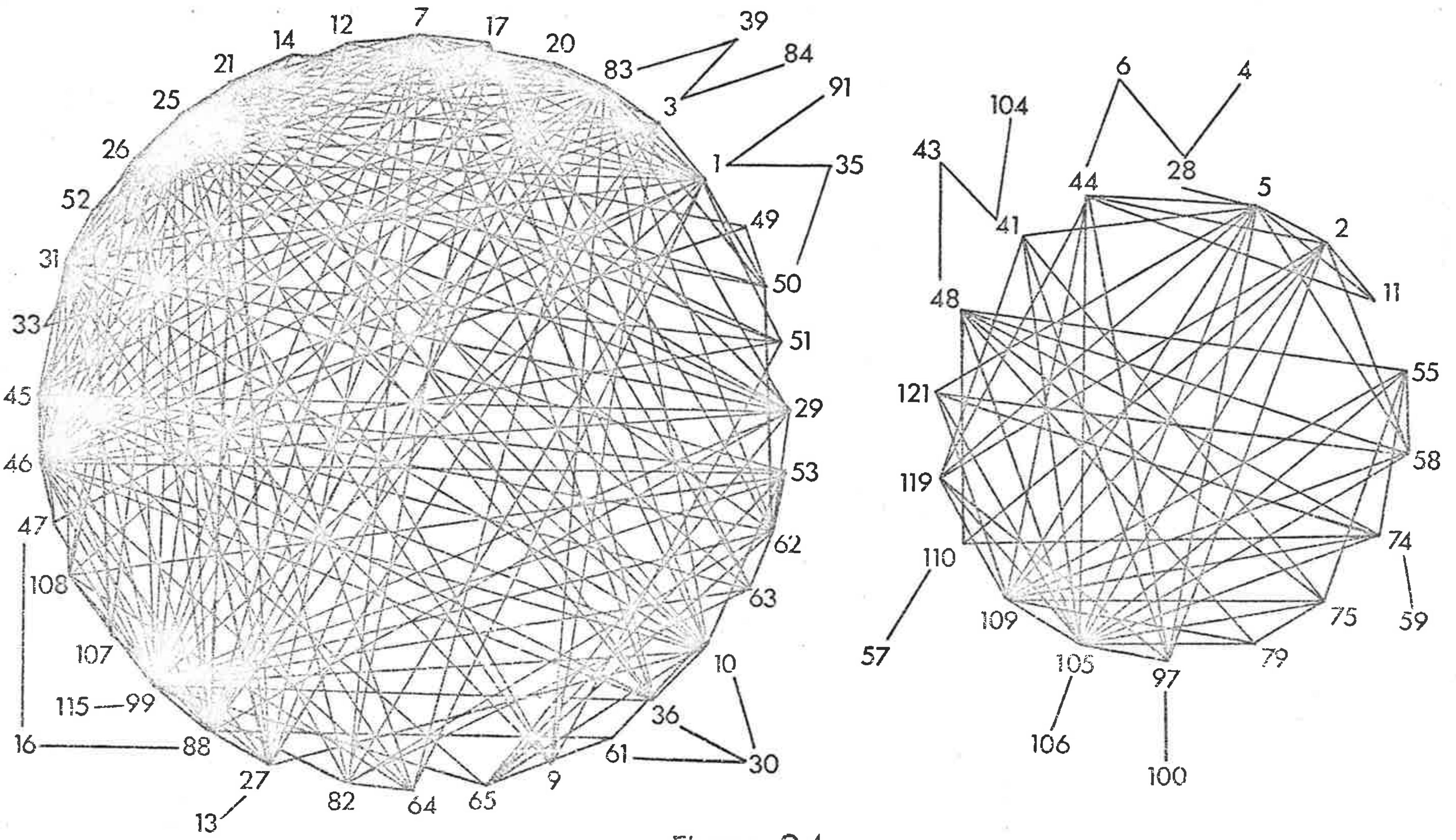


Figure 9.4.

9.9.4. Plant Species Inter-relations (Cont.)

Such species as *Ehrharta longiflora* and *Briza maxima* are present in large numbers.

The soils are important factors in determining the plant distribution and groupings. The results also clearly show the importance of the nature of adjacent land-holdings. The number of alien species along the edges of the park and in the south-western corner leave no doubt as to the importance of adjacent land-holdings.

Man's alteration of the drainage in the area has encouraged the spread of these alien species which in sections of the park have completely replaced the native ground-cover of shrubs and grasses. The large proportion of introduced species in the second group associated with *Eucalyptus leucoxylon* illustrates the importance of the influence of man in determining the nature of the vegetation.

The relatively small area in the north of the park supports a vegetation with very few alien species. It is noteworthy to compare the two groups, *Eucalyptus obliqua* with associated species and *Eucalyptus leucoxylon* with associated species (Fig. 9.4.). The large difference in the number of species in each group is important. The lack of disturbance or invasion of the northern area of the park has favoured the maintenance of a large variety of plants.

9.9.5. Plant Distribution Patterns

The distribution maps of the species sampled are presented in Volume II, Appendix VI, Maps 9.1. to 9.38 inclusive.

The results discussed in 9.9.3. are clearly illustrated by comparing the distribution patterns of the plant species. The majority of the species fall into one of the two groups. First those restricted to the south-west corner and second those distributed in the central and northern sections of the park. The maps of *Eucalyptus obliqua, Leptospermum myrsinoides, Melaleuca decussata, Eucalyptus leucoxylon* and *Eucalyptus fasciculosa* typify the distribution patterns for the different species of the two groups, see Maps 9.30 and 9.31.. The native grasses including *Microlaena stipoides, Stipa pubescens,* and *Danthonia semiannularis* are restricted in distribution to the central and northern area and are associated with *Eucalyptus obliqua.* On the other hand the introduced grasses including *Briza maxima, Bromus diandrus, Holcus lanatus, Ehrharta longiflora* and *Paspalum dilatatum* are restricted to the south-western corner.

The introduced species are mainly confined to the south-western corner of the park and the edges. *Plantago lanceolata, Chasmanthe aethiopica, Freesia refracta, Homeria miniata, Medicago polymorpha* and *Vicia sativa,* all show this pattern of distribution. *Zantedeschia aethiopica* (Arum Lily) is along the borders of the park with only the incidental occurrence in the central area of Nixon-Skinner

9.9.5. Plant Distribution Patterns (Cont.)

Conservation Park.

9.10. Summary

The past influences of man were reflected in the vegetation of Nixon-Skinner Conservation Park. The influence of the proximity and nature of adjacent properties was clearly illustrated by the number of introduced plant species along the fringes of the park and in the south-western corner.

The influence of adjacent landholdings is of prime importance and the "border effect" discussed in earlier chapters is accentuated in this park due to its size. Man's influence in the park by altering the drainage is also reflected in the vegetation in the south and south-western corners. The nature of adjacent land-holdings can be seen by the distribution maps of species such as *Freesia refracta, Chasmanthe aethiopica* and *Oxalis incarnata*. These three species are amongst the many aliens that have spread from adjacent areas or roadways into the park.

In summary the *Eucalyptus obliqua* association is only disturbed in localised areas. The border of the park in the north, for example, has been disturbed by man's activities. However in the southern area the influence of man is clearly reflected in the vegetation. Although man's influence in this park is not as extensive as in Kyeema Conservation Park the spread of alien species in the park is important in conservation and management considerations.

CHAPTER X

THE KNOLL CONSERVATION PARK

10.1 Introduction

The Knoll Conservation Park (Hundred of Adelaide, Section 612) lies thirteen kilometres south-east of Adelaide between Belair Recreation Park and Stirling (Fig. 10.1.).

This area was dedicated as the Knoll Wildlife Reserve in 1963, under the control of the National Parks and Wildlife Reserves Act, 1891 - 1960. The park was renamed the Knoll National Parks Reserve with the introduction of the National Parks Act in 1966. It is now managed and controlled under the National Parks and Wildlife Act, 1972, as a Conservation Park. Except for several islands off the coast of South Australia the Knoll Conservation Park, only two hectares in area, is the smallest park controlled by the National Parks and Wildlife Division of the Department of Environment and Conservation.

10.2. Historical Background

The Mt. Lofty Ranges were settled in the middle of the nineteenth century. The main occupation of man included timber cutting, cultivation of wheat, stripping of bark of the species of *Acacia* for the tanning industry and later grazing and mixed farming (Jackson, 1957).

Figure 10.1.

Location of the Knoll Conservation Park

(▲ indicates the location).

THE KNOLL CONSERVATION PARK

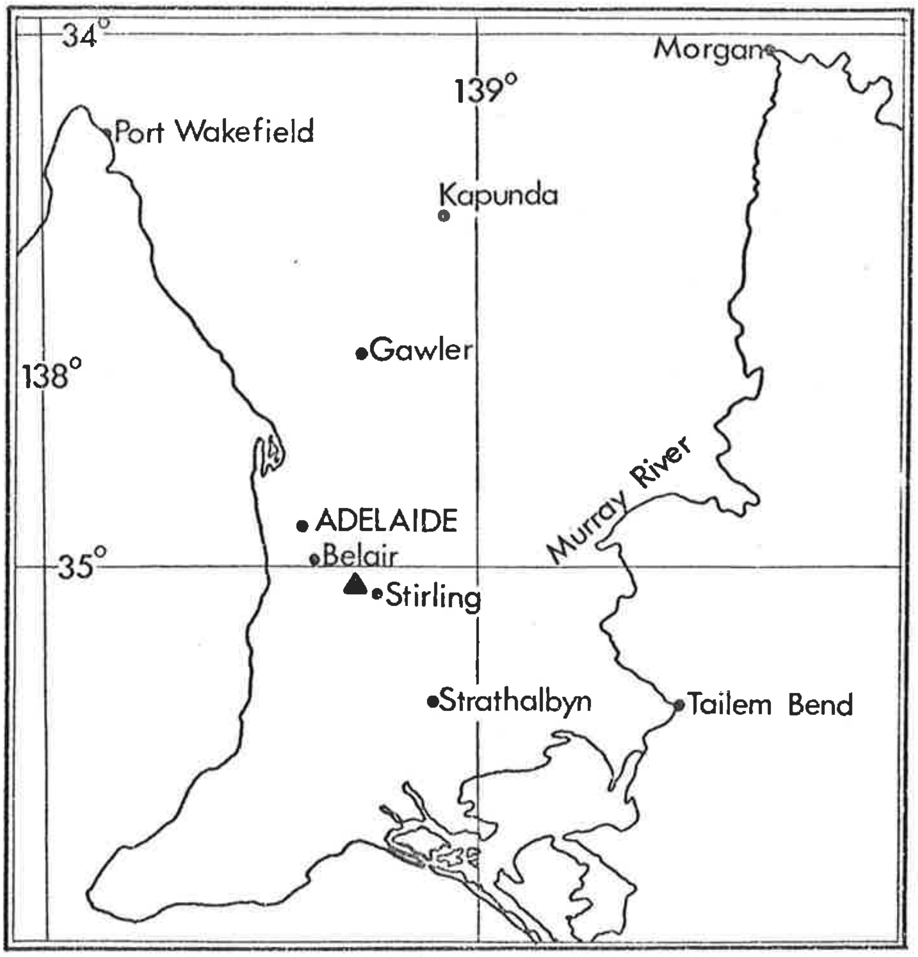


Figure 10.1.

10.2. Historical Background (Cont.)

In more recent years, the emphasis has been on housing developments so many areas of native scrub and agricultural land have been replaced by suburbs.

In view of the extent of agricultural and settlement activities in the surrounding districts, interest was centred on the feasibility of managing and conserving the vegetation of a park as small as the Knoll Conservation Park. This park was selected as it is comparable with sections of Belair Recreation Park. Due to its close proximity similar vegetation, climatic and geological conditions exist in the two parks.

The relatively steep sides of the Knoll Conservation Park render the area unsuitable for agricultural purposes. The park is surrounded by private properties, the Upper Sturt Road and a small patch of undeveloped land on the southern boundary.

The area was originally donated to the Government in 1917 by Mr. Commissioner Russell (Fenner and Hossfield, 1964). For many years it has been used as a convenient stopping place for motorists and tourists to admire the surroundings. The main access track into the park leads to a flattened area. Several car tracks run through the western area of the park which is not as steep as the eastern edge (Fig. 10.2.).

Figure 10.2.

The main features of the Knoll Conservation Park

(Scale 1 cm = 20 metres).

A	=	Access Area
T	=	Top of Crest
--------	=	Creek-bed
-·-·-·-·-	=	Track
————	=	Ridge

THE KNOLL CONSERVATION PARK

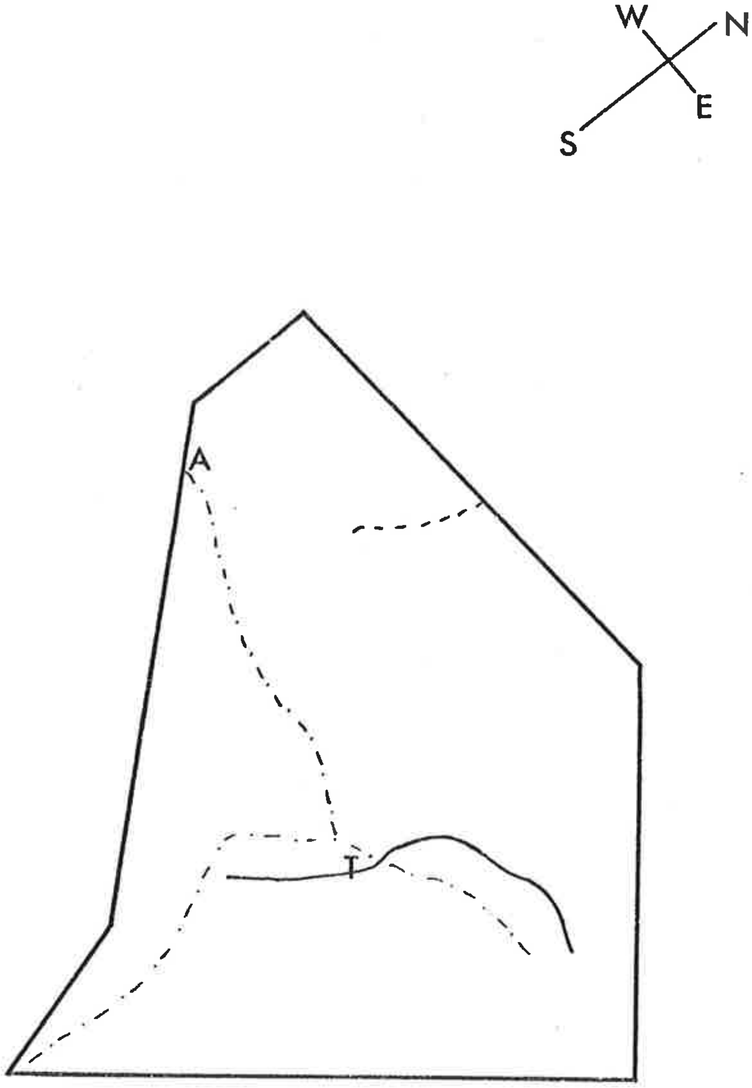


Figure 10.2.

10.2. Historical Background (Cont.)

The problem of alien species in this park has long been recognised and efforts have been made in the past to control selected species. *Ulex europaeus* has been slashed in previous years. However, these weed control measures have proven inadequate as dense thickets of *Ulex europaeus* still appeared in the northern area of the park at the time of investigation in 1974. Since then the gorse, *Ulex europaeus*, at the northern end of the park has been slashed to ground level.

10.3. Climate

The climate is similar to that of Belair discussed in chapter eight: with cold, wet winters and hot, dry summers. The rainfall and temperature data for Stirling (Table 10.1.) is to be compared with that of Belair "Kalyra" (Table 8.1.). The Knoll Conservation Park lies between these two meteorological stations. There is a slight gradient from west to east in both temperature and rainfall with Stirling being wetter and colder throughout the year.

10.4. Physiography and Drainage

The Knoll, a small crest, six hundred and forty metres above sea-level is situated on the Waverley Ridge in the Mount Lofty Ranges (Fenner and Hossfield, 1964). The drainage consists of one small creek, supporting a thicket of blackberry, *Rubus* spp. *aff. fruticosus*, on the northern side of the park (Fig. 10.2.).

Table 10.1

The temperature and rainfall recordings for Stirling (taken from the records of the Bureau of Meteorology, Adelaide

	No. Yrs.	J	F	M	A	M	J	J	A	S	O	N	D	Year
Ave. Max. Temp. °C	47	24.9	24.4	22.6	18.1	14.4	11.7	10.6	11.7	14.4	17	19.9	22.5	17.7
Ave. Min. Temp. °C	47	11.6	11.8	10.7	8.9	6.9	5.4	4.7	4.8	5.9	7.2	8.7	10.3	8.1
Mean Temp. °C	47	18.3	18.1	16.7	13.5	10.7	8.5	7.7	8.3	10.1	12.1	14.3	16.4	12.9
Extreme Max.Temp.°C	47	41.3	40.6	39	32.4	27.5	22.2	20.3	27.9	29.4	33.3	38.6	40	
Extreme Min.Temp.°C	47	3.1	3.2	2.3	0.6	-0.7	-3.9	-3.9	-2.5	-2.3	-0.9	0.3	0.3	
Mean Rainfall (mm.).	80	39	37	43	96	143	183	161	156	124	99	61	48	1190
Median Rainfall (mm.).	80	33	22	34	79	129	172	161	150	112	93	46	41	1192
Rain Days	80	6	6	7	13	15	17	18	18	15	14	11	9	150

10.4. Physiography and Drainage (Cont.)

The drainage of the south-western slopes runs into the Upper Sturt Valley and Minno Creek which flows through the Belair Recreation Park. On the eastern edge the drainage is down towards the Mount Lofty Railway Station in the valley parallel to that of Minno Creek in Belair Recreation Park.

10.5. Geology and Soils

The geology of the Mount Lofty Ranges has been adequately described by other authors (Howchin, 1904, 1906; Fenner, 1931; Sprigg, 1942, 1945, 1946). The podsolized soils found at the Knoll Conservation Park are low in nutrients and comparable with those of the eastern edge of Belair Recreation Park (Specht and Perry, 1948). This similarity in soils made it feasible to compare the vegetation of this area with that of sections of Belair Recreation Park. The disturbance from vehicular traffic in sections of the park has resulted in compaction of the soils.

10.6. Vegetation

The area is covered with a *Eucalyptus obliqua* association and a variable understorey.

The large number of alien species present in this park in the main are confined to the northern and access areas.

10.6. Vegetation

The southern area which has a dense understorey of *Acrotriche fasciculiflora* has only the occasional introduced species present. The main alien species include *Ulex europaeus* (gorse), *Senecio pterophorus* (South African daisy), *Rubus* spp. *aff. fruticosus* (blackberry) and *Erica lusitanica*. *Erica lusitanica*, a northern Mediterranean plant, is a species localized in distribution to Crafers and Stirling (Black, 1963).

The vegetation of the Mount Lofty Ranges is mainly determined by the soil types as can be seen from the results at Belair Recreation Park. The influences of the vehicular tracks and of the proximity of adjacent landholdings is given particular attention in this park. The importance of aspect as a determinant of vegetation has clearly been shown for other areas and was investigated also at this park.

10.7. Research Objectives

The enormous difficulties associated with weed control in the Mount Lofty Ranges in agricultural, pastoral and undeveloped areas are well recognised by the South Australian Department of Agriculture and the National Parks and Wildlife Division of the Department of Environment and Conservation. In many of our local parks the problems are accentuated as many weed infested areas are inaccessable.

10.7. Research Objectives (Cont.)

The frequent occurrence of fires encourages the introduction and/or spread of weeds. A review of the South Australian National Parks Annual Reports of the last eight years illustrates the large number of fires in the local parks. The other major problem is the use of weed eradication or control techniques in areas with native plant and animal species present. In most instances the side effects of such techniques are not known.

The Knoll Conservation Park has a large section infested by introduced species. The influence of man's activities on the introduced and native plant species was investigated. The influences of park size and the proximity of adjacent landholdings were also studied. These results were compared with those found in Nixon-Skinner Conservation Park where similar influences were studied. This park therefore provides additional information on the feasibility of conserving the vegetation of small parks.

The research objectives were carried out with the following objectives in mind -

a. To carry out a reconnaissance of the area

b. To construct a floristic list for plant identification

c. To survey the presence and absence of plant species in the park

10.7. Research Objectives (Cont.)

d. To review the soil and climatic conditions

e. To compare the results with those of other National Parks in the Adelaide Hills

f. To develop comparisons reflecting on the possible significance of park size and its surroundings as possible determinants of the vegetation.

10.8. Research Methods

The reconnaissance and collection of species were carried out on several occasions. The vegetation of the Knoll Conservation Park was studied by a systematic grid of thirty nine quadrats at twenty metre intervals (measured by pacing) along traverses twenty metres apart on a compass bearing of three hundred and ten degrees. The first traverse was five metres in inside the eastern fence starting at the south-eastern corner of the park. The quadrats were circular in shape with a radius of five metres so that they were comparable with those of Belair Recreation Park.

Presence/absence data for all species were recorded. An association analysis was carried out on the binary data to study the inter-relations between the plant species in the park. The aspect was also included in the binary data and will be discussed as a possible determinant in the distribution of plant species. Density measurements were collected for all major plant species.

10.9. Results

10.9.1. Introduction

A floristic list of plant species recorded at the Knoll Conservation Park appears in Appendix II.

The podsolised soils in the park have already been discussed by Specht and Perry (1948). Their uniformity along with climatic conditions over the two hectares therefore are unlikely to be important as far as determinants of the vegetation.

The past influence of man through the use of vehicular traffic and the laying of tracks through the area along with the proximity of adjacent private properties are important factors. The relatively undisturbed state of an area in the southern section of the park is reflected in the lack of alien species amongst the large numbers of native plant species in the understorey (Volume II, Appendix VII, Maps 10.1 to 10.36 inclusive). A comparison of the distribution maps for *Acrotriche fasciculiflora* and *Ulex europaeus* clearly illustrate this point, see Maps 10.16; 10.24; 10.32; 10.35..

The frequency of the species followed at the Knoll Conservation park are presented in Table 10.2.. The inter-relations of the plant species with aspect and other plant species will be discussed in the sections 10.9.2. and 10.9.3.. The distribution and density maps will be discussed in 10.9.4.. Species of particular interest will also be discussed in 10.9.4..

Table 10.2.

The plant species sampled at the Knoll Conservation Park. The percentage of total samples in which they occur (frequency). Introduced species are prefixed by an asterisk.

Species	Frequency
Eucalyptus obliqua	97.44
Acrotriche fasciculiflora	92.31
Exocarpus cupressiformis	76.92
Chamaescilla corymbosa	74.36
Pultenaea daphnoides	71.79
Pteridium esculentum	71.79
Moss sp.	69.23
Poa laevis	64.10
Microlaena stipoides	61.54
* *Ulex europaeus*	58.97
Acaena anserinifolia	56.41
Tetratheca pilosa	53.85
Hibbertia exutiacies	48.72
Dianella revoluta	48.72
* *Senecio pterophorus*	46.15
Haloragis tetragyna	46.15
Daviesia virgata	43.59
* *Briza maxima*	43.59
Thysanotus dichotomus	43.59
* *Hypochoeris glabra*	43.59
* *Oxalis pes-caprae*	41.03
Ixodia achillaeoides	38.46
* *Rubus* spp. *aff. fruticosus*	25.64
Acrotriche serrulata	25.64
Oxalis corniculata	25.64
* *Erica lusitanica*	23.08
* *Pittosporum undulatum*	23.08
Caesia vittata	23.08
Haloragis elata	23.08

Table 10.2. (Cont.)

	Species	Frequency
*	*Genista maderensis*	20.51
	Eucalyptus viminalis	20.51
	Scaevola albida	20.51
	Gnaphalium japonicum	20.51
	Lomandra dura	17.95
	Cassytha glabella	17.95
	Banksia marginata	15.38
	Grevillea lavandulacea	15.38
	Lepidosperma semiteres	15.38
	Senecio hypoleucus	15.38
	Stackhousia monogyna	15.38
	Pimelea glauca	15.38
	Helichrysum scorpioides	15.38
*	*Allium triquetrum*	15.38
	Hedera helix	15.38
	Leptospermum myrsinoides	12.82
*	*Juncus capitatus*	12.82
*	*Aira caryophyllea*	12.82
	Acacia melanoxylon	10.26
	Xanthorrhoea semiplana	10.26
	Stipa sp.	10.26
	Brunonia australis	10.26
*	*Geranium molle*	10.26
*	*Dactylis glomerata*	10.26
	Juncus caespiticius	10.26
	Acacia longifolia	7.69
	Galium sp.	7.69
	Themeda australis	7.69
	Astroloma humifusum	7.69
	Neurachne alopecuroidea	7.69
	Leucopogon virgatus	7.69
	Viola hederacea	7.69
*	*Chrysanthemoides monilifera*	5.13

Table 10.2. (Cont.)

	Species	Frequency
	Epacris impressa	5.13
	Bursaria spinosa	5.13
*	*Anagallis arvensis*	5.13
	Pterostylis sp.	5.13
	Bossiaea prostrata	5.13
*	*Rhamnus alaternus*	5.13
	Lagenifera stipitata	5.13
	Craspedia uniflora	5.13
	Eucalyptus fasciculosa	2.56
	Acacia pycnantha	2.56
	Daviesia ulicifolia	2.56
*	*Grevillea rosmarinifolia*	2.56
	Ranunculus lappaceus	2.56
	Bulbinopsis bulbosa	2.56
	Kennedia prostrata	2.56
*	*Myosotis sylvatica*	2.56
*	*Picris echioides*	2.56
*	*Silybum marianum*	2.56
	Caladenia sp.	2.56
*	*Viola odorata*	2.56
*	*Sonchus asper*	2.56
*	*Plantago lanceolata*	2.56
*	*Rumex* sp.	2.56
	Dillwynia hispida	2.56
	Billardiera sericophora	2.56
*	*Bromus* spp.	2.56
*	*Crataegus monogyna*	2.56
*	*Holcus lanatus*	2.56
	Senecio biserratus	2.56

10.9.2. Plant-Topographic Relationships

The northerly aspect was the only physiographic feature that showed any significant association. The native perennial grass, *Microlaena stipoides*, was associated with the northerly aspect (Fig. 10.3. (a).).

10.9.3. Plant species inter-relations

The association analysis revealed four main groups of plants. Two of these were insignificantly associated with the other two major groups (Fig. 10.3. (b), (c), (d).).

Pimelea glauca and *Helichrysum scorpioides* were positively associated (Fig. 10.3. (b).). *Ulex europaeus* (gorse) was associated with *Pteridium esculentum* (bracken), (Fig. 10.3. (c).).

The other two groups were dissociated with each other. The first of these includes the two introduced plant species, *Genista maderensis* and *Rubus* spp. *aff. fruticosus*. These were dissociated with a large group of native plant species including a range of shrub and ground-cover species (Fig. 10.3. (d).). All species in Figure 10.3. were present in a minimum of fifteen per cent of the quadrats. The species of lower frequencies were not included.

10.9.4. Plant distribution patterns

The distribution and density maps for the Knoll Conservation Park appear in Volume II, Appendix VII, Maps 10.1 to 10.36 inclusive.

Figure 10.3.

Nodes of associated species at $\chi^2 \geqslant 10.83$ in the Knoll Conservation Park.

(a) Node of associated species with the northerly aspect.

(b), (c), (d),

Nodes of associated plant species

________ indicates association, positive association

---------- indicates dissociation, negative association

* indicates an introduced species

(4)		*Exocarpus cupressiformis*
(9)	*	*Ulex europaeus*
(10)	*	*Genista maderensis*
(12)		*Pultenaea daphnoides*
(13)		*Daviesia virgata*
(16)	*	*Rubus* spp. *aff. fruticosus*
(17)		*Pteridium esculentum*
(21)		*Ixodia achillaeoides*
(22)		*Tetratheca pilosa*
(23)		*Hibbertia exutiacies*
(25)		*Acrotriche serrulata*
(36)		*Pimelea glauca*
(38)		*Dianella revoluta*
(41)		*Lomandra dura*
(50)		*Helichrysum scorpioides*
(52)		*Gnaphalium japonicum*
(54)		*Haloragis elata*
(55)		*Haloragis tetragyna*
(59)		*Oxalis corniculata*
(64)		Northerly aspect
(69)		*Microlaena stipoides*

THE KNOLL CONSERVATION PARK

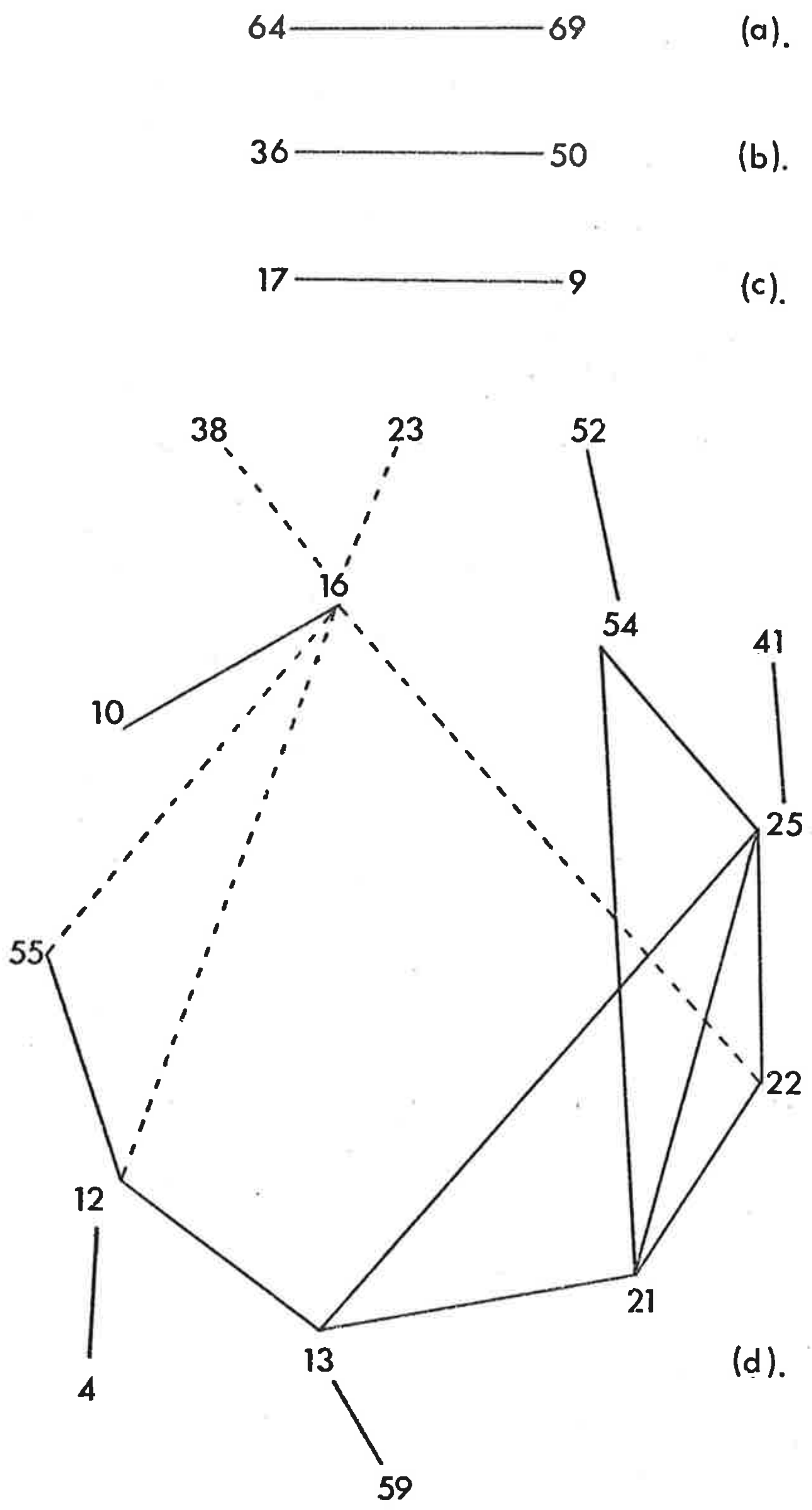


Figure 10.3.

10.9.4. Plant distribution patterns (Cont.)

The results clearly show that the native plants in the main are confined in their distribution to the southern and eastern edges of the park.

The majority of the species have low frequencies (Table 10.2.). Exceptions to this include the introduced shrubs *Ulex europaeus, Rubus* spp. *aff. fruticosus, Genista maderensis* and *Senecio pterophorus*. *Ulex europaeus* appears in those areas disturbed by man both in the northern area and along the tracks on the western edge (Map 10.16.). The native species present in large numbers include *Pteridium esculentum, Exocarpus cupressiformis, Daviesia virgata, Pultenaea daphnoides, Hibbertia exutiacies, Acrotriche serrulata, Acrotriche fasciculiflora, Tetratheca pilosa* and *Eucalyptus obliqua*. All of these native plants tend to grow in the southern area of the park. The alien ones on the other hand tend to grow in the northern area.

The presence of such introduced garden escapes as *Crataegus monogyna* (Hawthorn), *Ilex aquifolium* (Holly), *Myosotis sylvatica* (Forget-me-not) and *Allium* spp. in the northern area reflects the vegetation of the adjacent landholdings.

The native vegetation where left undisturbed by man has only low numbers of introduced species present. If left undisturbed this southern area is more likely to conserve the native species than the northern area where disturbances to the shrub layers has already taken place.

10.10. Summary

The past influences of biotic factors including man were reflected in the vegetation of the Knoll Conservation Park. The influence of the proximity of adjacent properties was clearly illustrated by the northern and western edges of the park which supported a large number and variety of introduced species. *Genista maderensis, Ulex europaeus* and *Rubus* spp. *aff. fruticosus* were particularly dense in the northern area where only the occasional native plant species can be found in the understorey.

The size of the park, less than two hectares, accentuated the importance of the vegetation of the adjacent landholdings. This "border effect" seen in the majority of the parks was particularly marked in the Knoll Conservation Park.

The past efforts made to control the gorse, *Ulex europaeus,* have failed and this species still remains as one of the serious weeds in the park. *Senecio pterophorus* although present in low numbers could become a problem if a fire occurred in the Knoll Conservation Park.

In summary the vegetation of the area has been disturbed in the major part of the park with many introduced species present. As a result only the southern section of the park conserves the native undershrubs such as *Hibbertia exutiacies, Acrotriche fasciculiflora, Daviesia virgata* and *Pultanaea daphnoides.*

CHAPTER XI

SUMMARY OF CHAPTERS VI TO X

It is perhaps useful at this point to bring together some points which emerge from a comparative retrospect on the detailed situations from the various sites treated in Chapters VI to X. Two things at least are common to all the various cases examined, viz: the effects on native vegetation which can be attributed to the influence of man are similar and, secondly, they are pronounced.

The association analyses' results clearly segregate the species associated with the influence of man from those associated with other factors. Several trends are apparent in the vegetation in the parks. The alien plant species in general tend to associate, forming well defined groups which may or may not be associated with native plant species. These well-defined groups are in the main related to the activities of man. Similarly the native plant species tend to associate, also forming complex well-defined groups. These groups are usually related to factors such as soil or topographic features. The spatial layout of the components of these groups permits the conclusion that there is no matching with any zoned pattern of man's impress, to suggest a causative correlation. One exception to these clearly defined groups is seen in the Belair Recreation Park results. These results demonstrate an intermingling of alien and native plant species. This result is not surprising in view of the long history of man in this park; in fact it has few areas that are free of alien species. The overlapping of species' association between groups reflects the wider tolerance of some species.

The adequacy of the parks to conserve the vegetation is doubtful. The results indicate that the vegetation in the parks is markedly influenced by such disturbances as clearing, grazing, track systems, provision of recreational facilities, fire, nature of adjacent landholdings, cultivation, interruption of drainage systems, inadequate fencing, exotic plantings, uncontrolled access to stray animals, logging practices and the presence of man, horses, vehicles, vermins and alien plant species. Data or observations bearing on each of these factors is within the results reported earlier. In the five parks the influences of cultivation, clearing and grazing were shown to be the major determinants of change in the vegetation. All these activities led to the dominance of alien species in sections of the parks studied. Further the size of the park is of prime importance as regards the feasibility of conserving the vegetation. The "edge effect" or "border effect" observed in the parks is accentuated in the smaller ones. This "edge effect", with its associated intermingling of species reflects the proximity and nature of adjacent landholdings. The size of the park is also important as regards the conservation of individual plant species. Many of the species encountered were infrequent or rare, and in some instances were very restricted in their distribution. As a result a small park will not adequately provide for the conservation of these species. Further a local change in the prevailing conditions may lead to the disappearance of these species. For example a change in the hydrology of an area may eliminate a local population of the species.

CHAPTER XII

BELAIR RECREATION PARK - PYRIC SUCCESSION STUDIES

12.1. Introduction.

As outlined in Chapter III, fire is one of the major problems facing the local park authorities. There is extensive literature on the effects of fire on the Australian vegetation. However, up to date, the emphasis has been on the native species and their responses to the advent of fires. In this chapter emphasis is placed on several alien species and how they respond to the occurrence of a wild fire.

Both Cleland Conservation Park and Belair Recreation Park have been subjected to increasing numbers of fires in the last decade. Consequently it seemed appropriate to select an area in Belair Recreation Park to undertake a study to investigate the response of some alien plant species to a wild fire. To this end, the pyric succession study was carried out in a localised area of Pittosporum Valley in Belair Recreation Park (Fig. 8.2.). The wild fire that occurred in Pittosporum Valley on the eighth of April, 1972 was particularly severe and left few plants unscorched if not dead. In view of the large number of alien plants in this area the opportunity existed to follow their response to a wild fire. Detailed attention was given to *Senecio pterophorus* and *Hypericum perforatum*. These plants are of particular interest as they are among the major current problems facing the park authorities in Belair Recreation Park. Before details of this experiment are outlined a brief account of the history of this area and of the two plant species will be given.

As this area is in Belair Recreation Park in many instances the discussions in chapter eight are applicable.

12.2. Historical Background.

12.2.1. Historical Background of Pittosporum Valley.

The history of Belair Recreation Park is discussed in 8.2.. The recent history of the area is based on my own observations in the last few years.

As in other sections of this park, Pittosporum Valley has been subjected to a large number of fires. As a result of these fires and other influences such as grazing, clearing and trampling very little remains of the original vegetation. In fact the majority of the species of plants present are alien. The area also has been grazed by sheep and rabbits. There was a small group of wild sheep present in the valley during the experiment. Trampling and grazing were the main effects of these sheep. The inability of these animals to penetrate the thickets of *Senecio pterophorus* restricted their grazing. The rabbits were present in relatively low numbers.

The largest influence other than fires, was man. His influence was in the form of trampling of the undergrowth as well as physical damage to many of the plants (whether alien or native). This influence in the main was restricted to the valley bottom near its entrance. The ridges were left relatively undisturbed as the main access to the area studied was via the entrance to the valley.

12.2.2. History of *Senecio pterophorus* in South Australia.

African Daisy, *Senecio pterophorus,* is a short-lived perennial, native to Natal in South Africa. This plant was first collected in South Australia near Port Lincoln in 1927. It was first recorded in the Adelaide Hills in the *Eucalyptus leucoxylon-Eucalyptus obliqua* woodlands in 1942. Subsequently the plant has been recorded in the Murray Districts and in the south-east of South Australia. In the late 1950's and early 1960's, *Senecio pterophorus* rapidly spread from a few plants to cover nearly a hundred square miles (Ross, 1963). In recent years the plant has spread to occupy most un-cultivated areas in the Adelaide Hills. Its distribution has been described by several workers including Ross (1963) and Tideman (Agronomy Branch Report No. 37).

Senecio pterophorus belongs to the family Asteraceae. An average adult plant has been estimated to produce 1,200 flowers per year and in the vicinity of 40,000 to 50,000 viable seeds per year (Baldwin, 1972). The very small seed has a ring of fine bristles called a pappus and is wind borne. As a result, its dispersal is widespread. This plant flowers from November to the end of autumn. It is well recognised that this plant is able to establish readily in disturbed areas and that it requires a minimum rainfall of 500 millimetres per annum and a growing season of more than five months (Baldwin, 1972). Ross (1963) recognised its ability to establish after fires.

This plant is not recognised as an agricultural weed and therefore interest at attempts to control it have been limited.

12.2.2. History of *Senecio pterophorus* in South Australia (Cont.)

The control methods used have included hand pulling, application of superphosphate and spraying of weedicides (Ross, 1963). Its recent spread into young pine plantations, e.g. in the Mount Bold Reservoir Encatchment Area, has posed threats to the growth of the pines in these areas.

In Pittosporum Valley this plant was present in relatively low numbers prior to the wild fire. *Senecio pterophorus* was studied as it provided the opportunity to follow the influence of fire and management policies as possible determinants of the vegetation.

12.2.3. History of *Hypericum perforatum* in South Australia.

Hypericum perforatum originates from Europe. The first introduction of *Hypericum perforatum* into Australia was traced to Ovens Valley in north-eastern Victoria during a gold boom in the 1800's when a German woman living at Bright imported seed from her homeland and established the plants for medicinal purposes (Parsons, 1973).

Before the 1900's *Hypericum perforatum* spread to South Australia where it became established in the Adelaide Hills. It is recognised that the most vigorous infestations occur at elevations of about six hundred metres above sea-level and where the annual rainfall is over seven hundred millimetres. A well developed plant can produce up to 30,000 seeds per year. The main means of dispersal is by seed which may be spread by wind but more readily by water and animals. This plant like *Senecio pterophorus* is able to compete with other plants to the point of dominance.

12.2.3. History of *Hypericum perforatum* in South Australia (Cont.)

The result is almost complete elimination of other plant species. The plant also spreads by developing from broken pieces of rhizomes.

Attempts at control of this plant include the application of salt, the introduction of insects and the application of weedicides (Moore and Cashmore, 1942; Clark, 1953a and 1953b; Parsons, 1973).

12.3. Climate.

The climate for Belair has been discussed in 8.3.. The monthly rainfall figures for Belair "Kalyra" are provided both prior to and for the length of the experiment. It is noteworthy that in March, 1972 the rainfall was particularly low (a total of only one millimetre), see Table 8.1. and Table 12.1.. As a result it is not surprising that a wild fire occurred early in April of that year. The low rainfall combined with the relatively high temperatures led to ideal conditions for the advent of a wild fire.

Table 12.1.
Rainfall recordings for Belair "Kalyra"
(Monthly recordings in millimetres taken from records of the Bureau of Meteorology, Adelaide).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Yearly Total
1972	45	41	1	52	22	29	107	84	37	40	10	20	488
1973	36	54	43	93	75	93	96	55	77	70	38	62	792
1974	42	70	1	76	-	-	-	-	-	-	-	-	-

12.4. Physiography and Drainage.

Pittosporum Valley is a relatively open bottomed valley with steep sides. In the wetter months a small creek flows down the valley to join Minno Creek. The study area is at an approximate elevation of three hundred and fifty metres above sea level on the ridge between the Joseph Fisher Pavilion Valley and Pittosporum Valley and extends down into the latter valley.

12.5. Geology and Soils.

The geology and soils are described in 8.5.. Briefly, the soils are uniform throughout the area studied and are grey brown podsols. The argillaceous rocks weather rapidly and the soil material tends to accumulate over most of the ridges. Despite this, small outcrops of rock occur in places on the ridges where the top soil has been removed.

12.6. Vegetation.

The woodland of *Eucalyptus leucoxylon-Eucalyptus viminalis* covers the area studied in Pittosporum Valley. There is also the occasional *Eucalyptus camaldulensis*. The undershrubs consist of mainly alien species with only the occasional native species. These native plant species include *Acacia pycnantha*, *Acacia melanoxylon*, *Exocarpus cupressiformis*, *Goodenia primulacea*, *Scaevola albida*, *Beyeria leschenaultii*, *Hibbertia exutiacies*, *Ajuga australis*, *Anguillaria dioica*, *Bulbinopsis bulbosa*, *Haloragis tetragyna* and *Senecio quadridentatus*.

12.6. Vegetation (Cont.)

Most of these plants are present in low numbers e.g. there are only two plants of *Hibbertia exutiacies* in the area studied.

On the other hand there are large numbers of alien species including the grasses, *Aira caryophyllea, Avena barbata, Holcus lanatus* and the species of *Briza* and *Vulpia*. In addition, the alien species include *Sparaxis* spp., *Romulea longifolia, Rumex angiocarpus, Fumaria muralis, Geranium molle, Hypericum perforatum, Vinca major, Convolvulus arvensis, Plantago lanceolata, Trifolium* spp., *Senecio pterophorus, Anagallis arvensis* and *Silybum marianum*.

The vegetation in Pittosporum Valley typifies that found in Belair Recreation Park in that it is dominated by alien plant species.

12.7. Research objectives.

Pittosporum Valley with its predominantly alien flora offered the opportunity to follow the plants in this area with regard to their ability to withstand, establish and/or regenerate after a wild fire. The particular plants of interest were *Hypericum perforatum* and *Senecio pterophorus*. The response of these two plants to the wild fire was investigated. A pyric successional study was undertaken with the object of investigating the sequence of events with time in this area. Therefore the approach was -

a. To carry out a reconnaissance of the area.

12.7. Research Objectives (Cont.)

b. To study the plant community by measuring density and frequency of some of the plant species.

c. To measure the height of the South African daisies in order to follow the population changes with time.

d. To review the response of the alien species to a wild fire.

12.8. Research Methods.

Reconnaissance and collection of species were carried out on several occasions. The floristic list for Belair Recreation Park that appears in Appendix II includes the plant species found in this area. The plant species of particular interest are referred to in this chapter.

The results for the first time interval (prior to the fire) were estimated by measurements immediately following the fire. The results were measured at sixteen time intervals on an area one hundred metres by two hundred metres. One hundred quadrats were on a systematic grid within this area. There were ten traverses ten metres apart. The quadrats of size ten metres by one were placed at twenty metre intervals running parallel with these traverses. All quadrats were pegged.

Density and/or frequency measurements were collected for some of the species. The heights of all *Senecio pterophorus* plants in the hundred quadrats were measured to the nearest ten centimetres and the results presented in histograms for the sixteen time intervals.

12.8. Research Methods (Cont.)

The results presented are those of the more frequent plant species with the exception of *Acacia pycnantha* which only occurred in a few of the quadrats.

12.9. Results.

12.9.1. Introduction.

The results for some of the main plant species in this area are presented in this section. Emphasis is placed on *Hypericum perforatum* and *Senecio pterophorus* as these two species are the dominants in this area. Reference also will be made to other plant species for comparison. After the fire the plant community resembled that prior to the fire. The frequencies of some of the plant species are discussed in 12.9.2.. The density results for *Hypericum perforatum* and *Senecio pterophorus* are discussed in 12.9.3.. In 12.9.4. the heights of *Senecio pterophorus* at the sixteen times are discussed.

12.9.2. Frequency Results.

The majority of the plant species regenerated after the wild fire. This regeneration followed the rain in late April and early May.

The results presented in Figure 12.1. show the frequencies (percentage of total samples in which the species occur) of eight plant species. These plant species show a range of results.

Hypericum perforatum was present in most quadrats prior to the wild fire.

Figure 12.1.

Frequency of some plant species in the pyric succession study area of Pittosporum Valley in Belair Recreation Park.

Introduced species are prefixed by an asterisk.

Species Number	Species
1	* *Hypericum perforatum*
2	* *Trifolium subterraneum*
3	* *Trifolium dubium*
4	* *Senecio pterophorus*
5	*Acacia pycnantha*
6	* *Avena barbata*
7	* *Vulpia* spp.
8	* *Geranium molle*

Time

1 ...	7. 4.72	9 ...	16.11.72
2 ...	8. 4.72	10 ...	9. 1.73
3 ...	28. 4.72	11 ...	12. 3.73
4 ...	15. 5.72	12 ...	7. 5.73
5 ...	15. 6.72	13 ...	27. 7.73
6 ...	15. 8.72	14 ...	24.10.73
7 ...	15. 9.72	15 ...	16. 1.74
8 ...	15.10.72	16 ...	15. 4.74

BELAIR RECREATION PARK

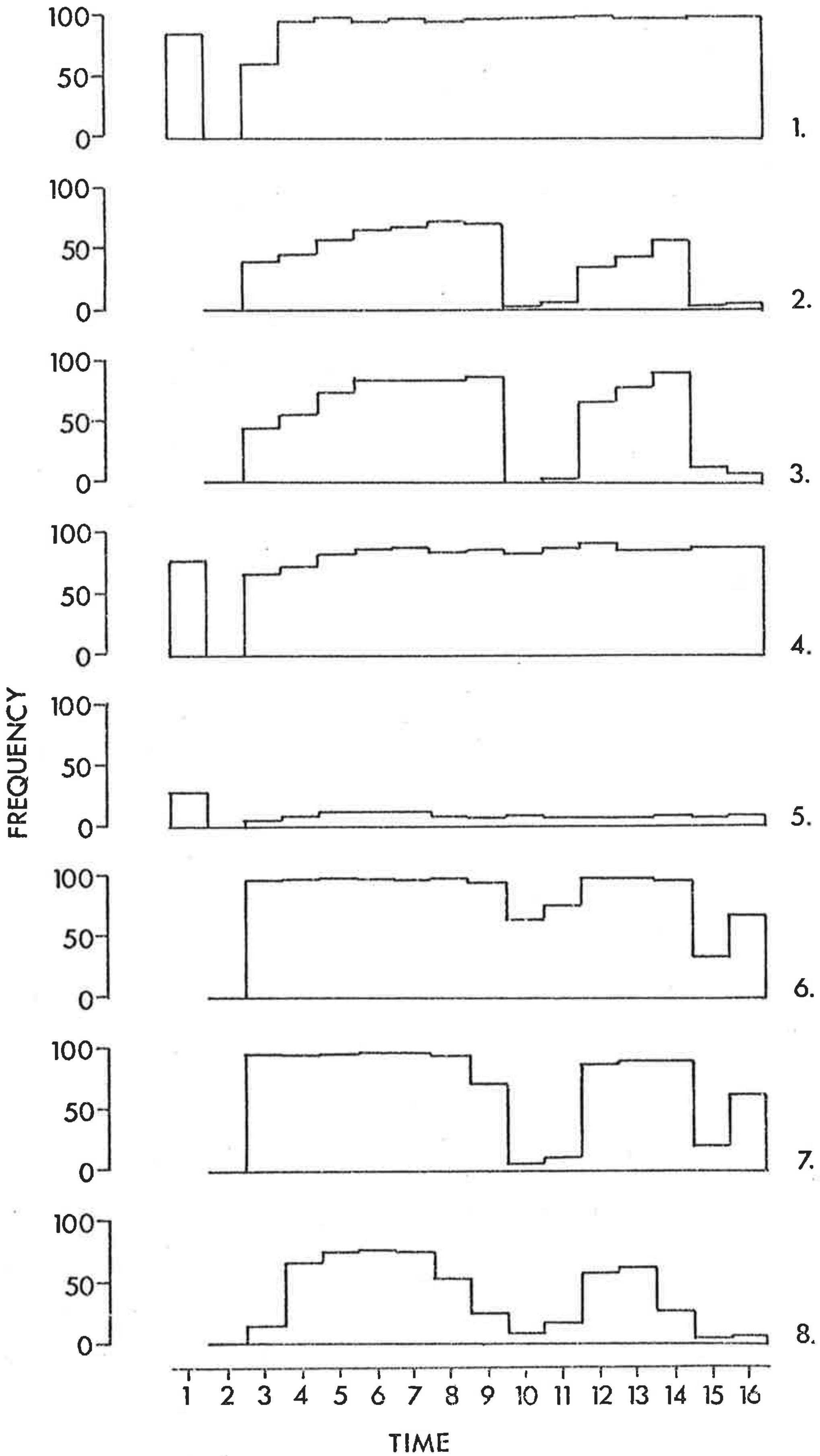


Figure 12.1.

These results were collected after the fire by following the burnt remains of the plants. The characteristic stems as well as the clumps of stems enabled this species to be distinguished easily from other plants in the area.

The high frequencies of *Hypericum perforatum* and *Senecio pterophorus* (both prior to and after the fire) illustrate their dominance in this area. Both these species are important as weeds in Belair Recreation Park. They readily establish after a wild fire. These plants have the added advantage as perennials, of establishing and maintaining their dominance throughout the year.

In comparison the native perennial shrub, *Acacia pycnantha* had a lower frequency after the fire. The slight fluctuations in its frequency can be accounted for by several plants regenerating then dying. It is of interest that this species did not establish by seedlings. All plants present regenerated by regrowth on the old stems and rootstocks. The lack of seedlings may be due to several factors including the lack of seeds in the area, the inability of the seeds to mature after the fire and the unsuitable conditions for regeneration. The lack of seedlings is of interest particularly when compared with the results for *Acacia pycnantha* in the controlled burning experiment discussed in the following chapter. *Acacia melanoxylon* which also was present in low numbers similarly regenerated from stems of older shrubs.

The other plant species measured were all introduced annuals, see Figure 12.1..

12.9.2. Frequency Results (Cont.)

The results prior to the fire could not be collected therefore only those after the fire appear in the results. *Trifolium dubium* and *Trifolium subterraneum* illustrate a similar response with time. They both increased in frequency following the rains in autumn and winter of 1972. The frequency of these two species decreases rapidly in summer. The seasonal response and the corresponding fall in frequency were seen again in the summer months in the latter part of 1973 and early 1974. Other species of *Trifolium* in this area included *Trifolium glomeratum, Trifolium campestre, Trifolium striatum, Trifolium arvense* and *Trifolium angustifolium*. These latter species of *Trifolium* were all present in relatively low numbers.

The introduced grasses *Avena barbata* and the species of *Vulpia* were also present in this area and their results are presented in Figure 12.1.. These annual grasses show a similar seasonal response as described for the species of *Trifolium*. However, in late summer and early autumn of 1974 these two species had established before the species of *Trifolium*. The grasses also showed a smaller decrease in frequency in the previous summer. This could be related to the different requirements for the growth of the grasses, particularly *Avena barbata*, in these drier months; for example the valley bottom remained relatively moist in the summer months. The other grasses in this area included the two native perennials, *Themedia australis* and *Danthonia caespitosa*.

12.9.2. Frequency Results (Cont.)

Themeda australis was present in low numbers and was mainly restricted to the lower slopes of the valley. *Danthonia caespitosa* was restricted to the shallow soils on the upper slopes and the ridge. The introduced annual grasses in the area also included *Aira caryophyllea, Briza minor, Phalaris canariensis, Avena sativa, Cynosurus echinatus* and species of *Bromus*. The majority of these were present in low number and/or restricted sections of the area. The introduced perennial grasses included *Holcus lanatus, Dactylis glomerata* and *Anthoxanthum odoratum*. *Holcus lanatus* was restricted to the damper bottom of the valley.

Geranium molle had a seasonal growth period with slightly different frequencies from the other annuals. This difference was the slower initial increase in frequency and gradual decrease in the drier months. The marked decrease seen in the grasses and species of *Trifolium* was not seen in the results for this plant species.

12.9.3. Densities of *Hypericum perforatum* and *Senecio pterophorus*.

The results for the densities of these two species appear in Table 12.2.. The standard errors are also provided.

Hypericum perforatum develops rhizomes so difficulties were overcome by selecting the unit of individual as follows: The stems of this plant species tend to clump together and are separated from the next clump by a distance of usually more than thirty centimetres. These clumps of stems were classified as individuals as they were distinguishable as separate groups.

Table 12.2.

Densities of *Hypericum perforatum* and *Senecio pterophorus* in the pyric successional study area in Belair Recreation Park (Numbers per hectare).

Time	*Hypericum perforatum*		*Senecio pterophorus*	
	Mean	Standard error	Mean	Standard error
7. 4.72	16940	2180	7950	1609
8. 4.72	0	0	0	0
28. 4.72	7410	1261	0	0
15. 5.72	23500	2634	0	0
15. 6.72	42110	4679	100	100
15. 8.72	60420	6561	13530	2146
15. 9.72	52920	5464	37160	7420
15.10.72	58740	6508	36130	7439
16.11.72	68010	7699	66050	11874
9. 1.73	58090	5596	77700	12586
12. 3.73	69780	6221	125310	18404
7. 5.73	66510	5252	165770	20636
27. 7.73	46280	4062	177090	21882
24.10.73	60030	5447	151900	18772
16. 1.74	65220	5129	147220	16362
15. 4.74	79590	5583	163540	18731

The other alternative was to count all stems but this was unsuitable as the young basal growth could not be easily distinguished as separate stems. Thus the above choice was considered to be the most appropriate.

The individuals of *Senecio pterophorus* were readily distinguishable. The young seedlings (with only a few leaves) had a red tinge to the under-surface of their leaves so making them readily distinguishable from other seedlings. In the density results only those plants greater than ten centimetres were considered in the first counts after the advent of the fire.

The shoots of the *Hypericum perforatum* plants were all killed during the fire. However the regrowth of the rootstocks was apparent in the winter months. The increase in numbers after the fire was particularly marked. The numbers of *Hypericum perforatum* after the initial increase in the winter of 1972 stabilized and did not increase markedly. The slight fluctuations can be accounted for by some plants dying and not producing any new basal growth during the autumn and winter months. The woody, erect stems were produced in the spring months. The plants that regenerated from rootstocks flowered in the first and subsequent summers. The seedlings that were established after the fire did not flower this first summer but did the following year.

Senecio pterophorus was present prior to the fire. This plant readily established after the fire. The seedlings did not reach a height of ten centimetres until June, 1972.

12.9.3. Densities of *Hypericum perforatum* and *Senecio pterophorus*. (Cont.)

This delay in part could be related to intraspecific competition, in that a mat of young *Senecio pterophorus* seedlings appeared after the fire. The ability of this plant to regenerate on burnt areas was evident from the millions of young seedlings. Although there was some regeneration from the stems of some plants of *Senecio pterophorus*, the majority of plants were seedlings. There was a rapid growth of seedlings in the winter months after the fire. This increase in numbers continued throughout 1973 and stabilized in 1974. Despite the large numbers in the area prior to the fire the increase during the two years was particularly marked. The numbers were approximately twenty times higher at the end of the experiment than before the fire. The occasional plants that did regenerate following burning, flowered during the first summer after the fire. The majority of plants did not flower and seed until the second summer. The high densities of *Senecio pterophorus* can be emphasized further by measurements in several areas where the densities were greater than ten million plants per hectare. The results for *Senecio pterophorus* will be discussed further in the following section.

12.9.4. Heights of *Senecio pterophorus*.

The results are presented in Figure 12.2. These four pages of histograms present the results collected at the sixteen different times.

Figure 12.2.

Heights of *Senecio pterophorus* in the pyric succession study area of Pittosporum Valley in Belair Recreation Park.

Time

1 ..... 7. 4.72

5 ..... 15. 6.72

6 ..... 15. 8.72

7 ..... 15. 9.72

8 ..... 15.10.72

Note: No heights greater than ten centimetres were recorded for 8.4.72; 28.4.72; 15.5.72.

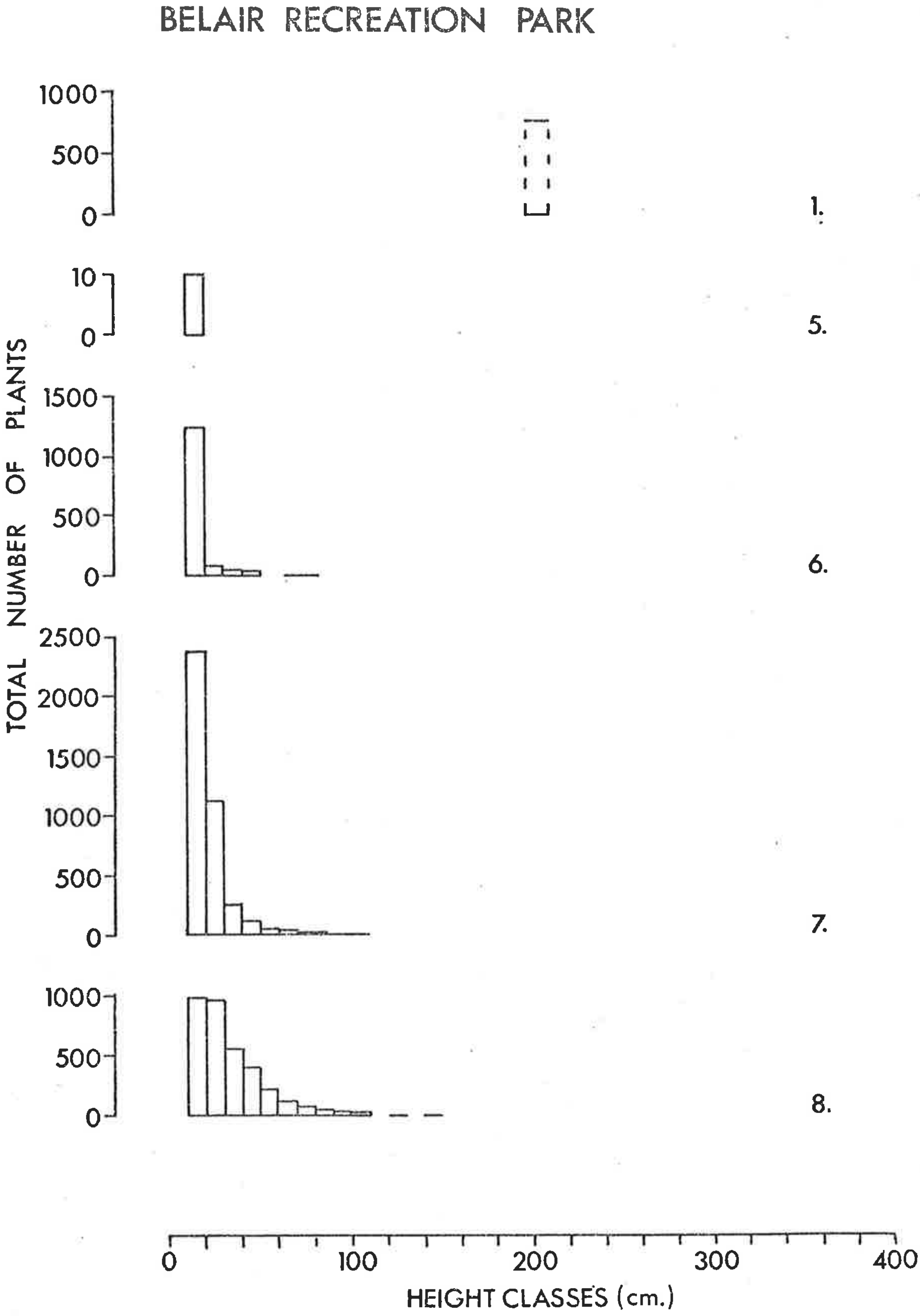

BELAIR RECREATION PARK
TOTAL NUMBER OF PLANTS
1000
500
0
1.
10
0
5.
1500
1000
500
0
6.
2500
2000
1500
1000
500
0
7.
1000
500
0
8.
0
100
200
300
400
HEIGHT CLASSES (cm.)

Figure 12.2.

Figure 12.2. (Cont.)

Heights of *Senecio pterophorus* in the pyric succession study area of Pittosporum Valley in Belair Recreation Park.

<u>Time</u>

9	.....	16.11.72
10	.....	9. 1.73
11	.....	12. 3.73

BELAIR RECREATION PARK

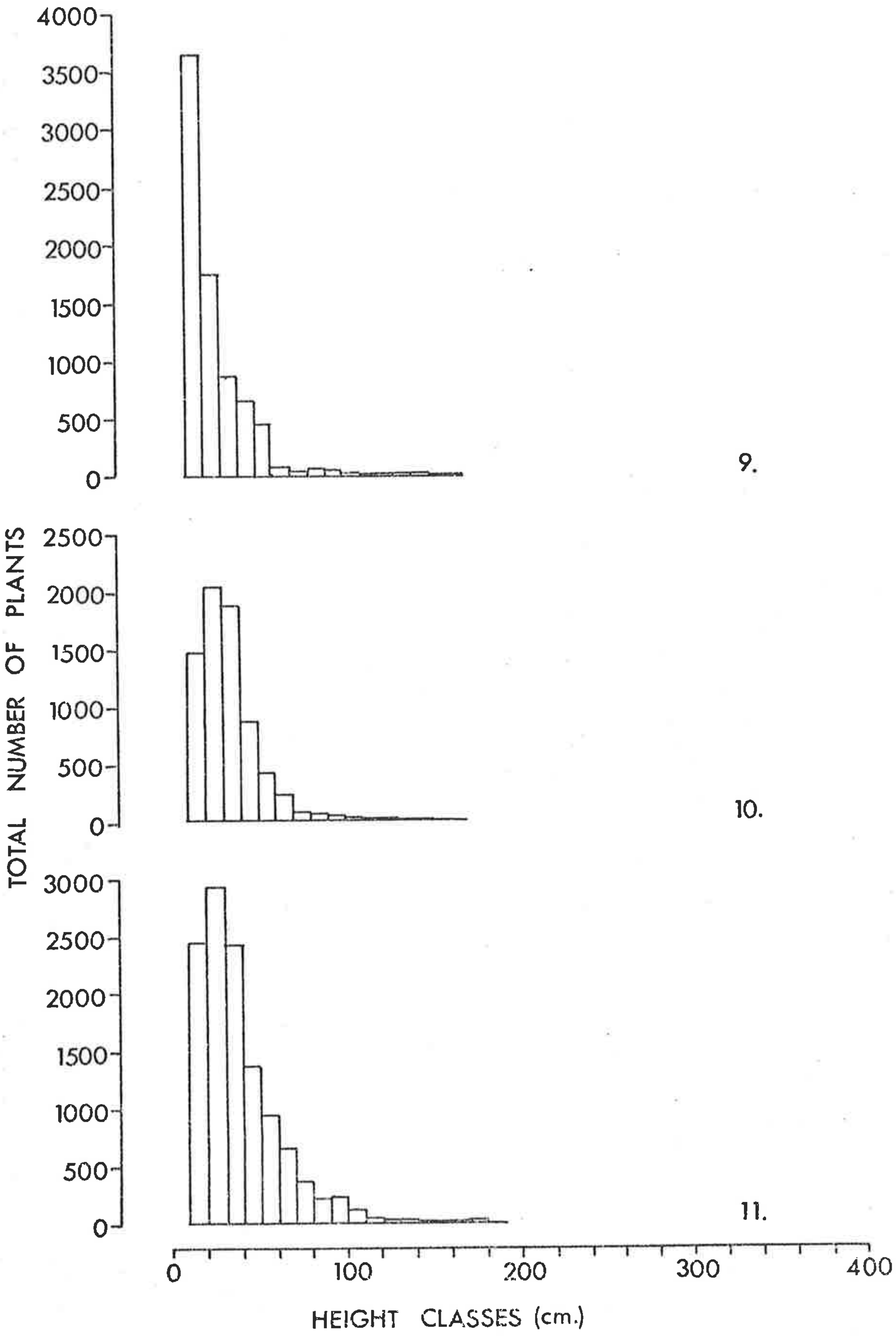


Figure 12.2. (cont.)

Figure 12.2. (Cont.)

Heights of *Senecio pterophorus* in the pyric succession study area of Pittosporum Valley in Belair Recreation Park.

Time		
12	.....	7. 5.73
13	.....	27. 7.73
14	.....	24.10.73

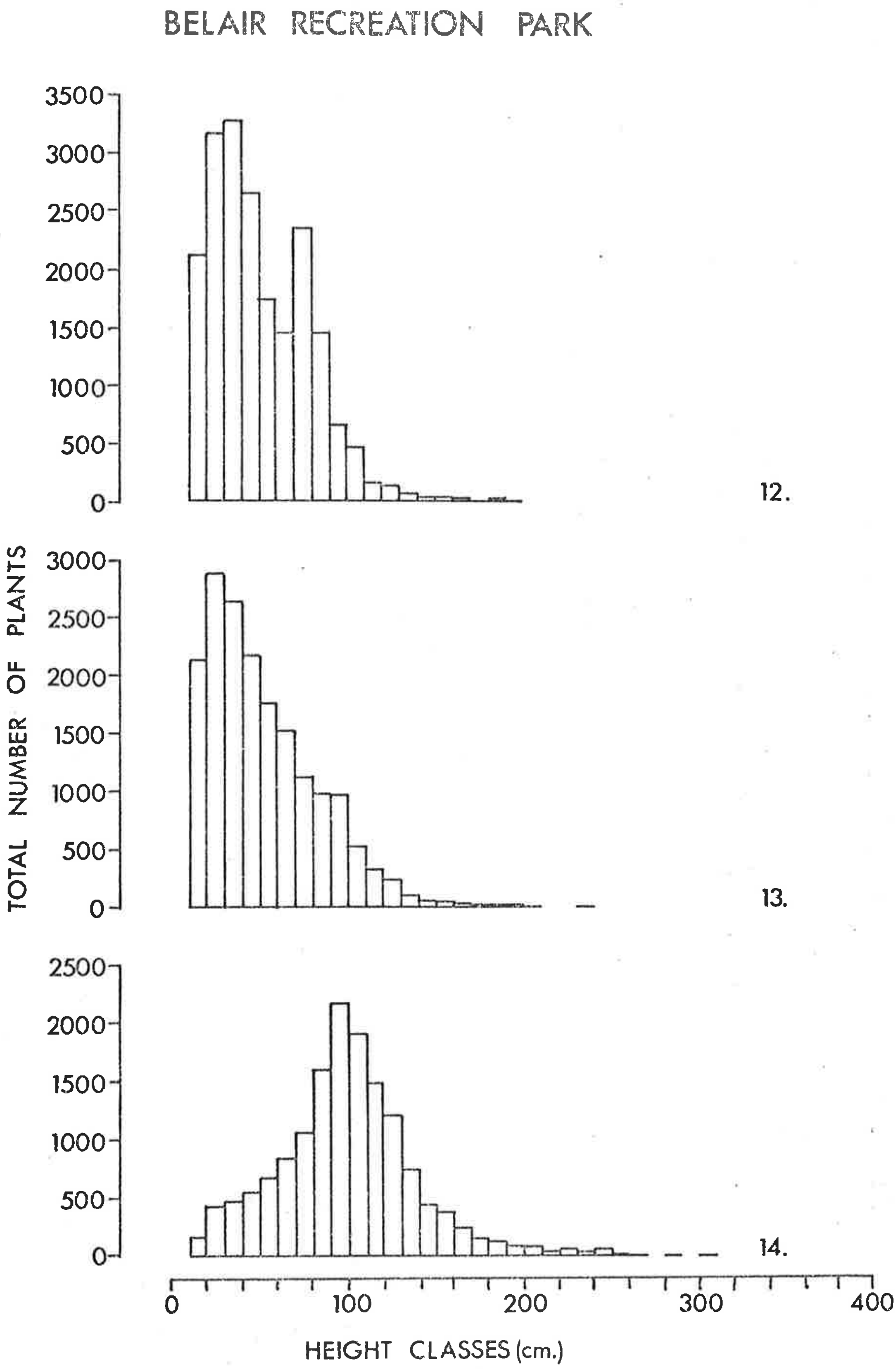


Figure 12.2. (cont.)

Figure 12.2. (Cont.)

Heights of *Senecio pterophorus* in the pyric succession study area of Pittosporum Valley in Belair Recreation Park.

<u>Time</u>

15 ..... 16. 1.74

16 ..... 15. 4.74

BELAIR RECREATION PARK

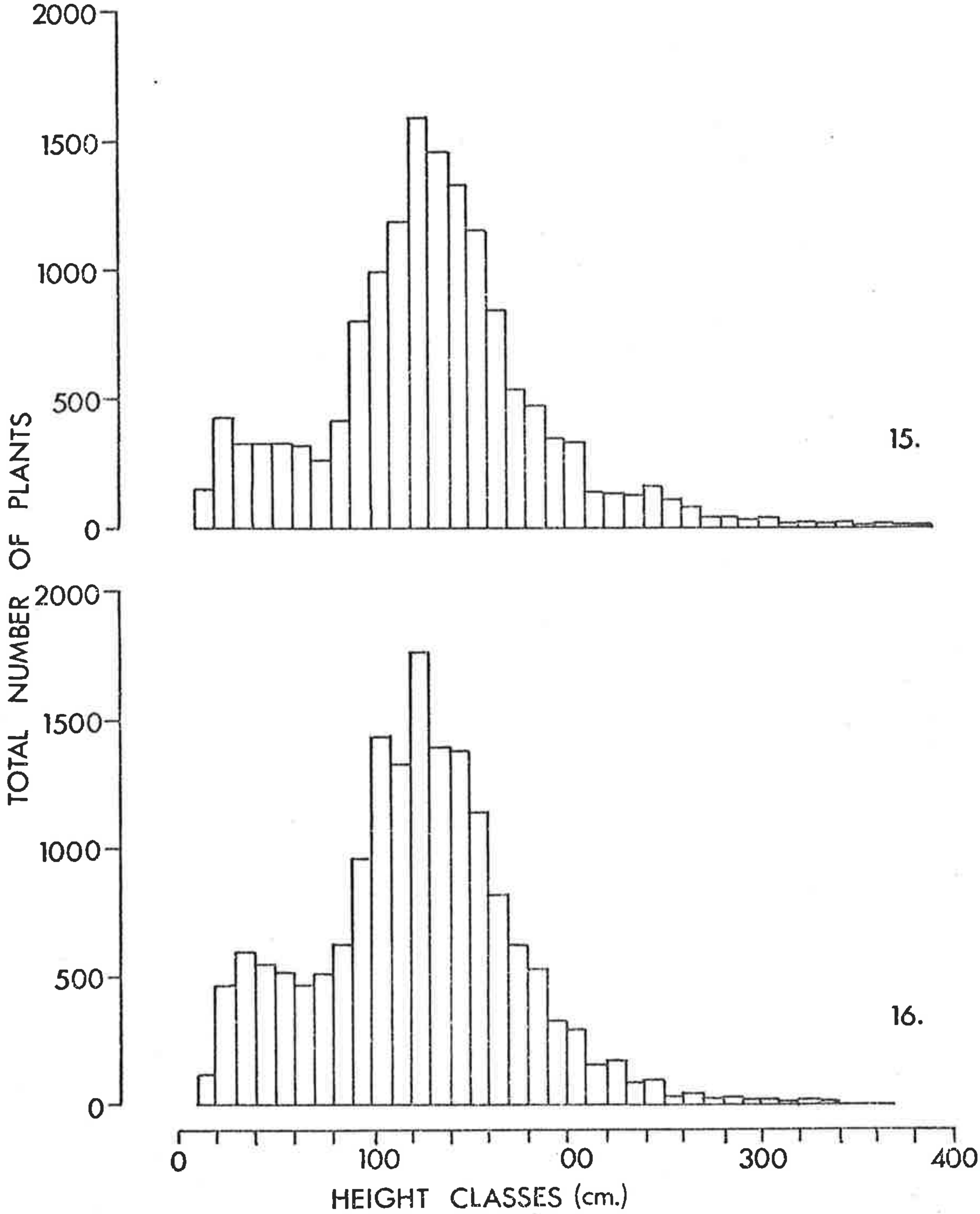


Figure 12.2.(cont.)

12.9.4. Heights of *Senecio pterophorus* (Cont.)

The heights for the first time were not available so the results shown only give an indication of their actual heights. The heights for April and May were not measured as they were below ten centimetres. In sections of the area the seedlings were so dense that they formed a mat over the ground. In June some of the plants were greater than ten centimetres in height. In August and September there was a rapid increase in the number of seedlings above ten centimetres. Until the end of 1973 the seedlings grew rapidly in height with the numbers of seedlings increasing. In the autumn of 1973, there was a further increase in young seedlings which grew rapidly in the remainder of 1973 so that the majority of plants present in October 1973 were approximately a metre in height. In the autumn of 1974 there was a further increase in young seedlings so giving two peaks in height results.

The ability of *Senecio pterophorus* to regenerate and establish after a wild fire is clearly evident. On the basis of these results the advent of another wild fire would predictably lead to a further increase in numbers and spread of this plant species.

12.10. Summary.

The pyric succession studies carried out in Pittosporum Valley indicate that a wild fire favours the growth of alien species in this area. The two dominant perennial plant species, *Hypericum perforatum* and *Senecio pterophorus* both increased in numbers and spread in their distribution.

12.10. Summary (Cont.)

The wild fire favoured their establishment. The results presented clearly indicate that fire is undesirable if the control of these species is required.

Only the occasional native species were able to regenerate and/or establish from seed after this wild fire. The low numbers of both *Acacia pycnantha* and *Acacia melanoxylon* clearly illustrated this inability. The restriction of growth of native species to localised areas further supports the dominance of the alien species in this area. In relation to management the occurrence of another wild fire in this area would predictably increase the problem of weeds in this valley. The large seed source established since the last fire in 1972 would encourage also the establishment of more weeds in the event of another fire. Possibly the control measures attempted in the past may alleviate the problem to some extent. However the very large numbers of both *Hypericum perforatum* and *Senecio pterophorus* pose further difficulties.

This chapter indicates that if it is desirable to conserve the native vegetation in this valley, the place of fire in weed infested areas needs to be carefully considered. Further understanding of the response of individual plant species to increasing numbers of fires in our local parks is of prime importance if management policies are to be met. The study presented gives an example of the response of a variety of plant species to a wild fire. Such studies will further increase the availability of information and hence help the park authorities to make management decisions.

CHAPTER XIII

MOUNT BOLD ENCATCHMENT AREA

CONTROLLED BURNING STUDIES

13.1. Introduction.

The controlled burning experimental area is situated in a part of Section 225 of the Hundred of Noarlunga in the encatchment area of the Mount Bold Reservoir. The area is located approximately twenty-four kilometres south-south-east of Adelaide (Fig. 13.1.). Although this area is not controlled by the park authorities it provided an ideal opportunity to study the effect of control burning on a dry sclerophyll eucalypt forest. The vegetation found in the area studied is similar in composition and structure to that in many of South Australia's local parks. The South Australian Bushfire Research Council suggested the use of controlled burning as a management tool in our local parks in order to reduce the risk of wild fires threatening adjacent private properties. These techniques have been used in other areas of Australia. The amount of quantitative data on which to base these management decisions is minimal. In many instances the information consists of only descriptive accounts. To this end, an experiment was undertaken to investigate the effect of controlled burning in spring and autumn on the vegetation in this area.

13.2. Historical Background.

Stoddard (1936) was among the first to advocate the use of controlled or prescribed burning. In Australia control burning in eucalypt forests has received increasing attention over the last few years. Its use as a management tool is related to the historical development of forest management and fire control methods. (McArthur, 1962).

Figure 13.1

Location of Mount Bold Encatchment Area

(▲ indicates the location)

MOUNT BOLD ENCATCHMENT AREA

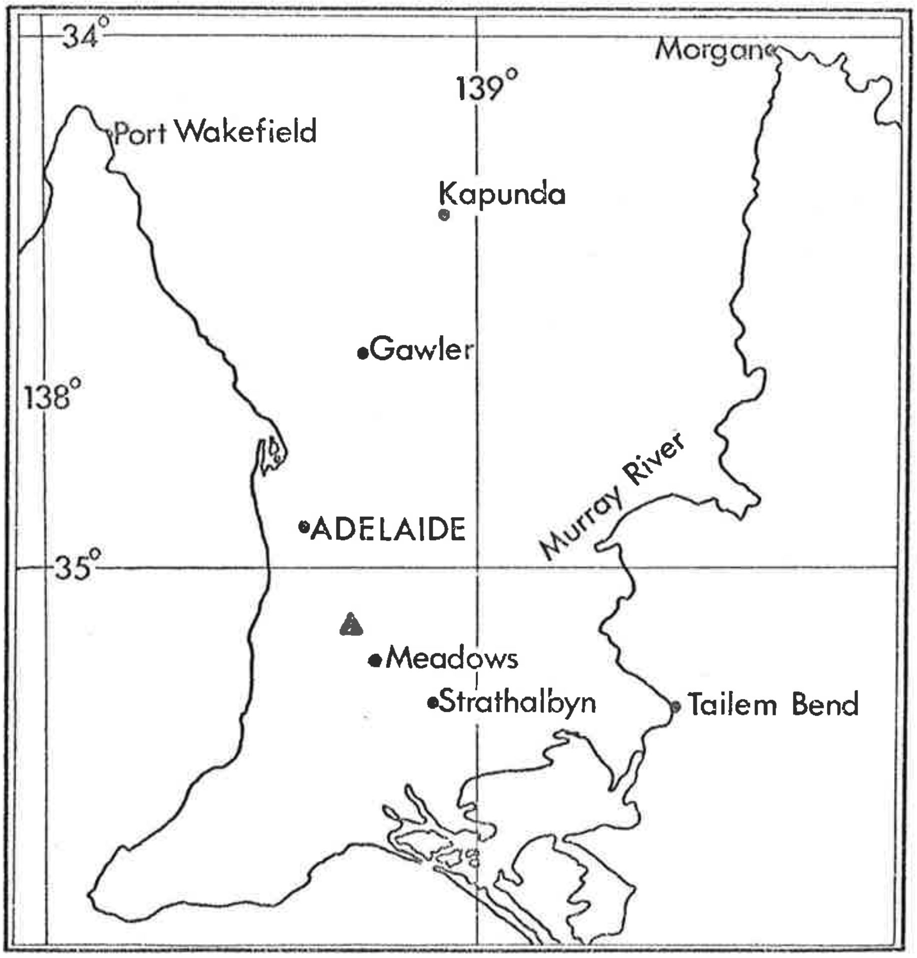


Figure 13.1.

The South Australian Woods and Forests Department previously has attempted a controlled burning on the southern side of the Mount Bold Reservoir where the quantity of undergrowth was low compared with that in the area studied in this experiment. The controlled burning in the experimental area was undertaken in autumn and spring of 1972.

The last fire in the Mount Bold Encatchment Area was in January, 1955 ("Black Sunday"). The restriction of public access to this area has left most areas undisturbed by man. The surrounding lands have been used for a variety of agricultural purposes including grazing and market gardening. The encatchment area of the Mount Bold Reservoir in comparison with these surrounding areas has been left relatively undisturbed. The edges of the encatchment area are regularly ploughed. The northern and western edges of the experimental area similarly have been ploughed. These areas and the tracks have encouraged introduced plants to establish in the encatchment area. There were also several instances of logging of eucalypts for fence posts during the twenty-nine months that the experiment was running. This logging was carried out on two of the plots and in other areas adjacent to the tracks.

Rabbits were present in low numbers in the area. Several alien plant species spread into the experimental area from the adjacent grazed paddock which was located in Section 223 of the Hundred of Noarlunga. On the north-western and western sides of the experimental area there was a young pine plantation in which African daisy, *Senecio pterophorus* was present in large numbers. This plant was among the major alien species present in the experimental area.

Rubus spp. *aff. fruticosus* (the blackberry) was present in the gullies and creeks adjacent to the experimental area.

In view of the interest in reducing wild fires in the local national parks this area provided an ideal opportunity to collect quantitative data on the response of some plant species to controlled burning in spring and autumn.

13.3. Climate.

The climatic data for Belair "Kalyra" in Table 8.1., gives an indication of the prevailing conditions at Mount Bold. The rainfall recordings for Mount Bold over the last three years are provided in Table 13.1..

Table 13.1.
Rainfall Recordings for Mount Bold
(Taken from the records of the Bureau of Meteorology, Adelaide and the South Australian Department of Woods and Forests).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total for Year
1972	50	50	1	54	24	53	138	130	61	56	23	17	657
1973	28	56	46	64	105	121	140	98	126	69	34	57	944
1974	40	63	10	92	87	64	163	87	128	146	8	36	925

The marked seasonal variation in rainfall and temperature is clear from Table 8.1. and Table 13.1.. The climate therefore approximates that found in previously discussed areas and consists of cold, wet winters and hot, dry summers.

13.4. Physiography and Drainage.

The main physiographic features of the area are the deeply dissected, steep sided valleys. The elevation of the area studied varies from two hundred and forty metres to three hundred and seventy metres above sea level. The area forms part of the original extensive peneplain which has been block-faulted and subsequently dissected by several rivers including the Onkaparinga River (Specht and Perry, 1948). The Mount Bold Reservoir is built on this river. The waters of the Onkaparinga River enters St. Vincent Gulf at Port Noarlunga. Around the reservoir the valleys are steep and narrow, however towards the coast they become broader.

13.5. Geology and Soils.

The geology of the Mount Lofty Ranges has been described by several workers including Sprigg (1942), Sprigg (1946) and Rix and Hutton (1953).

The underlying rocks consist of Pre-Cambrian sediments called the Adelaide Series, which have been extensively faulted and folded. In the experimental area of the Mount Bold Encatchment Area the parent material consists of phyllites and slates with minor quartzites. The plots in the western part of the experimental area consist principally of sandstone and sandstone quartzite lensing out into sandy slates. The plots in the eastern part of the experimental area consist of principally sandstone and argillaceous sandstone with numerous interbedded sandy and silty shales (Sprigg, 1954). The soils vary from sandy-loam in the western part to sandy soils in the eastern part of the experimental area.

13.6. Vegetation.

The vegetation varies from an *Eucalyptus obliqua-Eucalyptus leucoxylon* association to an *Eucalyptus obliqua - Eucalyptus fasciculosa* association. *Eucalyptus obliqua* is well established throughout the experimental area. The undergrowth varies a great deal across the area. The plots at the higher altitudes, which support the *Eucalyptus obliqua - Eucalyptus fasciculosa* association have a dense sclerophyllous understorey consisting of *Banksia marginata, Acacia pycnantha, Acacia myrtifolia, Pultenaea daphnoides, Daviesia virgata, Xanthorrhoea semiplana* and species of *Hakea*. The undershrubs include species of *Hibbertia, Platylobium obtusangulum, Tetratheca pilosa, Calytrix tetragona* and *Isopogon ceratophyllus*. The ground cover is sparse and consists of native grasses and herbs. Some alien species are present in this vegetation but in the main are restricted to localised areas.

The *Eucalyptus obliqua - Eucalyptus leucoxylon* association occurs on the lower valley slopes and sheltered areas. A dense undergrowth is absent, the main plants being *Acacia pycnantha, Xanthorrhoea semiplana* and *Lepidosperma semiteres*. The ground cover is dense and supports a large range of native and alien grasses and herbaceous species. The heterogeneity present in the vegetation gave the advantage of observing the effect of the controlled burning on a larger range of species. The only limitation was that by including this variety into the experimental area the replication of similar undergrowth was restricted.

The presence of *Senecio pterophorus* in the experimental area was of particular interest, particularly in light of the work carried out in Belair Recreation Park where the results indicated that this species was favoured by the advent of a fire.

Although this work was not carried out in a national park it provided an ideal opportunity to study the impact of prescribed burning on the native vegetation in the *Eucalyptus obliqua* sclerophyll forest. This is particularly relevant in view of the fact that the *Eucalyptus obliqua* forest is known to be particularly prone to firing in the Adelaide Hills. Further, man in his decision to use this tool could affect markedly the vegetation present in the local parks.

If controlled burning favoured by many, does reduce the fuel accumulation and hence the risk of wild fires it may help to avoid a conflagration. Others have suggested that numbers and amount of undershrubs is increased so defeating the original aim of prescribed burning i.e. to reduce fuel accumulation. The frequency of fires then becomes an important consideration. The limitations of time did not enable subsequent burns. Prescribed burning is also questioned in light of the fact that many native species have adapted over the years to regular firing.

The research was therefore carried out with the following objectives in mind:

a. To carry out a reconnaissance of the Mount Bold Encatchment Area to gain a general description of the area.

b. To construct a floristic list as a basis for the identification of plant species.

c. To study the response of the plant communities to both spring and autumn controlled burns.

d. To investigate the response with time of individual plant species to the burns by measuring the density and/or biomass and/or cover of some of the plant species.

Reconnaissance and the collection of plants were carried out on several occasions. The floristic list presented in Appendix II is complete as far as practical.

The area was divided into ten plots of which the last nine were sixty metres by eighty metres in size, while the first was one hundred metres by forty metres. The location of the plots is shown in Fig. 13.2. The odd numbered plots were burnt in autumn, 1972 and the even ones were burnt in spring of the same year, see Table 13.2.. The third plot was not burnt as the undergrowth was too wet. As a result there were four autumn plots and five spring plots. In the first plot there were ten large rectangular quadrats (ten metres by two metres) and ten small square quadrats (one metre by one metre). In all other plots there were twelve large and ten small quadrats. The location of the larger quadrats was systematic along parallel traverses twenty metres apart. The smaller were also along these traverses but their positions were randomized. The location of the quadrats was along these traverses due to time considerations.

The vegetation was followed by measuring the density and/or biomass and/or cover of the major plant species in this area at different time intervals over a period of twenty-nine months. The density and biomass of the plants were recorded for both large and small quadrats. The results presented were separated into four categories, autumn burn - large quadrats, autumn burn - small quadrats, spring burn - large quadrats and spring burn - small quadrats. Biomass was measured by estimating the biomass of individual plants and then converting this estimate into kilograms per hectare. The biomass estimations were collected using a unit of estimated weight and comparing the biomass of individual plants with this estimate. The conversion was carried out by collecting plants of estimated weights

Figure 13.2.

Location of the experimental plots in the Mount Bold Encatchment Area.

---------	Border of the Mount Bold Reservoir
– – – –	Onkaparinga River
═════	Tracks

MOUNT BOLD ENCATCHMENT AREA

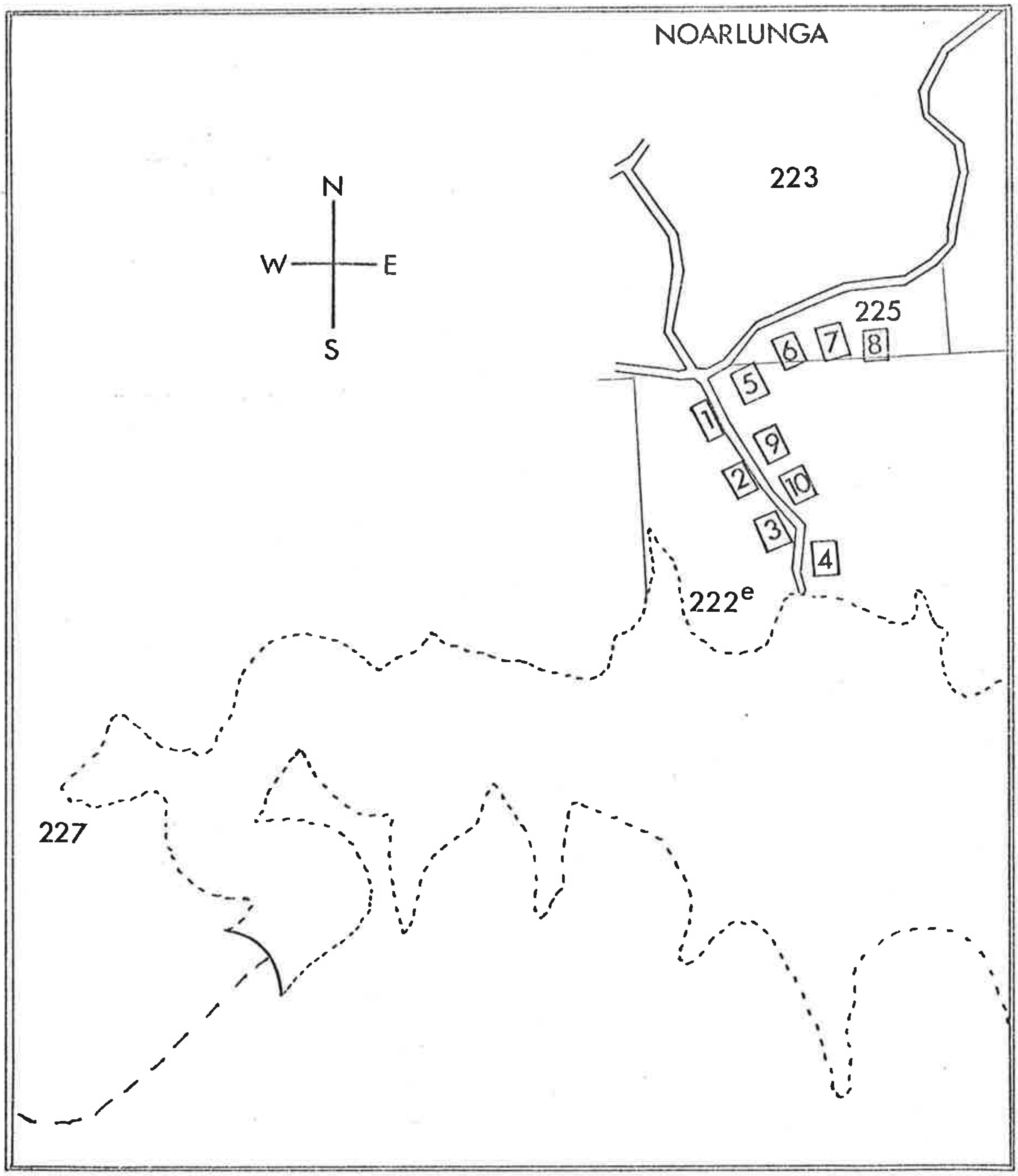


Figure 13.2.

and then weighing them for both wet and dry weights. The dry weights were measured by drying the plants in an oven at eighty degrees Celcius for forty-eight hours.

Percentage cover, i.e. cover, was measured by the total line interception on eleven parallel lines (in the one metre by one metre quadrat) ten centimetres apart.

$$\text{i.e. Percentage cover} = \frac{\text{Total line interception of plant species}}{\text{Total line interception (1100 cm.)}} \times 100$$

All means and standard errors were calculated using the CDC 6400 Computer at the University of Adelaide. The results were then plotted for the four different categories. The means for the different times were tested by using a T-test program which does not assume that the variances are equal. The program was based on a subroutine for T-tests taken from the IBM Application Program Manual.

The fuel quantity (tons/Ac.), rate of spread (ft/min.) and fire intensity (B.T.U./ft./sec.), date of burning, aspect and percentage burn are provided in Table 13.2.. These results are taken from the records of the South Australian Department of Woods and Forests.

The results for some of the plant species are presented in the following section. Obviously the inclusion of all the results in this thesis is not practical. Therefore only references will be made to the other plant species in this experimental area.

13.9. Results.

13.9.1. Introduction.

The floristic list is presented in Appendix II. The experimental area was first examined in May, 1972.

Unfortunately limitations of time did not allow a study of seasonal changes in the vegetation prior to the burning experiment. The results for some of the shrub species are presented in the following sections. Species are discussed separately in the following sections - *Platylobium obtusangulum* (13.9.2.), *Acacia pycnantha* (13.9.3.), *Senecio pterophorus* (13.9.4.), *Hibbertia sericea* (13.9.5.), *Hibbertia stricta* (13.9.6.) and *Hibbertia exutiacies* (13.9.7.). The discussion of significance of changes in density biomass and cover are based on the T-test results. A probability level of five per cent is accepted. The Fisher and Yates' Statistical Tables for Biological, Agricultural and Medical Research, were used to test the significance of the values of t. All of these species will be discussed separately and then finally in sub-section 13.9.8..

13.9.2. Results for *Platylobium obtusangulum*.

The results for *Platylobium obtusangulum* appear in Figure 13.3. and 13.4.. *Platylobium obtusangulum* is a member of the family, Fabaceae. It is relatively frequent in South Australia and extends in distribution from Kangaroo Island to the Mount Lofty Ranges and into the south-east. This perennial, glabrous shrub is one of four species of *Platylobium* in Australia. In Mount Bold Encatchment Area this plant species is widespread.

The density results for *Platylobium obtusangulum* appear in Fig. 13.3. *Platylobium obtusangulum* is present in relatively large numbers in all plots except for plots two, nine and ten. Therefore this species varies in its numbers through the experimental area. The results clearly indicate that all four treatments (autumn burn - large quadrats, autumn burn - small quadrats, spring burn - large quadrats and spring burn - small quadrats) show an increase with time, in the number of plants of this species .

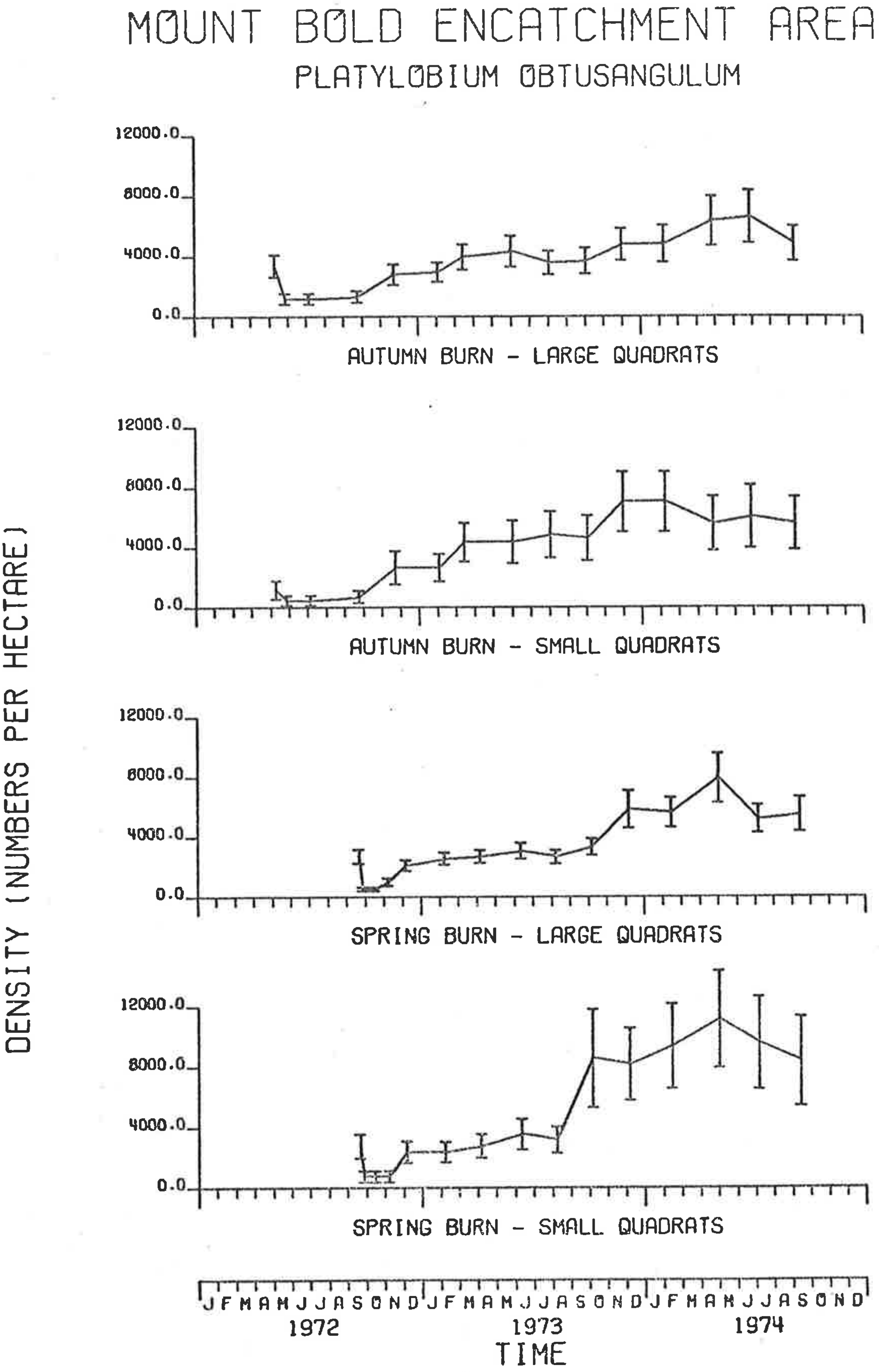

MOUNT BOLD ENCATCHMENT AREA
PLATYLOBIUM OBTUSANGULUM
12000.0
8000.0
4000.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
DENSITY (NUMBERS PER HECTARE)
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.3.

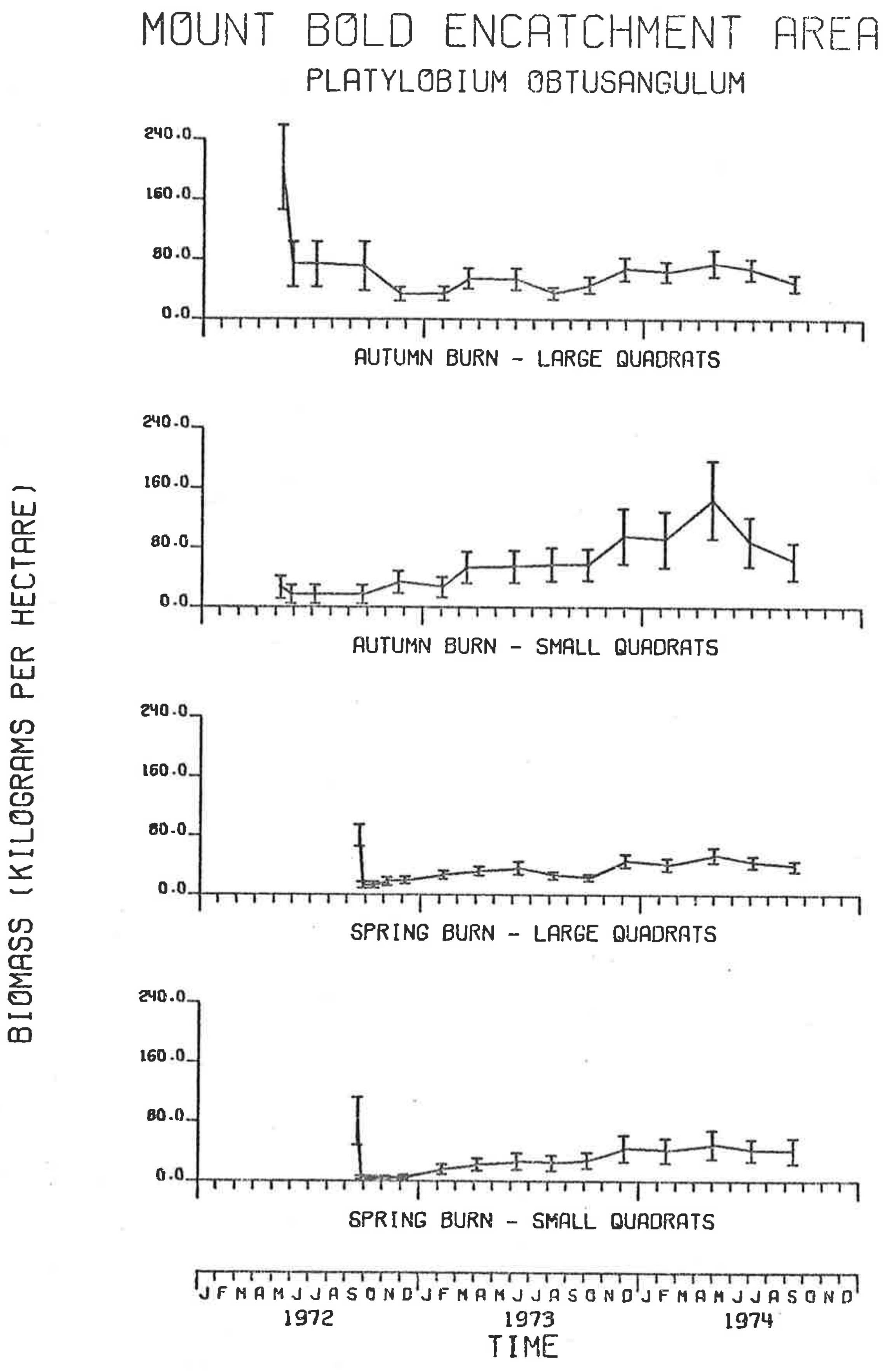

MOUNT BOLD ENCATCHMENT AREA
PLATYLOBIUM OBTUSANGULUM
BIOMASS (KILOGRAMS PER HECTARE)
240.0
160.0
80.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.4.

The autumn burn - large quadrats show a statistically significant decrease in the numbers of *Platylobium obtusangulum* after the fire in May, 1972. In November this trend was reversed with an increase in plants as a result of regrowth and the establishment of new seedlings. This increase in numbers continued well into 1974. Despite this apparent increase, the numbers after the fire did not significantly increase above those numbers prior to the fire.

The autumn burn - small quadrats supported low numbers of *Platylobium obtusangulum* before the fire. There was not a significant drop in numbers after the fire. However by March, 1973 the numbers had significantly increased when compared with those before the fire. This trend continued with a further increase in numbers of *Platylobium obtusangulum* in the last few months of 1973.

The spring burn - large quadrats show a statistically significant drop in numbers of *Platylobium obtusangulum* plants after the fire in September, 1972. The number of plants did not significantly increase until December, 1973. The number of plants in the last ten months was significantly higher than prior to the fire.

The spring burn - small quadrats show a similar decrease in numbers after the fire. Similarly a significant increase in the density of *Platylobium obtusangulum* was seen after December, 1973. The numbers stabilized and then dropped slightly in the middle of 1974.

In summary, the density of *Platylobium abtusangulum* increased in all four categories. However, the autumn burn results for the large quadrats were not significantly higher than prior to the fire.

From these results it is possible to predict that both spring and autumn burns favour the regrowth and establishment of seedlings of *Platylobium obtusangulum*. As the majority of plants present prior to the fire regrew from vegetative parts the large increase in numbers is due to the establishment of seedlings.

The biomass results for *Platylobium obtusangulum* appear in Figure 13.4..

The autumn burn - large quadrats show a decrease in biomass after the controlled burn. However, in November 1972, there was a further decrease which was statistically significant when compared with that prior to the fire.

This trend continued to the end of the experiment in 1974. Therefore despite an increase in the number of plants after the fire the biomass remained significantly lower than before the fire.

The autumn burn - small quadrats show a slight decrease after the controlled burn and then a slight increase which was not significantly different from that prior to the fire except for the reading in April, 1974. The reduction in biomass in the latter part of 1974 can be explained by some of the regrowth on the regenerated plants dying. In some instances this dying off resulted in large sections and/or whole plants dying. This process is also reflected in the density results in Fig. 13.3., where there is a drop in the number of plants during 1974.

The spring burn - large quadrats show a statistically significant decrease in the biomass of *Platylobium obtusangulum* after the controlled burn.

In the summer of 1973 and into 1974 there was a slight increase in biomass. The large number of seedlings that established in 1973 and 1974 were still very small and hence did not contribute significantly to the biomass of this species.

The spring burn - small quadrats show a significant decrease in biomass after the fire, however, this trend was reversed in February 1973 and the biomass then slightly increased with time. The biomass in 1974 does not differ significantly from that prior to the fire.

In summary, despite the increase in numbers of plants the biomass is significantly lowered by controlled burning. On one hand there is therefore an increase in the number of plants, but on the other a decrease in biomass. Predictably the large number of seedlings of *Platylobium obtusangulum* would result in an increase in biomass in the next few years unless intra and interspecific competition restricts their numbers and biomass. The plants that regenerated from rootstocks flowered in September 1974, however, the seedlings did not flower during the length of the experiment.

13.9.3. Results for *Acacia pycnantha*.

The density results for *Acacia pycnantha* are presented in Fig. 13.5..

Acacia pycnantha (Golden Wattle) is a tall, glabrous shrub or small tree. It is widespread in distribution in South Australia. In the Mount Bold Encatchment Area it is frequent as it is in the remainder of the Adelaide Hills.

The autumn burn - large quadrats show a significant decrease in numbers after the fire. In September 1972 there was a slight

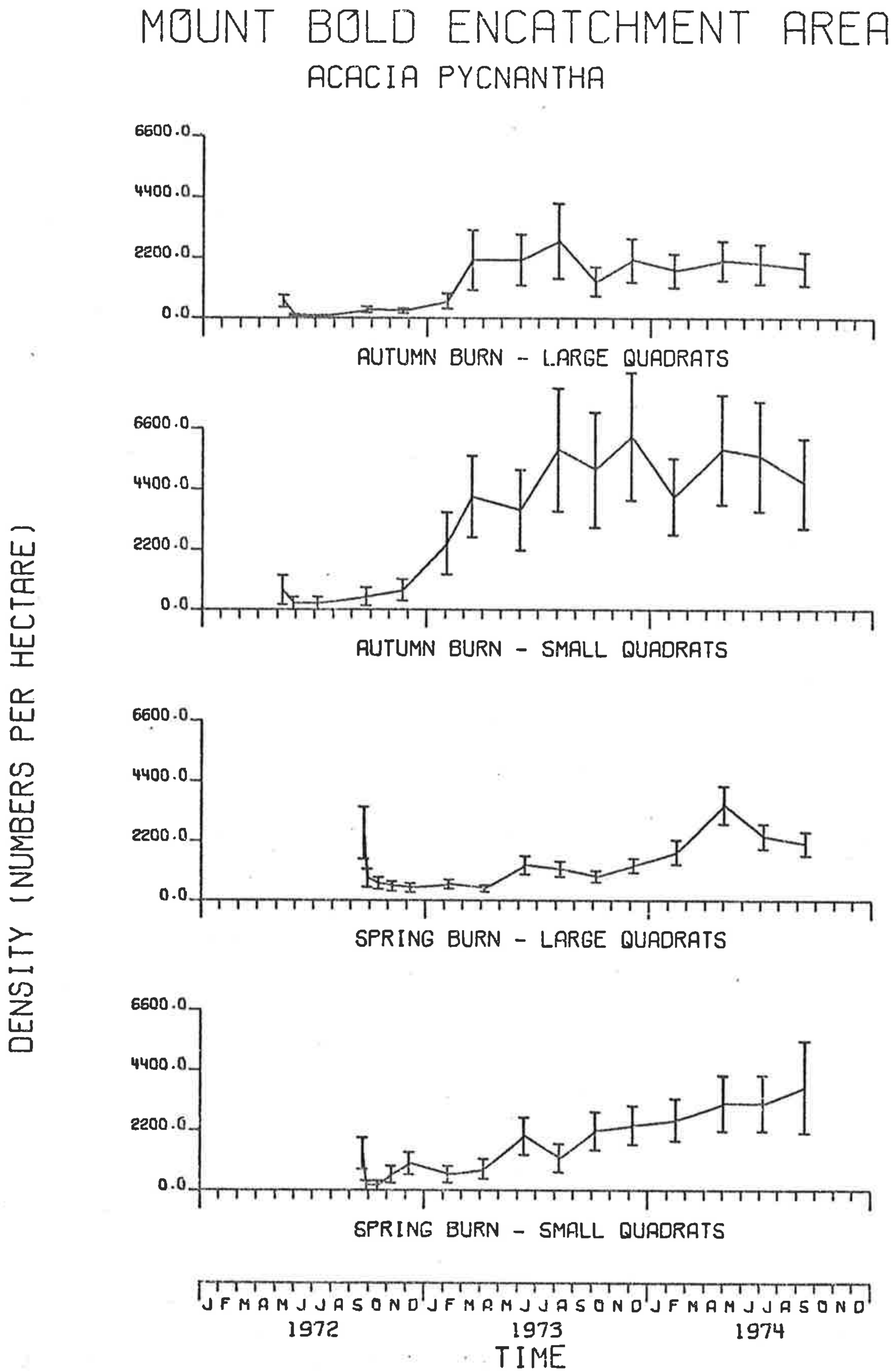

MOUNT BOLD ENCATCHMENT AREA
ACACIA PYCNANTHA
DENSITY (NUMBERS PER HECTARE)
6600.0
4400.0
2200.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.5.

increase in numbers and this was maintained throughout the experiment. However, at no time was the density of *Acacia pycnantha* significantly higher than that before the fire.

The autumn burn - small quadrats supported low numbers of *Acacia pycnantha* prior to the fire. However after the fire there was a significant increase in the numbers of *Acacia pycnantha*. After the middle of 1973 these numbers stabilized and were significantly higher than those prior to the fire.

The spring burn - large quadrats show a decrease in the numbers of *Acacia pycnantha* after the fire. The December (1972) and April (1973) densities were significantly lower than those prior to the fire. There was a subsequent increase in the number of plants of *Acacia pycnantha*, however the numbers were not statistically significant from those prior to the controlled burn.

The spring burn - small quadrats show a decrease in numbers after the fire. However in summer, 1972, the numbers of plants increased and continued to do so through the experiment. The number of plants of *Acacia pycnantha* at the end of the experiment were still not significantly higher than before the fire.

The majority of results for *Acacia pycnantha* indicate that the densities of this plant did not change significantly after the fire. The autumn burn - small quadrats were the exception to this. After the fire the population of *Acacia pycnantha* consisted of mainly young seedlings and only the occasional plant that had regenerated. Only the occasional *Acacia pycnantha* in the burnt area flowered in the spring of 1974.

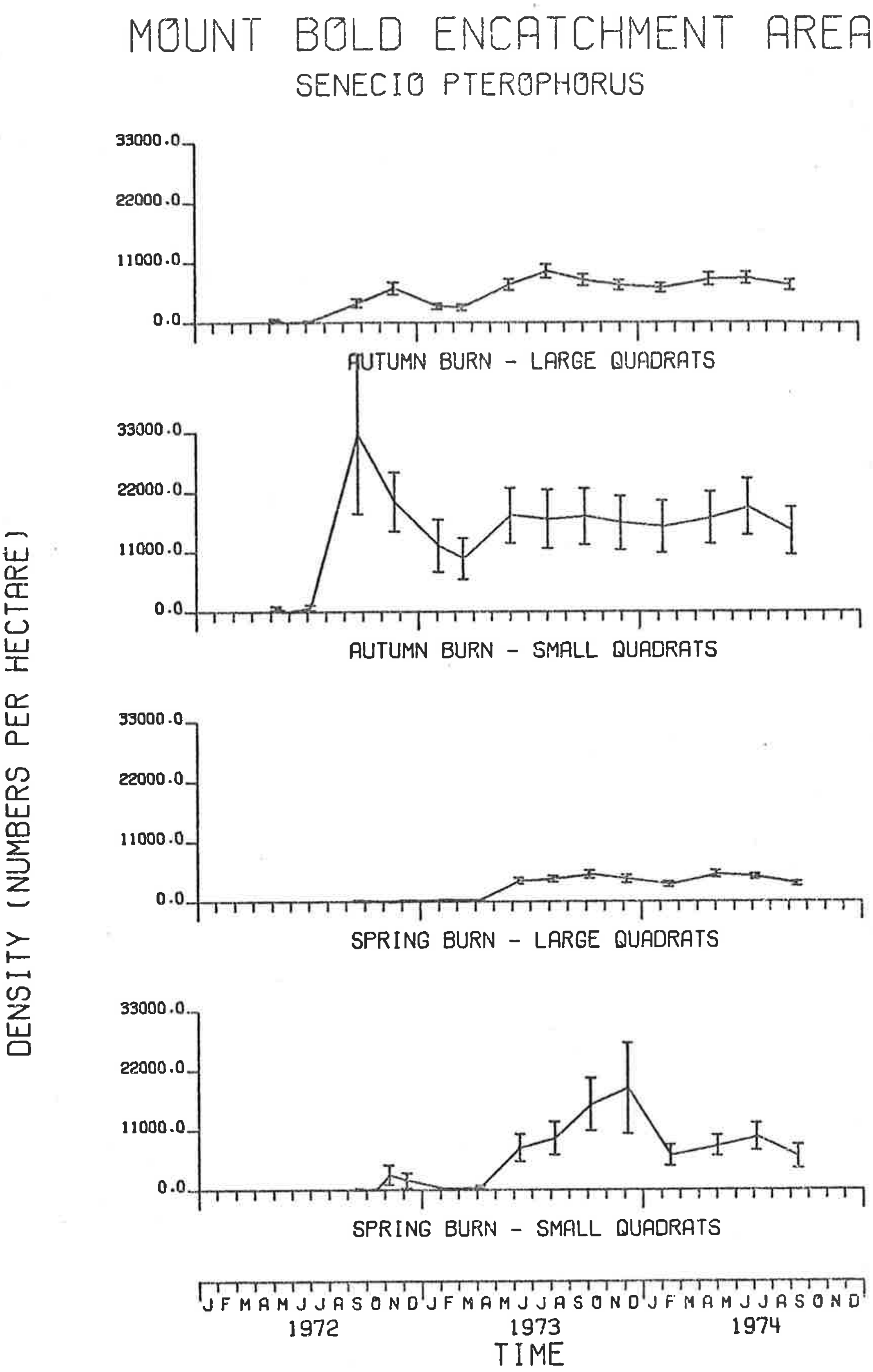
The density results for *Senecio pterophorus* are presented in Fig. 13.6..

Senecio pterophorus, a tall shrub, is one of the major weeds in many of the local parks in South Australia. The history of this plant has already been discussed in 12.2.2.. In the Mount Bold Encatchment Area the plant is mainly restricted to the ploughed areas and the margins of the native vegetation. However it is present in large numbers in the young pine plantations.

The autumn burn - large quadrats show a statistically significant decrease in numbers after the fire. The numbers however rapidly increased and were significantly higher than those prior to the fire. The numbers after the fire were approximately eleven times what they were prior to the fire.

The autumn burn - small quadrats show a slight fall after the fire. In September 1972 there was a rapid increase in the number of seedlings. After this initial increase many of the seedlings died off in the summer months. In 1973 and 1974 the numbers stabilized to approximately sixteen thousand plants per hectare. The majority of the plants after the fire established from seeds. The increase of twenty times the number in the course of the experiment clearly illustrates that fire encourages the growth of this plant.

The spring burn - large quadrats show a decrease in plants of *Senecio pterophorus* after the fire. The numbers rapidly increased in the winter of 1973 to be significantly higher than before the fire. The increase in numbers at the end of the experiment was sixteen times that at the beginning.



MOUNT BOLD ENCATCHMENT AREA
SENECIO PTEROPHORUS
DENSITY (NUMBERS PER HECTARE)
33000.0
22000.0
11000.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.6.

The spring burn - small quadrats show a similar result to those discussed for the large quadrats. The difference lies in the changes in numbers being exemplified. For example there was a reduction of seedlings in the summer months. The increase in numbers at the end of the experiment is thirty times that at the beginning.

The large increases in *Senecio pterophorus* in all four categories clearly indicates that fire is undesirable. Only the occasional plant flowered and seeded in 1973 and 1974. The seasonal variation in numbers of *Senecio pterophorus* may possibly be used in considerations of control techniques.

13.9.5. Results for *Hibbertia sericea*.

The density and biomass results for *Hibbertia sericea* appear in Fig. 13.7. and 13.8..

Hibbertia sericea, a small shrub, is a member of the family, Dilleniaceae. It is widespread in its distribution in South Australia. This plant is present in relatively large numbers in the Mount Bold Encatchment Area. The distribution in the experimental area varies a great deal.

The density and biomass of *Hibbertia sericea* in the larger quadrats were not recorded prior to the burn. As a result the smaller quadrats are used to compare the results prior to the fire with subsequent ones.

In the autumn burn - large quadrats the results clearly indicate a significant increase in numbers of *Hibbertia sericea* in the winter of 1973.

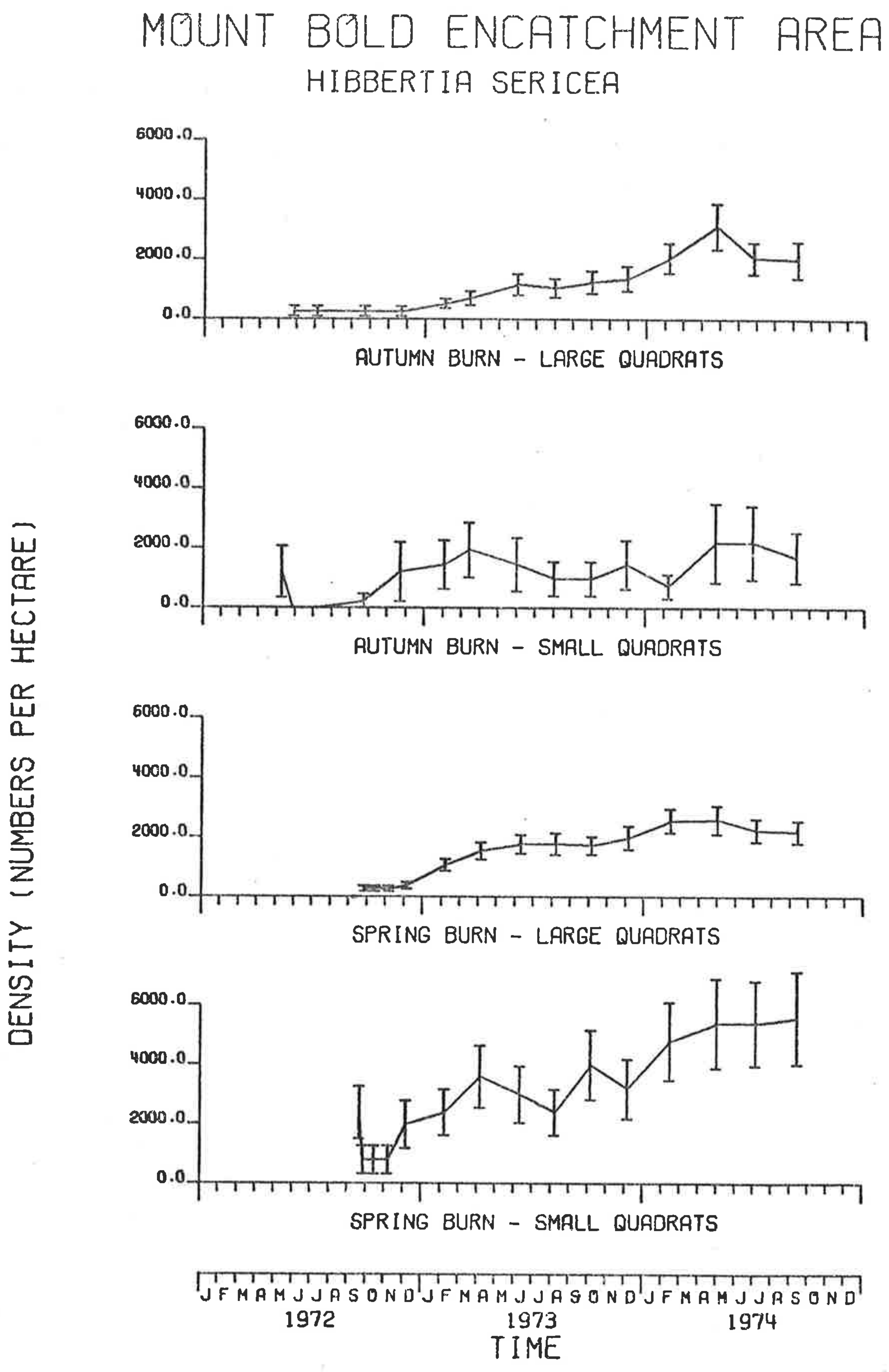

MOUNT BOLD ENCATCHMENT AREA
HIBBERTIA SERICEA
DENSITY (NUMBERS PER HECTARE)
6000.0
4000.0
2000.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.7

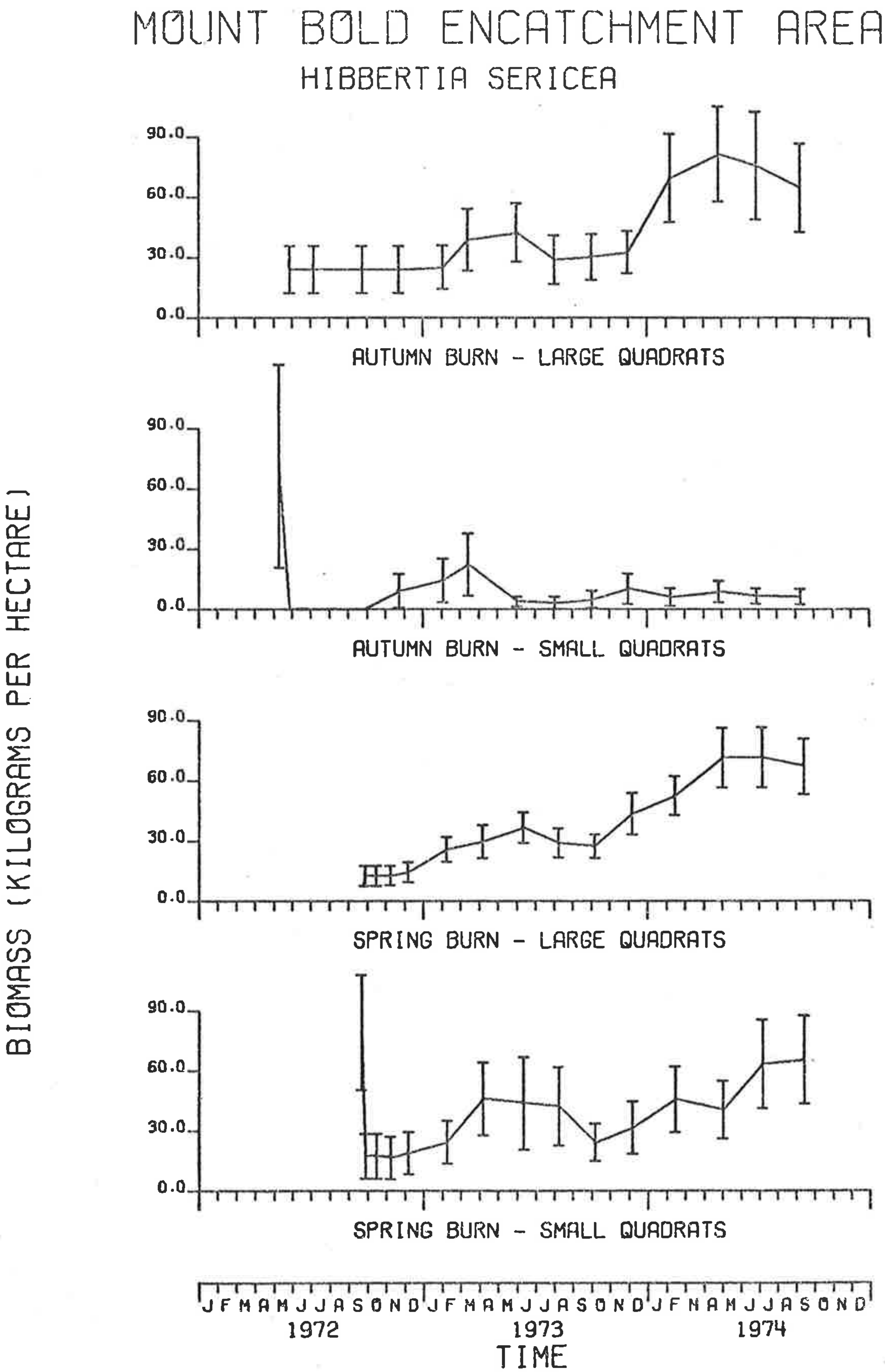

MOUNT BOLD ENCATCHMENT AREA
HIBBERTIA SERICEA
BIOMASS (KILOGRAMS PER HECTARE)
90.0
60.0
30.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.8.

This trend continues with a further increase in numbers in 1974. The autumn burn - small quadrats show a decrease in numbers after the fire. The density of *Hibbertia sericea* then increased, however the numbers at the end of the experiment were not significantly higher than before the fire.

In the spring burn - large quadrats there was a significant increase in the numbers after February 1973. This increase was continued and stabilized through 1973 into 1974. The spring burn - small quadrats show a decrease in numbers after the controlled burn. *Hibbertia sericea* regrew in the summer of 1972-1973. This increase continued in 1973 and 1974. The densities in 1974 were not significantly higher than those before the burn. This was due to the low number of seedlings. The majority of plants regenerated from rootstocks after the fire. Of these a few flowered during the latter part of the experiment.

The biomass results for *Hibbertia sericea* in the autumn burn - large quadrats indicate that the biomass gradually increased after the controlled burn. The recording in April 1974 was the only one that was significantly higher than the biomass after the fire. The autumn burn - small quadrats show a significant decrease and then an increase in biomass after the controlled burn. The biomass of the plants does not increase markedly after the fire.

The spring burn - large quadrats show a marked increase with time. The slight decrease in biomass in winter to spring of 1973 soon changed in the following summer and autumn. The spring burn - small quadrats show a significant decrease in biomass after the burn. The biomass then increases but does not become higher than that before the fire.

13.9.5. Results for *Hibbertia sericea* (Cont.)

These results for *Hibbertia sericea* clearly indicate that there was only a slight change in the density but a lowered biomass on all plots. The plants in the spring plots appeared able to regrow better than those in the autumn plots. This higher biomass can be explained by the higher density of *Hibbertia sericea* in the spring plots.

Cover was recorded for this species but the results were insignificant as the percentage cover was so small. No significant change in cover was recorded with time.

13.9.6. Results for *Hibbertia stricta*.

The density, biomass and percentage cover results for *Hibbertia stricta* appear in Fig. 13.9., 13.10. and 13.11..

Hibbertia stricta, a member of the family, Dilleniaceae is a small erect shrub. It is widespread in its distribution in South Australia. This plant is present in relatively large numbers in the Mount Bold Encatchment Area. The distribution in the experimental area varies a great deal.

The density and biomass of this plant in the large quadrats were not recorded prior to the fire. As a result the smaller quadrats are used to compare the results prior to the fire with subsequent ones. The results for the autumn burn - large quadrats clearly indicate that there was a significant increase after March 1973. This trend continued until the end of the experiment. These last nine densities were significantly higher than the density at the time of the fire. The autumn burn - small quadrats show no significant change in the density of *Hibbertia stricta* in the last three years.

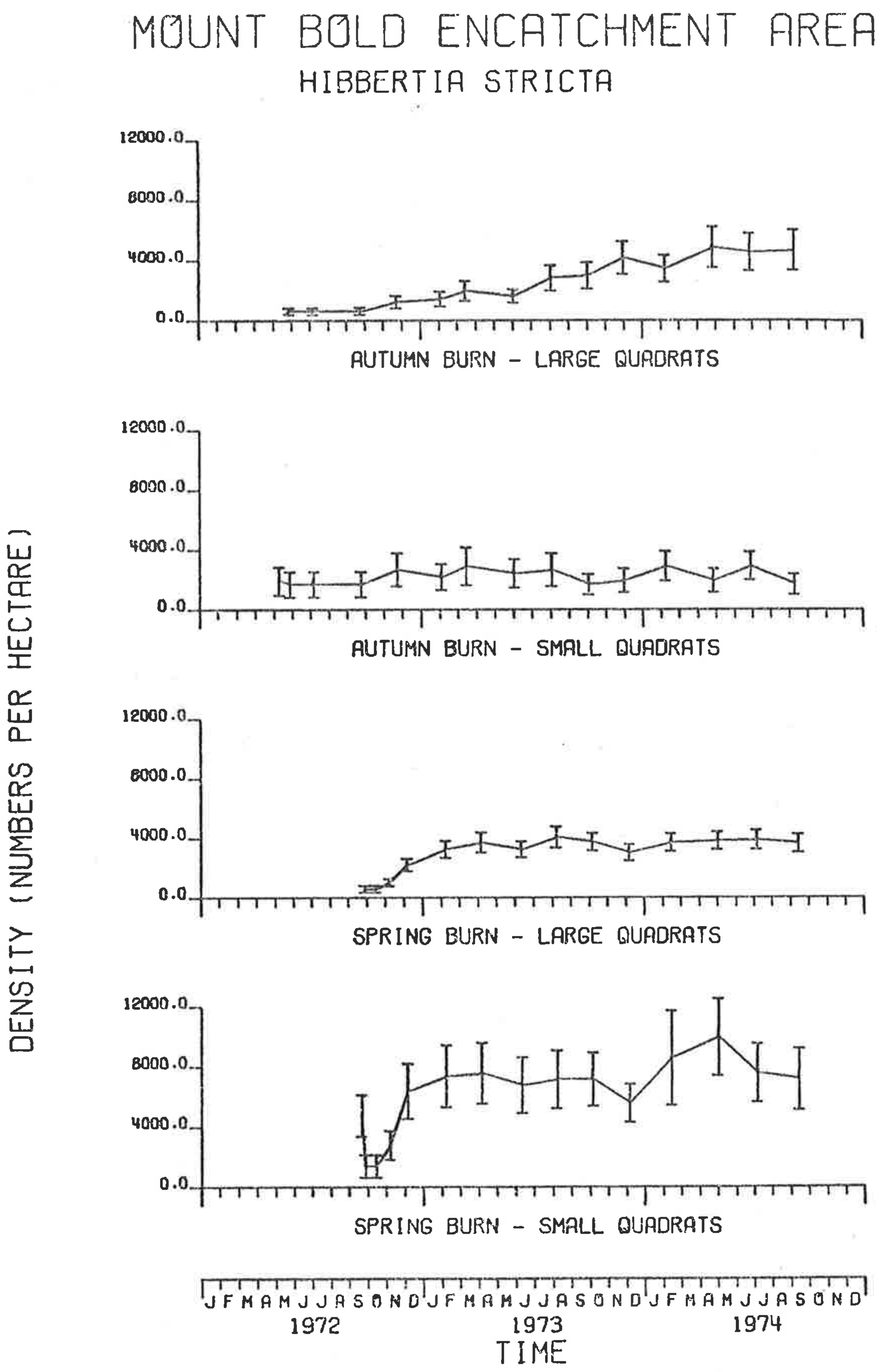

MOUNT BOLD ENCATCHMENT AREA
HIBBERTIA STRICTA
DENSITY (NUMBERS PER HECTARE)
12000.0
8000.0
4000.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.9.

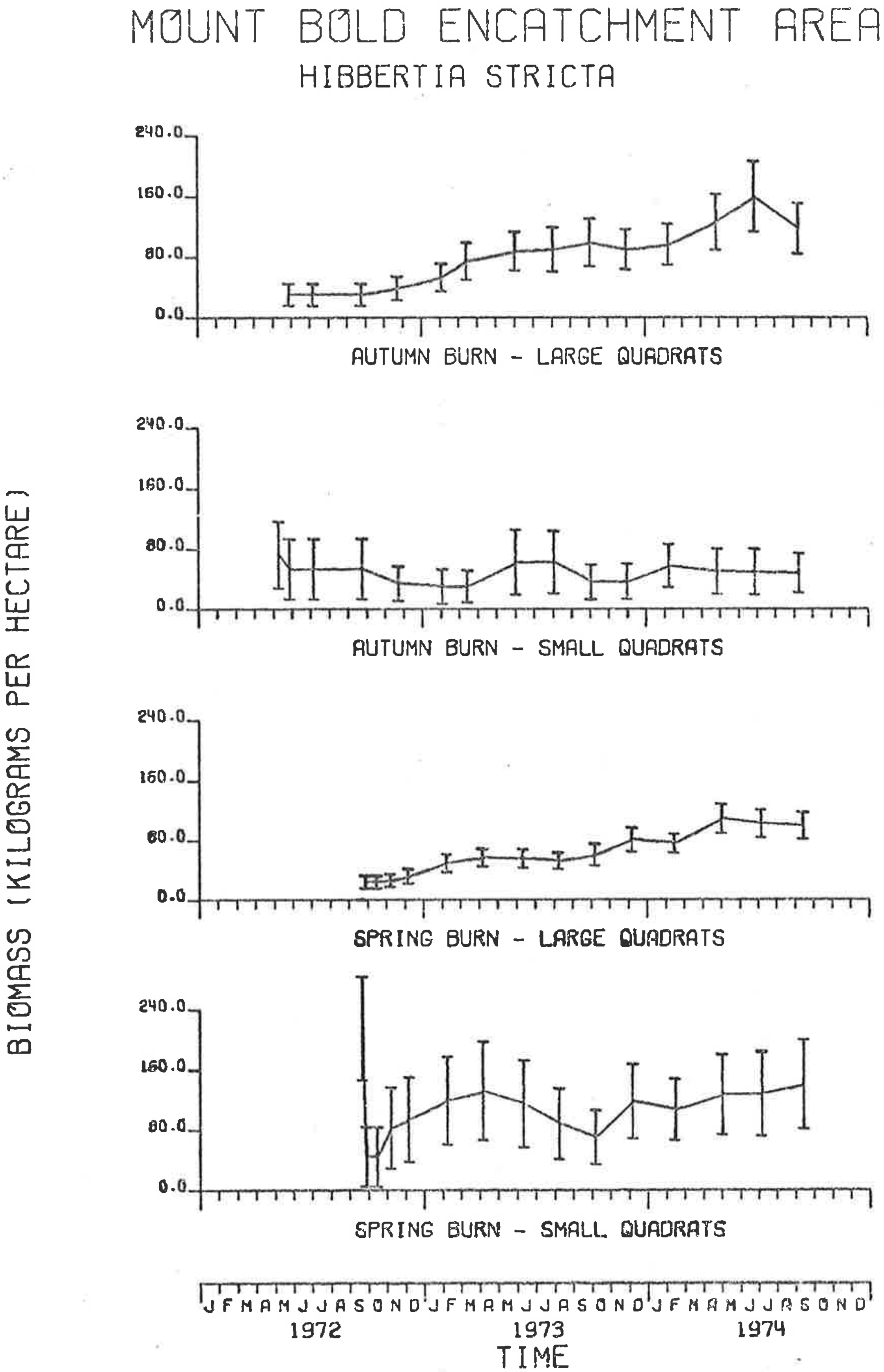

MØUNT BØLD ENCATCHMENT AREA
HIBBERTIA STRICTA
BIØMASS (KILØGRAMS PER HECTARE)
240.0
160.0
80.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.10.

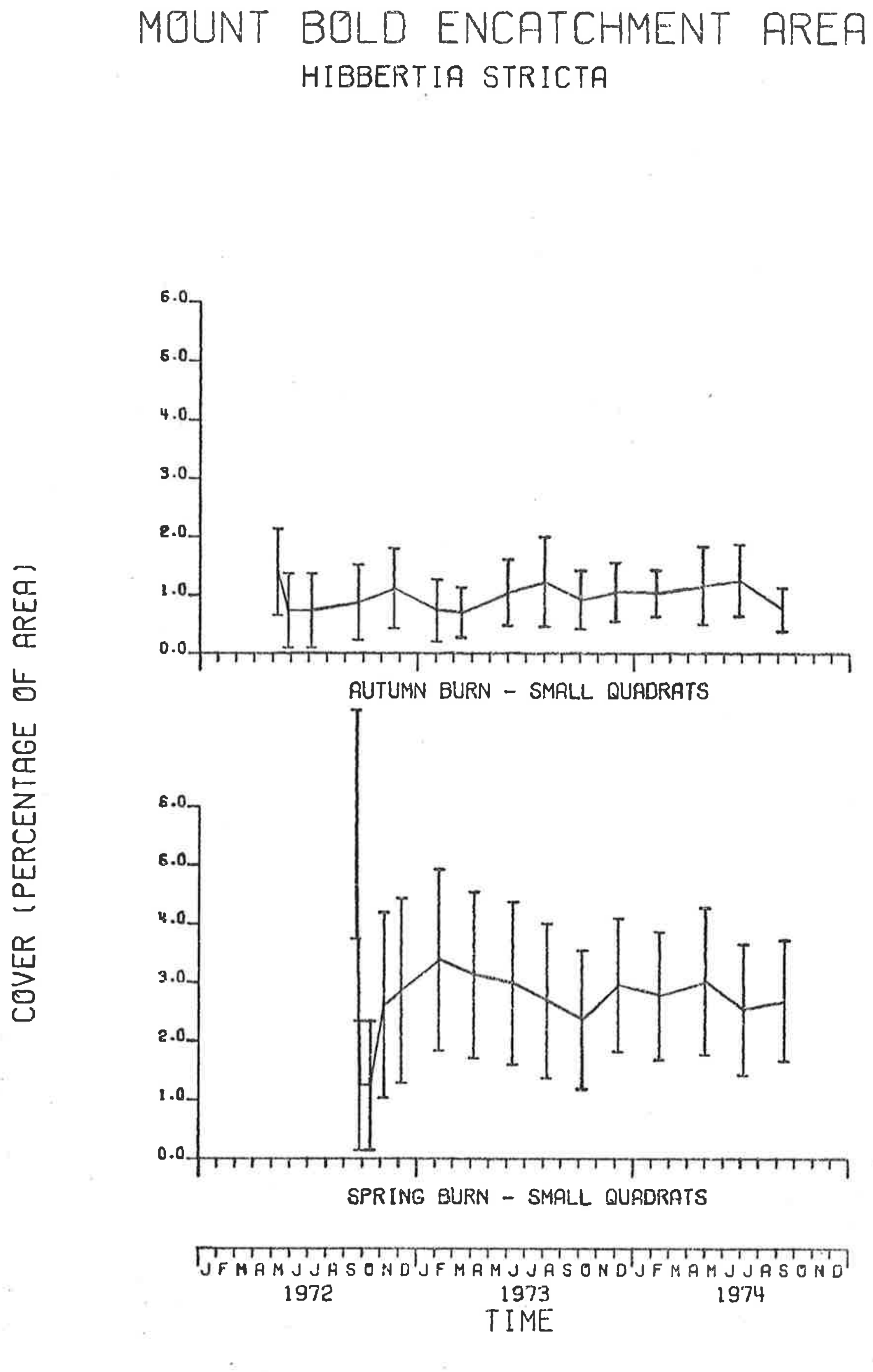

MOUNT BOLD ENCATCHMENT AREA
HIBBERTIA STRICTA
COVER (PERCENTAGE OF AREA)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
AUTUMN BURN - SMALL QUADRATS
6.0
5.0
4.0
3.0
2.0
1.0
0.0
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.11.

The spring burn - large quadrats show a significant increase in the density of *Hibbertia stricta* in December 1972. This increase stabilized after the summer to show little variation for the remainder of the experiment. On the other hand the spring burn - small quadrats showed a significant initial decrease in density with the controlled burn. In December 1972 the density was significantly higher than that immediately after the fire. However the density did not change significantly from that prior to the fire.

The density of *Hibbertia stricta* did not significantly change for the duration of the experiment i.e., the density prior to burning was similar to that in September 1974.

The biomass of *Hibbertia stricta* in the autumn burn - large quadrats did not increase significantly after the fire until 1974. In the autumn burn - small quadrats the biomass did not significantly change for the length of the experiment.

The spring burn - large quadrats show a slow increase in biomass after the controlled burn. In the last few months of 1973 and 1974 the biomass is significantly higher than that initially recorded after the fire. The spring burn - small quadrats show a significant decrease in biomass as a result of the fire. The biomass increases after November but it does not differ significantly from that prior to the fire. *Hibbertia stricta* indicates an insignificant change in biomass as a result of controlled burns, i.e. the biomass present at the end of the experiment does not differ significantly from that before the burning.

Despite relatively high recordings the percentage cover results similarly do not show a significant change with time. Some of the plants of *Hibbertia stricta* flowered in spring 1974.

13.9.7. Results for *Hibbertia exutiacies*.

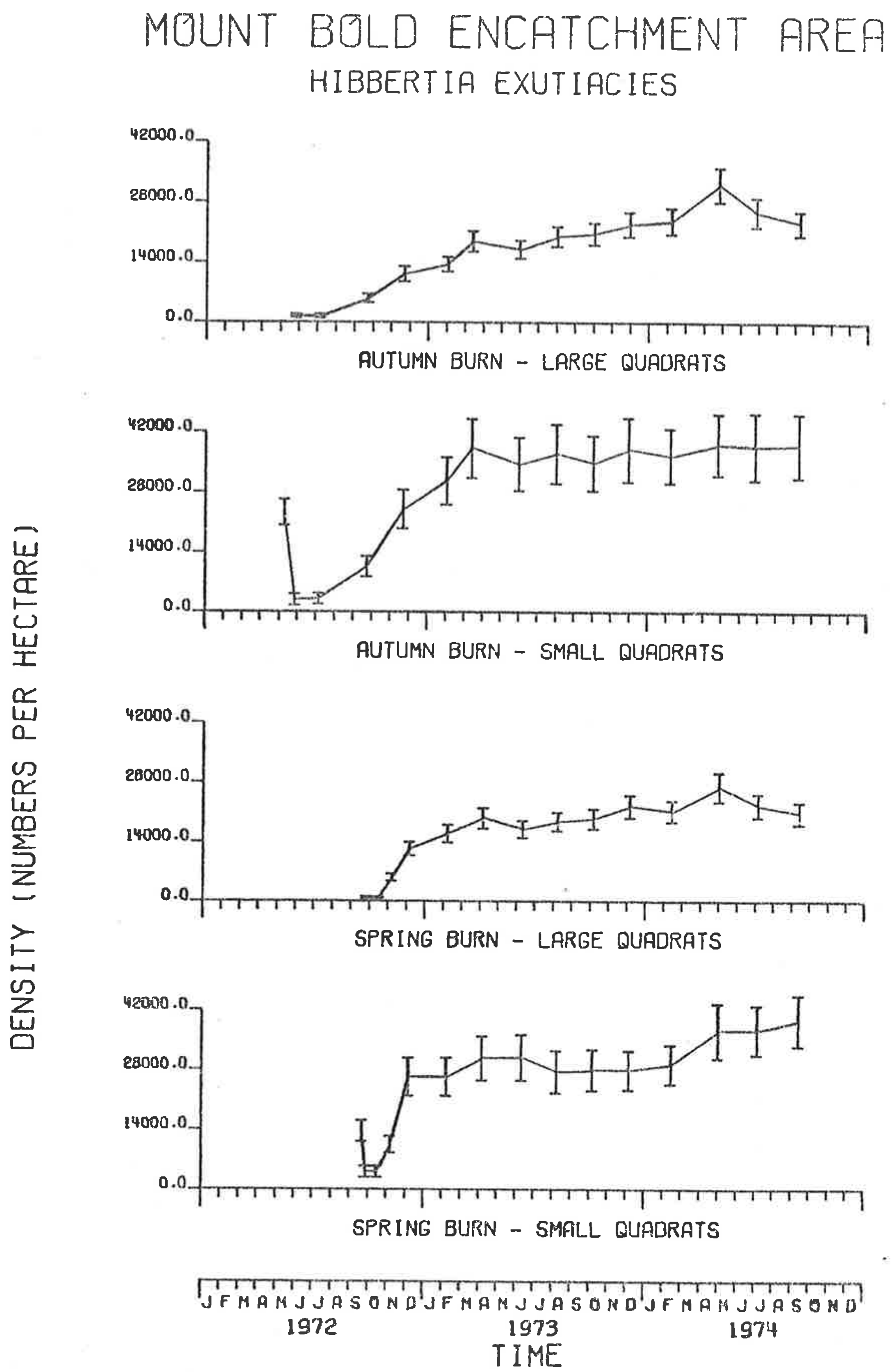
The density, biomass and percentage cover results for *Hibbertia exutiacies* appear in Figures 13.12., 13.13. and 13.14..

Hibbertia exutiacies, a small erect shrub, is a member of the family, Dilleniaceae. Its distribution includes the Mount Lofty Ranges, Bundaleer and the southern parts of the Flinders Ranges. In the Mount Bold Encatchment Area this plant is present in relatively large numbers.

The density and biomass in the large quadrats were not recorded prior to the fire. As for the other species of *Hibbertia* the results of the small quadrats are used to compare the measurements prior to the fire with the subsequent times. The autumn burn - large quadrats show a significant increase in numbers after September 1972 when compared with the low numbers initially present after the fire. The autumn burn - small quadrats show a significant decrease in numbers of *Hibbertia exutiacies* after the controlled burn. The number of plants rapidly increased at the end of 1972 and then stabilized in 1973 and 1974. It is of interest to note that the number of plants in 1974 does not differ significantly from those before the controlled burn.

The spring burn - large quadrats for *Hibbertia exutiacies* show similar results to those for the autumn burn plots. In November 1972, there is a significant increase in numbers which continues into 1973 and then stabilizes around twenty thousand plants per hectare. The spring burn - small quadrats show a similar response after November 1972. The initial significant decrease in numbers after the fire are clearly evident from the results.

The biomass for *Hibbertia exutiacies* in the autumn burn - large quadrats remains very low until early 1973 when it is significantly



MOUNT BOLD ENCATCHMENT AREA
HIBBERTIA EXUTIACIES
DENSITY (NUMBERS PER HECTARE)
42000.0
28000.0
14000.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.12.

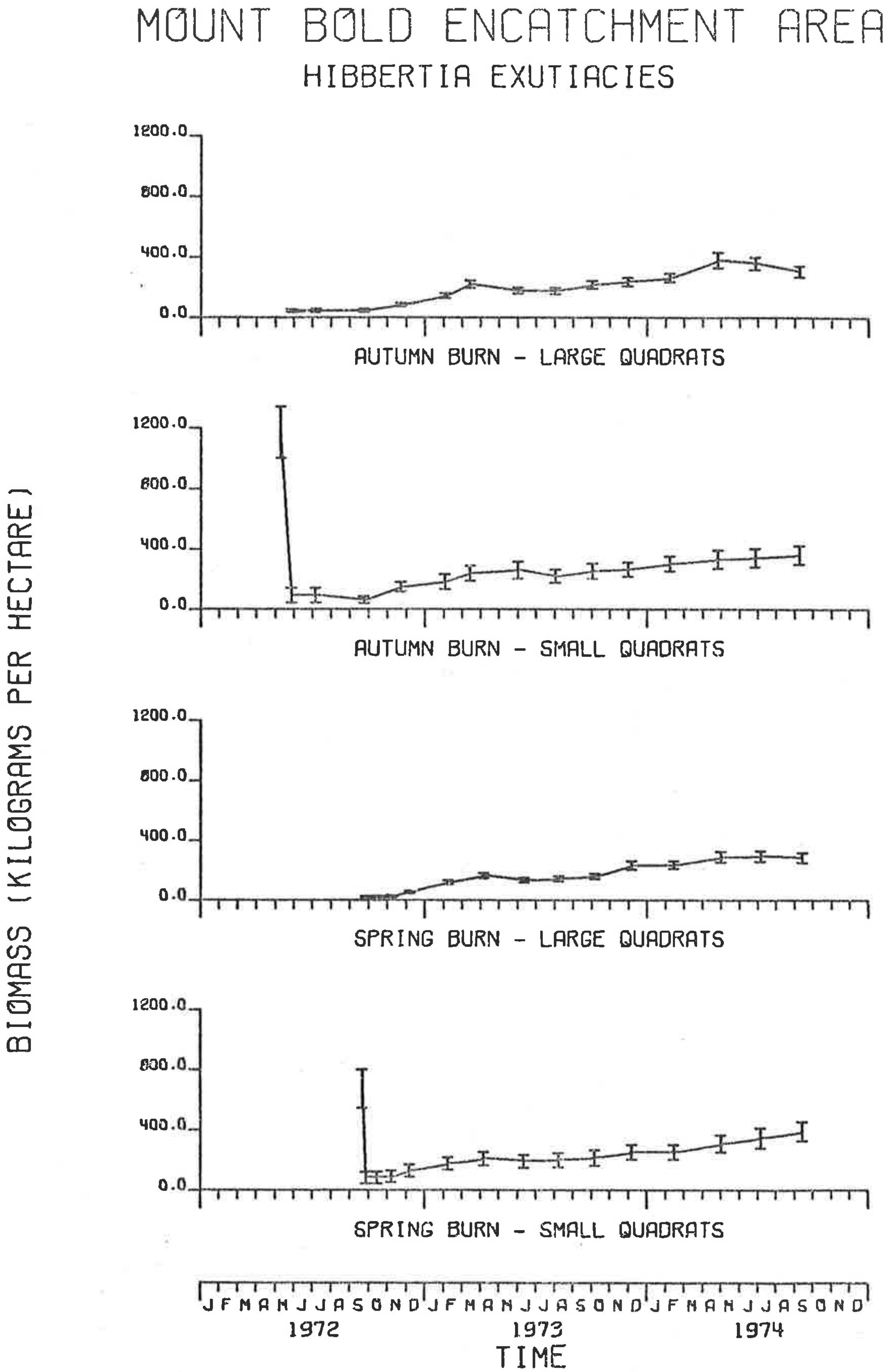

MØUNT BØLD ENCATCHMENT AREA
HIBBERTIA EXUTIACIES
BIØMASS (KILØGRAMS PER HECTARE)
1200.0
800.0
400.0
0.0
AUTUMN BURN - LARGE QUADRATS
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - LARGE QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.13.

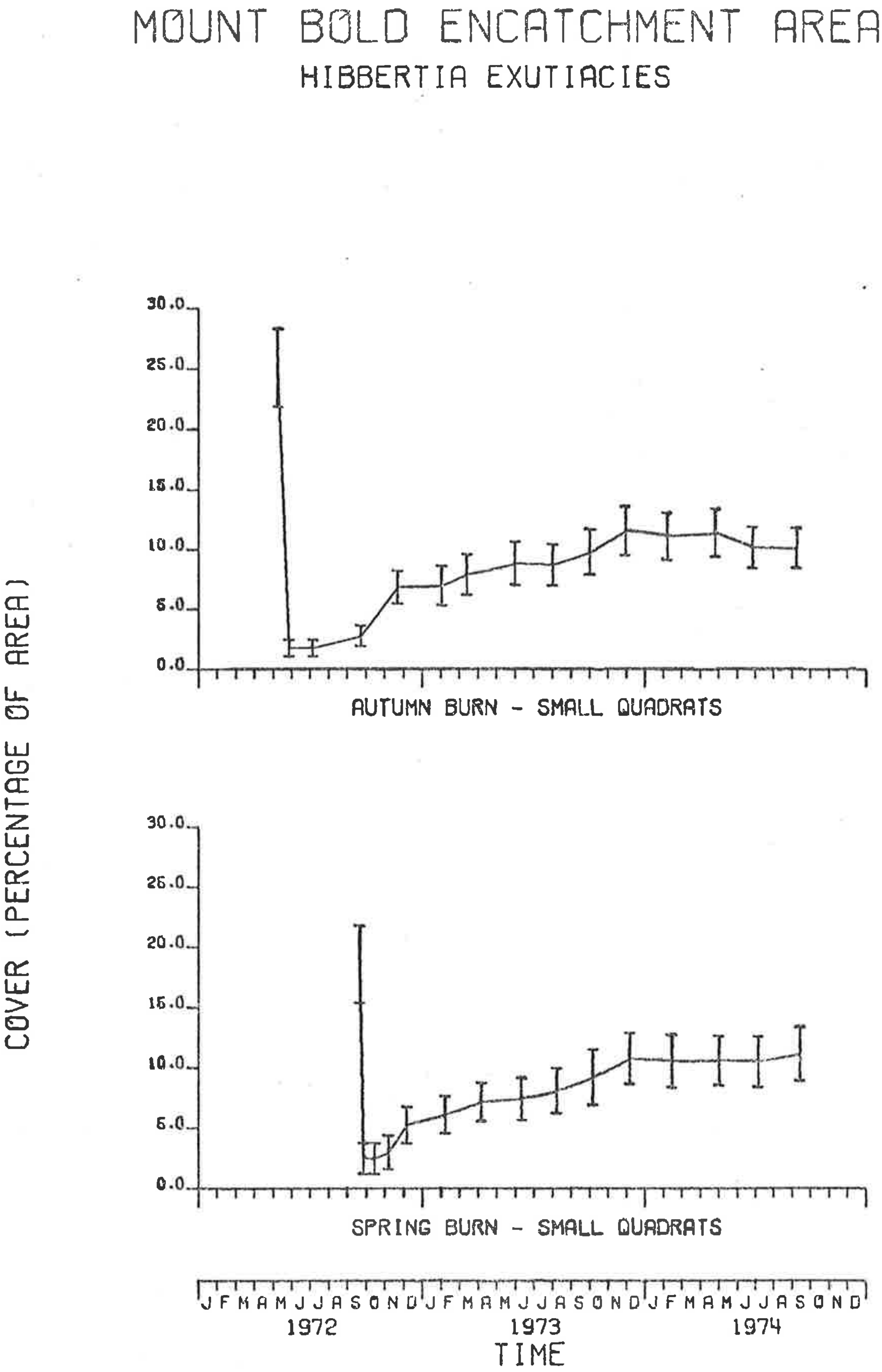

MOUNT BOLD ENCATCHMENT AREA
HIBBERTIA EXUTIACIES
COVER (PERCENTAGE OF AREA)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
AUTUMN BURN - SMALL QUADRATS
SPRING BURN - SMALL QUADRATS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1972
1973
1974
TIME

Figure 13.14.

13.9.7. Results for *Hibbertia exutiacies*. (Cont.)

higher than that initially after the controlled burn. This increase in biomass continues until the end of the experiment. The results for the autumn burn - small quadrats show a significant decrease in biomass after the fire. The biomass increases slowly but remains significantly lower at the end of the experiment. The spring burn results both show a similar response.

The percentage cover of *Hibbertia exutiacies* for the autumn burn - small quadrats shows a significant decrease in cover after the fire. Despite a gradual build up in cover, the value at the end of the experiment is significantly lower than that prior to firing. The spring burn - small quadrats show a similar response but the cover at the last recording does not differ significantly from that before the fire.

Therefore despite an increase in plants of *Hibbertia exutiacies* the biomass of the plants remains significantly lower after than before the fire. The percentage cover results resemble those for the biomass.

13.9.8. Discussion of Results.

The data collected by the Department of Woods and Forests (Table 13.2.) clearly indicates the variation in fuel quantity of the plots. Similarly, the fires varied in their rate of spread and intensity. It is therefore not surprising to find a large variation in the results.

The results for the plant species reflect the complexity of the response of this vegetation to controlled burning. The variation in response is also seen in other species in the experimental area. A brief review of these other species is given to indicate that any considerations of the use of fire as a management tool are confused further by the varying responses of plants to controlled burning.

Table 13.2.

MOUNT BOLD ENCATCHMENT AREA - CONTROLLED BURNING STUDIES

(data taken from records of the South Australian Department of Woods and Forests).

PLOT NO.	ASPECT	FUEL QUANTITY tons/Ac.			RATE OF SPREAD ft. / min.			FIRE INTENSITY BTU / ft. / sec.			Date of Burning	Percentage Burn
		LOW	HIGH	AV.	LOW	HIGH	AV.	LOW	HIGH	AV.		
1	E	4.7	11.6	7.8	1.0	2.25	1.5	34	185	107	12. 5.72	95
2	E	3.2	5.7	4.1	1.1	1.8	1.45	26.1	76.8	43.5	25. 9.72	95
3	S	2.1	5.0	3.6								
4	E	3.6	9.0	5.6	1.0	3.0	2.0	26.7	200	82.7	25. 9.72	90
5	S	1.6	8.2	4.5	0.8	1.5	1.1	9.5	91.1	36.7	2. 6.72	60
6	S	2.1	5.6	3.8	0.8	1.8	1.2	12.0	74.7	33.7	26. 9.72	60
7	S	3.6	6.3	5.4	0.6	1.2	0.9	16.0	56.0	36.0	2. 6.72	50
8	S	2.9	8.6	5.3	0.5	1.5	1.0	10.7	93.3	39.3	27. 9.72	65
9	E	4.5	19.8	11.0	1.2	2.2	1.7	36.1	322.7	138.2	29. 5.72	95
10	E	3.2	6.8	5.0	0.9	2.2	1.6	21.3	110.8	59.3	26. 9.72	90

The members of the family, Proteaceae, show a variation in response to the burning. This variation is typified by the species of *Hakea*. *Hakea ulicina* increased in numbers markedly in the latter part of 1973 due to the enormous numbers of young seedlings. It is noteworthy that some of these seedlings withered or died in the summer of 1973-74. In addition the plants of *Hakea ulicina* regenerated from vegetative parts. These plants that regenerated flowered in the latter part of the experiment. On the other hand *Hakea rostrata* only regenerated from old rootstocks. This variation in the one genus reflects the difficulties associated with predicting the results of controlled burning. *Isopogon ceratophyllus* and *Banksia marginata*, also members of the family, Proteaceae, resembled *Hakea ulicina* in that they regrew from rootstocks as well as establishing seedlings. Only the occasional plant of *Grevillea lavandulacea* was present in the experimental area. This plant only regrew from rootstocks.

Acacia pycnantha a member of the family Mimosaceae has already been discussed in 13.9.3.. *Acacia rotundifolia* and *Acacia myrtifolia* were also present in localised sections of the experimental area. Both of these species like *Acacia pycnantha* regenerated from vegetative parts, however they both established seedlings in large numbers. For example, *Acacia rotundifolia* was localised in distribution to a section in one of the plots burnt in spring. The number of plants after the fire was twice that prior to the fire. The plants that regenerated from rootstocks flowered in the latter part of the experiment.

Platylobium obtusangulum, a member of the family, Fabaceae has already been discussed in 13.9.2.. Other members of this family, e.g. *Daviesia virgata, Pultenaea daphnoides, Kennedia prostrata,* *Hardenbergia violacea* and *Bossiaea prostrata* were present in varying quantities but all show a similar response to controlled burning. As for *Platylobium obtusangulum* these plants regenerated from rootstocks as well as establishing from seed. *Indigofera australis* was restricted to the third plot (which was not burnt) so no results were collected on its response to controlled burning. The introduced plant species of the family of Fabaceae were scattered in the experimental area and were present in low numbers.

In comparison with other areas studied there are relatively low numbers of alien species present in this experimental area. The majority of the alien species are restricted to the valleys and the disturbed area (e.g. track verges). The exception to this is *Senecio pterophorus*. The results in 13.9.4. clearly indicate that the growth of this plant is favoured by a controlled burn whether in autumn or spring. In fact there are slightly more plants after the spring burn than the autumn burn. These results support earlier results discussed in chapter XII that fire is undesirable if the numbers of this plant are to be controlled. The other alien species in this experimental area are listed in Appendix II. These alien species include a range of grasses, *Rubus* spp. *aff. fruticosus*, species of *Trifolium* and species of the family of Asteraceae. *Rubus* spp. *aff. fruticosus* does not appear in the plots but is confined to the creek beds and gullies adjacent to the experimental area. The alien grasses and species of *Trifolium* are mainly restricted to the valleys and the occasional patch in the sandy areas at the higher altitudes. In comparison the native grass species are widespread in their distribution.

The three species of *Hibbertia* discussed in 13.9.5., 13.9.6. and 13.9.7. once again reflect the variation in response of the plant species.

Pteridium esculentum, bracken, is restricted to one of the plots on a sandy soil. Although new plants grew after the fire there was a corresponding decrease in plants from death. As a result there was little change in the number of plants during the experiment. Other species that showed little change in numbers to the controlled burn were the members of the families, Cyperaceae and Juncaceae. For example *Lepidosperma semiteres* which is present in large numbers regenerated from existing rootstocks. The numbers of this plant species were significantly reduced after the fire. They then regrew from the rootstocks, so in all treatments the numbers did not differ significantly at the conclusion of the experiment when compared with those prior to the fire. Similar results were observed with *Lepidosperma carphoides, Schoenus apogon, Scirpus antarcticus* and *Juncus caespiticius.*

There was a prolific growth of orchids in the spring of 1973. This growth of orchids was reduced in the following spring. The range of orchid species observed are listed in Appendix II. There was a large variation in numbers of these species.

Acrotriche fasciculiflora, Acrotriche serrulata, Astroloma conostephioides, Astroloma humifusum, Epacris impressa and the species of *Leucopogon* all re-established after the fire. For example *Epacris impressa* not only regenerated from vegetative parts but also produced large numbers of new seedlings. The plants that regenerated flowered during the latter part of the experiment.

The members of the family, Myrtaceae also were present in large numbers. The eucalypts produced only the occasional seedling both in the spring and autumn controlled burning.

Leptospermum myrsinoides and *Calytrix tetragona* which were restricted in distribution to the sandy soils, produced large numbers of seedlings as well as regenerating from vegetative parts.

13.10. Summary.

The results presented in this chapter clearly indicate that controlled burning has a variety of effects on the plant species present in the *Eucalyptus obliqua* dry sclerophyll forest. Any management decisions are confused by the complexity of responses. There is no doubt that controlled burning as a management tool would affect the vegetation.

The increase in density with time, of many of the native plant species would lead to an increase in fuel accumulation. Owing to time limitations on the research work this increased density in some species was not accompanied by a corresponding increase in biomass. This was due to the fact that many of the seedlings were extremely small hence did not contribute significantly to the total biomass. As the majority of plants regenerated from rootstocks and/or seed many of the plant species are well adapted to the advent of fires and are therefore unlikely to suffer markedly from controlled burning. Other plant species did not change significantly in density, biomass or cover in response to these treatments. The large number of plants in the area and their variety of reactions to controlled burning only emphasize the need to gather more quantitative data on which the park authorities can make management decisions. The presence of alien species, many of which are well adapted to the conditions created by the advent of fire, must be given due consideration. In this experiment *Senecio pterophorus* typified the type of reaction that alien species can have to controlled burning.

The significant increase in this species along with the resulting fuel accumulation, must be weighed against the advantages of controlled burning. Obviously, consideration must be given to all plant species in the area if the desired effect of controlled burning, i.e. a reduction in the fuel accumulation, is to be achieved.

The considerations of frequencies of fires was not included in this research. However, the data collected (some of which is presented in this thesis) provides a basis for the continuation of this experiment. In summary, the large variation in responses of the species to controlled burning in autumn and spring clearly indicates the need to encourage further collection of quantitative data which will assist both the park authorities and all those concerned with the management of native vegetation.

Chapter XIV

SUMMARY OF CHAPTERS XII AND XIII

This chapter brings together the major points which emerge from the pyric succession studies in Belair Recreation Park and Mount Bold Encatchment Area. The results in both areas demonstrate the complexity of responses of plant species to fire.

The ability of some alien species to regenerate and establish after a fire is clearly evident from the results. The results also show a marked increase in the abundance of some alien species. Hence firing must be avoided if the control of such species is desired. Clear examples are the populations of *Senecio pterophorus* and *Hypericum perforatum* in Belair Recreation Park. Following fires these plants establish quickly and soon build up a high accumulation of fuel in the area. This therefore defeats any previous efforts of weed control. *Senecio pterophorus* demonstrates the same behaviour under controlled burning at the Mount Bold Encatchment Area. Therefore if burning is considered the disadvantages of increasing the alien species must be carefully weighed against the supposed advantages of controlled burning.

Many of the native plant species regenerated and/or increased after the controlled burning at the Mount Bold Encatchment Area. Further, the increase in numbers of some of the native species was a result of their ability not only to regenerate from vegetative parts but also to establish seedlings. Predictably this increase in numbers will lead to an increase in biomass and fuel quantity. The results show a decreased biomass in some plant species. This is a result of the small contribution of the seedlings to the biomass.

Controlled burning is intended to reduce fuel quantities. However, although biomass decreased in the short term, the regeneration and establishment of seedlings at Mount Bold is likely to result in greater fuel quantities. To keep fuel levels down, burning would then need to be repeated at regular intervals. As yet in South Australia no quantitative data is available on which suitable intervals of time between fires can be determined. Individual species showed a wide variation in the responses to the controlled burning. In the two studies there were wide variations in the responses between different species although individual species in the two areas showed a similar response. Because of this complexity, controlled burning cannot be accepted as a park management tool on the basis of present information.

CHAPTER XV

FINAL DISCUSSION

15.1. Introduction.

The object of this thesis was to investigate the influence of man on the vegetation in the national parks of South Australia. This was achieved by a detailed examination of the vegetation in a selection of situations. The detailed discussions and conclusions have been given in previous chapters. This chapter discusses the wider implications as regards management problems and the future of the national parks.

The vegetation studied in the five parks showed marked signs of degradation in response to the influences of man. The results discussed in these selected parks typify those observed in other parks in South Australia. Although some of the changes in the vegetation reflect the use of the areas prior to their dedication as parks the majority of changes are shown to be due to current influences or activities. This degradation varied from complete removal of vegetation in localised patches to marked changes in the composition and structure of the plant communities.

15.2. Management problems in national parks.

This discussion covers the wider implications of the results and my own observations in other situations in South Australia during the last three years.

Clearing has been one of the major influences. Alien species were dominant in the cleared areas studied. Logging and other clearing processes encouraged the introduction of alien species. The need for cleared areas in recreational parks and some edges of the parks (to create fire-breaks) is not denied. However excessive clearing should be avoided if the conservation of native plants and communities is desired.

The provision of recreational facilities (e.g. ovals and barbecues) are linked with the processes of clearing. Such facilities should be limited in number to maintain a balance between the cleared areas and native vegetation. If the recreational facilities and resulting clearing become excessive the native vegetation will be restricted to localised patches. As discussed in previous chapters these localised patches are extremely vulnerable to invasion by alien species. The change in behaviour of people with the rise in the use of private vehicles has placed increasing demands on the parks and has resulted in marked destruction in sections. Further, few people go far from their private vehicles so placing greater demands on localised areas. The park authorities have in part overcome this problem by careful placing of logs and chains to restrict the access of vehicles, e.g. Para Wirra Recreation Park. A further aid could be the provision of alternative transportation as in the United States. People should not necessarily be discouraged from these parks but their activities should be carefully reviewed.

There is no doubt that the increasing populations are placing greater demands on the national parks in South Australia.

The damage to the soils and vegetation from visitors is clearly evident from such parks as Belair Recreation Park, Para Wirra Recreation Park and the Flinders Ranges National Park. In many instances man's activities have resulted in complete removal of the vegetation. This phenomenon is not restricted to the parks providing recreational facilities but also includes conservation parks and national parks. This damage reflects the inadequacy of the parks to meet the ever-rising demands of the public on their facilities. Further destruction can be avoided in several ways; for instance by limiting the access of vehicles and people (this limit on people is undesirable as it creates public antagonism); by redirecting these people to other alternative areas. This latter point may imply the need to acquire more areas for recreational purposes or more feasibly the involvement of local councils in providing further recreational facilities in areas under their control (e.g. small parks or roadside verges). The provision of recreational needs is obviously desirable. However, the majority of recreational needs are undesirable if the prime object is to conserve the vegetation. Conservation of the flora can still be achieved in the recreation parks by restricting access to selected areas. This could be done by not providing tracks and roads in sections of the parks, as in the instance mentioned above.

Tracks per se modify the vegetation directly, in addition to the modifications brought by its provision of access. First they cause a local clearing and disturbance of the vegetation. Second this disturbance encourages the introduction of alien species into these areas. Hence, alien species spread into areas in which they otherwise would not have penetrated. Further the tracks have led to a disturbance of the soils. The nature of the disturbance varies from one of compaction of the surface soils to removal of the top-soil. For instance, in parks with sandy soils, tracks have acted as a focus for wind erosion. The presence of man and animals have encouraged this removal process and in many cases have exposed and damaged underlying root systems. Although many of these processes are local, the increasing numbers of tracks in many parks exacerbates these impacts. For example, in the northern section of Belair Recreation Park, the number of tracks used by the public riding horses has increased markedly in recent years. In recreation parks, access tracks are necessarily important. In addition the provision of fire tracks is particularly important in the local parks: as the ever-increasing number of fires pose serious threats to the surrounding housing developments.

Fire is well recognised as an important management problem in the areas of native vegetation in Australia. The frequency of fires in the local parks has increased in the last few decades. This increase is a result of man's influence in that there has been a large number of accidental and intentional fires. These frequent fires have led to changes in the vegetation. Despite many of the native plants being well adapted to the fires, the ability of alien species to regenerate and establish after the fires has further encouraged these changes. Interest has been shown in controlled burning in recent years in both small patches and on a broad scale. These small patches might include roadside or break burnings. The latter may be for protection of property, exotic plantings or particular areas. The management problems in parks associated with fire includes the risk of damage to adjacent properties, the risk of loss of human life and the encouragement of alien plant species.

The size of parks has been questioned before, but little information has been available to date on the minimum size required. The smaller parks in South Australia are unlikely to conserve the vegetation as the adjacent landholdings are in the main cultivated. The laissez-faire approach to the majority of these parks has resulted in the "edge effect" and associated intermingling of species being accentuated. In the larger parks the adequacy of the area is also questioned as many plant species are rare or restricted in distribution. If the conservation of individual plant species is desirable obviously many of the parks are inadequate. The adequacy of parks to conserve plant communities is also questioned as many have been subject to major disturbances resulting in changes to the vegetation.

Grazing is one of the major influences on the vegetation in the parks. This grazing may be due to either native or introduced animals. The inadequate fencing of all parks has failed to keep native animals in and introduced animals out. As a result sheep, horses, rabbits and cattle have unrestricted access to some. This uncontrolled grazing has led to changes in the vegetation. The difficulties associated with catching these animals is usually enhanced by the inaccessibility of many sections of the parks. Further local attitudes of some adjacent land-owners who encourage their animals into the parks does little to assist with this problem.

On the other hand the lack of adequate fencing and water facilities also encourages the native animals in drier seasons to compete with the sheep and cattle on neighbouring properties. Such an occurrence does little to alter the attitudes of the local farmers towards conservation. The carrying capacity of the parks for native animals needs to be investigated. The problems associated with grazing are further accentuated in sandy-soils because of increased soil disturbance. If grazing is already carried out in sections of some of the parks the removal of the animals from these areas is likely to encourage the growth of grasses and annuals leading to a possible fire risk. The use of grazing as a means of maintaining fire breaks to minimize such a risk must be investigated. The other alternative is to remove these animals and re-establish the vegetation. Re-establishment is not a simple matter due to the higher fertility levels of the soils and associated weed problems. There is no doubt that fertilizers have encouraged the establishment and growth of alien species. In fact wind drift of agricultural fertilizers has led to marked changes in the vegetation, particularly in small parks and on the edges of the larger ones. Similarly where the drainage systems run off areas with a higher level of fertility the result is a change in the vegetation. Therefore the nature and proximity of the adjacent landholdings is once again important.

In many parks, due to their recent acquisition, there are dams and interruptions of the watercourses. This has resulted in changes in localized areas. The disturbance of the soil during the construction of dams has further encouraged the

15.2. Management problems to national parks (Cont.)

introduction of alien species. In the smaller parks the drainage systems have been altered so resulting in changes in the vegetation. This interruption of natural drainage is usually seen in those portions situated on slopes of hills or in gullies.

Introduced species pose a major problem in the local parks. Their presence is usually a result of one or more of the preceeding disturbances. The fact that they often grow along side native plant species limits the use of many of the control measures employed in agricultural situations. As there is little known on the side effects of such control measures on native plant species difficulties are met in selecting the most suitable techniques. As in most instances these plants are present as a result of some past disturbance, clearly it is desirable to remove this causal factor first. However, if this cannot be carried out, the control of these introduced species becomes a problem. If control methods are undertaken they need to be accompanied by careful monitoring experiments.

15.3. Future prospects for the National Parks in South Australia.

The effectiveness of the parks to conserve the native vegetation for the foreseeable future is doubtful unless park management is carried out on an adequate information basis. At present this information is lacking for the majority of parks. The laissez-faire attitude adopted up to date is unsuitable for many parks if the conservation of the native communities is to succeed.

15.3. Future prospects for the National Parks in South Australia (Cont.).

Park size is of major importance. Many of the smaller parks have little chance of fulfilling their purposes without appropriate management. Such management must be instigated in the near future.

The presence of man in most parks has led to the destruction of the vegetation. The possibility of restricting access must therefore be investigated as an aid to conservation. In many instances management decisions such as limiting the access of vehicles and providing camping facilities could be instigated by redirecting people to adjacent areas. For example, one could provide camping grounds adjacent to parks rather than in them. Further areas could be zoned for different purposes : this would assist the conservation of areas for the future.

The place of man in all four categories of parks needs to be carefully reviewed. The marked destructive effects he has had in the parks up to date brings into question the future prospects for the parks without more adequate management. On the basis of the research of this thesis it is possible to predict that many areas of vegetation will not be conserved without appropriate management. It could further be stated that the less common plant species, if not endangered now, will be in the near future. If degradation continues as at present, the conservation of native communities and individuals is doubtful.

15.4. Conclusions.

Such considerations aside, the several conclusions of this research are as follows.

15.4. Conclusions (Cont.)

..... The techniques, using incidence and density data, have shown that there are definite groupings of plants and spatial patterns associated with the influence of man in the parks. Further these changes in the composition and structure of the plant populations segregate those associated with the influence of man from those associated with natural influences. It is clear that man has caused marked changes in the vegetation from its complete removal to encouraging monocultures of weed infestations.

..... The alien species can usually be regarded as indicators of deleterious change.

..... The extent of the disturbed areas varies in the different parks. This disturbance as reflected by indicator species may be localized in some sections or widespread. The incidence and density results also reflect the spatial distribution of disturbances.

..... High frequencies of fires in the parks are undesirable because the alien species present are encouraged by firing. Selected alien species showed marked increases in abundance after fires.

..... The use of controlled burning is questioned in light of the complexity of the responses of individual plant species. This complexity of response requires detailed and quantitative examination.

15.4. Conclusions (Cont.)

The ideas that arise out of these conclusions and the preceeding discussions point to the need to gather further similar data, which up to date have been lacking.

Additional studies on plant communities would further assist the park authorities, by providing an increasing understanding of the relationships involved. This understanding is essential if the management objectives of the different parks are going to be reached. Further individual parks will need individual management strategies.

Within the provisions of "The National Parks Act, 1972" the management of the parks must be carried out on a more rigorous basis than at present. This will only be possible by the collection of adequate quantitative data.

Particular attention must also be given to the monitoring of management decisions. If these management decisions are found to be detrimental then appropriate changes can be undertaken. It is most unlikely that a full understanding of all the vegetation in all the parks and all the management problems affecting the vegetation will ever be gained.

This thesis has outlined some of the influences of man that affect the vegetation, so providing a basis for the future management of these and other related parks. The descriptive accounts of the parks up to date have provided an inadequate basis for management decisions. In this thesis, I have presented documented details and quantitative results, which hitherto have not been obtained. These results leave no room for complacency.

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APPENDIX I

The following list of parks and their areas was compiled from the National Parks and Wildlife Act, 1972; and from the records of the Division of National Parks and Wildlife of the Department of Environment and Conservation

NATIONAL PARKS

No.	Name	Hundred	Section	Approx. Area (Hectares)
1	Lincoln	Flinders Smith Island, Hopkins Island, Lewis Island, Little Island, Owen Island, Albatross Island, Liguanea Island, Rabbit Island (being section 395, North out of Hundreds) Curta Rocks	2, 3, 4, 5, 6, 12-14	15,971
2	Flinders Ranges	Edeowie Bunyeroo Parachilna North out of Hundreds	148 177 61 106, 333, 473	58,136
3	Gammon Ranges	North out of Hundreds	35, 464	15,538
4	Innes	Warrenben Island of Pondalowie Bay (excluding South Island being Section 88, Hundred Warrenben)	99-102	6,112

National Parks (Cont...../2)

No.	Name	Hundred	Section	Approx. Area (Hectares)
5	Coorong	Glyde Santo	17, 59, 60 6, 43, 52	6,013
6	Canunda	Rivoli Bay Mayurra Benara	377, 378, 379, 396 157 386	8.950
7	Flinders Chase	Borda Gosse McDonald South out of Hundreds Casuarina Islets (The Brothers)	11 64 17 66	59,003
8	Mount Remarkable	Winnowie Wongyarra Baroota	176 471, 474, 488, 489 180, 210, 216, 217, 218, 219	8,243
			TOTAL	177,966

CONSERVATION PARKS

No.	Name	Hundred	Section	Approx. Area (Hectares)
1	Nixon-Skinner	Myponga	245	7.966
2	Ferries-McDonald	Freeling	266-268, 103, 271, 272, 238, 241, 242, 245, 246	844.8
3	Fairview	Woolumbool	93, 98	1,089
4	Waitpinga	Waitpinga	355	2.536
5	Eric Bonython	Waitpinga	356, 357	6.060
6	Spring Gully	Clare	365, 568, 572	324.1
7	Hincks	Hincks Murlong Nicholls North out of Hundreds	2 25 11, 12 365	66,240
8	Peebinga	Peebinga	21, 22, 31, 19, 30	3,144

Conservation Parks (Cont..../2)

No	Name	Hundred	Section	Approx. Area (Hectares)
9	Hambidge	Hambidge North out of Hundreds	7 364	37,839
10	Kellidie Bay	Lake Wangary	1-13, 21, 273-277, 295	1,753
11	Mount Rescue	Archibald Makin	7, 8, 9, 10 3, 4	28,385
12	Billiatt	Auld Billiatt	26 15, 18	36,814.5
13	Cleland	Adelaide Onkaparinga	608, 637, 500, 920 424	789.3
14	Horsnell Gully	Adelaide	609, 613	139.8
15	The Knoll	Adelaide	612	1.725

Conservation Parks (Cont...../3)

No	Name	Hundred	Section	Approx. Area (Hectares)
16	Penguin Island	Rivoli Bay South out of Hundreds, Un-numbered Section (Penguin Island)	374	4.552
17	Mundoora	Mundoora	439-442	782.3
18	Torrens Island	Port Adelaide	467	58.27
19	Messent	Messent Colebatch	1 1	12,213
20	Hale	Barossa	119, 124, 125, 135, 138, 315	190.8
21	Big Heath	Spence	17-20, 169	2,351
22	Sandy Creek	Barossa	72, 317, 319	104.1
23	Spring Mount	Encounter Bay	633, 715	199.2

Conservation Parks (Cont...../4)

No	Name	Hundred	Section	Approx. Area (Hectares)
24	Warren	Barossa Para Wirra	321 118, 387, 388	363.4
25	Calectasia	Short	157	13.79
26	Desert Camp	Marcollat	87, 105	49.06
27	Guichen Bay	Waterhouse	360, 361	76.2
28	Jip Jip	Peacock	86	141.6
29	Mount Magnificent	Kuitpo	293	89.76
30	Morialta	Adelaide	833, 834	372.2
31	Elliot Price	North out of Hundreds	49	64,570
32	Mount Boothby	Colebatch	3	4,045

Conservation Parks (Cont...../5)

No	Name	Hundred	Section	Approx. Area (Hectares)
33	Simpson Desert	North out of Hundreds	48	692,680
34	Ridley	Ridley Fisher	479, 480, 483 144	414.3
35	Yumbarra	North out of Hundreds	457	106,189
36	Beachport	Lake George	5, 31, 32, 40, 58	623.7
37	Parndana	Seddon	58	310.2
38	Warrenben	Warrenben	44, 45, 54, 97	4,061
39	Wittelbee	Bonython	101	121.4
40	Scott	Goolwa	218, 347	209.2
41	White's Dam	Lindley Maude	197, 199, 201, 202 252	911

Conservation Park (Cont...../6)

No	Name	Hundred	Section	Approx. Area (Hectares)
42	Carcuma	Carcuma	23	2,881
43	Karte	Kingsford	3, 4	1,862.4
44	Piccaninnie Ponds	Caroline	598, 692	382.7
45	Sleaford Mere	Sleaford	36	687.9
46	Unnamed	Messent Santo	14 19	563.7
47	Cox's Scrub	Kondoparinga	1972, 1979-1985	487
48	Dudley	Dudley	294-296, 302, 303	933.3
49	Unnamed	North out of Hundreds	50	2,132,600
50	Pooginook	Pooginook	7, 8, 14	2,851

Conservation Parks (Cont...../7)

No	Name	Hundred	Section	Approx. Area (Hectares)
51	Swan Reach	Fisher	38, 39, 40, 41, 42, 43, 55, 56, 57, 58, 59, 60	1,901
52	Mount Taylor	Newland	102	17.53
53	Bascombe Well	Kappawanta Barwell Blesing Cowan	2 29 11 39, 65	29,186
54	Scorpion Springs	Fisk Quirke South out of Hundreds	16 9, 10 65	30,366
55	Gum Lagoon	Wells Petherick	9, 30 8, 37	4,000
56	Telowie Gorge	Telowie	439, 491	1,945
57	Penola	Monbulla	255, 256	226.2

Conservation Parks (Cont'd...../8)

No	Name	Hundred	Section	Approx. Area (Hectares)
58	Clinton	Clinton	568	396.5
59	Glen Roy	Comaum	276, 279, 479	540.8
60	Pinkawillinie	Pinkawillinie Panitya	114 29	17,718
61	Gower	Hindmarsh	517	39.5
62	Cape Torrens	Borda	10	748
63	Cape Hart	Dudley	377, 384	290.6
64	Cape Gantheaume	Haines MacGillivray Seddon plus Pelorus Island (s.e. from Vivonne Bay)	258, 275-279, 284 66, 67 52	20,489
65	Western River	Gosse	8, 47	2,286

Conservation Parks (Cont...../9)

No.	Name	Hundred	Section	Approx. Area (Hectares)
66	Vivonne Bay	Newland	7, 8, 106	847.5
67	Kelly Hill	Ritchie	5, 9, 10	6,307
68	Seddon	Seddon	67	23.5
69	Port Gawler	Port Gawler Port Adelaide	616 483	432.9
70	Kelvin Powrie	Archibald Stirling	34 475	17.66
71	Padthaway	Parsons	136	984.3
72	Cudlee Creek	Talunga	57	49.37
73	Montacute	Onkaparinga	210, 473, 523, 524, 5586, 5587, 5589, 5590	195.5

Conservation Parks (Cont...../10)

No	Name	Hundred	Section	Approx. Area (Hectares)
74	Lowan	Bowhill	71	673.6
75	Deep Creek	Waitpinga	130, 216, 217, 365	570.7
76	Lake Gilles	O'Connor North out of Hundreds Pastoral Block 958	1-14, 16-20, 25-43 316	45,113
77	Whyalla	Cultana	14	1,011
78	Mount Shaugh	Shaugh	5	3,460
79	Black Hill	Adelaide Onkaparinga	669, 670, 671 526	142.4
80	Dingley Dell	MacDonnell	Pt. 138, C.T. Vol. 1231, Fol. 123	5.827
81	Fort Glanville	Port Adelaide	Pt. 415, C.T. Vol. 1987, Fol. 104	4.678

Conservation Parks (Cont...../11)

No	Name	Hundred	Section	Approx. Area (Hectares)
82	Naracoorte Caves	Jessie Joanna	466 392, 395, 396, 398, 397	93.47
83	Tantanoola Caves	Hindmarsh	213	13.91
84	Tumby Island	North out of Hundreds	682	30.35
85	Kapunda Island	Bookpurnong (Kapunda Island) in River Murray		1.214
86	Media Island	Gordon (Media Island) in River Murray		1.011
87	Rilli Island	Gordon (Rilli Island) in River Murray		4.451

Conservation Parks (Cont...../12)

No	Name	Hundred	Section	Approx. Area (Hectares)
88	Seal Bay	That portion of Seddon, bounded as follows: - Commencing at S.W. corner of Section 2, Hundred Seddon, thence generally E. along S. boundary of latter section and across road to S.W. corner of Section 52; generally S.E. along S.W. boundary of latter Section to its intersection with E. boundary of said Hundred; S. along portion of latter boundary to L.W.M. generally N.W. and W. along portion of said L.W.M. to its intersection with production S.E. of S.W. boundary of Section 2, Hundred Seddon; thence N.W. along said production to point of commencement Nobby Island		91.45
89	Eba Island	Streaky Bay adjacent to Scott, out of Hundreds		121.4
90	West Island	Waitpinga	360	10.11

Conservation Parks (Cont...../13)

No	Name	Hundred	Section	Approx. Area (Hectares)
91	Nuyt's Archipelago	Eyre Island Franklin Islands, Goat Island, Lacey Island, Lound Island, Purdie Island		1,981
92	Isles of St. Francis	Freeling Island, Smooth Island, St. Francis Island (excluding Section 220, North out of Hundreds) Dog Island, Egg Island, Fenelong Island, Masillon Island, West Island, Hart Island		1,351
93	Investigator Group	Topgallant Island, Ward Island, Pearson Island (excluding Section 12 and 13, North out of Hundred)		117.3
94	Gambier Islands	Three islets S and W. from Wedge Island North Island		64.74

Conservation Parks (Cont...../14)

No	Name	Hundred	Section	Approx. Area (Hectares)
95	Sir Joseph Banks Group	Blyth Island, Boucaut Island, Duffield Island, English Island, Sibsey Island, Reevesby Island, Marum Island, Partney, Lusby, Kirkby, Dalby, Langton, Hareby, Roxby, Stickney & Winceby (Islands) (excluding Section 375)		776.9
96	Whidbey Isles	Four Hummocks Island (excluding Southern-most Island) Perforated Island, Price Island, Unnamed Island south from Pt. Avoid.		265
97	Beatrice Islet	Beatrice Islet, N.N.E. from Kingscote		10.11
98	Busby Islet	Busby Islet, N.N.E. from Kingscote		10.11

Conservation Parks (Cont...../15)

No.	Name	Hundred	Section	Approx. Area (Hectares)
99	The Pages	The Pages Islands, S.E. from Cape Jervis		20.22
100	Pullen Island	Pullen Island, adjacent Port Elliot		1.011
101	Neptune Island	North and South Neptunes (excluding southermost island of South Neptunes)		343.9
102	Althorpe Islands	Althorpe Islands (excluding Section 13 and 61, South out of Hundreds)		4.856
103	Lipson Island	Lipson Island (N.E. from Tumby Bay)		0.4046
104	Olive Island	Olive Island (N.W. from Streaky Bay)		12.14

Conservation Parks (Cont...../16)

No.	Name	Hundred	Section	Approx. Area (Hectares)
105	Rocky Island (north)	Rocky Island (N. from Coffin Bay)		16.18
106	Rocky Island (south)	Rocky Island (W. from Four Hummocks)		8.093
107	Sinclair Island	Sinclair Island (E.S.E. from Fowlers Bay)		2.428
108	Cap Island	Cap Island (N.W. from Mount Hope)		8.093
109	Baird Bay Islands	Wrenfordsley, island in Baird Bay Jones Island	181	24.27
110	Nuyt's Reef	Wookata, Nuyt's Reefs south of Cape Adieu		1.014

Conservation Parks (Cont...../17)

No	Name	Hundred	Section	Approx. Area (Hectares)
111	Greenly Island	Lake Wangary, Greenly Island, 20 miles W.S.W. from Port Whidbey		202.3
112	Mount Dutton Bay	All Islands in Mount Dutton Bay The Brothers, Goat Island and Rabbit Island		14.36
113	Waldegrave Islands	Waldegrave Island and small island west of Waldegrave Island adjacent to Hundred Ward		323.7
114	Pelican Lagoon	Dudley	475, 476, 477, 478 and 479	36.41
115	Pigface Island	Pigface Island, Hundred Scott	Adjacent to 54	6.171
116	Avoid Bay	Black Rocks adjacent Coffin Bay Peninsula and small unnamed island, S.E. from Section 107 and 108, Hundred Lake Wangary		16.18

Conservation Parks (Cont...../18)

No.	Name	Hundred	Section	Approx. Area (Hectares)
117	Bird Island	Bird Island, S.W. from Wallaroo, Hundred Wallaroo		7.587
118	Salt Lagoon Islands	Islands E. of Section 78 and 80, Hundred Baker and waters within 5 chains		48.24
119	Maize Island Lagoon	Waikerie Irrigation Area, Holder Division, Hundred Holder	365, 427	44.10
120	Baudin Rocks	Godfrey Islands, north of town of Robe and west from Hundred Waterhouse		4.856
121	Myponga	Myponga	269 and 270	166.1
122	Belt Hill	Rivoli Bay	339	9.801
123	Carribie	Carribie	153	15.3

Conservation Parks (Cont...../19)

No.	Name	Hundred	Section	Approx. Area (Hectares)
124	Goose Island	Goose Island and White Rocks Island N.W. of Wardang Island and N.W. from Port Victoria		5.563
125	Kyeema	Kuitpo	92,522, 688, 850 and 302	348.9
126	Hacks Lagoon	Robertson	249	193.3
127	Grass Tree	Hynam	451	15.9
128	Mount Scott	Murrabinna	571	1,237.53
129	Black Rock	Erskine	76	170
130	Nene Valley	Kongorong	388-391, 604-606, 620	373.2
131	Laura Bay	Blacker	41, 42, 50 & 150 link reserve	250.5

Conservation Parks (Cont...../20)

No.	Name	Hundred	Section	Approx. Area (Hectares)
132	Reedy Creek	Fox Kennion Smith	288 227 154	81.6
133	Point Labatt	Wrenfordsley	62, 188 and foreshore	30.7 and foreshore
134	Rudall	Rudall	49	348.4
135	Carapee Hill	Pascoe	100	781.5
136	Furner	Kennion	245	285.5
137	Bangham	Geegeela	4	783.3
138	Pandappa	Wonna	68, 69, 189	1,057
139	Yulte	Myponga	268	42.49

Conservation Parks (Cont...../21)

No.	Name	Hundred	Section	Approx. Area (Hectares)
140	Calpatanna Water-hole	Wrenfordsley	121, 122, 128, 129, 144, 179, 180, 189	3,602.74
			TOTAL	3,397,617

GAME RESERVES

No.	Name	Hundred	Section	Approx. Area (Hectares)
1	Katarapko	Katarapko, Gobdogla Irrigation Area, Weigall Division	73, 74	4,063
2	Bool Lagoon	Robertson	223, 224, 356	2,660.75
3	Coorong	Santo, that portion of the Coorong situate between a straight line joining Jacks Point to the N.E. corner of Section 5 and a straight line, being the production of the S.E. boundary of Section 5 to the Eastern boundary of the Coorong. Teal Island, North Pelican Island, Halfway Island, Pelican Island and Mellor Island		6,840
		Santo	1, 5, 31, 36, 37, 40, 44-48, 50, 51, and 150 link reserve adjacent to 5 and 13	
		Pelican Reef, South Reef, Seagull Island, Snipe Island and Wild Dog Island		

Game Reserves (Cont...../2)

No.	Name	Hundred	Section	Approx. Area (Hectares)
4	Mud Islands	Baker	642-644, 646-652	137.9
5	Tolderol	Freeling	349 and 150 link reserve adjacent to 349	229.5
6	Bucks Lake	Kongorong	618	137.5
			TOTAL	14,069

RECREATION PARKS

No.	Name	Hundred	Section	Approx. Area (Hectares)
1	Belair	Adelaide	675	835
2	Para Wirra	Barossa Para Wirra	182, 183-185, 199, 217, 181, 237, 311, 238 and 299 423, 428, 429	1,416.5
3	Glossop	Berri Irrigation Area	1444	2.911
4	Totness	Macclesfield	124	29.94
5	Caratoola	Haslam	53	54.65
6	Brownhill Creek	Adelaide	676	51.54
7	Coulthard	Moorooroo	Pt. 161, C.T. 2362/58	29.94
8	The Elbow	Adelaide	Pt. 1285, C.T. 1655/79	12.08

Recreation Parks (Cont...../2)

No.	Name	Hundred	Section	Approx. Area (Hectares)
9	Ferguson	Adelaide	Pt. 289, C.T. 367/196, C.T. 2051/195	8.063
10	Greenhill	Adelaide	578	26.5
11	Kingston Park	Noarlunga	1540, 1541	8.274
12	Lenswood	Onkaparinga	Pt. 5148, C.T. 2126/186	17.45
13	Loftia	Noarlunga	421 and 422, 1557, 1558 C.T. 3635/150	90.75
14	Windy Point	Adelaide	597	2.933
15	Shepherds Hill	Adelaide	Pt. 14, Pt. 35, C.T. 2396/141,Pt. 15, C.T. 3481/181, Pt. 36, C.T. 2201/97	88.89
16	Sturt Gorge	Adelaide Noarlunga	625, 674 1549, 1556, 1561	131
			TOTAL	2,806

APPENDIX II

Plant Species recorded in the following six areas in the course of research.

Sandy Creek Conservation Park (SCCP)
Kyeema Conservation Park (KCP)
Belair Recreation Park (BRP)
Nixon-Skinner Conservation Park (NSKCP)
The Knoll Conservation Park (KNCP)
Mount Bold Encatchment Area (MB)

The above abbreviations in brackets appear in the following pages of Appendix II.

An 'X' in the column indicates the presence of the particular species in the six areas. The abundance, if known, for those plant species recorded in the areas is categorised as 'VC' = Very Common (plant species present in 50 per cent or more of the quadrats in the particular area), 'C' = Common (plant species present in more than 10 per cent and less than 50 per cent of the quadrats in the particular area), 'R' = Rare (Plant species present in less than 10 per cent of the quadrats in the particular area). No abundance categories are given for Mount Bold Encatchment Area. Introduced plant species are prefixed by an asterisk.

The plant species are named and ordered according to J.M. Black's "Flora of South Australia" (2nd Edition) and H. Eichler's "Supplement to J.M. Black's Flora of South Australia".

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Bryophyta						
Moss spp.	VC	C	C	VC	VC	X
Polypodiaceae						
Adiantum aethiopicum		X	R			
Cheilanthes tenuifolia			R			
Pteridium esculentum		C	C		VC	X
Pinaceae						
Pinus halepensis			R			
Pinus radiata		R	R			
Araucaria sp.			R			
Callitris sp.			X			
Callitris preissii	C					
Poaceae						
Themeda australis		X	C	R	R	X
Neurachne alopecuroidea	X	X		C	R	X
* *Paspalum dilatatum*	X			R		
Panicum prolutum	X					
* *Cenchrus tribuloides*	X					
* *Pennisetum villosum*	X					
* *Ehrharta longiflora*	X			C		X
* *Ehrharta calycina*	R					
Microlaena stipoides		C	C	C	VC	X
* *Phalaris minor*		R		R		X
* *Phalaris canariensis*			R			
* *Anthoxanthum odoratum*		X	X			
Stipa variabilis	X		X			
Stipa falcata		X				
Stipa semibarbata						X
Stipa plagiopogon		X				
Stipa pubescens				C		X
Stipa eremophila		X	X			
Stipa compacta			X			X
Stipa aristiglumis	R					
Stipa verticillata	X					X
Stipa clelandii						X
Stipa spp.	X	R	R		R	X
Echinopogon ovatus		X				
Sporobolus africanus		X				X
Agrostis limitanea		X				
Agrostis aemula						X
Deyeuxia quadriseta		R				X
Dichelachne crinita		X				X
Dichelachne sciurea						X

Appendix II (cont.)

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Poaceae (cont.)						
* *Aira caryophyllea*	C	R	C	C	C	X
* *Periballia minuta*						X
* *Avena fatua*	C					
* *Avena barbata*		X	X			X
* *Avena sativa*			X			X
* *Holcus lanatus*	X	C	R	R	R	X
Danthonia clelandii		C				X
Danthonia geniculata		C				X
Danthonia semiannularis				C		
Danthonia setacea		C				X
Danthonia purpurascens						X
Danthonia caespitosa		C	R			X
Danthonia spp.	R	C	X	C		X
Enneapogon nigricans	X					
* *Cynosurus echinatus*	X	R	R	R		X
* *Avellinia michelii*	X					
* *Lophochloa phleoides*				VC		
* *Briza maxima*	C	R	C	C	C	X
* *Briza minor*	R	R	X			X
* *Dactylis glomerata*		R	X		R	
Poa poaeformis		X				X
Poa laevis		C	C	C	VC	X
* *Poa annua*		X	R	R		X
* *Vulpia myuros*	VC	R	R			X
* *Vulpia bromoides*		R	R			X
* *Vulpia* spp.		R	R			X
* *Bromus diandrus*		R	X	R	X	X
* *Bromus madritensis*	C	R	X			
* *Bromus unioloides*					X	X
* *Bromus mollis*		R	X			X
* *Bromus* spp.		R	X		R	X
Cynodon dactylon	C			R		
* *Lolium perenne*		R	X			X
* *Hordeum leporinum*	X	X				
Cyperaceae						
Cyperus tenellus		X				
Schoenus tenuissimus				C		
Schoenus maschalinus	C					
Schoenus apogon						X
Schoenus sp.		C				
Scirpus antarcticus		X				X
Lepidosperma longitudinale	X					
Lepidosperma laterale	C			C		
Lepidosperma semiteres		VC	R	VC	C	X
Lepidosperma carphoides	X	X	R	VC		X
Machaerina gunnii	X	R		C		

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Cyperaceae						
Gahnia trifida		R	X			
Carex inversa			X			X
Carex appressa				R		
Araceae						
Zantedeschia aethiopica		X	R	R		
Restionaceae						
Hypolaena fastigiata				C		
Centrolepidaceae						
Aphelia pumilio				X		
Centrolepis aristata	X	X		C		X
Centrolepis fascicularis						X
Centrolepis strigosa	C			C		X
Juncaceae						
* *Juncus capitatus*		X		C	C	
Juncus caespiticius			R		R	X
Juncus pallidus	X			R		
Juncus polyanthemos		R				
Juncus pauciflorus		X				
Liliaceae						
Dianella revoluta	R	C	C	C	VC	X
* *Asparagus asparagoides*	C		R	C		
Burchardia umbellata		R	R			X
Anguillaria dioica	X		R			X
Lomandra dura	R	C		C	C	X
Lomandra multiflora	X	X				
Lomandra effusa			R			
Lomandra fibrata				R		
Lomandra sororia		R				X
Thysanotus patersonii	X			C		
Thysanotus dichotomus				C	C	
Caesia vittata	X	X	VC	C	C	X
Chamaescilla corymbosa	VC			VC	VC	X
Tricoryne elatior	X	R	R			X
Bulbinopsis bulbosa			R		R	X
Arthropodium strictum			R			X
Arthropodium fimbriatum		R	X			
Laxmannia sessiflora	X			X		
Xanthorrhoea semiplana	C	VC	R	VC	R	X
* *Allium triquetrum*			C		C	X
* *Muscari neglectum*					X	
* *Endymion* sp.					X	

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Amaryllidaceae						
Hypoxis glabella		X		R		
Hypoxis pusilla			X			X
Iridaceae						
* *Chasmanthe aethiopica*				C		
* *Freesia refracta*			X	C		
* *Sparaxis tricolor*			X			
* *Sparaxis* spp.			C		X	
* *Babiana stricta*	X					
* *Romulea longifolia*	X		X			
* *Homeria miniata*				R		
Orchidaceae						
Calochis robertsonii						X
Thelymitra antennifera						X
Thelymitra spp.				X		X
Microtis unifolia						X
Corybas dilatatus						X
Acianthus caudatus				C		X
Acianthus reniformis				C		X
Caladenia leptochila						X
Caladenia dilatata						X
Caladenia menzeisii						X
Caladenia spp.				X	R	X
Glossodia major						X
Diuris longifolia						X
Pterostylis concinna						X
Pterostylis nana						X
Pterostylis vittata						X
Pterostylis sp.				R	R	X
Casuarinaceae						
Casuarina stricta	C	X	R	R		X
Casuarina striata		C	R			
Casuarina muelleriana		X		C		X
Moraceae						
Ficus macrophylla			R			
Proteaceae						
Isopogon ceratophyllus		VC	R	C		X
Conospermum patens	X					
Persoonia juniperinum		C				
Hakea rostrata	X	C		VC		X
Hakea rugosa		C	R	R		X
Hakea ulicina		VC	R	C		X

Appendix II (cont.)

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Proteaceae (cont.)						
Banksia marginata	C	C	R	C	C	X
Grevillea lavandulacea	R	R	R	C	C	X
* *Grevillea rosmarinifolia*					R	
Santalaceae						
Exocarpus cupressiformis		R	C	R	VC	X
Polygonaceae						
* *Rumex pulcher*			X			
* *Rumex obtusifolius*				R		
Rumex crystallinus		X				
* *Rumex crispus*			X			
Rumex bidens		X				
* *Rumex angiocarpus*	R	C	R			
* *Rumex* sp.					R	
Muehlenbeckia adpressa	X					
Aizoaceae						
* *Carpobrotus aequilaterus*	X					
Portulacaceae						
Calandrinia eremaea	X					
Calandrinia neesiana	C					
Caryophyllaceae						
* *Moenchia erecta*				X		
* *Cerastium glomeratum*		X	R			X
* *Stellaria media*			X	R		X
* *Spergula arvensis*						X
* *Silene gallica*			X			
Scleranthus pungens				X		X
Ranunculaceae						
Ranunculus lappaceus			R		R	X
Lauraceae						
Cassytha glabella	X	VC	R	VC	C	X
Cassytha pubescens	X	X		C		
Fumariaceae						
* *Fumaria muralis*		C	R	R		
Brassicaceae						
* *Brassica tournefortii*	R					
* *Coronopus didymus*						X

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Droseraceae						
Drosera whittakeri	VC	X	R	C		X
Drosera planchonii	X		VC			X
Drosera auriculata	VC			VC		X
Drosera spp.	VC	R	R	VC		X
Crassulaceae						
Crassula colorata	C					
Crassula pedicellosa	X					X
Pittosporaceae						
* *Pittosporum undulatum*			R		C	
Bursaria spinosa		R	R		R	
Cheiranthera cyanea						X
Billardiera sericophora		R	R	VC	R	X
Rosaceae						
* *Rubus* spp. *aff. fruticosus*			R		C	X
* *Rosa rubiginosa*		R	R			
* *Crataegus monogyna*			R		R	
Acaena ovina		R	X			X
Acaena anserinifolia		R	X	R	VC	X
Acaena spp.		R	C			X
Mimosaceae						
Acacia armata	X	X	R			X
Acacia rotundifolia	R		R			X
Acacia spinescens				C		X
Acacia retinodes		R				X
Acacia liqulata	X					
Acacia myrtifolia		VC	R	C		X
Acacia pycnantha	R	X	VC	VC	R	X
Acacia calamifolia	C					
Acacia verniciflua						X
Acacia melanoxylon		X	R		R	X
Acacia verticillata		C				X
Acacia longifolia			R		R	
Fabaceae						
Gompholobium ecostatum		C				
Daviesia virqata		C	R		C	X
Daviesia ulicifolia		C	R	C	R	X
Daviesia brevifolia		R				X
Pultenaea daphnoides		VC	C		VC	X
Pultenaea involucrata		C		C		X
Pultenaea largiflorens		R	C			X

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Fabaceae (cont.)						
Dillwynia hispida	R	X		R	R	X
Platylobium obtusangulum		VC		VC		X
Bossiaea prostrata		X	R		R	X
* *Ulex europaeus*		R	R		VC	
* *Chamaecytisus proliferus*					X	
* *Genista maderensis*			R		C	X
* *Trifolium campestre*		R	X			
* *Trifolium dubium*			X			X
* *Trifolium micranthum*		R				
* *Trifolium fragiferum*		R	R			
* *Trifolium repens*		C				
* *Trifolium glomeratum*			X			X
* *Trifolium subterraneum*			X	X		X
* *Trifolium striatum*			X			
* *Trifolium arvense*	C	X	X			
* *Trifolium angustifolium*	X	R	R			X
* *Trifolium* spp.			R			
* *Medicago truncatula* var. *longispina*	X					
* *Medicago polymorpha* var. *vulgaris*	C			R	X	
Indigofera australis						X
Psoralea patens			X			X
* *Vicia sativa*			R	R	X	X
Kennedia prostrata		X	R	R	R	X
Hardenbergia violacea		X	R			X
Geraniaceae						
Geranium pilosum		X	C	R		
* *Geranium molle*			X		R	
* *Erodium botrys*	R	R				
Pelargonium littorale						X
Oxalidaceae						
Oxalis corniculata		X	R	R	C	X
* *Oxalis pes-caprae*	C	R	C	C	C	X
* *Oxalis incarnata*				R		
Linaceae						
* *Linum gallicum*		X				
Rutaceae						
Correa pulchella	R			X		
Correa reflexa						X

Appendix II (cont.)

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Tremandraceae						
Tetratheca pilosa		VC	C	VC	VC	X
Polygalaceae						
Comesperma volubile						X
Euphorbiaceae						
Beyeria leschenaultii			R			
Stackhousiaceae						
Stackhousia monogyna		X	R		C	X
Sapindaceae						
Dodonaea viscosa	C		R			X
Rhamnaceae						
* *Rhamnus alaternus*			R		R	
Spyridium parvifolium		C				X
Spyridium spathulatum						X
Spyridium sp.	R					
Cryptandra tomentosa	X	X		C		
Sterculiaceae						
Lasiopetalum baueri						X
Dilleniaceae						
Hibbertia sericea	X	VC	C	X		X
Hibbertia stricta var. *gabriuscula*	X					
Hibbertia stricta var. *canescens*	X					
Hibbertia stricta	C	VC	R	VC		X
Hibbertia exutiacies		C	C		VC	X
Hibbertia virgata	C			X		
Guttiferae						
Hypericum gramineum		R		VC		X
Hypericum japonicum			R			
* *Hypericum perforatum*		R	C			
Violaceae						
Viola hederacea		R	R	C	R	X
* *Viola odorata*			R		R	X
Viola spp.			R		R	X
Hybanthus floribundus	R	X				X

Appendix II (cont.)

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Thymelaeaceae						
Pimelea glauca		R	R	C	C	X
Pimelea stricta	R					X
Pimelea spathulata		R				X
Pimelea humilis		X	R			
Pimelea dichotoma	X					
Pimelea octophylla		R				
Pimelea phylicoides				R		
Lythraceae						
Lythrum hyssopifolia		R				
Myrtaceae						
Baeckea behrii	VC					
Leptospermum juniperinum		C	R	R		X
Leptospermum pubescens		R				
Leptospermum myrsinoides	X	VC	R	VC	C	X
Kunzea pomifera	R	X				
Callistemon macropunctatus	R					
Callistemon sp.			X			
Melaleuca decussata		R	R	C		
Melaleuca lanceolata				X		
Melaleuca uncinata		X				
Eucalyptus ficifolia			R			
Eucalyptus obliqua		VC	C	VC	VC	X
Eucalyptus baxteri		C				
Eucalyptus odorata	R	X	C			
Eucalyptus leucoxylon	X	R	C	C		X
Eucalyptus leucoxylon var. *macrocarpa*	X					
Eucalyptus fasciculosa	C	C	C	VC	R	X
Eucalyptus cladocalyx			R			
Eucalyptus cosmophylla		C	R			
Eucalyptus camaldulensis		X	C	R		
Eucalyptus viminalis		X	C		C	
Eucalyptus rubida		R				
Eucalyptus ovata		X		R		
Calytrix tetragona	VC	X	R	VC		X
Haloragaceae						
Haloragis tetragyna		VC	C	VC	C	X
Haloragis teucrioides				R		X
Haloragis elata	X	X		R	C	X
Haloragis odontocarpa	X					
Haloragis spp.	C	C		C	C	X

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Araliaceae						
Hedera helix			R		C	
Apiaceae						
Xanthosia pusilla		X	R	C		X
Hydrocotyle callicarpa	X		R	C		X
Trachymene pilosa	X					X
Trachymene cyanopetala				C		
Oreomyrrhis eriopoda						X
Eryngium vesiculosum						X
Daucus glochidiatus		X				
Platysace heterophylla		X		R		
Ericaceae						
* *Erica lusitanica*			R		C	
Epacridaceae						
Astroloma humifusum	R	C	R	R	R	X
Astroloma conostephioides	VC	C	R	VC	X	X
Lissanthe strigosa			R			
Leucopogon hirsutus		X				
Leucopogon concurvus		C				X
Leucopogon virgatus		C	R	VC	R	X
Leucopogon cordifolius	R					
Acrotriche serrulata		C	R	C	C	X
Acrotriche fasciculiflora			C		VC	X
Brachyloma ericoides		X				
Epacris impressa		C	R		R	X
Primulaceae						
* *Anagallis arvensis*		X	X		R	X
* *Anagallis arvensis* var. *caerulea*	C		X			
Oleaceae						
* *Olea europaea*			C			
Loganiaceae						
Mitrasacme paradoxa						X
Gentianaceae						
Sebaea ovata		X				X
* *Centaurium minus*		R	R			
* *Centaurium maritimum*		X				

Appendix II (cont.)

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Apocynaceae						
* *Vinca major*			X			
Asclepiadaceae						
* *Asclepias rotundifolia*			R		X	X
Convolvulaceae						
* *Convolvulus arvensis*			X			
Boraginaceae						
* *Echium lycopsis*	C	X	R			
Lamiaceae						
Ajuga australis			R			X
* *Mentha spicata*		X				
* *Stachys arvensis*			X			X
Solanaceae						
Solanum nigrum			R			
Scrophulariaceae						
* *Zaluzianskya divaricata*	X					
Plantaginaceae						
Plantago varia			X			
* *Plantago lanceolata*		R	C	R	R	X
Rubiaceae						
* *Sherardia arvensis*			R			X
Galium australe			X			X
Galium sp.			X		R	X
Valerianaceae						
* *Fedia cornucopiae*			X			X
* *Valerianella truncata*						X
Campanulaceae						
Wahlenbergia gracilenta	X					X
Wahlenbergia stricta			X			
Wahlenbergia sieberi			X	X		X
Wahlenbergia sp.	X	X	X	X		X
Lobelia gibbosa		X				

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Goodeniaceae						
Goodenia geniculata	X					
Goodenia primulacea		C	R	C		X
Goodenia ovata		C				X
Scaevola albida	X	X	C		C	X
Brunoniaceae						
Brunonia australis		X	R	C	R	X
Stylidiaceae						
Stylidium graminifolium		R		C		X
Asteraceae						
Lagenifera stipitata		X	R		R	X
Vittadinia triloba	X					
Olearia tubuliflora		C	R	VC		
Olearia ramulosa		X		X		X
Olearia ciliata						X
* *Senecio pterophorus*	R	R	C		C	X
Senecio odoratus		X				
Senecio hypoleucus					C	
Senecio biserratus		X			R	X
Senecio laceratus	X					
Senecio quadridentatus	R	R	R			X
Senecio hispidulus		X				
* *Chrysanthemoides monilifera*	C		C		R	
* *Arctotheca calendula*	C	R	R			X
Gnaphalium japonicum		X	R		C	X
Helipterum hyalospermum	X					
Helipterum pygmaeum	X					
Helipterum laeve	C					
Helichrysum baxteri		R				
Helichrysum leucopsideum	X					X
Helichrysum scorpioides				VC	C	X
Helichrysum apiculatum	X	X				
Helichrysum bilobum	R					
Podotheca angustifolia	C					
Millotia tenuifolia	VC					
Rutidosis multiflora	X					
Toxanthus muelleri						X
Ixodia achillaeoides		C	R		C	X
* *Inula graveolens*			R			X
Agianthus strictus	X					
Calocephalus drummondii	C					
Actinobole uliginosum	C					X
Craspedia uniflora		X	X		R	X
* *Cynara cardunculus*	X		R			

Species	SCCP	KCP	BRP	NSKCP	KNCP	MB
Asteraceae (cont.)						
* *Carduus tenuiflorus*			X			
* *Silybum marianum*			R		R	
* *Onopordum acanthium*		R	R			
Microseris scapigera			X			X
* *Hypochoeris radicata*		C	X			X
* *Hypochoeris glabra*	VC	X	X	X	C	X
* *Hypochoeris* sp.	X	X	C	X	R	X
* *Picris echioides*			R		R	
* *Taraxacum officinale*			X			
* *Sonchus asper*		X		X	R	X
* *Sonchus* sp.				X		X