HISTORICAL CHANGES IN LAND CONDITION IN THE SOUTH AUSTRALIAN ARID PASTORAL ZONE

by

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Frontispiece: Travelling in the far north collecting historical records - just out of Birdsville, Queensland.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Following Page:

MAPS

FIGURES

PHOTOGRAPHS

On Page:

TABLES

ABSTRACT

During this project, historical changes in land condition of two north-eastern pastoral districts of South Australia were examined. Changes in rangeland condition, from 1880 to 1994, were assessed from historical data. The data was compiled from a variety of sources, including pastoral records, State archives, and personal observation. Information was also collected on four of the main factors that influence rangeland condition - stock, rabbits, kangaroos, and rainfall.

The two regions of interest were the North East Pastoral and the Marree Soil Conservation Districts (SCDs). A methodology, involving classification of all reliable historical data on a five-point scale of land condition, was developed for the North East Pastoral SCD. The scale, specifically designed for the area, was based on plant cover and soil stability, the two features which could be most easily and reliably judged from the historical data. Rigorous criteria were used to extract 580 pieces of reliable data on historical land condition for the North East Pastoral SCD, from the many thousands of records examined. The classified data was then analysed graphically and statistically.

Graphs of classified data, and a land condition index, showed that land condition deteriorated rapidly from the 1880s to the turn of the century, remained low until the 1930s, and has since improved substantially. These trends are derived from the classes of broad-scale plant cover, and do not include detail of more subtle indicators of condition, such as biodiversity or shifts in species composition.

The classification method, the main focus of this project, was found to be a useful approach to organising information from disparate sources for the North East Pastoral SCD, largely due to the homogeneity of the area and the smaller size of stations. The method was unsuccessful in the Marree area, due to the vastly contrasting land systems, each with internal heterogeneity, intermingled throughout the area. The sheer size of the area also limited the number of historical records for each land system, as well as the amount of land that could be usefully assessed during this project.

The results are discussed in terms of the value of historical context for assessments of land condition, the limitations of the methods employed, and the current debate on land condition in the rangelands of South Australia.

DECLARATION

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

I give my consent to this thesis being made available for photocopying and loan.

Nicola E. J. Barnes

November 1997

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ABBREVIATIONS AND ACRONYMS

ABARE	Australian Bureau of Agriculture and Resource Economics
CSIRO/CSIR	Commonwealth Scientific and Industrial Research Organisation
DENR	Department of Environment and Natural Resources, South Australia
MARREE SCD	Marree Soil Conservation District
NEP SCD	North East Pastoral Soil Conservation District
NSW	New South Wales
PCC	Plant Cover Class
PCI	Plant Cover Index
PCS	Plant Cover Scale
PMB	Pastoral Management Branch of DENR
SA	South Australia
SAFF	South Australian Farmers Federation
SAPP	South Australian Parliamentary Papers
SCD	Soil Conservation District
SE's	Sheep Equivalents

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

There has been a steadily increasing focus on environmental and conservation issues in Australia over the last 20 years. The result of this increasing concern has ranged from small scale, individual responses (eg. increase in household recycling) through to the formation and prominence of large environmental groups (eg. Save the Trees, Greenpeace, Australian Conservation Foundation). This has also stimulated a large amount of scientific research into the wide variety of environmental issues relevant to Australia. Additionally, production focuses have shifted from purely economic gain to those concerning sustainable resource usage.

Environmental issues have also become increasingly prevalent in government policies over recent years due to strong public support. This culminated in 1989 with the Australian Government introducing assistance for projects aimed at improving our environment, under the registered name of 'Landcare'. This project is but one under the auspices of the National Landcare Program.

Most of the Australian environment is arid (75%) and incorporates large areas of rangelands (**Map 1**). One of the main topics of debate and controversy in this area is the sustainability of pastoralism - the major land use in the arid zone. In brief, the aim of this project is to examine changes in rangeland condition that have occurred since European settlement in order to place the sustainability of pastoralism in South Australia into an historical perspective. Many of the issues discussed in this thesis will relate to Australian rangelands in general, however the focus for this project is on the rangelands in the north east of South Australia.

1.2 RANGELAND ISSUES

1.2.1 Definition of South Australian rangelands

The rangelands in Australia are the areas of unimproved pastures used for stock grazing (see **Map 1**). In the more recent years since European occupation, large parts of these areas have been 'reallocated' as Aboriginal land and National Parks. In South Australia, the rangelands are all in the arid zone, which is unsuitable for agriculture (receiving less than 250mm annual rainfall) and thus they have largely retained their natural vegetation (Maconochie, 1996; Purdie, 1986 as cited by Wilson, 1990). Though there is a difference in their definitions, the terms 'arid zone' and 'rangelands' are often used interchangeably.

The area of arid land in South Australia encompasses about 80% of the state and is divided into three main administrative units- pastoral leases (60%), Aboriginal land (24%) and Conservation parks (16%). Other rangeland uses include mining and tourism, however the most predominant use is pastoralism - stock grazing on native pasture.

1.2.2 Significance of Australian rangelands

Australian rangelands are often perceived as being remote, desert areas where little can grow or survive. Nevertheless, they are inhabited by 300 000 people (Robertson, 1996) who cope with these harsh conditions as part of their daily lives. These and many other people have a vested interest in the current and past management of the Australian rangelands.

Those in the mining, pastoral and tourism industries are all reliant upon the resources provided by rangelands. In South Australia, oil and gas are produced at Moomba by SANTOS; copper, uranium, silver and gold are mined at Olympic Dam (Roxby Downs) by the Western Mining Corporation and coal is mined at Leigh Creek for power generation at Port Augusta. Pastoralists utilise the rangeland vegetation, which is harvested via the sale of sheep, cattle and wool. In addition, many outback towns and places of interest such as Innamincka and Lake Eyre have provided the basis for an outback tourism industry which markets the aesthetic value of the arid zone.

The unique biodiversity and landscapes offered by Australian rangelands are of significant conservation value, and there are many places, such as Coongie Lakes (Innamincka), that

Map 1. Australian rangelands (shaded) as defined by ABARE. Note that the shaded area also includes Aboriginal lands and Conservation Parks.

are of significant natural heritage value. Much of our coastal environment has been irrevocably altered or destroyed by encroaching urbanisation, and radiating around these areas, large tracts of the natural environment have been cleared for agricultural purposes. In comparison, the rangelands have remained relatively unaltered by civilisation and as such represent a unique ecosystem even by world standards.

Finally, despite being an urbanised country, the images associated with the 'Australian Outback' are important to our national identity. It is of immense cultural value to both indigenous and non-indigenous Australians as it forms an important part of our heritage. Added to this is the intrinsic value of appreciating rangelands as the dominant type of country in Australia.

A focus for debate

The South Australian rangelands invoke a diversity of interests and perspectives from the variety of groups with a vested interest in their management. This sometimes introduces complexities, which often arise from different perceptions of how the land has been managed in the past. A clear understanding of how historical practices have impacted on rangelands will offer insights into reconciling both current and future perceptions, condition and management of one of Australia's most valuable resources.

1.2.3 Past degradation

Most Australians are aware of the extreme land degradation that occurred in the rangelands when pastoralism commenced. The colonisation of South Australia in 1836 was characterised by a 'colonise and conquer' attitude and policies to encourage the development of many small, prosperous farms throughout the state. Due to unrealistic expectations and ignorance of climate and land capabilities, the land was overgrazed, leading to widespread degradation. Vast tracts of country lay denuded and eroded in the arid north east of South Australia in the 1930s (Ratcliffe, 1936), and this degradation was largely the result of over-stocking.

1.2.4 Views on the sustainability of modern pastoralism

While the occurrence of past degradation is generally agreed upon, the current state of the rangelands is not. The variety of different interest groups mentioned previously has resulted in a number of attitudes towards the current sustainability of pastoralism. One perception, common to both the scientific community and the general public, is that pastoralism is not sustainable and the land is being continually degraded.

In contrast, a recent survey (Day *et al.*, 1995) shows that South Australian pastoralists' opinions are to the contrary and they believe that less land degradation is occurring now than in the past. These are but two views amongst a of a variety of strong opinions in what is getting to be quite a heated debate. With competing land use options such as Aboriginal tenure and World Heritage Listing, the success of pastoralism as a land use in the arid zone has come under close scrutiny.

The confidence of pastoralists in their opinions on current land condition has led them to seek scientific appraisal, which resulted in the commencement of this project. Pastoralists in the north east of South Australia suggested the idea of a scientific study of their land's history to the South Australian Farmers Federation, who in turn organised the funding from the National Landcare Program.

1.3 AIMS

Early land degradation (around the turn of the century), is accepted. The main question now is "how has the land changed since then and why?". The aim of this project was to examine this question by:

- constructing a history of broad changes in land condition over the last 120 or so years;
- constructing similar histories of changes in influences on land condition (eg. stock, rabbits, rainfall etc); and
- comparing the influences with the changes.

This project was conducted by drawing together disparate strands of historical evidence including photos, diaries, anecdotal evidence etc. A major aspect, then, was the development of a methodology to incorporate these unorganised and disparate strands of data into a coherent form suitable for scientific analysis.

CHAPTER 2

DESCRIPTION OF THE STUDY REGIONS

2.1 CHOICE OF THE TWO STUDY AREAS

This study focussed on two pastoral areas in the north-east of South Australia with the aim to compare and contrast findings. The north east of the state was chosen because the initial idea for the project came from pastoralists in this area, and it had been relatively understudied. Two adjoining Soil Conservation Districts (SCDs) were selected for study:

- North East Pastoral SCD - vegetation mainly chenopod shrublands grazed by sheep.
- Marree SCD - variety of land systems with largely ephemeral vegetation grazed by cattle.

The two study areas are shown on **Map 2** and are described below.

2.2 THE NORTH EAST PASTORAL SCD

2.2.1 Location

The North East Pastoral SCD lies on the New South Wales border about 400km NE of Adelaide (**Map2**). National Route 32 (Adelaide to Broken Hill), passes east to west through the study area, through the towns Mannahill, Olary, Mingary (deserted) and Cockburn (**Map 3**). The area extends north of the highway to the Dog Fence, and south to the southern boundary of Mutooroo Station, and encompasses 31 429 km^2.

2.2.2 Climate

The climate in the North East Pastoral SCD is mainly warm and dry, with short cool to cold winters (Laut *et al.*, 1977a). Historical temperature values are available for Yunta, which lies just outside the western boundary of the area. The temperature ranges from a mean minimum of 3°C in July to a mean maximum of 32.8°C in January (**Figure 2.1**).

The area lies within the 150 - 250 mm rainfall isohyets (Laut *et al.*, 1977a), and is thus semi-arid. Annual rainfall tends to be highest in the SW corner of the study area and decreases to the NE. However rainfall is extremely variable both temporally and spatially, so while the mean for the area is 215mm, it may vary from <50 to 400^{+}mm (**Figure 2.2a**) and does not follow any seasonal pattern (**Figure 2.2b**). Also, evaporation is very high, causing much of the rainfall to be 'ineffective'. Aspects of rainfall are discussed in further detail in chapter 6.

2.2.3 Landforms and soils

A series of low ranges runs north easterly through the middle of the area (alongside the highway). These are known as the Olary Spur and are an eastward offshoot of the Flinders Ranges (Laut *et al.*, 1977a). Watershed from these ranges occurs both northwards to the Lake Frome plains, and south to the Murray plains via a network of small ephemeral creeks.

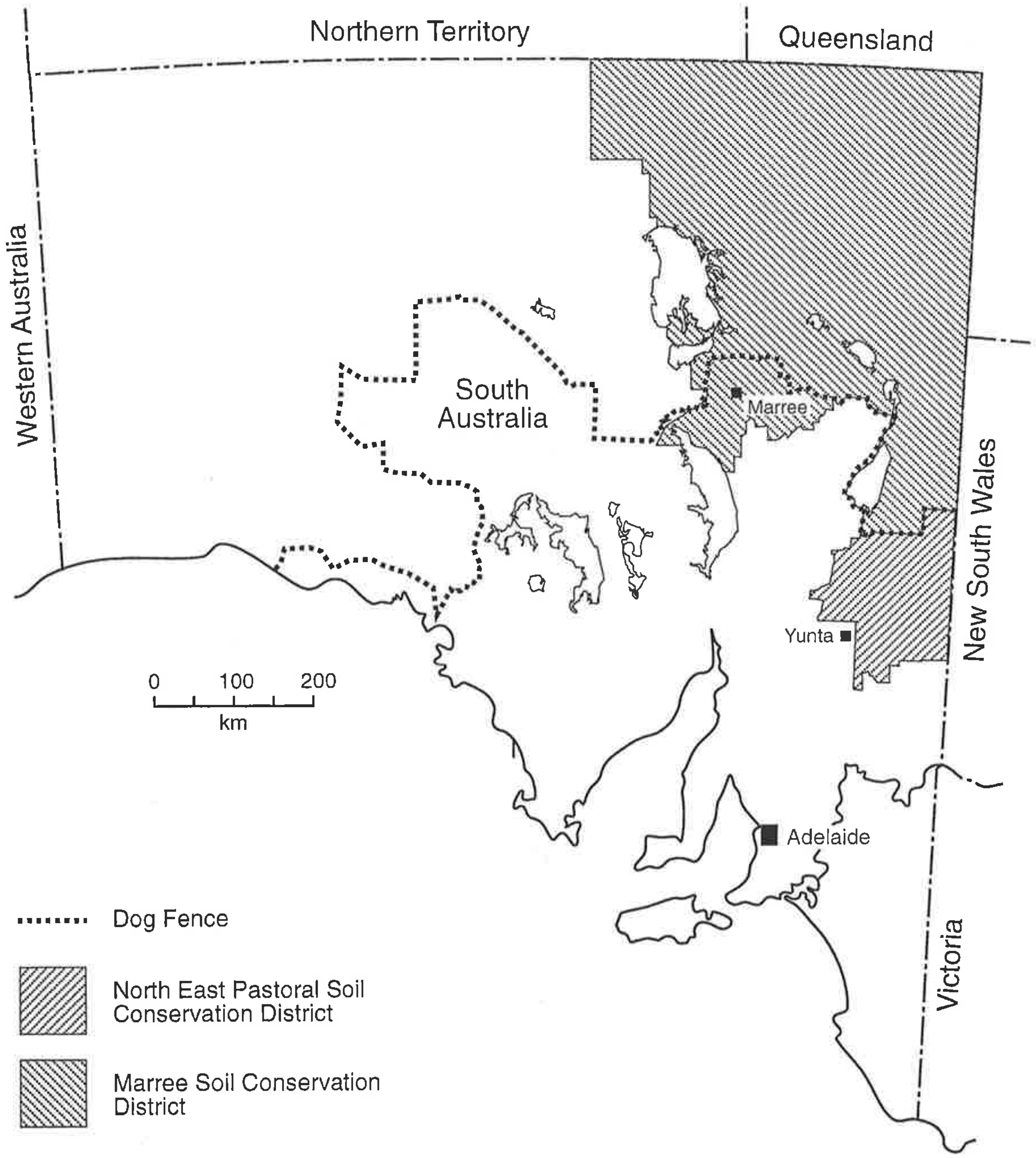
The soils in the area are described by Northcote (1968) and shown in **Figure 2.3**. Overlying the Olary spur are shallow, nutrient poor calcareous loams, and to the east of these ranges are crusty alkaline and neutral red duplexes. On the plains to the north and south of this belt are brown calcareous earths.

2.2.4 Land Systems

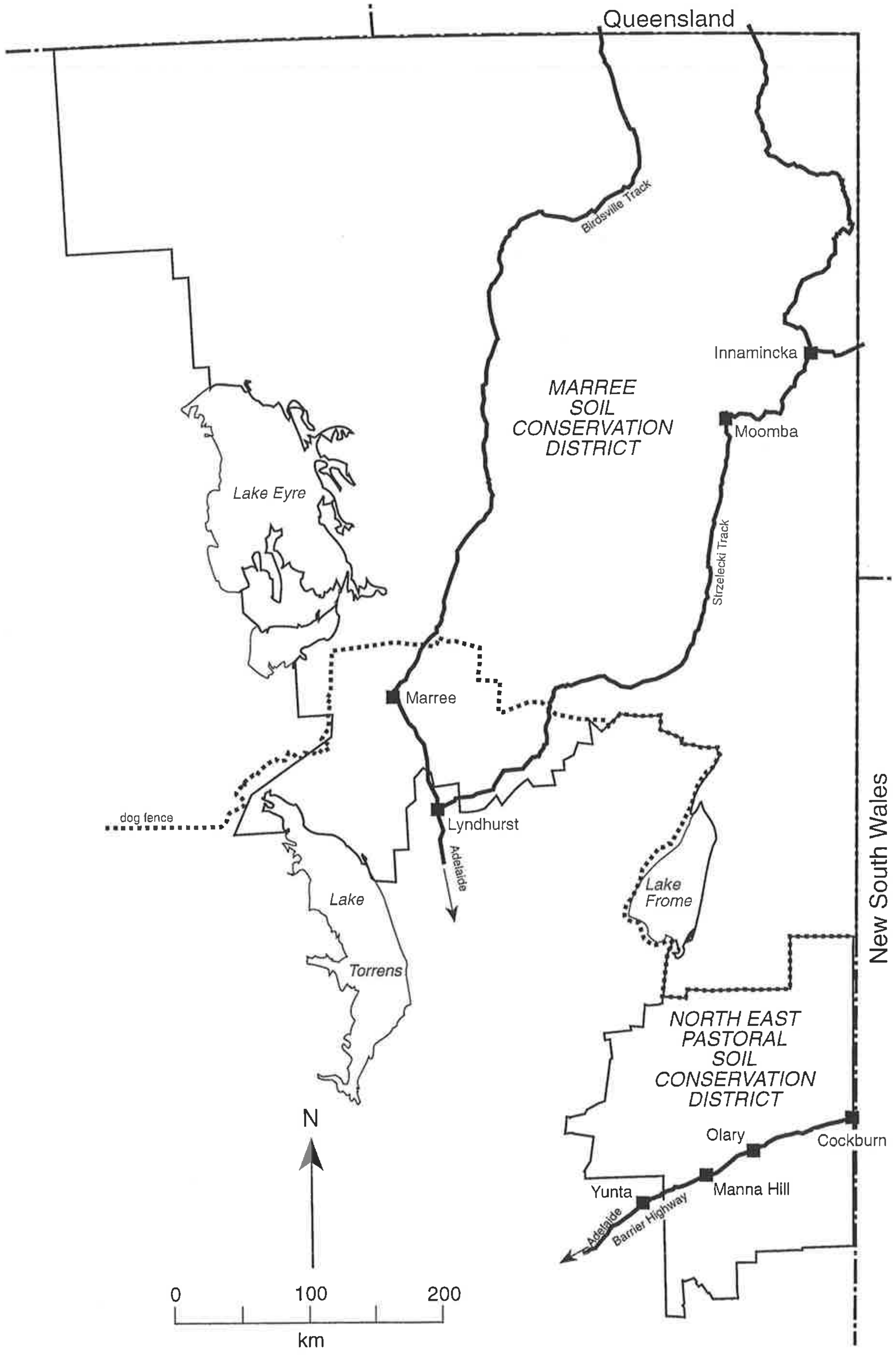
The NEP SCD lies almost completely within the top two-thirds of the Eastern Pastoral Province as described by Laut *et al.* (1977a). Most of the stations lie within the second and third landform regions, the 'Olary upland' and the 'Lake Frome plains' (see **Figure 2.4**).

2.2.5 Vegetation

Specht (1972) has described most of the area as 'low shrubland' dominated by saltbush (*Atriplex* spp.) and bluebush (*Maireana* spp.). In the upland area of the Olary Spur, tall shrublands occur including turpentine, broom (*Eremophila* spp.), birdseye (*Senna* spp.), hopbushes (*Dodonea* spp.) and wattles (*Acacia* spp.) (Laut *et al.*, 1977a). On the more northerly plains, some areas support a scattered overstorey of mulga (*Acacia aneura*); scattered blackoak (*Casuarina cristata*) and/or bullockbush (*Alectryon oleifolium*) occurs



Map 2. The North East Pastoral and Marree Soil Conservation Districts of South Australia.



Map 3. Location of major roads and towns in the North East Pastoral and Marree Soil Conservation Districts.

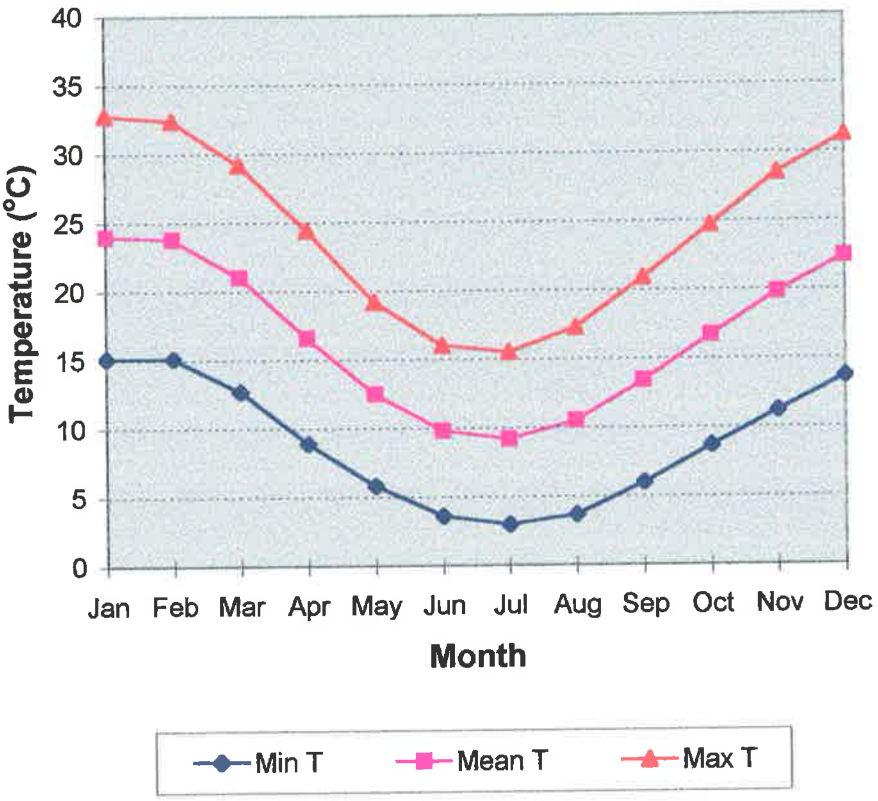
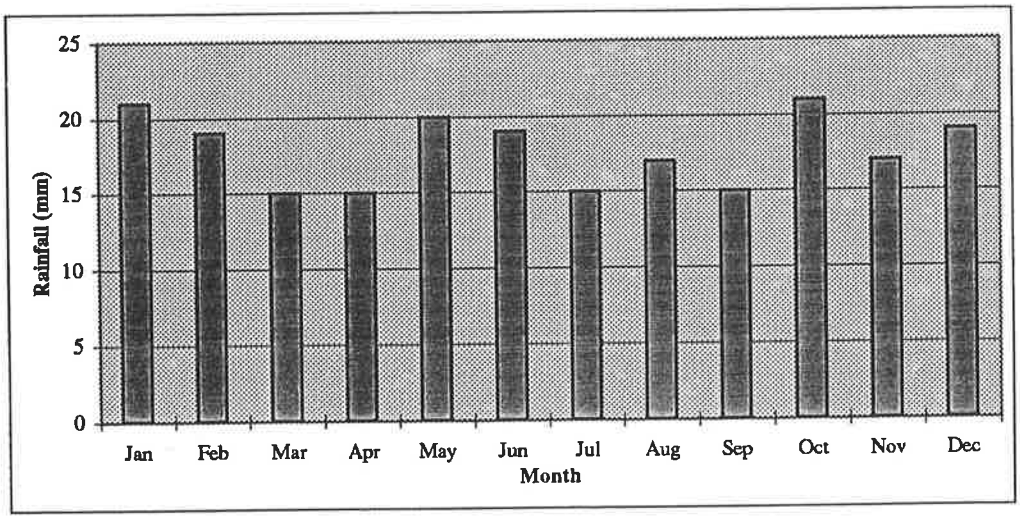


Figure 2.1: Long term average temperature data for Yunta, South Australia.

a)



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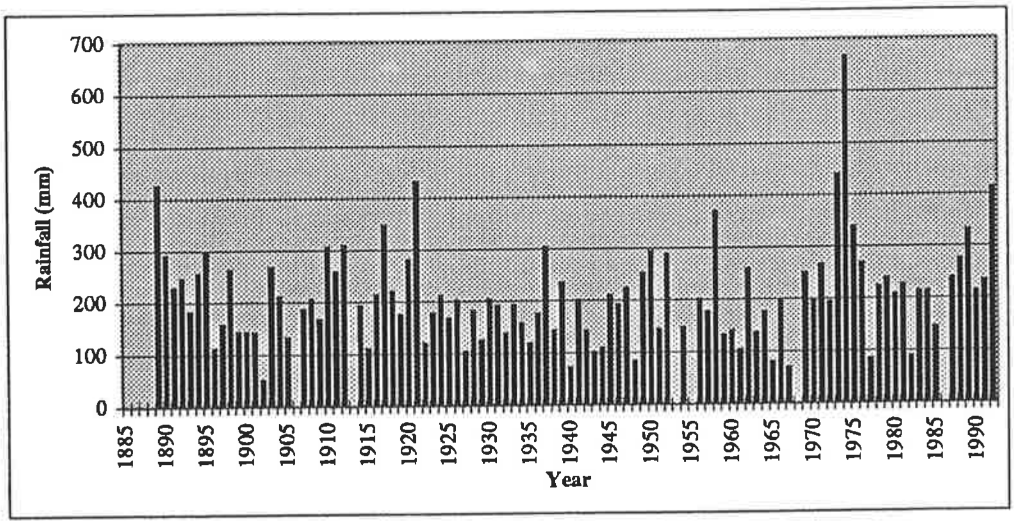


Figure 2.2: Aspects of rainfall at Mannahill, a) Long term monthly average rainfall and b) Historical annual rainfall.

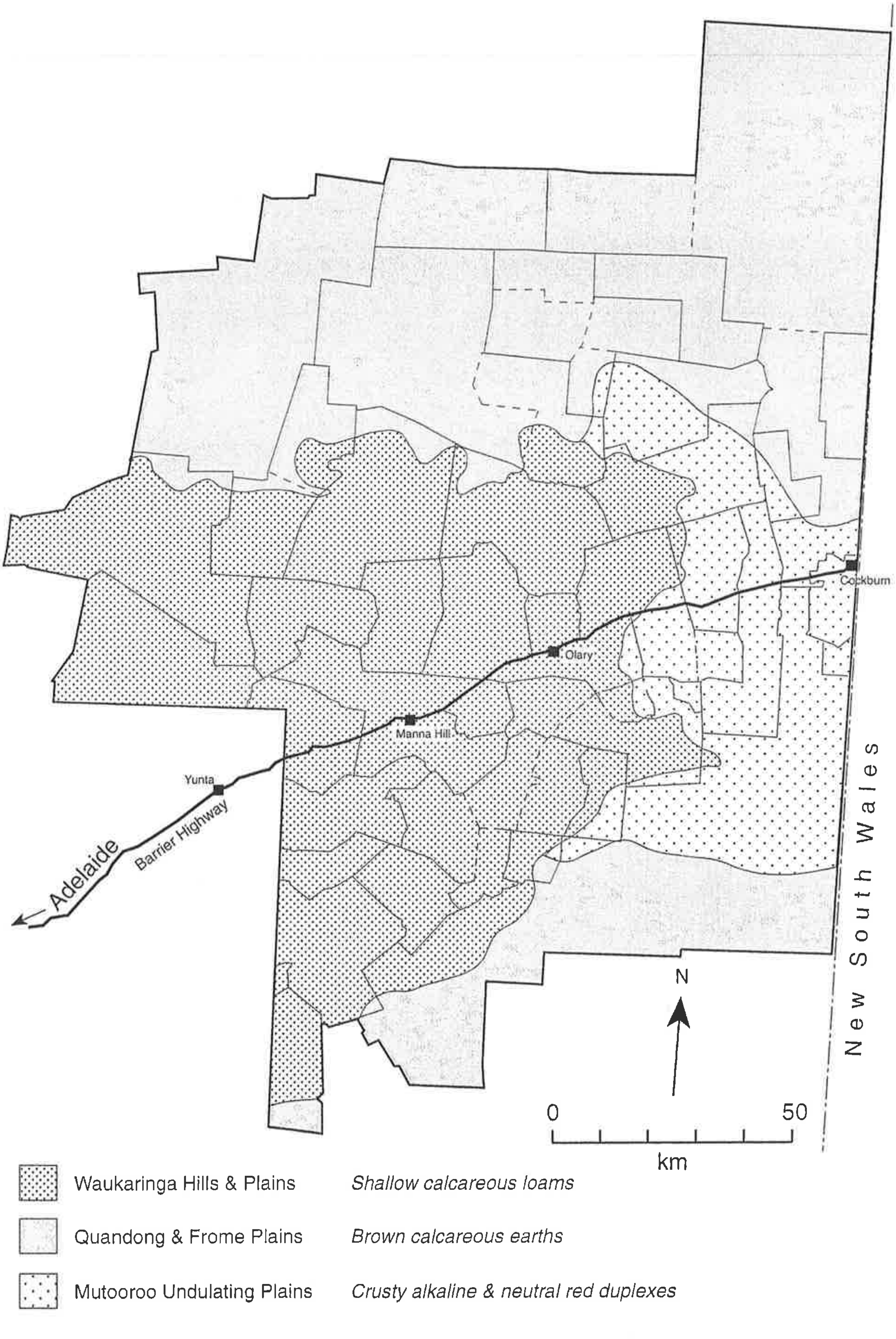


Figure 2.3: Soils of the North East Pastoral Soil Conservation District (after Northcote, 1968).

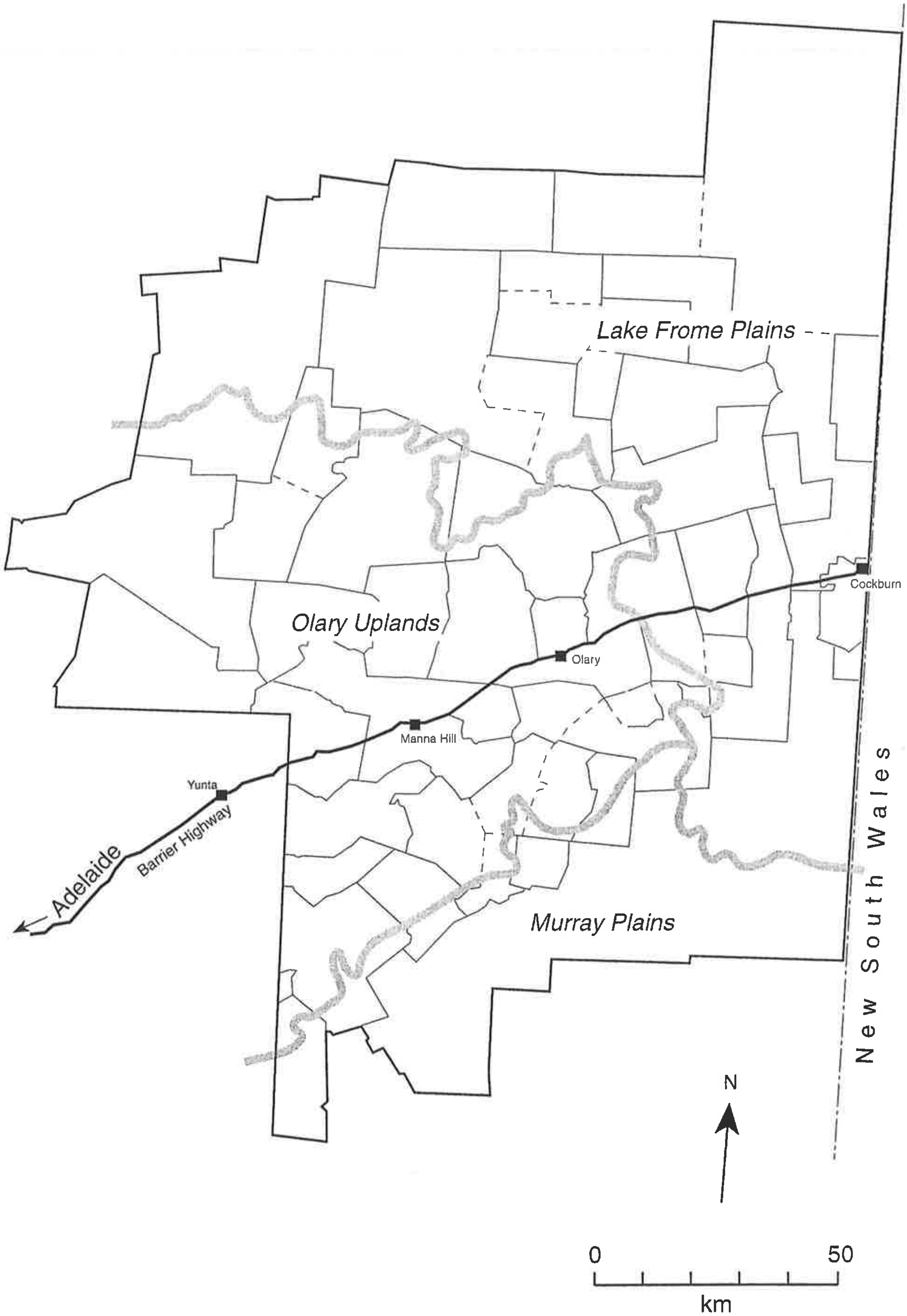


Figure 2.4: The North East Pastoral Soil Conservation District, showing the landform regions as described by Lant *et al*. (1977).

throughout. The southern fringe of the study area includes some isolated pockets of mallee (*Eucalyptus socialis*) marking the transition into the vegetation north of the Murray River.

On a broad scale, the entire area can be described as chenopod shrublands with or without a scattered overstorey, and is reasonably uniform throughout (see **Plate 2.1**).

2.2.6 Land use

There are 46 leases run as 35 stations in the region and all are leased for pastoral purposes (sheep or cattle grazing on natural vegetation), most lessees running sheep. A few lessees also run a small number of cattle and there are very few horses. In 1877 cropping was tried at the Mannahill Experimental Farm. This was successful for the first 2 years during above average seasons. However during the following years it failed completely and was not attempted again (Meinig, 1962).

Further descriptions of this area can be found in Tiver (1994), Brett (1990) and Gibbs (1986).

2.3 THE MARREE SCD

2.3.1 Location

The Marree SCD is in the top NE corner of the state (**Map 2**). A small portion of this district lies to the south of the dog fence, but was not included in the study. Marree is just outside the SW corner of the district and the boundary runs north to the QLD border and east to the NSW border. The area encompassed is 191 437 square kilometres. There are 2 main roads in the area - the Birdsville track runs from Marree to Birdsville, and the Strzelecki track (to the south and east) runs from Lyndhurst to Innamincka. Innamincka is the only town in the study area (**Map 3**).

2.3.2 Climate

The conditions throughout the Marree SCD consist of a hot, dry desert climate with short cool to cold winters. There is little variation in climate across the area due to its "inland location and lack of major orographic controls" (Laut *et al.*, 1977b; pp. 1). Historical temperature values are available for Marree, which lies just outside the south west boundary of the study area. The temperature ranges from a mean minimum of 4.8 °C in July to a mean maximum of 37.9°C in January (**Figure 2.5**).

Mean annual rainfall varies throughout the area, but is around 150mm (ranges from 119mm at Murnpeowie to 168mm at Innamincka). As in the NEP SCD, rainfall is extremely variable both spatially and temporally, but tends to fall more in the summer months (**Figure 2.6**). Mean annual evaporation is extremely high, varying between 3000-4000mm (Laut *et al.*, 1977b).

2.3.3 Landforms and soils

The Marree SCD consists of undulating plains and sandhills, with no ranges in the area. The area encompasses the Tirari, Strzelecki and Sturt Stony Deserts and part of the Simpson Desert. There are two main river systems, the Cooper Creek and the Diamantina River/Warburton Creek. These river systems originate in Queensland and the Northern Territory, and enter South Australia from the north east. They eventually feed into Lake Eyre, the largest inland lake in Australia, which borders the study area in the south west corner. An important aspect of these river systems is that they can flood as a result of high rainfall in Queensland even when there is none in South Australia, thus providing an additional water source to some areas.

Soils are predominantly red duplex soils and calcareous powdery red-brown loams, with isolated occurrences of grey-brown cracking clays in dune swales and drainage depressions on the tableland surface (Northcote, 1968). The dunes and sand sheets on the plains are dominated by siliceous red sands and reddish-brown sands which are well drained and generally remain stable when vegetated. The tableland and plains surfaces are covered with gibbers which provide a protective seal for the underlying soil. Overall, the susceptibility of relatively undisturbed examples of these areas to wind and water erosion is considered to be low.

2.3.4 Land Systems

The Marree SCD is included in the eastern half of Province 8, as described by Laut *et al.* (1977b). Most of the area is within Environmental Region 8.4, the Lake Eyre basin, with a very small area in Environmental Region 8.3, the Central Tablelands. However the land

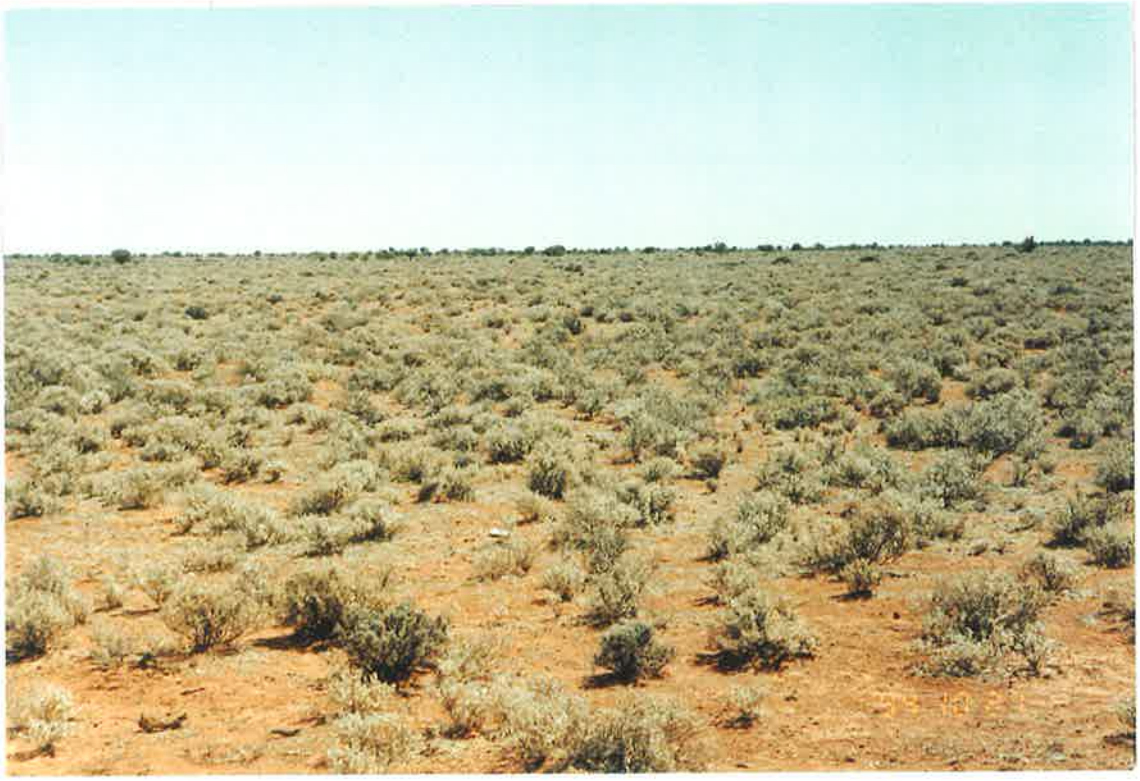


Plate 2.1: Examples of country in the North East Pastoral SCD.

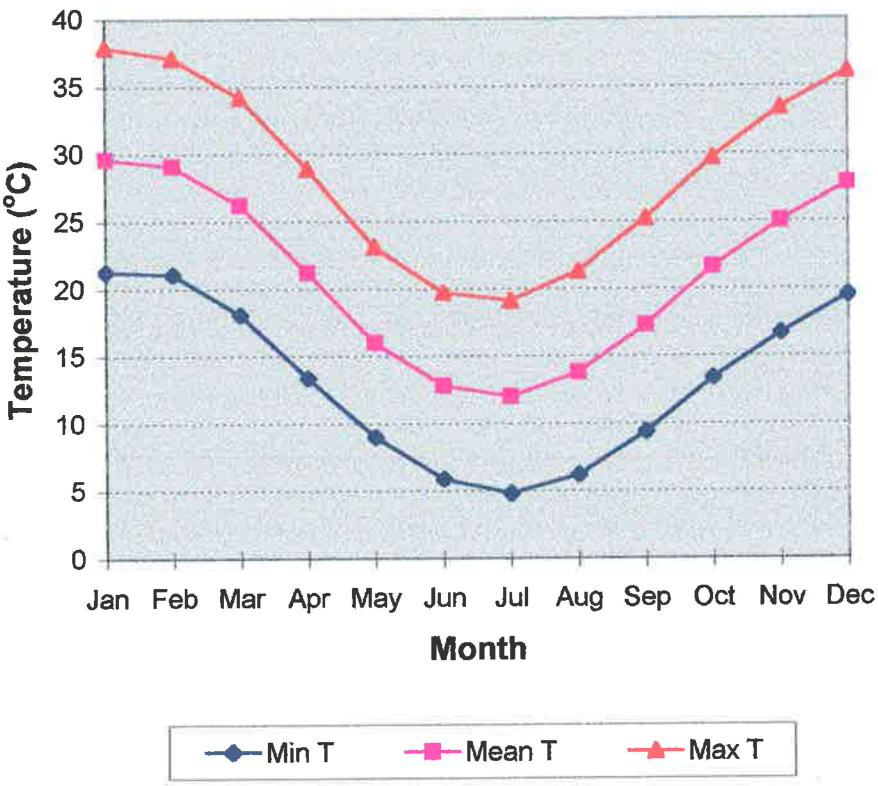
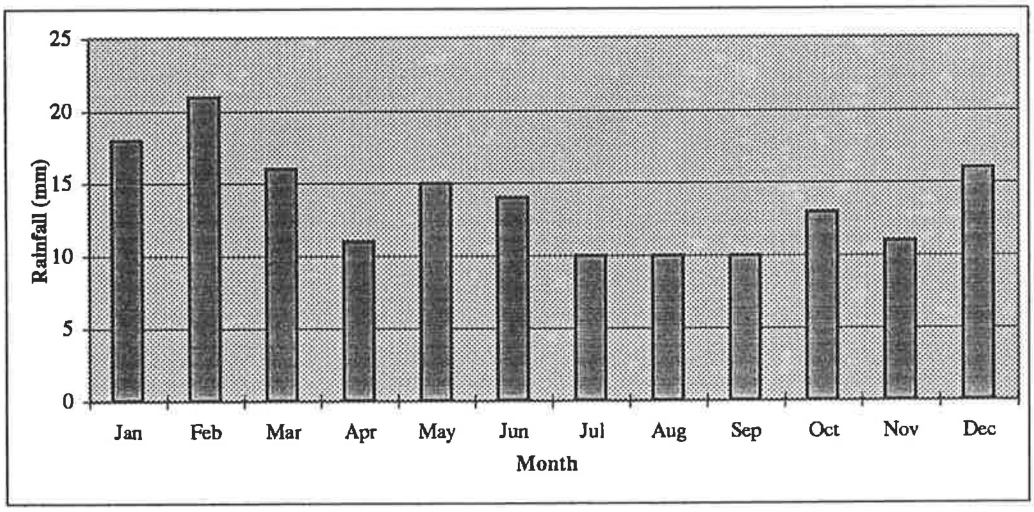


Figure 2.5: Long term average temperature data for Marree, South Australia.

a)



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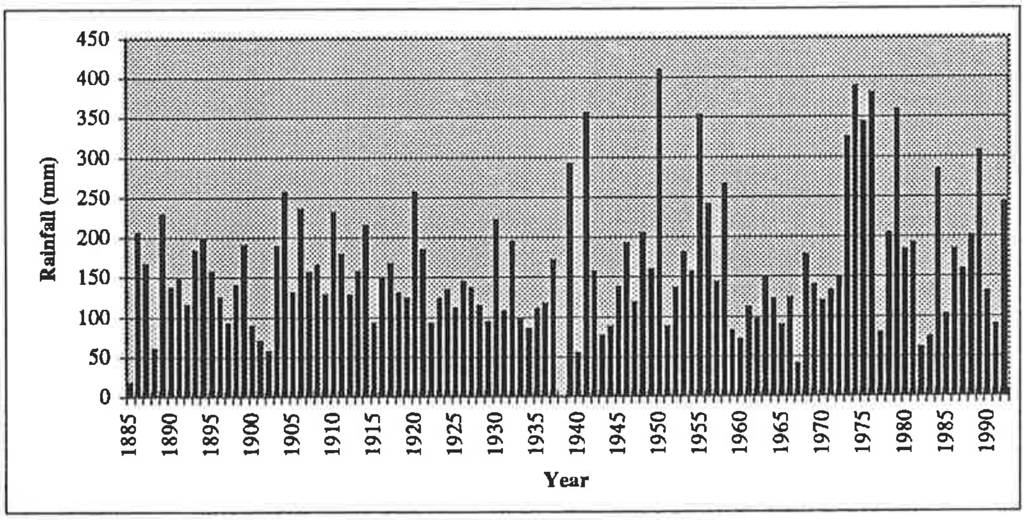


Figure 2.6: Aspects of rainfall at Marree Post Office, a) Long term monthly average rainfall and b) Historical annual rainfall.

systems can most easily be divided into the following four types:

- Sandhills - a series of north-south, parallel, long sandridges of varying height.
- Gibber - clay based sub-soils part or totally covered with gibbers (shiny stones).
- Watercourse country - river channels and floodplains.
- Saltlakes - inland saltlakes and immediately surrounding areas.

2.3.5 Vegetation

The vegetation consists of scattered overstories of various trees, mainly coolibah (*Eucalyptus microtheca*), with a largely ephemeral understorey. However, each of the 4 land types has quite distinct vegetation patterns associated with them:

- Sandhills (**Plate 2.2**) - Some have bare crests with constantly moving sand, and are vegetated only in very wet times. Others are lightly covered with wattles or perennial grass clumps (mainly sandhill canegrass; *Zygochloa paradoxa*) - when dry, the ground is bare and drifting in between bushes; after rain it becomes covered with a mass of low grasses and wildflowers.
- Gibber (**Plate 2.3**) - When dry there is little vegetation, mainly perennial grasses with predominantly dead foliage. After rain, a variety of ephemeral species grow in areas while surface water is available. Scattered throughout the gibber are isolated areas termed 'clay pans' which collect the excess water that runs off the surrounding stony areas, and these areas flourish with vegetation after substantial rains. Some areas support scattered stands of native fuchsia (*Eremophila* spp.) and dead finish (*Acacia tetragonophylla*).
- Watercourse country (**Plate 2.4**) - Vegetation differs depending on whether land is on edge of a river channel, or situated on a floodout. River red gums (*Eucalyptus camaldulensis*) and coolibahs (*Eucalyptus microtheca*) line the edge of most watercourses. Floodplain areas (ie. where water spills out of watercourses during floods) support a variety of vegetation depending on the frequency of flooding (which is also related to soil type). Common plants include a variety of *Acacia* (wattle) and *Atriplex* (saltbush) species, as well as ephemerals after rainfall events. The swampy areas between sandhills often support swamp canegrass (*Eragrostis australasica*), or old man saltbush (*Atriplex nummularia*).

- Saltlakes (**Plate 2.5**) - These contain water only during wet years and cover a relatively small area. Their vegetation is sparse, but consists of salt tolerant species such as samphires (*Halosarcia indica*) and nitrebush (*Nitraria billardieri*).

The above information on vegetation was compiled from Laut*et* al. (1977b), Wiltshire and Noack (1991), personal observation and communications with many of the pastoralists in the area.

2.3.6 Land use

There are 34 pastoral leases in the area, run as 21 stations which are mostly used for grazing cattle on native vegetation (pastoralism). Most of the area is outside the 'Dog fence', where sheep grazing is unviable due to dingo predation. Other land uses include:

- *Tourism* eg Innamincka, Coongie Lakes, Birdsville and Strzelecki tracks, Mungerannie, Muloorina (Lake Eyre).
- *Mining* eg. Moomba, Gidgealpa, Innamincka, Merty Merty.
- *Conservation* eg Strzelecki and Innamincka Regional Reserves, with Lake Eyre and Simpson Desert National Parks bordering on the western sides.

Further descriptions of this area can be found in Tyler et al (1990).

2.4 COMPARISON OF THE TWO AREAS

The key differences between the North East Pastoral SCD and the Marree SCD are outlined in **Table 2.1**. The more northerly Marree SCD is hotter, drier and much larger than the NEP SCD. Additionally, the North East area is a zone dominated by ephemeral streams that has a relatively homogeneous spread of land systems, whereas the Marree area shows a diversity of systems, supported in part by river systems originating outside the area.

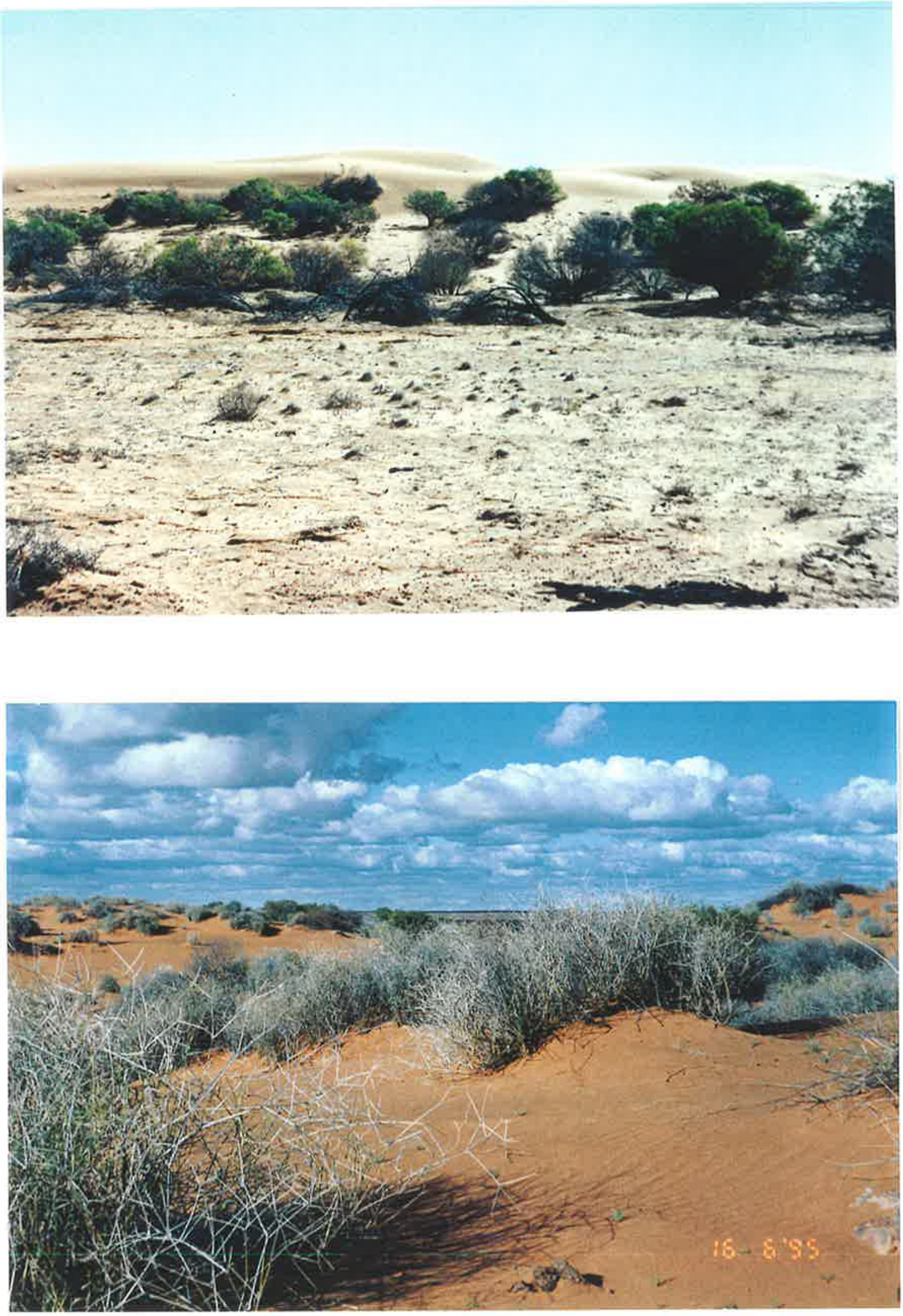


Plate 2.2: Examples of sandhill country in the Marree SCD.

Plate 2.3: Examples of gibber country in the Marree SCD.

Plate 2.4: Examples of watercourse country in the Marree SCD.

Plate 2.5: Examples of saltlake country in the Marree SCD.

Table 2.1: Summary of differences between the North East Pastoral and Marree SCDs.

	NEP SCD	Marree SCD
Pasture plants	Largely perennial	Largely ephemeral
Mean annual rainfall	215mm	150mm
	Rainfall tends to be non-seasonal	Rainfall tends to be slightly higher in summer
Mean temperature	16.6^{o}C (Yunta)	21.1^{o}C (Marree PO)
Mean station size	770km^2	7 050km^2
Stock grazed	Sheep	Cattle
Land Systems	Relatively uniform	Different, distinct systems

Stock management in the two areas is influenced by access to water. The North east area relies solely on dams and successful bores for stock water, and while the introduction of polypipe has enabled some spreading out of water points, pastoralists are limited by the amount of water they have and how far it can be pumped from its source. Many stations in the Marree area, however, have access to the Great Artesian Basin, an enormous underground water supply, which flows under its own pressure when tapped. Therefore, during dry times, stock in the North East area, with its perennial food reserve, are more likely to be affected by a lack of drinking water - while stock in the Marree area are more likely to be affected by lack of feed.

CHAPTER 3

A REVIEW OF THE BACKGROUND LITERATURE

This chapter provides a review of the relevant literature relating to central aspects of this study. The first section outlines the pastoral history of the study area, the second provides a background on historical ecology studies.

3.1 HISTORY OF PASTORALISM IN SOUTH AUSTRALIA

Since the widespread degradation in the early years of pastoral occupation is central to the debate on current land condition, the following brief account outlines the essentials of events at that time. The early history of pastoralism in South Australia was intimately bound up with the history of tillage agriculture in this State, which ultimately had a strong influence on the way in which the pastoral industry developed.

3.1.1 The Wakefield Theory

In the early 1830s an English convict, Edward Wakefield, published a series of articles discussing colonisation in Australia. He suggested a new strategy whereby the sale of land was controlled in such a way (and at such a price) that the profit could be used to fund further immigration from England (Roberts, 1968; Shaw, 1972; Wood, 1935). This approach was designed to provide Australia with much needed labour, and help alleviate the unemployment problems in the homeland.

Wakefield's ideas were eventually carried out when South Australia was colonised by the English in 1836, and the subsequent sale of land was controlled according to the 'Wakefield theory'. As the colony spread from the capital, Adelaide, large areas of land (termed 'hundreds') were surveyed and split into blocks which were then auctioned off before the next hundred was surveyed. Land was initially sold in a very controlled manner to facilitate the building of a thriving and prosperous new colony, which would keep pace with the development of agriculture.

In the end however, this system broke down, due to a run of excellent wheat harvests and impatience with the pace of development. The land buying panic associated with the introduction of credit purchase hastened the displacement of pastoralists and at the same time pushed the burgeoning wheat frontier beyond the limits of safe agriculture into the arid zone, in the forlorn hope that 'rain would follow the plough' (Meinig, 1962).

Earlier on (in NSW), utilisation of land outside the surveyed boundary was illegal and those who did so were called 'squatters', a term which came to be commonly used for pastoralists in general. However, by the time South Australia was colonised, pastoralists could apply for squatting licences on a 'first in, first served' basis (Brett, 1990). In South Australia, as elsewhere, the government did not want the land tied up by these early graziers because they wanted to keep their options open for closer settlement and agriculture - so the squatters were given no rights of renewal or pre-emption and legal tenure was not granted (Davidson, 1938). The graziers were granted leases under the Waste Lands Act (SAPP 225, 1857), which varied in length around 14 years, however these could be retracted with little notice.

3.1.2 Expansion into the South Australian pastoral country

The pastoral occupation of the arid zone in South Australia commenced in the 1850s. The first pastoral 'runs' were centred around springs associated with the Flinders Ranges, and the River Murray - the only permanent sources of water (Barker, 1972). Pastoral stations spread out from these sources as dams were put in and (later on and further north) artesian bores were sunk.

These early ventures in the arid zone were not without difficulties. In 1861 the Surveyor-General, G. W. Goyder was sent to value all of the pastoral runs (due to problems with the renewal of leases) but unfortunately for the squatters, there had been a succession of good seasons and coupled with the early optimism for the industry, the valuation was unduly high. Drought followed, and coupled with enormous rents this led to pastoralists suffering substantial losses. However, the country was only lightly stocked and the drought was thought of as a freak occurrence of bad luck (SAPP 57, 1865).

By 1865 many pastoralists had ventured into the north eastern areas of South Australia and were feeling the effects of another drought. In the Royal Commission conducted that year it was noted that "On one run, especially, we noticed that the entire surface soil, for a considerable distance, was swept away." (SAPP 57, 1865; to inquire into the state of the northern runs) This in itself was bad news, but indicated that it was not a common occurrence as yet. Some runs received rain in 1866, but by 1867 a large proportion of them had still not received a substantial rain since 1864 and these were suffering major losses. Another Royal Commission was conducted in 1867 which revealed that most pastoralists interviewed had lost thousands of sheep and the country was in a very poor state (SAPP 14, 1867; to inquire into the state of the runs suffering from drought). It was suggested that "the carrying capacity of the north has been overestimated..." and in many parts the saltbush was gone altogether.

Goyder was sent north in 1865 in order to survey the extent of the drought, and specifically to "...lay down on the map , as nearly as practicable, the line of demarcation between that portion of the country where the rainfall has extended, and that where the drought prevails." (SAPP 62, 1865). He later reported that this line represented the extent of where farming was practical, and suggested that the lands north of his line were to be considered solely for pastoralism (SAPP 82, 1865). This became known as Goyder's line and it roughly corresponds to the current 300 mm rainfall isohyet.

The 1870s was a time of favourable seasons and Goyder's line was ignored. Farming leases were granted north of Goyder's line and the graziers were pushed further north into the saltbush steppe of the 'arid zone' (Davidson, 1938). In 1888, a large number of pastoral leases expired and 28 000 square miles of country came up for auction (Kelly, 1962). Once again, high optimism and false expectation of the land pushed the prices high.

The graziers in the northern 'outback' country were encouraged to run as many sheep in their flocks as possible, both via high official stocking minima and enormous rents, as well as their own desire to run profitable businesses. Sheep numbers in the State escalated (with fluctuations due to climatic conditions) from 1 million in the 1850s, to an all time high of around 7.5 million in the early 1890s (Davidson, 1938).

This time was followed by drought in the 1890s. The high stocking rates coupled with widespread rabbit plagues and drought were reported to have a disastrous effect on the land. Also, because of dingo predation, low sheep and wool prices, too small holdings and not many improvements being made (due to insecure tenure), there were massive losses. Many people had to walk off their land, and 3000 square miles of pastoral country was abandoned by 1896 (Ratcliffe 1936).

In 1897, a Mr. E. Whitington visited a number of the north eastern pastoral holdings of South Australia (Whitington, 1897). He made extensive notes, commenting on land condition, stock condition and numbers, rainfall figures, management options and general outlines of the social and economic situations experienced by those living there. He returned to Adelaide with numerous tales of the ruin and hardships the pastoralists had faced and described the subsequent denudation and devastation of the land in an article printed in the South Australian Register in 1897. Most instances described land as "bare as street pavement" and "eaten-out within a radius of three miles of the water". The only sightings of land in 'good heart' (and these were few), were in places where there was no water available to enable herbivores to survive.

Insecure tenure also encouraged overstocking in the last few years of a lease as the more valuable a lease became, the less likely the pastoralist was of retaining it (Pick and Alldis 1944). The few years with good rains only served to delude pastoralists and Adelaidians (via the press) that the land was 'recovering' and their hopes were dashed when the herbage dried off and blew away with the soil, in the wind.

Eventually, cropping was abandoned in most of the country above Goyder's line and drought began to be accepted as a characteristic of the arid zone, not an unexpected catastrophe. A common phrase became "the best idea for a gambler is to play for a drought" (Whitington 1897). The Government realised the worth of encouraging the graziers to stay and manage the land. The first Pastoral Act was introduced in 1893, which abolished the auction process, lowered rents and increased tenure. This led to a reduction in deliberate overstocking as lessees had an incentive to manage better, but it in no way alleviated the existing problem.

In 1911, many leases expired and were subdivided into smaller holdings in the belief that it would lead to better profit from the land (Ratcliffe, 1936). This continued after the war and a number of the new leases created were leased out to returned soldiers - many of whom had little experience in pastoral country. These runs were small (less than 100 square miles), nevertheless a run of good seasons in 1917-1921 increased their hopes of success until the next dry time.

In 1935 the loss of vegetation and subsequent destruction of the soil surface was alarmingly high and the standing committee on Agriculture sent up one F. N. Ratcliffe to determine how to combat the soil drift and erosion in arid SA. His subsequent report (published in 1936) provided a detailed study of soil erosion in the north east corner of the state. Ratcliffe stated that "the greatest extent of erosion and drift has occurred in the "bush" country, where stocking (and not rabbits or drought) has been the direct cause of the destruction of the protective plant cover".

Pick and Alldis (1942), after describing the delicate equilibrium between vegetation, animals and soil structure in the arid zone before European settlement, went on to describe the entire Far North region as well on the way to becoming a real desert, and could see no hope of this not becoming a reality. The situation was considered so dismal that they believed the Cooper and the Diamantina Rivers, which had not flowed into Lake Eyre since 1918, would probably never do so again. Once again, they put the blame of this condition on over-grazing - both by stock and introduced herbivores.

Cecil Goode (at the time a pastoral inspector with the South Australian Pastoral Board), inspected most of the runs in the North East Soil Conservation District in the 1930s and 40s. He made extensive notes and took many photos, describing the generally poor state of these runs. Much of the land in the grazed area surrounding waters (termed 'piosphere'; Lange, 1969) was "windswept and drifting". There were several references to areas that were "well bushed", although these were largely well away from waters. Even Goode's descriptions of land said to be in good condition raises the question of perspective. Much of this was described as grass plains, which might be considered degraded if originally dominated by chenopod shrubs.

The subsequent progress of the Pastoral Industry has been towards better management and monitoring of the pastoral land. The high minimum stocking requirements were gradually reduced, until in 1962 stocking maxima were introduced to each property (**Figure 3.1**). Lease terms have extended, with the current "rolling" 42 year terms introduced in 1989.The most recent development was in 1989 with the introduction of the Pastoral Land Management and Conservation Act - with the aim of integrating conservation issues into the previously more economically based legislation.

Summary

The South Australian Pastoral Industry had a very rocky start, which was largely due to the new settlers' gross misconception of the nature of the land they had inhabited. This manifested itself in two ways - the government's misconceptions led to unsuitable and unreasonable land tenure legislation and the pastoralists' lack of knowledge was evident in their unwise and often rash land management practices. The lessons learned from the ensuing disasters led both parties to alter their practices - a process which is ongoing as we continue to learn about the arid zone. Nevertheless, a large amount of land degradation occurred during the early phase of 'trial and error' in the pastoral industry, and many believe that much of the degradation apparent today can be attributed to this time.

Detailed accounts of legislative history relating to arid South Australia can be found in Donovan (1995), Roberts (1968) and Young (1981).

3.2 METHODS OF HISTORICAL-ECOLOGICAL RESEARCH

"Predictions are dependent on explanations of how the present came to be" (Clark, 1990; p.1). Historical ecology is an increasingly prevalent scientific approach which is used to gain a better understanding of past processes in order to both understand our present and plan for the future. Such projects can be categorised into four types, depending on the nature of the data, and the approach used (**Figure 3.2**):

A. *Qualitative descriptions*

Many scientific accounts of history review and summarise relevant historical literature in order to draw conclusions about the past. The impact of European settlement on Australian vegetation has been reviewed in this way by many authors, with respect to vegetation patterns pre and post settlement (Adamson and Fox, 1982), vegetation and soil changes (Mitchell, 1991), succession theory (Fox, 1990) and how different ecosystems have responded to the impact (Hobbs and Hopkins, 1990).

Some authors also draw on their personal experience of past events. Driver (1996) presented a description and history of a property on the Riverina grasslands of NSW. He documented changes based on his own experience and knowledge passed on from his father and grandfather, as well as an old historical reference relating to the adjoining property.

Other methods of documenting changes qualitatively include those that involve photographs. Hastings and Turner (1980) compared paired photographs from around the 1890's and the 1960's in the western deserts of the USA in order to document changes in vegetation. Comparisons of photos from relocated photopoints have also been made by Correll and Lange (1966, as cited by Lay, 1972) and Specht (1969).

B. *Quantitative descriptions using data from the present*

In some instances, a knowledge of past events can be gleaned from their effect on the present landscape. The most common example of this is research on 'increaser' and 'decreaser' species, whereby the proportion of species in areas of different grazing pressures can indicate whether the populations are increasing or decreasing through time (eg. Tiver, 1994; Barker, 1972).

Another example is Ireland's work on 'fossil paddocks' in the South Australian arid zone (1997). By considering the current and past layout of fencelines and water points, she has been able to detect areas where sheep, which are thought to supress recruitment of western myall (*Acacia papyrocarpa*), have been unable to graze in the past. From this, she has been able to predict the expected presence or absence of cohorts known to have recruited since sheep were introduced to the region.

C. *Quantitative assessments using historical data designed for reanalysis)*

Some ecological experiments have been designed specifically to monitor change in the landscape with time. In such cases, trends can be assessed from photopoint records or

1830

1836 → South Australia founded

1840

1850

1851 → First pastoral lease commenced. No stocking requirements

1857 → Stocking MINIMA 50 sheep/sq. mile. Tenure up to 14 years

1858 → Stocking MINIMA 100 sheep/sq. mile

1860

1861 → Stocking MINIMA 50 sheep/sq. mile

1867 → Stocking MINIMA (A) 40 (B) 25 (C) 15 sheep/sq. mile. Tenure extended to 21 yrs

1870

1880

1884 → Stocking MINIMA 20 sheep/sq. mile

1890

1893 → First Pastoral Act

1900

1904 → Included covenant not to overstock in last 3 yrs of lease

1910

1920

1929 → Allowed exchange of old lease (with ~ 12 yrs left) for new 42 yr one

1930

1938 → Stocking MINIMA 5 sheep/sq. mile

1940

1942 → Restrictions placed on stock numbers

1950

1960

1962 → Stocking MAXIMA introduced, based on 1955-62 stock returns

1970

1976 → Included covenant enforcement (fine) for not destocking when asked

1980

1989 → Introduction of the Pastoral Land Management + Conservation Act

1990

2000

Figure 3.1: Summary of selected pastoral legislation changes since 1836.

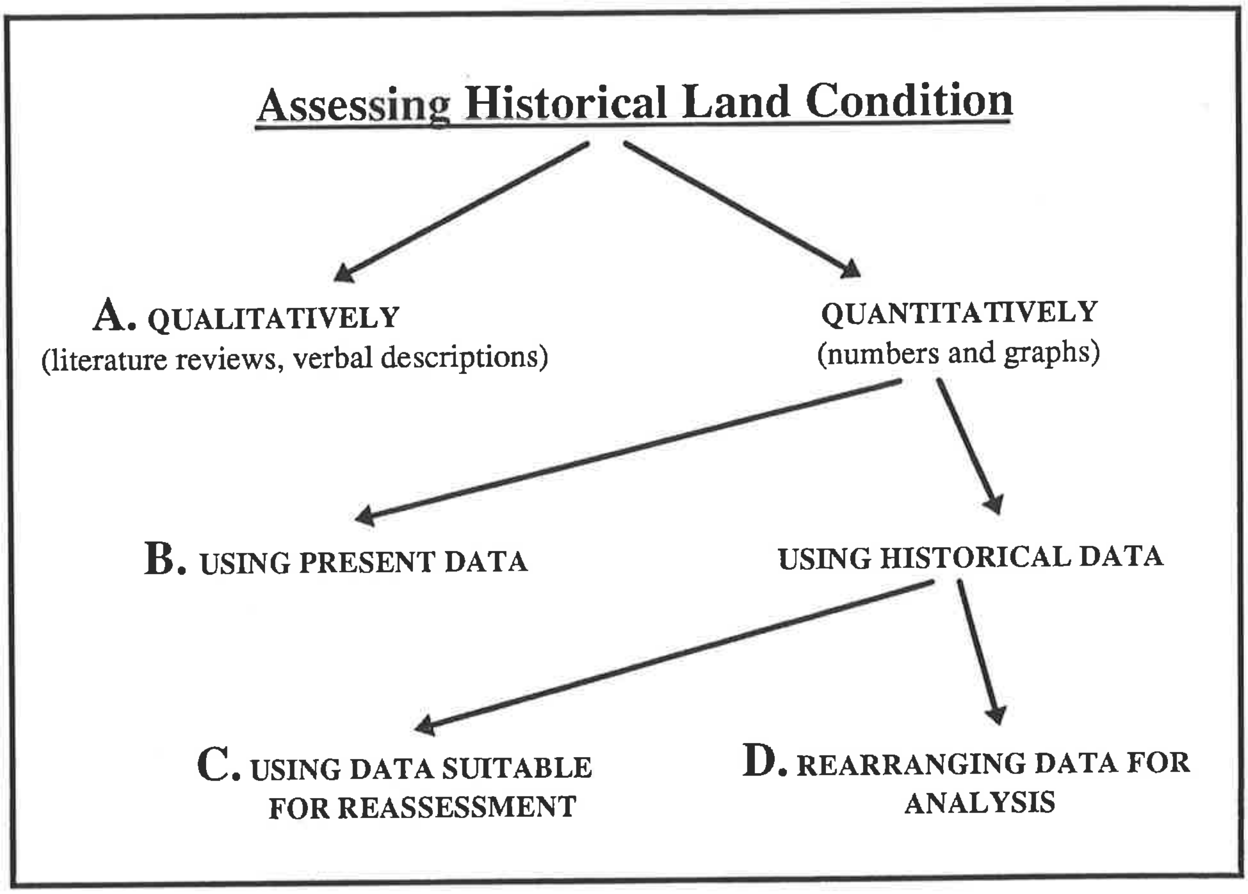


Figure 3.2 : Schematic representation of the 4 different processes of assessing data on historical land condition.

repeated measurements of various features on permanent quadrats. One of the best sets of historical vegetation data in arid South Australia exists on the Koonamore Vegetation Reserve. This reserve was fenced off (from sheep and rabbits) on Koonamore station in 1925 at which time it was badly degraded. It has since been monitored using regular vegetation surveys and photopoints. The collected data has been reviewed over the years by Wood (1936), Osborn *et al.* (1935), Hall *et al.* (1964), Crisp (1975) and Noble (1977).

Another example involves a vegetation survey carried out in the Kingoonya Soil Conservation District of South Australia. The original survey was conducted by Jessup (1951), who made notes on three of the major species, and kept records of his travels in case the work could be repeated. It was, by Lay (1972) as part of a Masters project, and more detailed records were kept with the definite aim of repetition at a later date. The most recent reassessment was made by Maconochie (Maconochie and Lay, 1996), with more planned in the future.

Similarly, Buffington and Herbel (1965) measured vegetation changes in the Jornada Experimental Range, New Mexico using information surveys conducted in 1858, 1915, 1928 and 1963.

D. *Quantitative assessments using data from other historical sources*

Most historical information has been collected without any specific plans for reassessment. The use of such information differs dramatically from mainstream ecological methods in that experiments can not be set up and carried out. Instead, methods need to be developed to extract information from the finite amount of data that has already been recorded.

The previously mentioned monitoring of the Koonamore Vegetation Reserve included an extensive photopoint record which was (and still is) updated annually. This is an obvious example of planned photopoints, however Noble (1977) later developed a method of extracting information from the existing set of photographs. He devised a method of comparing the photos to determine relative changes in biomass of several species. By estimating the *actual* biomass of the vegetation shown in the then current photos, he was able to make estimates of historical biomass which could then be compared with other factors such as rainfall. Similarly, Dunham (1989) derived quantitative information from historical photographs in the riparian woodlands of Zimbabwe, by using a 'Tree Index' to calculate rates of tree loss.

Oxley (1987a&b) used a number of different types of archival information to examine vegetation changes in southwest Queensland. Some of his sources included Surveyors' maps from which he compared information using transparent overlay grids, thus converting descriptive information from maps into quantitative data which he subsequently analysed.

3.2.1 Methodology relating to this project

The methods used in this project are most similar to those of Dunham (1989) and Oxley (1987a&b), in that they involve the quantitative appraisal of data not specifically designed for reassessment. The importance of quantitative approaches of this kind is outlined in Clark (1990; p.1) who claims that "Management of ecosystems requires knowledge of their history. Description and observation are inadequate for detecting underlying trends or understanding and predicting rates, directions and magnitudes of change in complex and dynamic systems".

Long term, quantitative descriptions of change through time enable information to be placed into context with any historical scale. In addition, quantitative analysis enables comparisons through time, allows for the determination of trends and also allows comparisons of information from different sources.

There are, however, a number of drawbacks to researching information which is not designed for analysis:

1. Many historical accounts are biased to some degree. For example, information from a land sale map has a very different bias than that of a conservation report. Also, as people's views and knowledge of rangeland issues changes through time, so does their perception of 'good' and 'bad' land condition (ie. what was considered to be good 50 years ago, may not be perceived as good now).

2. The sources of information are diverse and often patchy through time. As stated by Pickard (1990; p.247) ".. in all historical studies, there is no single complete source of data. Rather, there are numerous sources of incomplete and imperfect data which must be merged into a coherent body".

3. The detail of the scale is constrained by the coarsest forms of information used. Methods need to incorporate this, as comparisons need to be made using as much of the information as possible.

In the course of this study, it has been necessary to accommodate these factors by:

- identifying information in the historical sources that is both reliable and relevant to the question
- working at a scale that is both large enough to enable use of most of the information and facilitate reliability, and fine enough to be able to glean insights

3.3 SUMMARY OF BACKGROUND INFORMATION

The salient points to note about these two central aspects of the research are:

- This study employs quantitative assessments using data from historical sources
- Such data reflects various historical biases and prejudices which need to be accounted for
- An account of the history of pastoralism in the study areas preserves important information for understanding the validity and integrity of the diverse data sources
- Historical records offer insights into understanding not only the physical state of the ecosystems at the present, but also form a partial basis for the current conceptions different interest groups have of the land in the study area

CHAPTER 4

RESEARCH METHODOLOGY AND DATA COLLECTION FOR THE NORTH EAST PASTORAL SCD

4.1 PROJECT SETUP AND EARLY DEVELOPMENT

The research was to be carried out separately in the 2 soil conservation districts, the idea being to concentrate on one area first and then repeat the process for the other. The North East Pastoral SCD was chosen as the most suitable area to develop and test the methods to be used in this project for several reasons. It is closer to Adelaide, has a larger population, and land systems are more uniform across the district. Another deciding factor was my familiarity with the saltbush vegetation through previous studies in similar landscapes (Barnes, 1993). In contrast, the Marree district is far more remote, involving greater time and expense simply to access study sites.

The South Australian Farmers Federation (SAFF) organised a reference panel of 8 people, to help provide ideas and advice for the project (**Appendix A**). A phone conference was held with available members of the reference panel approximately every 2 months, for the first 18 months of the project.

4.1.1 Letter and questionnaire

Pastoralists in the study area were briefed on the project at a SAFF meeting in February 1994. A preliminary field trip was conducted soon after, when I visited two stations in the area to familiarise myself with the landscapes and distances involved - and to receive some initial advice about finding historical information. Following this test field trip, I sent out letters of introduction explaining the motivation and aims of the project to every owner and manager of stations in the NEP SCD (**Appendix B**). Included was a questionnaire designed to find out which stations would be included in the project and also aimed at obtaining some information on alternative sources of information in Adelaide.

4.2 DATA COLLECTION

4.2.1 Information from stations

Positive responses were received from the following people and stations (**Table 4.1**). The location of these stations provided a good spread across the study area (**Map 4**).

Table 4.1: List of station responses from the North East Pastoral SCD.

OWNERS/MANAGERS	STATION(S)
Robert Baxter	Bimbowrie
Heather and Langdon Badger	Boolcoomatta and Kalkaroo
Nick Shearer	Bulloo Creek
Adrian and Gloria Johnson	Curnamona
Vic and Anne Breeding	Faraway Hill
Ashley Harvey	Florina
David and Dot Sandland	Four Brothers and Morialpa
Garnham Skipper	Manunda
Richard Nitsche	Melton, Telechie and Kalabity *(not visited)*
Brian and Anne Treloar	Mooleulooloo and Strathearn
Jock MacLachlan	Mt Victor and Glenorchy
James and Alex Morgan	Mulyungerie and Benagerie
Peter Morgan, John Manning and Richard Gloster	Mutooroo, Lilydale and Lake Dismal
Maurice Francis	Oulnina, Eringa Park and Maldorkey
John and Judy Crawford	Outalpa
Andy Treloar	Tikalina
Paul and Cheryl Lewis	Tiverton
Will and Pauline Crawford	Weekeroo and Wawirra
Rick and Faerly Pearse	Winnininnie
Keith and Jenny Treloar	Yarramba and Wiawera

All of these stations were visited over four field trips during 1994. Approximately two days were spent on each station during which time I travelled over the leases taking photographs and notes. Discussion was conducted with the owners and/or managers about a variety of issues including land condition, rabbits, kangaroos, stock and rainfall.

The types of information collected were:

- current photos - (taken by myself)
- copies of old photographs - (these sites were also rephotographed where possible)
- rainfall records
- lease histories
- diaries/letters

Most of the discussions with the pastoralists generated ideas on the variety of factors related to land condition and land management, which helped in the consideration of how such factors could be incorporated into the project.

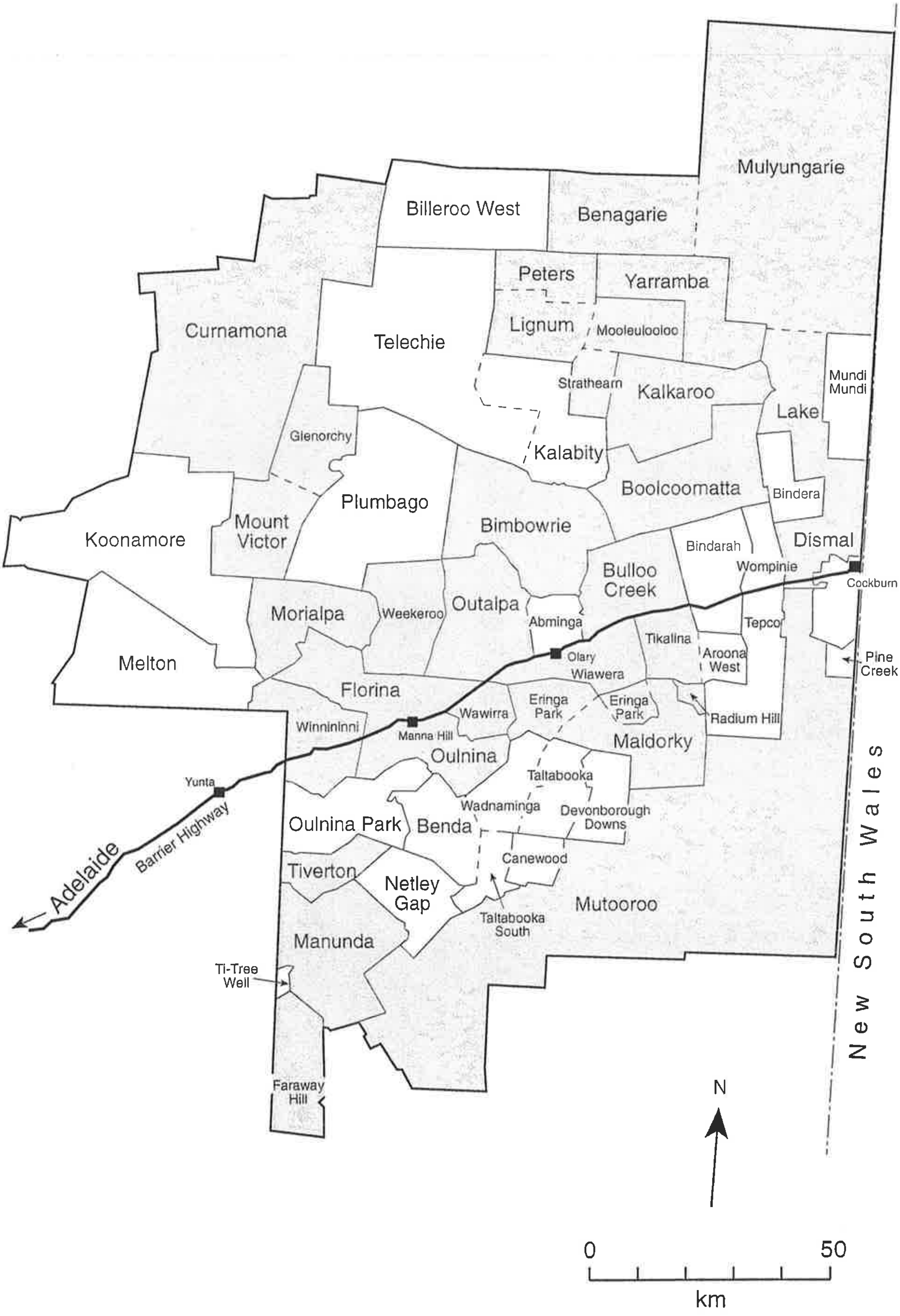
4.2.2 Information from other sources

Information was also collected from a number of other organisations around Adelaide that kept information on pastoral matters (**Table 4.2**).

Table 4.2: List of information sources around Adelaide and the type of information they contain.

SOURCE	INFORMATION AVAILABLE
State Records	Old Department of Lands dockets/other archives Valuation dockets, stock books, rent books, letters
Survey Records	History books - notes of the Lands department on a variety of information on many issues/leases. Some leasing details, routes of explorers, Surveyor-Generals Maps - improvements, survey information, plans
Pastoral Management Branch	Lease dockets, reports, stock records
National Parks and Wildlife	Kangaroo survey information
Commonwealth Bureau of Statistics	Statistics on wool clips, livestock products etc.
Commonwealth Bureau of Meteorology	Rainfall records
Mortlock Library	Old newspapers

There were also a number of other people, such as previous station owners and pastoral inspectors who were traced and interviewed (**Table 4.3**).



Map 4. Stations in the North East Pastoral Soil Conservation District, showing those involved with this project (shaded).

Table 4.3: Additional persons interviewed about the North East Pastoral SCD.

PERSON(S)	CONNECTION TO THE NORTH EAST
Don Burns	Past pastoral inspector
Garnham Skipper	Previous manager of Manunda
John Ratch	Grew up in the NE
Jack and Mary Hunt	Rabbit and Kangaroo shooters
Peter and Janet McBride	Previous managers of Bulloo Creek

4.3 COLLATING AND ORGANISING INFORMATION

Information was collected from all of the above mentioned sources. Each piece of information was recorded as a *piece of data relating to a year* (eg. rabbit plague in 1988). All of these pieces of data were recorded separately on a computer database, *Endnote® plus* (Niles and Associates Inc.). In this way, information about each piece of data could be easily retrieved. Information was recorded under the following headings (**Table 4.4**):

Table 4.4: Method for recording information on *Endnote plus*.

HEADING	INFORMATION RECORDED
Location	Name of station
Year	.. that the information relates to
Form of information	eg. photo, report, anecdotal, letter
Source of information	who or where the information was derived from
Classification	Class assigned to the data
For	what the information relates to eg. land condition
Information	The information that enabled me to make the classification and anything else of interest

4.4 EXAMPLES OF INFORMATION COLLECTED

To give an idea of the scope and variety of information collected, a number of examples from sources in the North East area are outlined below:

- **Old surveyors maps (Figure 4.1):** Some of these maps include notes on the vegetation made directly onto the map. The information is very broad scale, but can give insights into the land types in the area.

- **Family diaries/letters:** Information on land condition may be gained inadvertently from residents' comments on their lifestyle at the time. For example "The country is still a wind swept desert whenever the wind has control in Newton and Koonamore there are two patches of drift that have no trace of any road and take getting through" (Letter extract, 1944; courtesy Brian Treloar).
- **Station diary extracts** (eg. **Figure 4.2**)**:** These are, unfortunately, fairly rare as many have been lost or destroyed over the years. However when available, they usually yield valuable information.
- **Sale maps (eg. Plate 4.1):** These maps provide a lot of information about the land proposed for subdivision. There is little information on the condition of the land, but there is detail on the size of the new leases, the position of fencelines and current watering points.
- **Anecdotal evidence:** This is especially valuable if the person can remember the year that the circumstances occurred in eg. "Father had to shake the dirt out of the sheep before he could shear the sides, backs were left on. He did this for two years. There was no feed around, they had to cut scrub and feed chaff" (John Ratch *pers com.* on the conditions at Wiawera Station around 1939). This statement paints a clear picture of what the surrounding land condition must have been like at the time. Most of the anecdotal information collected was valuable for conducting the project, however only a small proportion of this sort of information was clear and reliable enough for use in further analyses.
- **Photos:** Old photos vary in quality, but are only useful if their location and date have been recorded. Current photos were taken on all stations visited. Some managers were also able to take me to the sites where previous photos had been taken and I was able to rephotograph them.
- **Parliamentary papers:** Most of the stock returns for the state around the turn of the century were published as Parliamentary papers (eg. **Figure 4.3**). There have also been a few Royal Commissions commenting on land condition during (or after) droughts (eg. **Figure 4.4**).

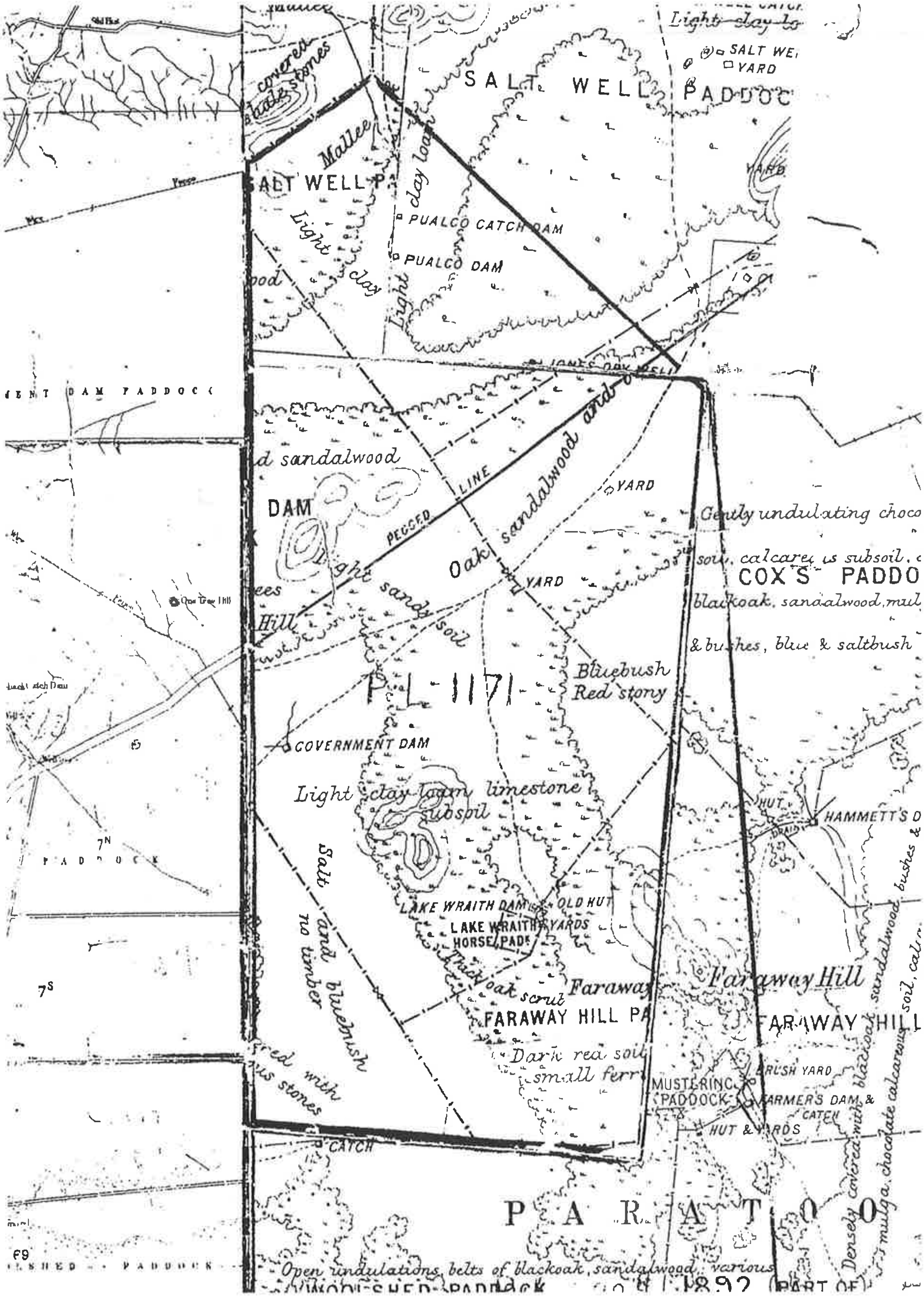
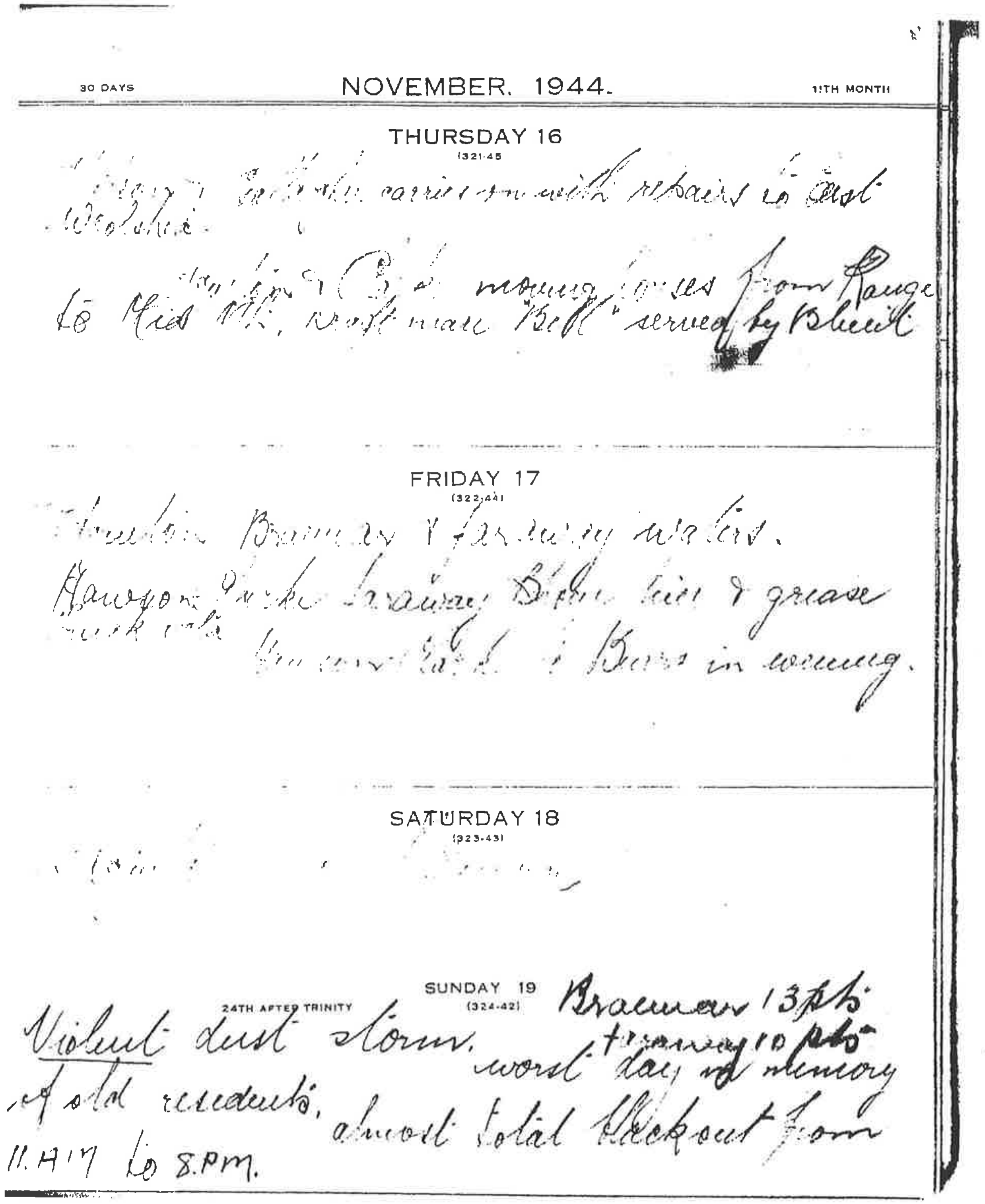


Figure 4.1: Surveyor's map of Faraway Hill Station, from around 1900.



30 DAYS NOVEMBER, 1944. 11TH MONTH

THURSDAY 16 (321-45)

FRIDAY 17 (322-44)

SATURDAY 18 (323-43)

SUNDAY 19 (324-42) 24TH AFTER TRINITY

Braemar 13 pts Faraway 10 pts

Violent dust storm. worst day in memory of old residents. almost total blackout from 11.AM to 8.PM.

Figure 4.2: Extract from 1944 diary of station manager of Braemar and Faraway Hill stations. Note entry on Sunday 19th (courtesy of Vic and Ann Breeding).

Plate 4.1: Sale map for Koonamore Station in 1928.

Statement of Pastoral Leases in South Australia, &c.—continued.

	No. of Lease.	Name of present Lessee.	Area Square Miles.	Situation.	Rate per Mile. £ s. d.	Stock. June, 1883. Cattle.	June, 1883. Sheep.	December, 1876. Cattle.	December, 1876. Sheep.	December, 1878. Cattle.	December, 1878. Sheep.	June, 1882. Cattle.	June, 1882. Sheep.
	1638		159	Near Streaky Bay				—	4,167	4	8,582		
	1762A		52	Ditto	0 11 0	11	13,909	—	—	—	—	4	12,085
	1997		45	Ditto									
	1998		28	Colpa, Streaky Bay									
	2014	Horn, W. A.	103	S.W. of Parla	0 16 0	40	20,776	50	18,140	47	17,972	50	19,096
	2015		32	Streaky Bay									
	2016		11	N.W. of Mount Cooper									
MULYUNGERIE	2935		100	N. of Booleoomata Run	0 2 6								
	2984		100	Ditto	0 7 7	—	2,067						
	2989		282	N.E. of Booleoomata Run									
WINNININNIE	1517		282	Winninnie, Eastern Plains				42	25,261	85	30,066		
	A.L. 663	Horn & Stirling	103	N.E. of Hundred Waroonee	0 10 0	72	36,230	—	—	—	---	172	34,160
	1681		100	Near Barrier Ranges	0 2 6								
	1767		50	E. of Booleoomata	0 2 6								
	15 9		175	Chillunga, near Denial Bay	0 2 6	—	—	3	2,853	5	2,581		
	2249	Hosken, W.	84	N. of Smoky Bay	0 2 6	—	—	—	—	—	---	4	1,307
	2307		41	Streaky Bay District	0 2 6	—	—	---	—	—	—		
OULNINA	1557	Hughes, Sir W. W.	896	Oulnina, Eastern Plains	0 10 6	170	55,511	165	37,508	195	41,661	170	55,191
	2737A	Hungerford, T.	5[illegible]4	On N. boundary of province, N. Cooper's Creek	0 4 3	3,600	450	—	---	---	---	3,200	500
	2862		300	On Queensland boundary									
OUTALPA	1540	Hurd & Foote	966	Outalpa, Eastern Plains	0 7 5	102	42,027	77	26,551	51	21,312	52	36,028
	2978	Ifould, W.	100	Oldea, N. of Great Bight	0 2 6								
	2115	Jackson, W.	20	E. of Hundred Bonney	0 15 6	60	1,500	—	400	---	---	---	667
	1692	James & James	238	Erudina, N.E. Plains	0 13 10	51	20,641	205	8,677	88	14,143	305	16,166
CURNAMONA	1620		169	Curnamona, N. of Mount Victor				31	4,400	281	17,069		
	1785	James, Sanders, and others	90	N. of Mount Victor	0 11 9	112	21,306	—	—	—	—	110	23,280
	1786		88	Ditto				—	—	—	—		
	2586	Jones & Moorhouse	400	N.E. of Lake Eyre	0 2 6	—	2,000						
	A.L. 565	Kelly, M.	32	W. and N. of Hundred Joyce	0 4 3	—	824	—	—	—	2,000	—	1,067
	A.L. 621	Killicoat, J.	30	E. Hundred Reeves	0 19 0	11	1,613	—	—	—	..	—	1,076
	2838		11	Kangaroo Island	0 2 6								
	2839	Kinch Bros.	40	Ditto	0 2 6	—	650	—	—	---	—	—	900
	2856		40	Ditto									
	1861		32	N.E. of Tilley's Swamp				18	6,210	14	9,298		
	1864		36	Duck Island, S.E. District				—	—	—	—		
	1865		44	S. of Mount Monster				—	—	—	—		
	1866		55	Ditto				—	—	—	—		
	1867		19	Ditto				---	—	—	—		
	2049		34	E. of Chinaman's Well				—	---	—	—		
	2050	Law, A.	46	Ditto	0 6 8	25	16,094	—	—	—	—	24	19,000
	2051		45	Ditto				—	—	—	—		
	2052		30	E. of Tilley's Swamp				—	—	—	---		
	2053		6	Tilley's Swamp				—	—	—	—		
	2103		30	S.E. District				---	—	—	---		
	2198		25	S.W. of the Monster				—	—	—	---		
	2988	Lawrence, W. J.	50	Near Tooligee Hill	0 2 6	—	300						
	2064	Lawson, R.	20	E. of Tilley's, S.E. District	0 5 0	—	600	—	—	—	400	—	600
	2247	Levi, P.	4	Wedge and Gambier Island	0 8 4	—	—	3	—	—	—	6	—
	2482A	Lindsay, S.	63	N.E. of Binney's Lookout	—	—	—	—	—	—	2,017		
	2743		22	E. of and adjoining Coolinong	0 2 6								
	1514		137	Streaky Bay				1	10,467	43	19,515		
	1515		14	Ditto	0 10 3	33	18,862	64	10,900	—	—	36	18,431
	2261	Linklater, J. M.	15	Ditto				—	—	—	—		

14

Figure 4.3: Excerpt from SAPP 148, 1883.

ABSTRACT of EVIDENCE taken by the RUNS INQUIRY COMMISSION of 1867, detailing the Losses sustained by the different Witnesses through the Drought of 1864–5–6, and the means which, in their opinion, the Government should adopt for the future Management of the Pastoral Country.

Compiled by order of the Commission by

WM. J. PETERSWALD, Secretary.

May 18, 1867.

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1. PETER FERGUSON, Lake Eyre.—Lost 8,000 sheep and 1,200 head of cattle: considers that an extension of tenure might be of use to the south of Port Augusta, but no concessions would avail in the Far North.

2. CHRISTIAN OGILVIE, Lake Gairdner.—Mr. Ogilvie's losses could not be attributed to drought: he took 14,000 sheep into a country which he had previously proved to have been without water, and was obliged to remove them.

3. Mr. MANSELL, Overseer to J. WILLIAMS, Black Rock.—See Mr. John Williams's evidence.

4. R. A. FIVEASH, Manager of Yudanamutana Mines.—Describes the state of the North during his frequent visits: recommends the Government to sow grass seeds, as in most places the vegetation has been completely destroyed.

5. JOHN RAGLESS, Eastern Plains.—Lost 4,800 sheep: considers that long leases of twenty-five years, with low rental, would be the only remedy.

6. JOHN CHAMBERS, Chambers Creek.—Lost 3,876 head of cattle: thinks that all the country above the Mundy should be let at a peppercorn rent for thirty years.

7. PHILIP LEVI, Merchant and Pastoral Lessee.—Lost 50,000 sheep and 10,000 head of cattle: recommends four or five years' remission, and extension of tenure of twenty-one years at 10s. per mile.

8. JOHN JACOBS, Mount Serle.—Lost since 1864 to the amount of £16,811 through drought: recommends five years' remission and extension of tenure for twenty-three years at a rental of five per cent. upon the profits.

9. F. W. STOKES, Coonatto and Yednalue.—Lost 20,000 sheep on one station and 9,221 on another, besides heavily-increased station expenses: recommends twenty-one years' extension at 10s. per mile, with remission of rent.

10. H. T. PRICE, Wilpena.—Lost 20,000 sheep: considers that he should have five years' remission, and extension for twenty-one years at a rental of 10s. per mile to enable him to fence his run: has confidence in the country yet: thinks all the leases should be surrendered and then consolidated.

11. J. R. PHILLIPS, Kanyaka.—Lost 20,000 sheep: recommends three years' remission of rent, and extended tenure of twenty-one years at 10s. to 15s. per mile.

12. A. D. TASSIE, Port Augusta, Storekeeper and Pastoral Lessee.—Lost about £6,000 on his station: stated that the export of wool from Port Augusta in 1863 was 13,000 bales; in 1864–5–6 about 6,000 bales: considers that an assessment on the number of sheep depastured without rent would be the fairest means of payment, also extension of tenure for fourteen years.

13. DANIEL MCALLUM, Willupa, Eastern Plains.—Lost altogether to the value of £12,000: considers that he should have seven years' rent, and ten years' extension, at 10s. per mile.

14. JOHN WILLIAMS, Black Rock.—Lost 8,856 sheep: recommends a permanent tenure of twenty-one years to enable squatters to fence their runs: does not object to 3d. per head assessment.

15. ALFRED HALLETT, Merchant and Pastoral Lessee.—Lost 10,000 sheep: recommends three years' remission of rent, and ninety-nine years' lease at 10s. rent, with the right of the Government of resuming the land if required for public purposes (such as a purchaser being found).

16. STEPHEN JARVIS, Overseer to Mr. Philip Levi, at Mount Margaret.—Considers that nothing the Legislature can do will benefit the country about Mount Margaret: thinks that 300 miles of country will be abandoned in eight months.

17. PETER WAITE, Eastern Plains.—Lost 29,000 sheep and 50 bullocks, and had to pay £1,000 for horse-feed: suggests three years' remission, and fourteen years' extension, at 10s. per mile.

18. JOHN BOWMAN, Crystal Brook.—Lost 14,000 sheep: recommends remission of rent, in consideration of which all leases should fall in at the same time: requires nothing further: finds sheepfarming profitable.

19. MALCOLM GILLIES, Willochra Creek.—Lost 4,940 sheep: recommends twenty years' extension, at 10s. per mile: has not found sheepfarming profitable: is insolvent through the losses by the drought.

20. HENRY SCOTT, Merchant and Pastoral Lessee.—Estimates the losses on runs in which he is concerned at from £60,000 to £70,000: recommends twenty-one years' extension at a rent ranging from 1s. to 10s. per mile of well-watered runs, and a peppercorn rent in the dry country: if an assessment is adopted it should not exceed from 2d. to 6d. per head, according to situation.

21. THOMAS BROWN, Managing the late John Taylor's estate at Rylands.—Lost 15,620 sheep on Mount Arden Run: considers that Government should reimburse him in some manner for the heavy assessment which he has paid: also recommends extension for twenty-one years at 10s.: thinks 4d. per head would be a fair assessment.

22. SAMUEL BROWN, Nettalie Run.—Lost 2,000 sheep: thinks he ought to have three years' remission, and a long extension at 10s. per mile.

23. Hon. JOHN BAKER, Pastoral Lessee.—Lost 11,903 head of cattle, 8,118 sheep, and 950 horses: thinks that no person will be induced to take up the country about his runs, unless they obtain them at a nominal rent, say 2s. 6d. per mile: has no wish for any extension at the present rental: complains of annoyance from natives being relieved at Police Stations: thinks the tenants of the Crown would be the most suitable for that purpose: considers 3d. per head would be a fair assessment for sheep.

24. R. E. ROBERTSON, employed by Mr. Thomas Elder to inspect his Runs.—Describes the wretched state of the country over which he has just passed—450 miles north: considers that no legislation would be of avail, unless the country has a thoroughly wet winter: thinks it will be a number of years before the country will be restored: looks upon Messrs. Browne and Elder as the mainstays of the North.

25. S. J. STUCKEY, Umberatana.—Lost 16,400 sheep, 2,488 cattle, 135 rams: thinks the whole country will be thrown up unless the Government give twenty-one years' leases at 1s. per mile; also suggests holding the north country by Joint Stock Companies, in large blocks.

26. GEORGE

No. 14.

Figure 4.4: Excerpt from SAPP 14, 1867.

4.5 LEASE HISTORIES

Many of the archival stock records consulted recorded all information in relation to the pastoral lease number of the property at the time. Many of these sources included information from the entire state, making a precise knowledge of the lease number vital. These have changed many times over the past 120 years, and thus it was necessary to construct histories of the pastoral lease number, lessee, and property size for each station in the study area (for example see **Figure 4.5**). This was an exceedingly time consuming task, requiring appraisal of many overlapping sources of information as the changes were often widespread and abrupt, or changed at the same time as the lessee.

These histories may also aid in the collection of information for other projects, and copies will also be submitted to the Pastoral Management Branch of DENR, SA for their records.

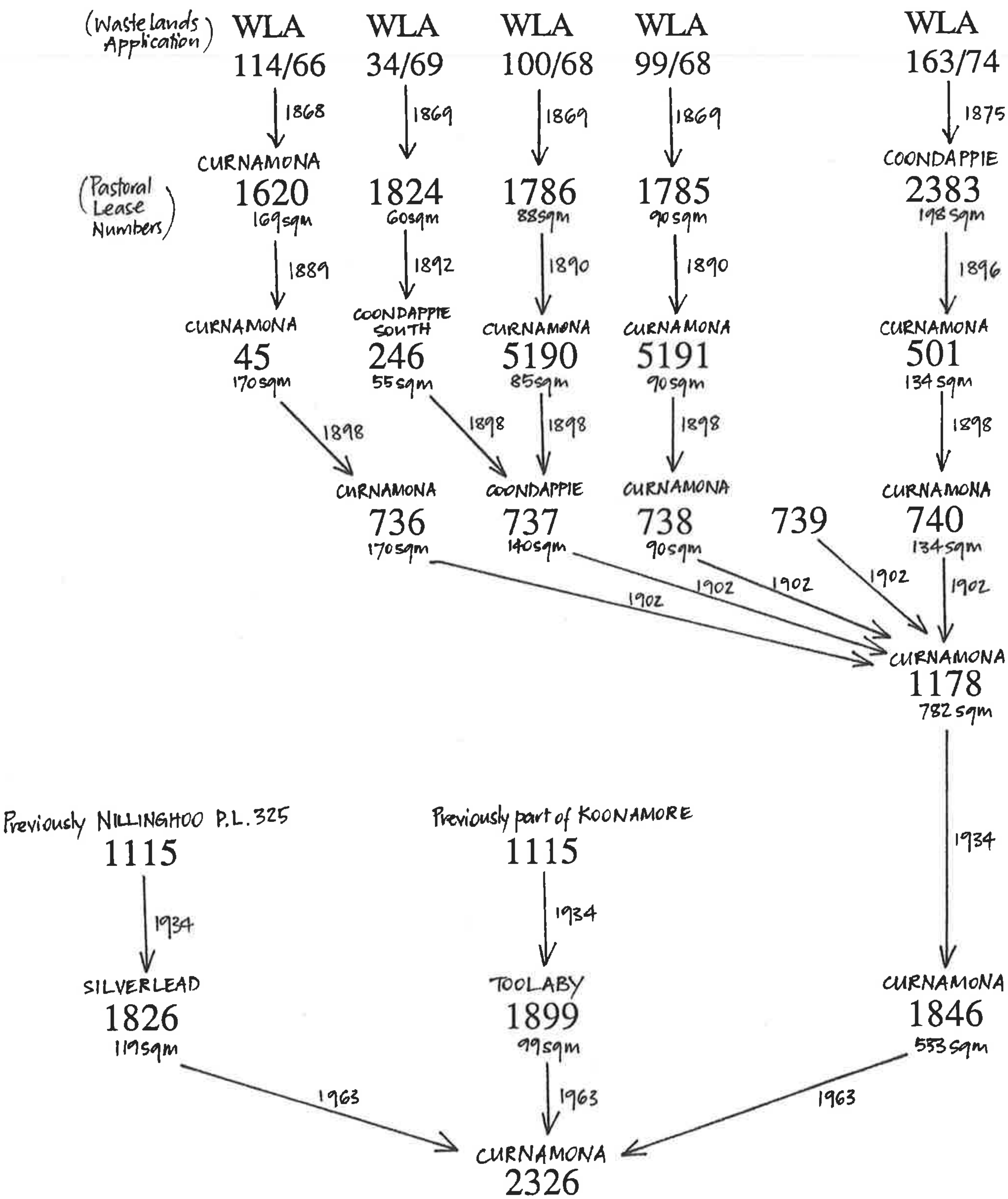


Figure 4.5: Lease history constructed for Curnamona Station.

CHAPTER 5

HISTORICAL CHANGES IN RANGELAND CONDITION

5.1 INTRODUCTION

The work described in this chapter deals with the broadscale changes in land condition in the North East Pastoral SCD since European settlement. The focus was primarily on when changes occurred, rather than why. I wanted to examine the trends in land condition in order to place the current condition of the land in context with its history. An attempt to place current land condition in context satisfies, in part, the conditions of the Landcare grant administered by the South Australian Farmers Federation, but the main purpose in this phase of the work was the development of methods to reliably identify change from diverse historical records.

The term *land condition* means different things to different groups with interests in the rangelands. Pastoralists are understandably most interested in production based factors such as the quality and value of the land for stock fodder, focusing on the palatability and nutritive value of the plants. On the other hand, a conservationist may be more interested in issues such as the maintenance of species diversity, the 'original' vegetation, or species under threat. Some or all of these criteria have been used in the various approaches to assessment of land condition reported in the literature.

5.1.1 Assessment of land condition

Friedel (1991; p.422) describes two approaches to rangeland assessment - "the ecological approach based on comparisons with the climax state and the site potential approach based on productivity, usually for a particular use". Friedel *et al.* (1988) discuss the use of multivariate analyses to determine the "condition state" of rangeland sites by grouping species into functional groups. The "condition states" are mainly discussed in terms of species' palatability and longevity.

Lindsay and Rowe (1990) describe a land capability assessment used in Victoria, which goes even further. In this approach rating tables, which include detailed soil variables, such as depth to seasonal water table and site drainage, are developed for each broad land type.

In South Australia, the Pastoral Land Management and Conservation Act of 1989 requires an assessment of the condition of each lease by the Pastoral Management Branch, essentially to determine the carrying capacity, and hence a stocking maximum. During this process, assessment teams classify sites on a 3 point scale which largely reflects the proportion of the original perennial species present. This scale is used to assess a number of points on each lease and the scores are then converted to a 'Land Condition Index' which gives a single value for that station as a whole (Lange *et al.*, 1994). This score is then compared to those of other leases in the district and also in relation to the maximum stocking rates of each lease.

5.1.2 Working with historical data

In contrast to the assessment procedures outlined above, the use of historical data imposes some limitations on design. Unlike schemes set up to assess current or future land condition (eg. Friedel *et al.*, 1988; Lendon and Lamacraft, 1976; Lindsay and Rowe, 1990) where the most appropriate criteria or procedures can be incorporated in the design, a task such as the one proposed here relies heavily on the quality and amount of information in the historical record.

For example, in most published monitoring schemes, the assessment criteria include some recognition of species composition, in particular the perennial shrubs or sub-shrubs. In this project the nature of the historical record prevents the use of detail at that scale. The contribution of the shrub layer to stability of the landscape has not always been fully recognised, and this is reflected in the few references to species composition in casual assessments of land condition in the past. Consequently I have been restricted to the use of much broader indicators of land condition in this thesis.

Apart from the limitations imposed by detail in the existing records, a second issue of data quality arises from the diversity of sources for historical information, and the circumstances surrounding its collection. Whereas the data for current assessments can be, and usually is, collected according to precise guidelines, the references to land condition in the past have been made by many people from a variety of backgrounds, and often with different perspectives on land condition. Hence, when compiling the data for this project, it was necessary to be aware of the potential for bias at all times in order to exclude misleading information. For example, information on land condition from a sale map is obviously going to emphasise the more positive points and may present a less than accurate picture of the state of the lease. Other examples can be found in the reports of some early pastoral inspectors, which often contain statements on land condition using broad descriptors such as "good condition" or "needs improvement". In earlier times, before the 1989 Pastoral Land Management and Conservation Act, the focus was more on production from pastoral lands, and hence statements such as these, which might refer to production goals, could not be used in this project. Examples of some of the useable and unusable information collected can be found in **Appendix C**.

Nevertheless, even with strict attention to such possible sources of error, some bias was unavoidable. For example, comment on land condition is often prompted only by the response of the land to especially good or bad years. There are certainly a large number of photographs available for the last 2 major floods, and much anecdotal information on the last 1 or 2 droughts - but information is rarely collected for the 'average' years. This last, and more intractable source of bias stems from the events, or even the climate of public opinion, which prompt people to make comment or take photos of land condition. The effects of this might be seen in the same tendency to record unusual landscape responses, or events in particularly responsive localities, rather than the unremarkable.

The two main sources of bias affecting data quality also reduced the amount of data available for building a useable database on past land condition. In these circumstances, the only option was to collect as much information as possible to ensure enough useable data remained once unreliable references had been filtered out.

Whereas the first two sources of bias could be countered in the manner suggested, the third was largely beyond control. Its potential influence on the assessment of historical land condition will be considered in the discussion.

5.1.3 Other considerations on design

Pickup (1989) discusses four further problems with assessing rangeland degradation:

- the need for compromise between detail of survey and the time and cost involved
- the need to distinguish between natural and human induced causes
- the need to determine if degradation "has occurred in the past and has ceased, or is ongoing" (p.74)
- the difficulties in quantitatively expressing the extent of degradation, a problem attested to by the many methods which are qualitative and not repeatable by others

In this case, the first of these is irrelevant to the extent that the limits on detail have been pre-determined by the nature of the data. The distinction between causes is dealt with in Chapter 6, in keeping with the focus, in this chapter, on the timing of changes rather than causes or mechanisms.

The two points most relevant here are the trends in degradation, or more broadly, land condition, and the quantitative expression of its extent.

Aims

With these points in mind, my aim was to collect all available historical information on land condition and present the data as a trend of change through time. This approach has allowed current land condition to be seen in the context of the historical trend of the last 100 years or so, but my main purpose in this phase of the work was to develop quantitative, repeatable procedures which would allow various forms of evidence to be expressed in the same form.

5.2 METHODS

This project involved the use of historical data (eg. photos, anecdotal information, diaries) which varies in form, accuracy and detail. It also included information collected by myself during field trips, mostly in the form of photographs. Given the variation in form of the information, I decided to develop procedures which would enable classification of all historical data on a nominal scale of land condition. In this way, descriptive historical evidence could be converted to a form suitable for graphical presentation and analysis.

These methods were developed for the North East Pastoral SCD, where the relative homogeneity of the vegetation allowed the development of a single scale for the entire area.

5.2.1 Development of the methodology - the Classification Scale

Design of the classification scale involved 3 main steps:

- Determining the factor(s) to be used in the classification (ie. as an indicator of land condition)
- Defining the extremes of the scale
- Deciding on the size of the scale (ie. the number of points between the extremes)

5.2.1.1 The factor to be used in the classification

In other historical studies, both 'relative plant biomass' (Noble, 1977) and 'comparative species number and distribution' (Oxley, 1987a&b) have been used to infer land condition. From both an ecological and pastoral perspective, the best measure to use would be some combination of species composition, abundance and soil stability because these factors draw together concerns about sustainability, palatability, biodiversity, and the all-important soil resource - issues of interest to both groups. However, for this project there was not enough information in the historical record to identify individual species. The best that could be deduced from the bulk of the information available (photos and diaries etc.) was an indication of the amount of vegetation present and the intactness of the soil surface. Therefore, there was little alternative to using 'plant cover', without regard to species composition, as the main measure of land condition - with consideration of soil stability wherever possible.

There are a number of advantages to using plant cover as an indicator of land condition:

- There is strong evidence that plant cover and soil erosion are inversely related (**Figure 5.1**; Perry, 1972; Lee, 1972), and one of the primary objectives in rangeland management is the maintenance of a stable soil surface (Holm *et* al., 1987).
- Plant cover is a fairly robust indicator of land condition in that, in <u>most</u> cases, an increase in total plant cover in the arid zone is beneficial, irrespective of the species composition.
- Plant cover can be inferred from a comparatively wide range of information sources.
- Broad scale plant cover is relatively quick to assess

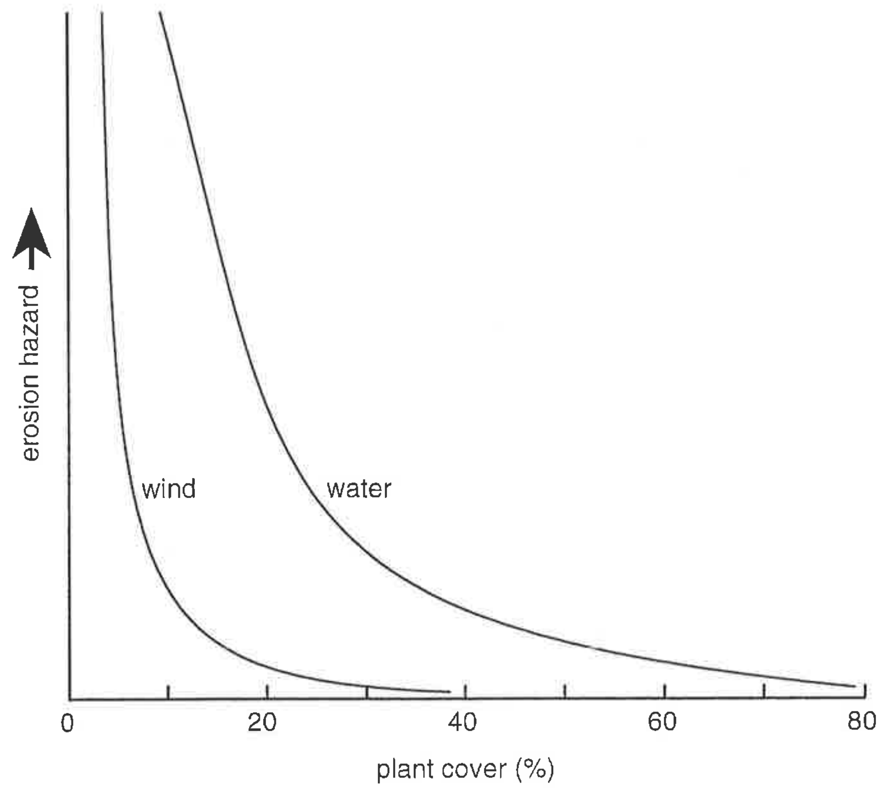


Figure 5.1: Relationship between plant cover and soil erosion (after Perry, 1972).

The major drawback of this choice was the lack of detail on key species, but in the circumstances the compensations were that it provided greater reliability and maximum use of the database. *For the remainder of the thesis, I will be using the term land condition as inferred from broad scale plant cover and soil stability.*

5.2.1.2 Defining the extremes of the scale

'Pristine' land condition

Pristine land condition is often seen as the ideal benchmark for comparison. Often statements about rangeland condition are made in comparison to some envisioned 'pristine' state which existed before European settlement. Unfortunately, there is very little detailed information describing the state of the north east of South Australia before the commencement of pastoralism in the late 1850s. The oldest information obtained in this project which gave a reliable indication of plant cover related to the 1880s. Hence, it was not possible to use 'pristine' land condition as one extreme in the classification scale. On a practical note, 'pristine' land condition may not be a very constructive factor to be considering in present times as the whole ecosystem has been irreversibly altered by the introduction of pastoralism and feral animals. Goals for ideal land condition now relate to current production or conservation attitudes.

'Best' vs 'worst' land condition

Without 'pristine' land condition as a benchmark, land condition can be compared to the best and worst conditions that have been recorded. Thus I used the best land condition (plant cover and soil stability) that I recorded as the 'top' of the scale, and the worst land condition for the 'bottom' of the scale. In this way the ends of the scale were described, with the emphasis on relative condition, in order to avoid the need of determining an original 'pristine' state.

5.2.1.3 The size of the scale

In determining the size of the scale, I was faced with the need for a compromise between detail and reliability. The scale was developed from a large subset of the historical records by categorising the data on increasingly finer scales. After a period of trial and error, it was found that a 4-point scale was too coarse to reveal much of interest, and a 6-point scale was not acceptably reliable. An intermediate scale of 5 points promised the most acceptable combination of sensitivity and repeatability. This scale was tested by assessing and later reassessing the same information from the North East Pastoral SCD and I found that these five distinct classes of plant cover could be reliably identified.

Summary

After consideration of a large portion of the data collected, a five point classification scale was developed, spanning the best and worst land condition recorded. Thus information on land condition was not classed by comparison with a hypothetical benchmark, but was ranked within the information collected.

5.2.2 Application of the methodology - the classification technique

Based on the criteria discussed in section 5.1, I designed the following classification scale (**Table 5.1**). Photographic examples are presented as **Plates 5.1 to 5.5**. I have termed this scale the 'Plant Cover Scale', though it does also take certain soil features into account.

Table 5.1: The Plant Cover Scale (PCS) designed for inferring land condition from historical data.

CLASS	DESCRIPTION
1	Very little (if any) vegetation; evidence of accelerated soil erosion and drift
2	Very sparse vegetation, soil unstable but not drifting OR stands of dead vegetation
3	Sparse vegetation - ephemeral or perennial.
4	Good vegetation cover, but not abundant. Special examples include instances of good vegetation cover, but where: - there is some evidence of grazing/trampling - bushes are healthy, but older (ie. no regeneration) and scattered - bushes have regenerated only along rip lines - there is good ephemeral but little permanent vegetation cover.
5	Very good, perennial vegetation cover.

This scale was used to assign all pieces of data to a class that would give an indication of plant cover and hence infer land condition.

Plate 5.1: Examples of Plant Cover Class 1.

Plate 5.2: Examples of Plant Cover Class 2.

Plate 5.3: Examples of Plant Cover Class 3.

Plate 5.4: Examples of Plant Cover Class 4.

Plate 5.5: Examples of Plant Cover Class 5.

During this process, only information that could reliably be categorised with the Plant Cover Scale was used. Any information with the potential for bias due to the perspective of the recorder was not used. Vague statements on land condition were also excluded. Examples of comments considered too ambiguous to use include: 'country needs rain'; 'country is in poor condition'; 'country is in good heart'; 'these are hard times'. Additionally, information was not used if it referred to areas immediately adjacent to watering points, homesteads, yards or sheds.

5.2.3 Analysis of changes in land condition over time

The changes in the land condition, as inferred from the PCS, were examined in two ways:

1. By the development of an index of the Plant Cover Scale - The Plant Cover Index (PCI) was calculated for each decade using the following equation:

$$\text{PCI} = \frac{\Sigma(\text{number of entries in each Plant Cover Class x Class number})}{\text{total number of entries for the decade}}$$

Although PCI values do not imply a steady increase or decrease between decades, the results were presented as a line graph (**Figure 5.2**).

2. By examining the relative frequency of each condition class - The percentage of data in each condition class was calculated and charted as a histogram (**Figure 5.3**).

5.3 RESULTS

From the many thousands of records examined, 580 separate pieces of information relating to land condition in the NEP SCD were found and classified. Much had to be discarded, either because it was irrelevant, undated, or ambiguous. **Table 5.2** outlines the amount of useful information found for each lease.

Table 5.2: Summary of amount of information from stations in the North East Pastoral SCD.

Lease	**Number of pieces of information collected**	**Leases ranked in order of amount of information classified**	
Benagerie	4	Benagerie	4
Bimbowrie	18	Mount Victor	5
Boolcoomatta	24	Maldorkey	6
Bulloo Creek	28	Lilydale	10
Curnamona	17	Mutooroo	10
Eringa Park	27	Outalpa	11
Faraway Hill	33	Four Brothers	15
Florina	23	Curnamona	17
Four Brothers	15	Kalkaroo	17
Kalkaroo	17	Bimbowrie	18
Karolta	18	Karolta	18
Lilydale	10	Manunda	18
Maldorkey	6	Mulyungerie	18
Manunda	18	Weekeroo	18
Mooleulooloo	30	Yarramba	19
Mount Victor	5	Tiverton	20
Mulyungerie	18	Winnininnie	22
Mutooroo	10	Florina	23
Oulnina	65	Wawirra	24
Outalpa	11	Boolcoomatta	24
Tiverton	20	Eringa Park	27
Wawirra	24	Bulloo Creek	28
Weekeroo	18	Mooleulooloo	30
Wiawera	80	Faraway Hill	33
Winnininnie	22	Oulnina	65
Yarramba	19	Wiawera	80
TOTAL	580	MEDIAN	18

The least information was found for Benagerie (4) and the most for Wiawera (80), however the median was 18 pieces of information per station. The main forms the information came in are shown in **Table 5.3**:

Table 5.3: Major sources of the information collected on land condition in the North East Pastoral SCD.

SOURCE	**PIECES OF INFORMATION COLLECTED**
Photos collected from others	224
Photos taken during the project	110
Reports (Whitington, 1896; Cecil Goode, Pastoral Inspectors etc.)	110
Anecdotes	28
Managers' diaries/reports	19

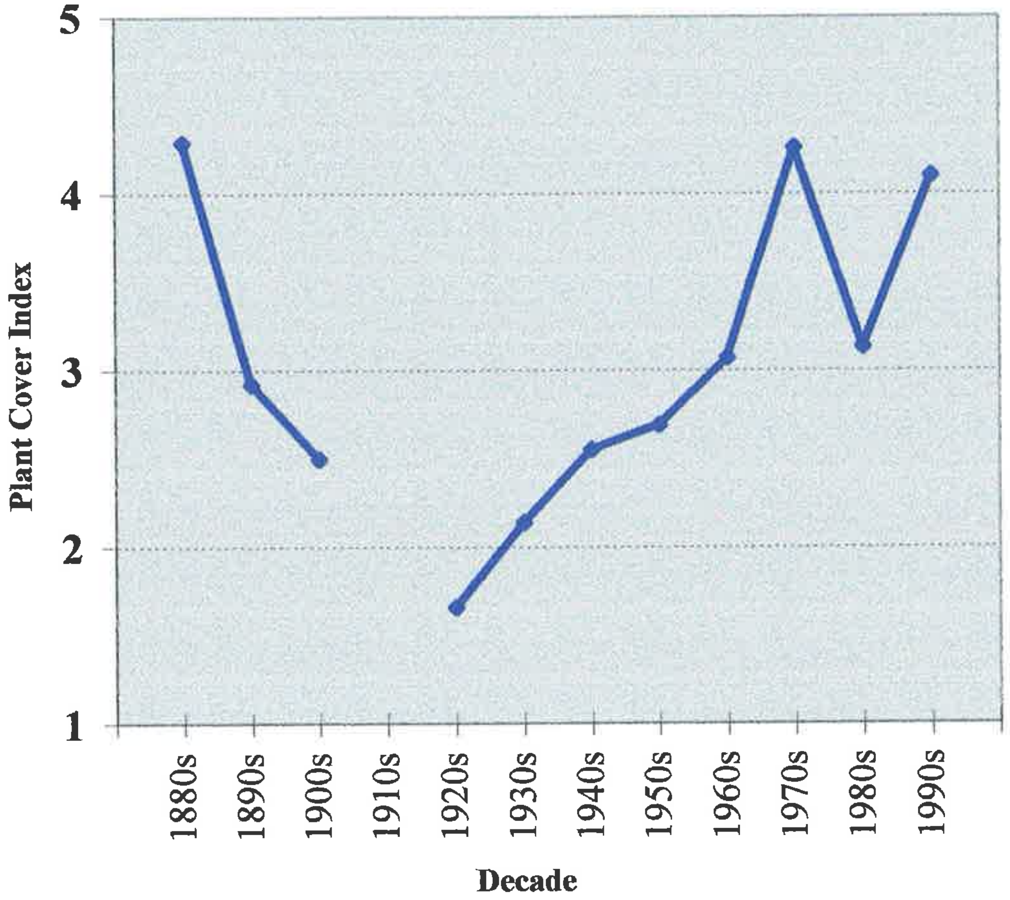


Figure 5.2: Change in Plant Cover Index over time

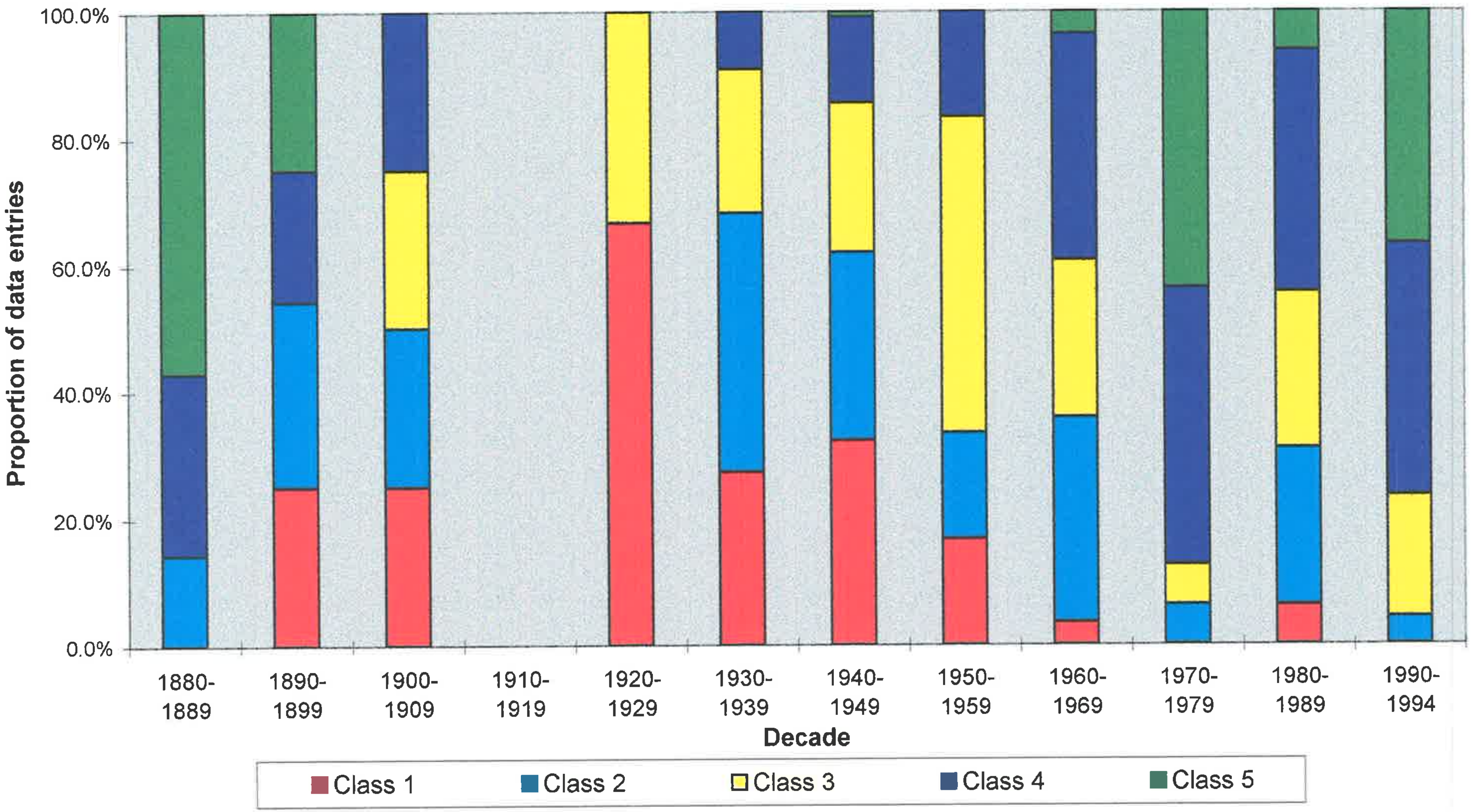


Figure 5.3: Proportion of data in each Plant Cover Class, for each decade from 1880-1994.

5.3.1 Trends of the Plant Cover Index

The PCI indicates a broad scale trend in plant cover for the NEP SCD (**Figure 5.2**). From a maximum value in the 1880s the index decreased to its lowest value in the 1920s (unfortunately, no information was available for the 1910s), then increased again to a very high value in the 1970s. Most marked is the dramatic decline from the 1880s to 1890s, and the subsequent steady increase from the 1920s to the 1970s.

5.3.2 Fluctuations in plant cover with time

The trends of change for each Plant Cover Class are shown in **Figure 5.3** and the main features for each decade since 1880 are summarised in **Table 5.3**.

Table 5.3: Highlights of change in land condition, as inferred by the Plant Cover Classes, from 1880-1994.

Decade	Inferred changes in land condition
1880-1900	the main characteristic is the plummeting of the occurrence of class 5 and the sudden occurrence of class 1
1910s	There was no information found relating to the decade 1910-1919
1920s	Very high prevalence of class 1 and no information from class 4 or 5
1930s	The extremes are softened, but classes 1, 2 and 3 are the most prevalent (all greater than 20%). The occurrence of class 4 is low, and class 5 is non-existent
1940s	As for the 1930s, but class 1 is marginally the most prevalent
1950s	The first dramatic decrease in class 1, but still no increase in class 5
1960s	The proportion of class 1 is still plummeting and there is the first rise in the occurrence of class 5
1970s	There is a major increase in class 5 and class 1 is reduced to 0
1980s	The proportion of class 4 drops for the first time since the 1920s and the sudden increase in the occurrence of class 5 is reversed. The occurrence of class 1 and 2 rises again slightly
1990-1994	No pieces of information were found relating to class 1, and few from class 2. By far the majority of information found was classed as 4 and 5

5.4 DISCUSSION

The Plant Cover Index was used to extract information on and draw conclusions about land condition from historical sources. Readers should keep in mind that comments on land condition are inferred from information on plant cover and soil stability alone, as defined in the Plant Cover Scale.

The trend in the indices of plant cover in the North East differs sharply from conventional assessments of the way pastoral land condition in Australia has changed since European settlement. Adamson & Fox (1982; p.121) summarise the general consensus of an overall decline in land condition in a hypothetical diagram depicting the stepwise fall to a lower equilibrium. They used temperate grazing lands as an example, but their diagram might well be applied to the arid zone judging from the literature (eg Perry, 1972, Hobbs & Hopkins, 1990). The initial decline in land condition in the North East parallels their example in broad terms, but the subsequent recovery in the latter half of the century is a major departure from the established view.

Whether this departure reflects special conditions in the North East, or is a function of the data in the historical record needs some elaboration. Given that the top of the plant cover scale is somewhere below the level which existed before the introduction of sheep and rabbits, the general shape of the PCI curve in this chapter could be modified to fit the published accounts. In particular, an arbitrary higher category for land condition at the beginning of the series (before 1880) would produce a curve more closely aligned with the general idea that land condition has stabilised, or is yet to stabilise, at a much lower level than its starting point (Hobbs & Hopkins, 1990). At the other end of the series, by removing the data on current condition which was assessed during this project, and in a sense is not part of the historical record, and assuming that the very wet years in the 1970s had an undue influence on the historical comments made in that decade, we end up with a curve which approximates the conventional assessment much more closely.

On the other hand, there is independent evidence from the North East Pastoral district which lends some indirect support to the idea of a general improvement in the condition of the district since the 1950s, as shown in the trend of PCI values. Koonamore Vegetation Reserve (on a station in the North East Pastoral SCD) has been recovering from an episode of severe overgrazing ever since it was fenced against stock in 1925. For many years, recovery of the perennial vegetation was very slow, but since about the 1950s there has been a marked increase in the population of saltbush (*Atriplex vesicaria*). The 1970s saw regeneration of other major perennials, a consequence of the good rains in that decade, and concerted efforts to control the rabbit population, started by chance in the years immediately preceding the rains (Sinclair, 1986).

Similarly, Maconochie and Lay (1996), who re-evaluated long-term vegetation surveys in the nearby Kingoonya SCD, found "there has been a modest but significant improvement in the density and regeneration status of most of the shrub populations...over the last 23 year period" (p.4).

In the light of this evidence, the suggested manipulation of the PCI graph seems a bit excessive. I am confident that the process of classification used in this thesis is robust, that the available data can be reliably placed in an appropriate category, and consequently that the PCI graph is an accurate portrayal of the data. Nevertheless, when the results for individual classes are examined closely, it seems clear that the historical record can only provide a very general guide to the trends in land condition in the past. This conclusion is most graphically highlighted by the fluctuations in class 5 - very good, perennial cover - in the last 3 decades. It seems highly unlikely that these fluctuations imply actual fluctuations in the proportion of land in that class over such short time periods. From the graph it seems that the reduction in class 5 in the 1980s was taken up by increases in class 2 and 3. The Koonamore records (Hall *et al.*, 1964, Sinclair, 1986) show that the transition from class 2 or 3 to class 5, at least for saltbush (*Atriplex vesicaria*), might take many decades, even in the absence of grazing.

Rather, these fluctuations may point to the existence of an unavoidable bias in the record, foreshadowed in the introduction, which reflects the preoccupation of those moved to comment, with the best or worst conditions at the time. For example, the 1970s contained two of the wettest years on record, and a correspondingly high proportion of information indicating the higher condition classes, including a marked increase in good perennial cover (class 5) from the previous decade. Similarly, in the following decade the trend is reversed, with a marked reduction in perennial cover. 1982 was a year of widespread drought in the chenopod shrublands of southern Australia (Eldridge *et al.*, 1990) The general trend in the Plant Cover Index might be unremarkable in such climatic conditions, except for those major fluctuations in perennial cover.

Again, however, there were events in the 1970s and 1980s which raise the possibility that at least part of the reversals in perennial cover may be real. The rains of the 1970s and the drought of 1982 may have been enough to cause some change in the perennial vegetation. The late 70s and early 80s also saw one of the periodic episodes of unexplained, widespread death of saltbush in eastern Australia (Clift *et al.*, 1987). The question is whether populations of perennial shrubs can respond quickly enough to register such large changes between decades. Widespread dieback, combined with a drought, could certainly reduce stands of perennial cover in class 5 to the stands of dead vegetation described by class 2, within a very short time, but no references to dieback were found in the records for the North East. The potential rate of recovery from such a drastic decline is more uncertain. I don't know of any instances of such a rapid recovery of natural populations of perennial chenopods in the presence of stock. However, Coleman (1982) found that seedling-sized cuttings of *Atriplex vesicaria* grew to much the same size as individuals in the surrounding mature population in less than 3 years at a field site (Koonamore) protected from grazing.

There is no doubt that land condition in the North East has improved since the low points of the 1920s and 30s, but the question as to whether the details of change described in this chapter are real, or an artefact of the data remains to be seen. There are points on both sides of the argument. It seems unlikely that the whole of the North East was unstable, or drifting sand, in the 1920s as implied by the data from that decade, especially as some parts of the country would have been beyond the reach of sheep ranging out from water. Yet the apparent anomaly of rapidly changing perennial cover in the last 3 decades, on the face of it equally unlikely, has some independent support, at least from observations on an ungrazed area. The answer is not clear cut. Some suggestions as to how any future historical study of the topic might address these issues are made in the final chapter, but in the meantime, the next chapter examines whether there is any support for the changes in land condition described here in other parts of the historical data collected so far.

CHAPTER 6

FACTORS THAT INFLUENCE RANGELAND CONDITION

6.1 INTRODUCTION

Much of the change in land condition since European settlement can be attributed, either directly or indirectly, to the activities of the settlers. The building of railways and mining activities have affected the surrounding areas due to removal of vegetation and disturbance of the soil. However, apart from indirect consequences (eg. spread of exotic weeds introduced in food for horses used during construction, timber getting for mine props) these effects have been mainly local. Individual species, such as *Santalum*, have been directly exploited for their export income in the past, but the major impacts on the land have been due to extensive operations such as grazing.

In this chapter, the focus is on the potential reasons for the changes in land condition outlined in Chapter 5. The most likely potential influences on these changes are grazing and its interaction with climate. Rainfall is described as a driving force in the arid zone. Grazing by domestic stock is an obvious impact, but not a simple one due to co-occurrence of native and feral herbivores

6.1.1 Climate

Climate, particularly rainfall, temperature and evaporation, has a profound influence on land condition in the arid zone (Walker, 1988). The timing and extent of rainfall events play a major role in the dynamics of both ephemeral, annual and perennial vegetation even in the absence of grazing (Noble, 1977).

Rainfall in the arid zone is low, by definition, and highly variable. The rainfall variability in the Australian arid zone, in particular, is 10% higher than the world average for places with the same annual rainfall (Williams, 1979). Gross measures, such as annual rainfall, may provide some indication of relative plant growth responses in years of above and below average rainfall, but they have limited use in explaining vegetation dynamics, especially for the long-lived perennials which provide protection against erosion. For these species, germination and establishment rely on the co-occurrence of rare events such as good rainfall at seed fall, adequate follow-up rains, and low populations of herbivores (Noble, 1986). Hence the effectiveness of a given fall of rain depends on the amount and timing, in relation to both season and previous falls.

In discussions during the course of this project, pastoralists identified several characteristics of effective rain in the arid zone. Most nominated a fall of about 1 inch (25mm) as a good rain, preferably spread over 2 or 3 days, rather than in a single fall. Smaller rains were considered effective if they occurred as 'back-up' rains within a month of a good rain. Timing of rainfall events was also seen as important for successful germination and establishment of seasonal pasture, as well as the influence of high temperature and low humidity on evaporation and soil moisture storage.

Published estimates of effective rainfall in saltbush country support the accumulated experience of those involved in the pastoral industry. For example, Osborn *et al.* (1932) defined an effective rain as one more than 25 points (>6mm). In this case, effectiveness was defined as rain sufficient to penetrate to the root zone of saltbush. The importance of prevailing conditions of temperature and humidity were highlighted by Cowling (1969) who claimed that the root zone of saltbush dried out within 20 days of a fall of 25 mm, but that a fall of 12.5 mm could dissipate by evaporation within a day in mid-summer.

The complexity of the interaction between rainfall and plant response in the arid zone was pointed out by Noble (1977) who's analysis of photopoint records from Koonamore showed that summer rainfall greater than 100mm (December - February) had a strong influence on subsequent plant growth. Again, the influence of season is reflected in the amount of rainfall, over 4 times the nominal effective rain, necessary to elicit such a response.

6.1.2 Grazing

Perhaps the most well-documented influence on range condition is that of grazing by domestic stock, native and feral animal populations. Herbivore numbers and composition have changed fundamentally since European settlement. With the introduction of stock and associated waters, kangaroo numbers have increased (Newsome, 1975) and their numbers in the North-east of South Australia are among the highest in the country (**Figure 6.1**). Rabbits arrived in the arid zone between 1880 and 1890 (**Figure 6.2**) not long after the land was opened up for pastoralism, and had spread to both SCDs by the turn of the century. Other herbivores (camel, goat, horse etc) were also introduced in the early days, but the main grazing pressure in the North East Pastoral SCD is from sheep, a few cattle and unknown number of rabbits and kangaroos.

The limitations on plant growth and recruitment dictated by climate are more critical when grazing is superimposed. The unpredictability of the climate adds complexity to management decisions such as the timing of destocking during drought, as well as affecting the dynamics of other animal populations such as kangaroos and rabbits.

In such a marginal environment, rare individual events such as fire or defoliation by freak hailstorms (Heather Badger *pers comm*) can have long-lasting impacts in local areas, but factors with the largest long term impacts on a broad scale are grazing by stock, rabbits and kangaroos, and rainfall. Rainfall is relatively well-documented, but the populations of the main herbivores are less well-known depending on the species. Pastoral leases now support 2.7 million of South Australia's 13.2 million sheep (Commonwealth Bureau of Statistics, 1995), but numbers have not been constant throughout the period covered by this study. Rabbit and kangaroo numbers have also fluctuated with the availability of feed, which in turn depends on rainfall. The remainder of this chapter is devoted to some exploratory analysis of the impact of rainfall, and grazing by the various herbivore species on land condition, followed by a more detailed analysis of potential interactions between those factors, in Chapter 7.

6.2 METHODS

The potential importance of rainfall, and numbers of stock, rabbits and kangaroos on change in land condition was explored initially by a simple comparison of time series of each variable with the trend in land condition. For clarity, the exploratory data analysis is presented and discussed briefly before the interactions are considered.

The nature of the data used for comparison of the chosen variables with land condition required two different approaches. Whereas figures were available for rainfall, and to a lesser extent domestic stock, throughout the period, rabbit and kangaroo numbers were not officially recorded for most of that time. Hence, trends in the populations of rabbits and kangaroos had to be inferred from historical sources, using a method similar to that adopted for reconstructing land condition classes.

6.2.1 Data

Domestic stock

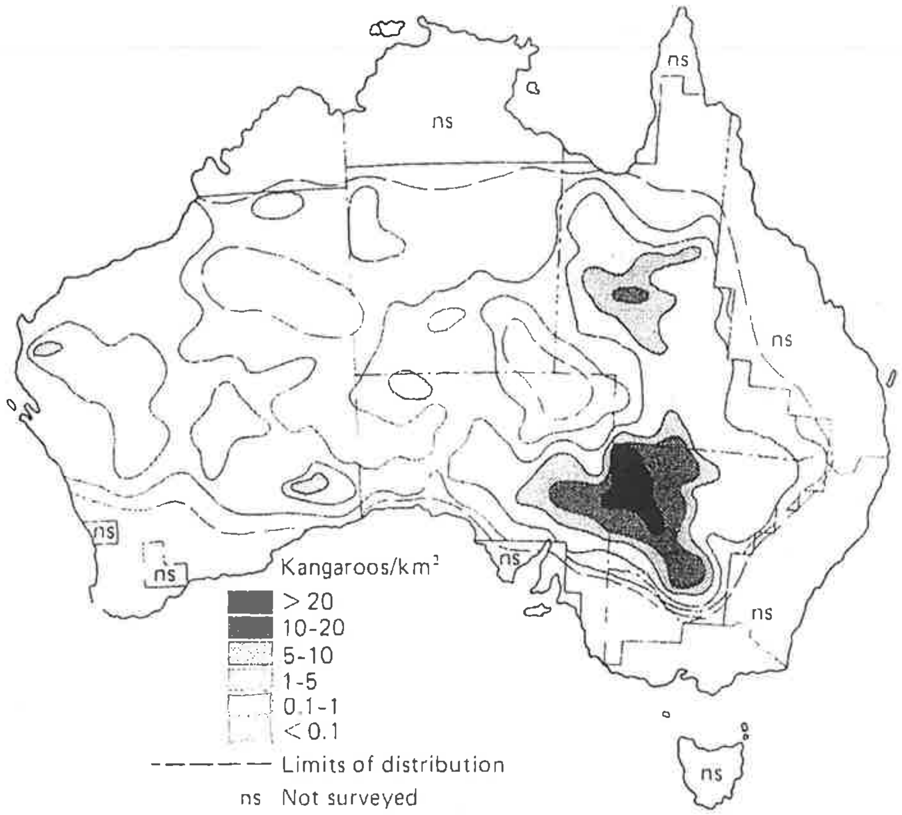
Stock records have been sent to the Government by station managers since the onset of pastoralism. They have been retained by the Pastoral Management Branch, of the Department of Environment & Natural Resources, or its equivalent, since 1955. Earlier records are scattered, with many lost or destroyed, and had to be compiled from a variety of sources (**Table 6.1**).

Table 6.1: Sources of historical stock figures used in this project.

YEAR	SOURCE
1872 - 1874	SAPP 153, 1875
1876 - 1883	SAPP 148, 1883
1917 - 1930	Stock Book, State Records
1935 - 1944	Cecil Goode's Reports, Pastoral Management Branch
1955 - 1994	Stock Returns, Pastoral Management Branch

The records maintained by the Pastoral Management Branch are expressed as total stocking rate in sheep equivalents per square mile, a figure which accounts for cattle and horses as well as sheep. Horse and cattle numbers can be presented as sheep equivalents by means of a conversion factor, which estimates the grazing impact of the animal as an equivalent number of sheep. The conversion factor used by the PMB since 1955 has been 5 sheep: 1 beast. For consistency, this figure was used to convert the separate entries for horses and cattle before 1955 to sheep equivalents.

a)



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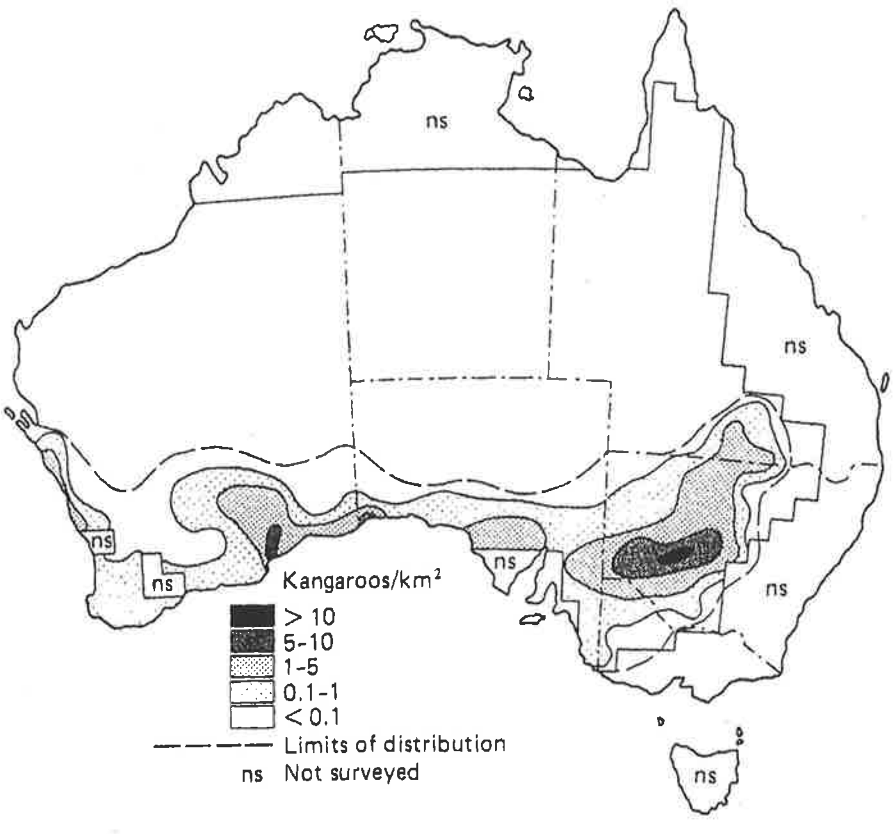


Figure 6.1: Distribution of the a) red and b) western grey kangaroos in Australia (from Caughley *et al.*, 1987).

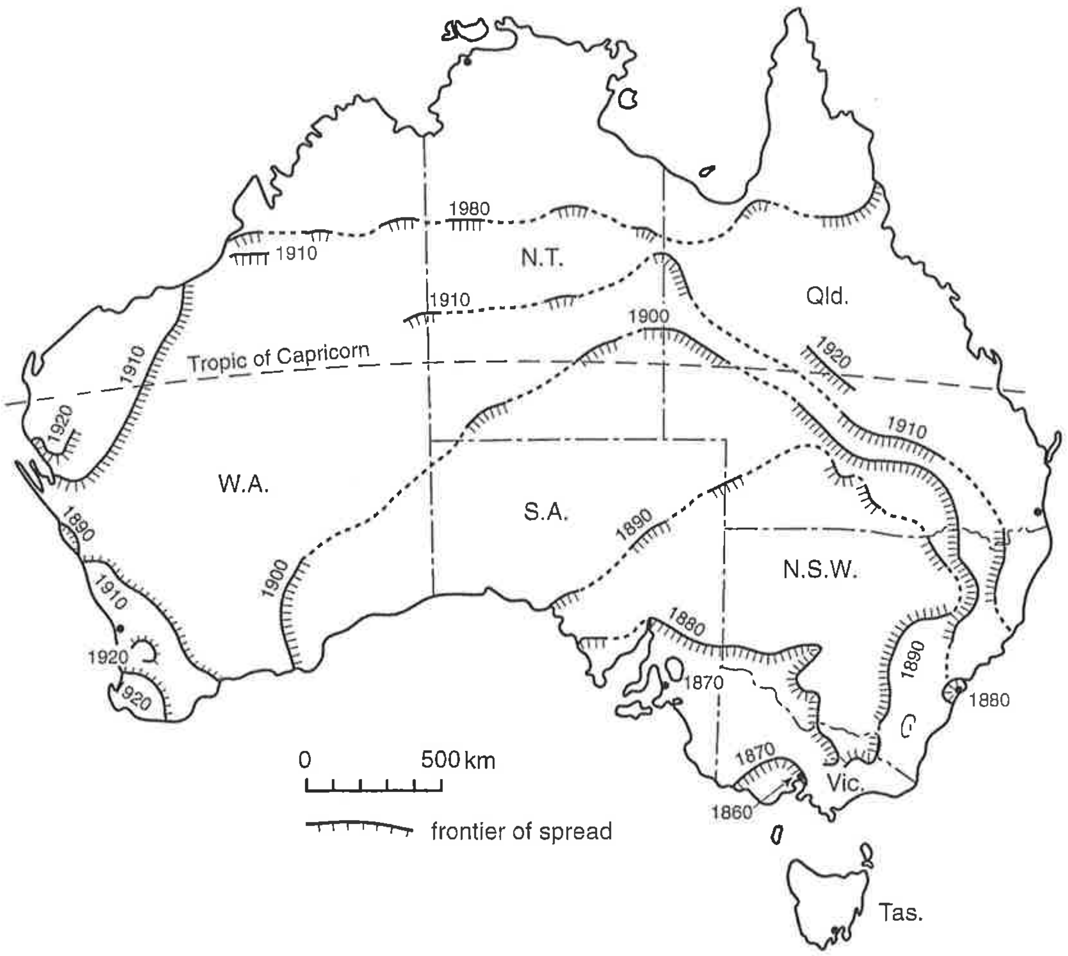


Figure 6.2: Summary of the spread of the rabbit over the mainland of Australia. From Stodart and Parer (1988).

Stocking rates for each station were expressed as sheep equivalents per square mile for convenience, because most managers still talk and think in square miles. One square mile is equivalent to 2.59 square kilometres.

Rabbits and Kangaroos

In contrast to stock numbers, which were collected for administrative purposes, quantitative information on populations of rabbits and kangaroos is far less common. Rabbit numbers have never been systematically collected, and have usually been noted only at times when numbers are extremely high. Estimates of the number of kangaroos in the area have been made from aerial surveys conducted by the National Parks and Wildlife Service since 1977, but before that time the quality of information is similar to that for rabbits.

Consequently, a similar scheme to that developed for land condition was adopted for classifying the mainly qualitative information on rabbit and kangaroo numbers. **Table 6.2** below describes a simple 3 point scale for both species.

Table 6.2: Classification scale used for information on rabbits and kangaroos.

Class	Rabbits	Kangaroos
1	Few	Few, scattered, or none
2	Many	Moderate
3	Plague	Very high

The main sources of information on numbers of these two herbivores were anecdotal, historical texts, pastoral inspectors reports, and in the case of kangaroos, survey information from the National Parks & Wildlife Service. Pastoral inspectors reports were a particularly useful source of information on rabbit numbers after 1970. I was able to convert their records of low, medium and high, directly to classes 1, 2, and 3. Nevertheless, information was sparse, and there are many gaps in the records, particularly in the first half of this century.

Rainfall

Rainfall records were obtained from the Bureau of Meteorology, Station owners, the Pastoral Management Branch (DENR) and *MetAccess* (Horizon Agriculture Pty Ltd), a computer program used for analysing weather records.

Records were available for 22 of the 35 Stations, and 4 towns in the North East Pastoral SCD. The extent of variation in rainfall over the area made an overall average meaningless. Results are therefore presented for three stations, which had the most complete set of rainfall records, and which spanned the area - namely, Boolcoomatta Station, Curnamona Station, and the town of Mannahill. An initial plot of the records suggested that extremes in rainfall (drought and 'flood' years) tended to occur simultaneously across the area.

The characteristic patterns of rainfall, identified by both pastoralists and ecologists as effective rainfall, were taken into account when defining the most useful potential correlates of land condition (see section 6.1.1). These included aspects of season, timing, and amount for a given rainfall event. For my purposes, a rainfall event was defined as any three successive rainy days, and included amounts, both before and after, if they fell within two days.

The measures chosen for exploratory analysis were

- annual rainfall
- number of rainfall events per year over 25mm
- summer rainfall (December - February)

6.3 RESULTS

Stock

Stocking rates for 10 stations with the most complete records are shown in **Figures 6.3 and 6.4**. In all cases stocking rates have fluctuated widely with time, particularly in the first half of the century when both official and industry estimates of carrying capacity were inflated. Over the last 50 years, they have mainly been in the range 20 - 60 sheep-equivalents per square mile. Within each station, the fluctuations from year to year are generally less than 20 sheep-equivalents per square mile. There is little evidence of any trend in total stock

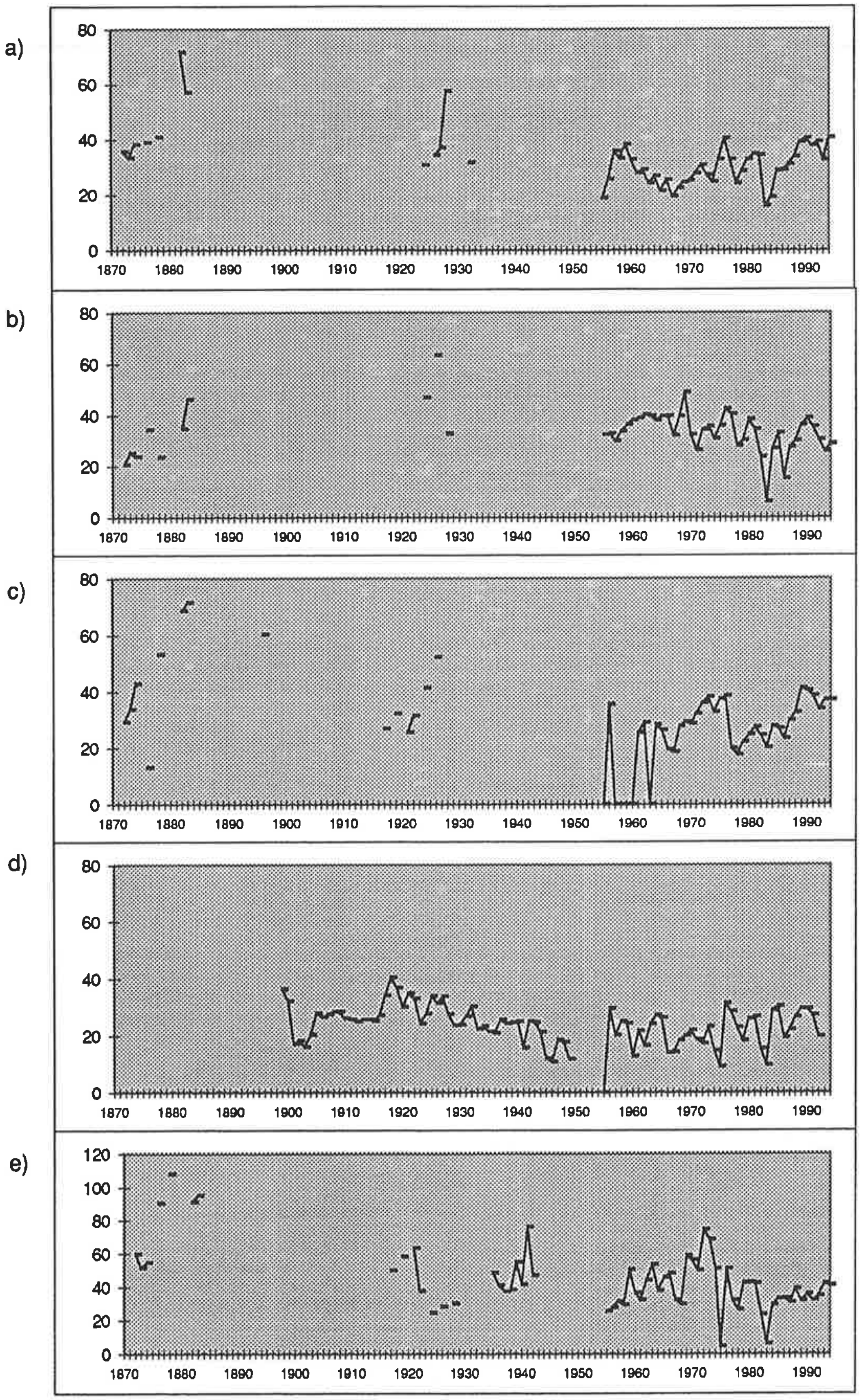


Figure 6.3: Historical stocking rates for 5 stations (a-e) in the North East Pastoral SCD

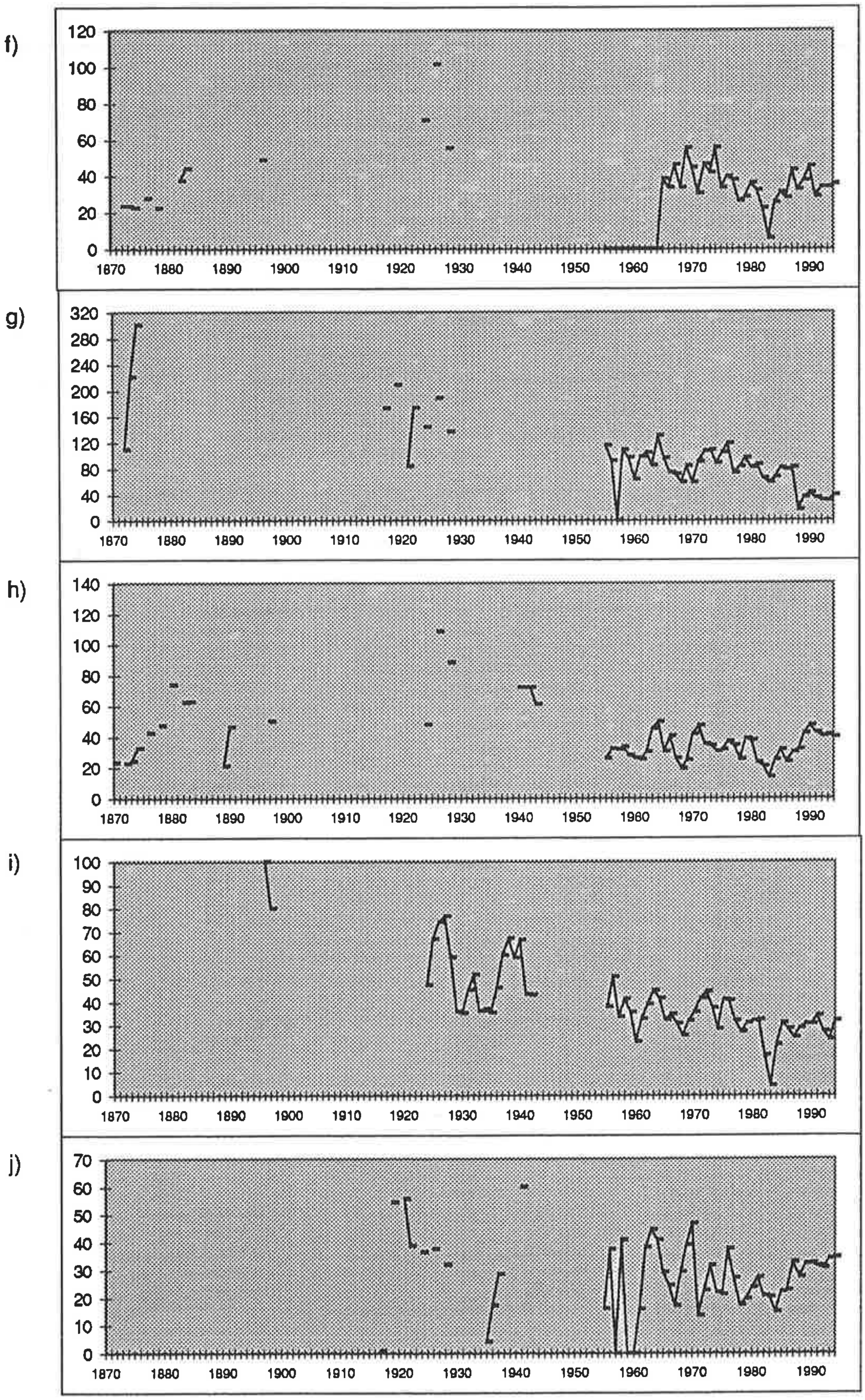


Figure 6.4: Historical stocking rates for 5 stations (f-j) in the North East Pastoral SCD

numbers which would explain the details of changes in land condition shown in **Figure 5.2**, except for an overall reduction in stocking rate in the last part of this century. **Table 6.3** lists the mean and median for the 10 stations before and after 1955, the date when stock figures were systematically maintained by government administration.

Table 6.3: Mean and median stocking rates (sheep equivalents per square mile) for 10 stations in the North East Pastoral SCD.

	Mean		**Median**	
	pre 1955	**post 1955**	**pre 1955**	**post 1955**
Bimbowrie	42	30	38	29
Boolcoomatta	35	33	34	34
Bulloo Creek	43	27	38	32
Curnamona	42	25	38	28
Faraway Hill	174	76	173	82
Florina	54	33	50	32
Manunda	56	32	52	32
Mutooroo	25	21	25	22
Winnininnie	56	38	51	36
Yarramba	33	26	37	27

Rabbits and Kangaroos

The data on rabbits and kangaroos, classified according to the scheme in **Table 6.2** is shown in **Figures 6.5 and 6.6**. In neither case is there any major long-term trend evident, however there was not enough information available to make any detailed comments on either rabbit or kangaroo population changes. For rabbits, information for the period before 1966 is scarce, and, for the most part, only indicated when plagues occurred. The records for the last 30 years were most complete, and indicate moderate numbers throughout.

Similarly, numbers of kangaroos have only been recorded systematically since 1977. Since then abundance has been mainly moderate to high (classes 2 and 3).

The absence of reliable data on both these herbivores before regular census of any kind, either nominal or quantitative, prevents any attempt at visual correlation, but the pattern since census began suggests that earlier data would not have improved the outcome, as the 3 point scale does not reveal much information.

Rainfall

Aspects of the rainfall regime for three recording stations, Mannahill, Boolcoomatta station and Curnamona station, are depicted in **Figures 6.7-6.9**. There has been no obvious change in the pattern of either annual rainfall, summer rainfall, or the annual number of effective rains since records began, certainly not at the scale observed for changes in land condition. Severe droughts occurred in 1864-5, 1898-1902, 1922, 1940, 1967 and 1982, while wetter than average years occurred in 1889, 1920, 1937, 1950, 1958, 1973-4 and 1992. The bulk of the 1920s and 1930s, when land condition was at its worst, were years of below average rainfall, and from the figures above drought years were more common in the early days when stock numbers were high.

Given the gaps in the rainfall records over the whole study area, perhaps the most valuable outcome of the rainfall analysis is the observed tendency for significant events to occur simultaneously at all three stations chosen to represent the region.

6.4 DISCUSSION

There are many reasons for the absence of matching long term trends in land condition and the potential causal factors chosen for analysis. Rainfall and grazing pressure are clearly the most likely influences on land condition, but they are not necessarily simply related. Apart from the obvious problems arising from missing data, including numbers of native and feral herbivores, coarse measurements such as overall stocking rate, in particular, do not reflect the actual grazing pressure on land accessible to stock. Interactions between stock and the landscape are centred on the waterpoint, and are confined to the area defined by the distance stock can walk before they need to return to water (the piosphere; Lange, 1969). Within paddocks, the distribution of grazing pressure is highly complex and variable (Lange, 1985). A paddock stocking rate, on the other hand, is calculated on the basis of total paddock area, some unused by stock, returning a figure which underestimates the true stocking pressure. The distortion can be compounded in an overall stocking rate for a station, depending on the number and location of waterpoints and relative size and shape of the paddocks (Lange *et al.*, 1984). The effort involved in development of the methodology for this project prevented more detailed analysis of the subtleties of grazing pressure, but any future studies of this kind may find a comparison of the history of the development of

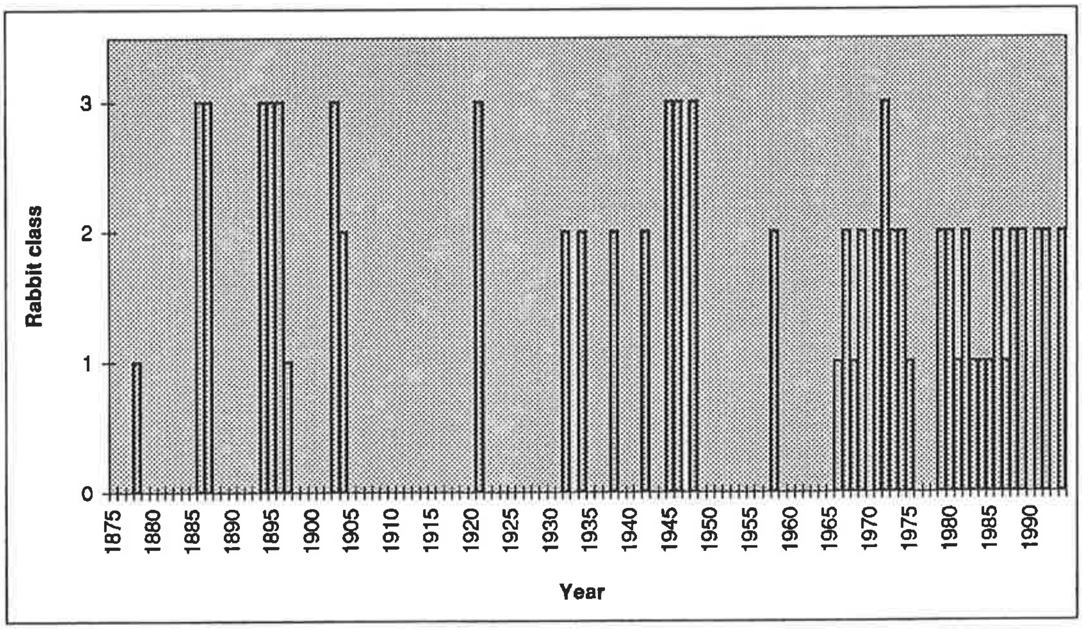


Figure 6.5: Historical 'Rabbit class' records in the North East Pastoral SCD. Note that this histogram represents the available information, not details of rabbit numbers.

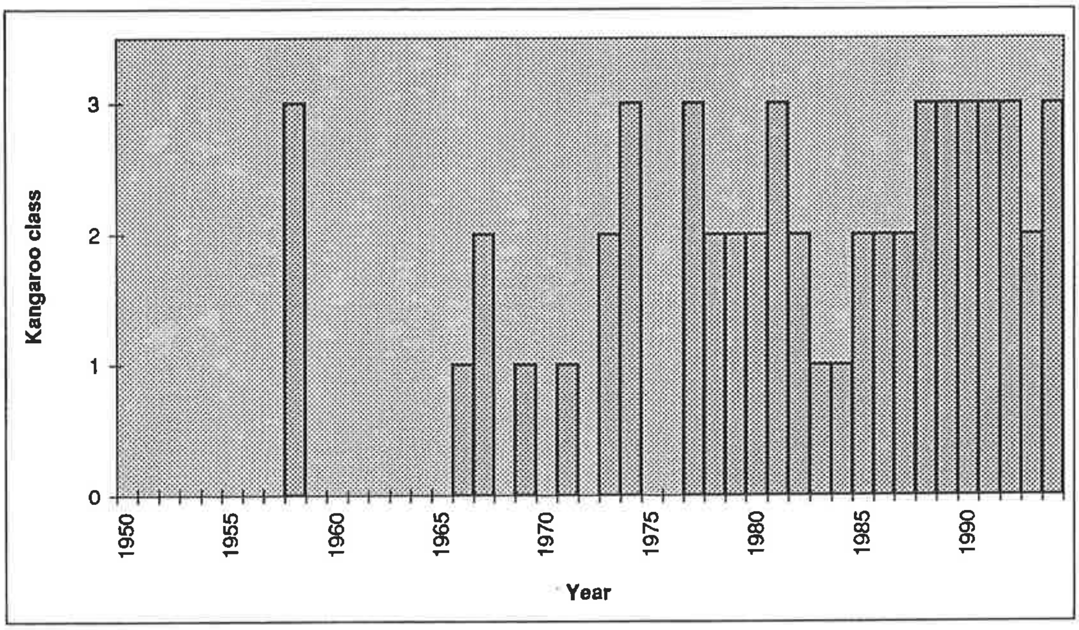


Figure 6.6: Historical 'Kangaroo class' records in the North East Pastoral SCD. Note that this histogram represents the available information, not details of kangaroo numbers.

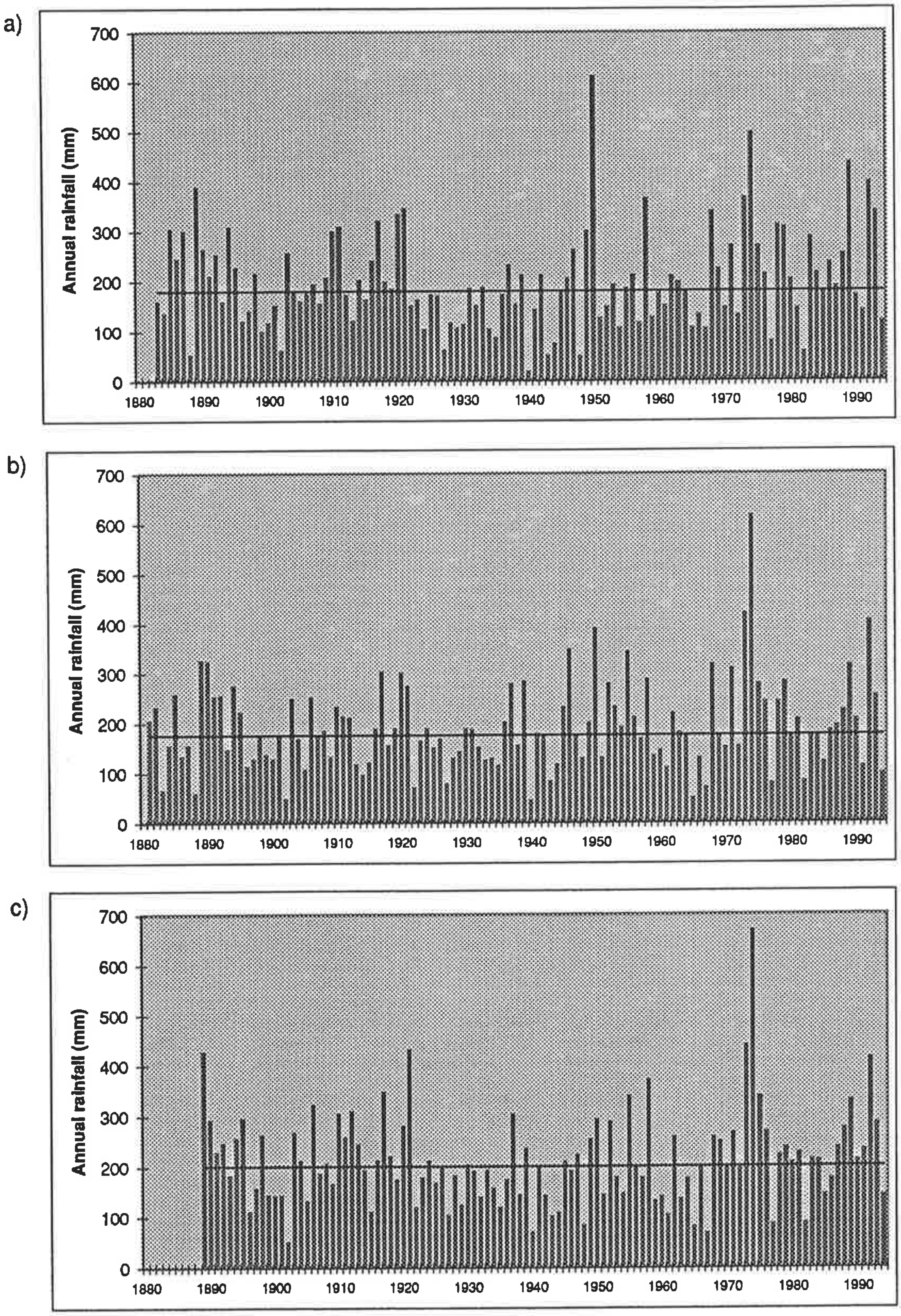


Figure 6.7: Historical annual rainfall for a)Boolcoomatta Station, b)Curnamona Station and c)Mannahill. Median is marked as a horizontal line.

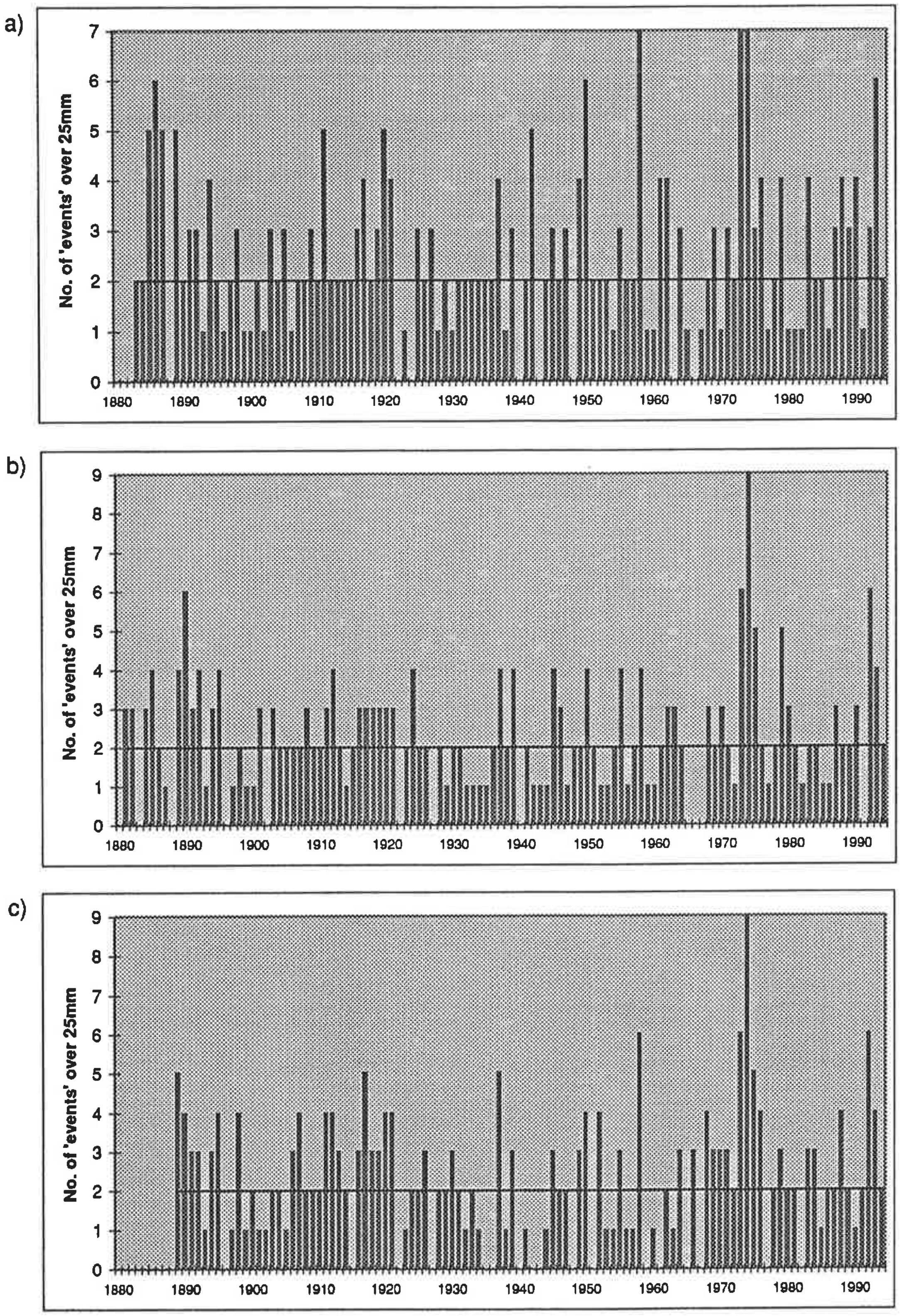


Figure 6.8: Annual number of rainfall 'events' over 25mm for a)Boolcoomatta Station, b)Curnamona Station and c)Mannahill. Median is marked as a horizontal line.

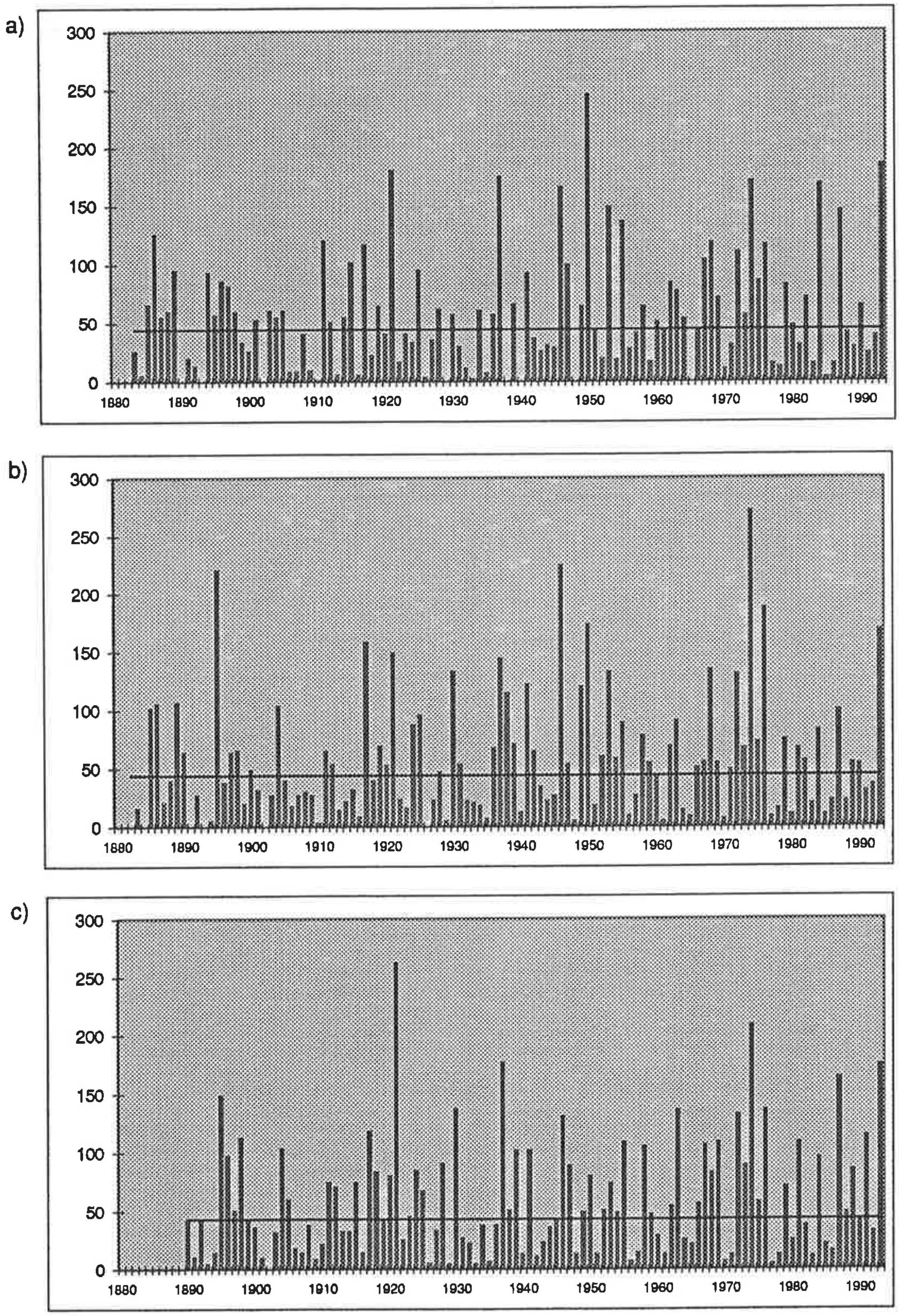


Figure 6.9: Summer rainfall (1 December - 29 February) for a)Boolcoomatta Station b)Curnamona Station and c)Mannahill. Median is marked as a horizontal line.

waterpoints with land condition a useful exercise. Old paddock plans and the location of waterpoints may well be available in the records kept by both Government and pastoralists.

Similarly, measures of the effectiveness of rainfall for improving perennial cover may need more detailed consideration of timing in relation to plant life cycles and recruitment. For example, Ireland & Andrew (1992) have speculated that recruitment of *Acacia papyrocarpa* (western myall) the dominant overstorey species in the North-west Pastoral District, relies on substantial summer rain at seedfall, in amounts sufficient to cause overland flow. The seeds are scarified and buried deeply enough in litter and silt to escape predation by harvester ants which in most years remove all seed. Successful germination and establishment may then follow, given adequate follow up rain and low grazing pressure.

The model of recruitment above serves as an example of the many interactions, and sometimes the precise timing, that control the responses of the landscape to biotic and physical influences. In light of this potential complexity, it is likely that none of the factors studied here has had an independent effect on land condition, but interact to produce their effect on the landscape. The potential interactions between grazing by various herbivores, aspects of rainfall and land condition are analysed in more detail in the next chapter.

CHAPTER 7

STATISTICAL ANALYSIS

7.1 INTRODUCTION

In the preceding chapters, it has been shown that large changes in land condition have occurred over the last 110 years, and that rainfall and herbivore numbers have fluctuated concurrently. No obvious relationships could be seen between land condition (or the cover classes extracted from the historical record), and the individual causal factors thought to have influenced land condition. This does not imply that the suggested factors have no influence, rather that grazing and climate interact in complex ways to produce their effect.

Without the opportunity to design experiments on such interactions, a difficult task in any circumstances, sorting out the relative influence of grazing and climate on land condition is not easy, especially in the face of incomplete data sets for some of the variables under consideration.

Statistical advice pointed to logistic regression as the best way of handling the data sets compiled during this project. The method chosen was a stepwise logistic regression. Details of the model fitting process will not be attempted here, but can be found in many standard statistical texts on logistic regression (eg. Hosmer and Lemmeshow, 1980). Briefly, an objective algorithm is used to assess the relative value of the independent variables (eg. rainfall, stocking rates etc.) as predictors of land condition (the dependent variable). Variables are successively included in the model until the remaining variables fail to improve the fit. Essentially, the procedure fits an equation involving those factors which best describe the land condition scores.

To make best use of this approach, and allow detection of possible interactions, several new variables were incorporated in the analysis, along with the standard factors considered in the previous chapter. The new variables, chosen for their potential influence on landscape response, were drawn from ideas in the literature, discussions with pastoralists, and my own observations during fieldwork and preliminary analysis.

For example, although the chenopod shrublands are relatively homogeneous, soil profiles and topography do vary across the North East Pastoral SCD, which raises the possiblilty that the response of vegetation to herbivores and climate may differ depending on location. The main division that could be place through the area would be to separate the hill country associated with the Barrier Ranges and the plains surrounding it. These two areas have been described by Laut *et al.* (1977a) as the Olary Uplands and the Lake Frome Plains. Time, specifically the division between the early part of the century when stock records were patchy, and the latter half with good records, was also considered in this context.

The most useful ecological variables available from the data sets were those which dealt with effective rainfall, and possible lags in the response of vegetation to climate or grazing. Potential relationships between several such variables and Plant Cover Classes are examined in the following pages.

7.2 METHODS

7.2.1 Setting up the data matrix

Stepwise logistic regression was used to investigate relationships between the potential predicting factors and land condition. A data matrix was set up (**Table 7.1**; see following page), starting off with every 'land condition' score collected and its associated year. A number of other variables were then chosen to reflect the influence of grazing and climate. Entries were made for each of the years and stations where available.

The standard factors used in the previous chapter were included (eg. stocking rate, annual rainfall, rabbit class), as well as a number of others that either the literature or anecdotal evidence suggested may be important (**Table 7.2**). The values of most factors in the previous year were included to allow for any possible 'lag' effects in the land condition response. Two additional rainfall variables were included - the number of rainfall events

Table 7.1: Excerpt from raw data matrix. See Table 7.2 for description of column headings.

STN	YEAR	LC SCORE	STOCK	STPREV	ANN RAIN	2YRS RAIN	RF>25	RF>12	SUMM RAIN	SUMM 100	RABS NOW	RABS PREV	KANG NOW	KANG PREV	LAUT	EPOCH
FAR	1994	4	39	30	153	510	2	4	110	1	2	N/A	3	2	1	2
FAR	1994	5	39	30	153	510	2	4	110	1	2	N/A	3	2	1	2
FLO	1885	4	80	63	233	368	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1
FLO	1897	1	50	80	159	412	1	4	50	0	1	3	N/A	N/A	2	1
FLO	1897	2	50	80	159	412	1	4	50	0	1	3	N/A	N/A	2	1
FLO	1897	4	50	80	159	412	1	4	50	0	1	3	N/A	N/A	2	1

over 12mm, to see if rainfall events less than one inch are significant, and another factor that simply gave an indication of whether or not the summer rainfall was over 100mm.

Table 7.2: The factors included in the statistical analysis and their abbreviations.

ABBREVIATION	FACTOR INDICATED
STN	Station name abbreviation
YEAR	The year the data relates to
LCCLASS	The land classification assigned to the data (1-5)
STOCKNOW	The stocking rate for the station that year (sheep equivalents per square mile)
STOCKPR	The stocking rate for the station the previous year (sheep equivalents per square mile)
ANNRAIN	The annual rainfall for that year (mm)
RAIN2YR	The annual rainfall for that year plus the previous year (mm)
RF25	The number of rainfall events that year over 25mm
RF12	The number of rainfall events that year over 12mm
RABBSNOW	The rabbit classification for that year (1-3)
RABSPR	The rabbit classification for the previous year (1-3)
KANGNOW	The kangaroo classification for that year (1-3)
KANGPR	The kangaroo classification for the previous year (1-3)
SUMMRAIN	The rainfall for the December, January and February at the start of the year (mm)
SUMM100	Indicates whether the summer rainfall was above or below 100mm
LAUT	The 'Laut province' the station falls in (choice of 2; assigned 1,2)
EPOCH	Splits the time scale into pre and post 1950 (assigned 1,2)

To investigate any spatial differences, the stations were split into two groups, based on the provinces described by Laut *et al.* (1977a; see **Figure 2.4**). Time was incorporated into a factor titled 'epoch'. It was not technically possible to incorporate individual years into the analysis, however it was important to consider the possibility that the influence of the various factors may have changed over time. Thus the data set was split in half at 1950, with 53% of the data pertaining to pre 1950 (epoch 1) and the rest post 1950 (epoch 2).

Location within the NEP SCD (ie. individual stations) was not considered due to insufficient data and so the north east was analysed as a whole.

7.2.2 Analysing the data

As mentioned in chapter 5, there were 580 pieces of information from records on land condition, however not all of the other fields could be filled in (ie. found) for each of these entries. Thus, each of the variables was filled in for a proportion of the total 580 land condition entries (**Table 7.3**). Each land condition entry and its associated variables (ie. the fields in each row) was termed a 'response' and only complete responses (ie. those with all variables represented by a value) could be used in the analysis. Because of this, the factors were not all analysed together otherwise the data set would have been reduced to an unacceptably low number of responses for a meaningful statistical interpretation.

Table 7.3: Simple data description for the North East Pastoral SCD.

Variable name	Categories	Total Frequency
LCCLASS	C123, C45	580
YEAR	value	580
STOCKNOW	value	513
STOCKPR	value	473
ANNRAIN	value	580
RAIN2YR	value	576
RF25	value	574
RF12	value	574
RABBSNOW	R1, R23	321
RABBSPR	R1, R2, R3	293
KANGNOW	K1, K2, K3	255
KANGPR	K1, K2, K3	252
SUMMRAIN	value	569
SUMM100	L1, L2	569
LAUT	LT100, GT100	580
EPOCH	LE1949, GE1950	580

Program LR, BMDP Statistical Software, UCLA (ed W. Dixon), was used for the analyses presented here. The logistic regression was run on the data set 5 times, each time using a different selection of factors for the model. In the initial analysis, as many factors were included as could be with minimal reduction of the data set, and these were mostly rainfall indicators. Then, additional factors were substituted in order to determine their effect.

7.3 RESULTS

The factors included in each run of the model and the associated outcomes are presented in **Table 7.4**. Results are the most reliable in cases where the number of responses used in the model is greatest. For all of the Logistic Regressions performed, similar factors came up as indicators of land condition, which suggests there is no unusual skewness in the data set brought about by the pattern of missing data values. Only the first fit of the model, based largely on rainfall factors, produced a result that was statistically significant at a 0.05 level. However it is useful to outline the results of all five runs to examine what the lack of significance of grazing factors says about the nature and adequacy of the available data.

In all cases, the annual rainfall for the previous two years and the summer rainfall were found to be descriptors of land condition. The annual number of rainfall events over 25mm was also found to be a good descriptor and was only ignored in the fourth run, which was not as reliable due to the lower number of responses included. In no case was annual rainfall found to be a descriptor of land condition, nor was the annual number of events over 12mm.

The epoch factor was also selected as a good descriptor of land condition, which indicates knowing whether information relates to pre- or post- 1950 aids in predicting the associated land condition. This in turn suggests that land condition was significantly different before 1950 compared with what it has been like since.

Stock numbers, either in the targeted year or the previous one, did not show any relationship with land condition and thus was not a good indicator. Similarly, neither rabbits nor kangaroos showed any relationship with the land condition scores.

The Laut classification (ie. spatial distribution of stations) was not found to be an descriptor of land condition.

Table 7.4. : Summary of the 5 Stepwise Logistic Regressions (SLR's).

Factors considered for the model	Number of responses used to determine the model	Factors chosen as best descriptors of land condition	Goodness of fit (Hosmer-Lemeshow) P-value
RAIN2YR RF25 RF12 SUMMRAIN SUMM100 EPOCH LAUT	567	EPOCH RAIN2YR RF25 SUMM100 EPOCH*SUMM100	0.007
ANNRAIN RAIN2YR RF25 RF12 SUMMRAIN SUMM100 EPOCH LAUT STOCKNOW	504	EPOCH SUMM100 RAIN2YR RF25 EPOCH*RAIN2YR	0.129
ANNRAIN RAIN2YR RF25 RF12 SUMMRAIN SUMM100 EPOCH LAUT STOCKPR	465	EPOCH SUMMRAIN RAIN2YR EPOCH*RAIN2YR RF25	0.052
ANNRAIN RAIN2YR RF25 RF12 SUMMRAIN SUMM100 EPOCH LAUT RABBSNOW RABBSPR	127	RAIN2YR SUMM100	0.086
ANNRAIN RAIN2YR RF25 RF12 SUMMRAIN SUMM100 LAUT RABBSNOW RABBSPR KANGNOW KANGPR	100	RAIN2YR SUMM100	0.462

Terms joined with an asterisk (*) indicate an interaction effect between those terms.

Summary of results

- Rainfall was the only 'factor' seen to be statistically related to land condition.
- Land condition was significantly different pre 1950 to post 1950.
- There were no significant differences in land condition in the two Laut provinces (ie. on a broad spatial scale).

7.4 DISCUSSION

Leaving aside, for the moment, the potential biases inherent in the primary data set on land condition, two main points emerge from the analysis.

Firstly, the only factors found to be statistically related to land condition scores were ones representing rainfall. Annual rainfall, the most common rainfall statistic in use in the arid zone, in fact did not show a significant relationship with land condition. This result highlights the need for a careful choice of variables, where possible, to reflect the ecological processes operating in the landscape. In these circumstances, an encouraging outcome of the analysis was the detection of relationships between inferred land condition and variables selected, from the literature and elsewhere, for their ecological relevance. In particular, those variables chosen to represent the effectiveness of rainfall, the number of falls of 25 mm or more, and summer rainfall over 100 mm, both showed significant relationships. The lack of significance for the number of falls of 12 mm supports the views of many pastoralists that rainfall events need to be about 1 inch (25 mm) or greater to be of major significance for vegetative growth and reproduction. The total amount of rain in the previous two years was also a good predictor of land condition, indicating a lag between rainfall and vegetative response as suggested by Noble (1977). However, given that rainfall is the driving force for vegetation dynamics in arid zones the successful detection of relationships between land condition and appropriate variables is not unexpected.

The second, and surprising outcome of the analysis is that none of the indicators of grazing pressure were found to predict land condition. The results from the previous chapter, along with other historical evidence, suggest that the impact of stock and rabbits may have been reduced since the 1950s, due, among other things, to the introduction of stocking maxima and myxomatosis (Fenner and Ratcliffe, 1969). If this had occurred and was responsible for a change in land condition, it would have been expected to manifest as a significant interaction term with the epoch variable (eg stock*epoch or rabbits*epoch). Neither of these interactions was detected.

The overwhelming evidence from the literature reviewed earlier, is that stock and rabbits can and do have a significant effect on the land. In the case of variables representing rabbit and kangaroo grazing pressure, the most likely explanation for the lack of significance is that the data was simply too patchy, and the classes too broad for a relationship with land condition to show up. To a certain extent this is also true for stock numbers, particularly in the early part of the century, when records were not maintained systematically. Irrespective of the missing data for stock, however, it is undoubtedly true that records of stocking rate, a yearly total for a given station, are not sensitive enough to describe grazing pressure for the reasons outlined in the previous chapter. In short, conventional stocking rates in sheep per square mile, or similar measures, are poor indicators for stocking pressure in a paddock, much less for a station as a whole. The inadequacy of stocking rates expressed in this way has recently been demonstrated by Maconochie and Lay (1996). They found no clear relationship between stocking rates and long term changes in chenopod populations in the Kingoonya District of South Australia, even from far more quantitative data than used in this study.

There is no denying that stock have had an effect on land condition, and hence the results of this analysis lead to the conclusion that the effect of stock is determined more by management practices than by the actual number of stock, at least within certain limits. Indeed, the stocking impact varies with drought conditions, vegetation composition, the number and position of water points, as well as the number of stock, a conclusion which is well documented for smaller study areas in the literature. Consequently, in the same way that the significance of rainfall variables depended on the way they were expressed, those representing grazing pressure also need to be selected for their relevance to the way the landscape is used. The scale at which grazing interactions operate in the landscape is probably too fine to be detected in such a broadscale approach as used in this thesis.

This results of the analysis suggest that land condition has improved since the 1950s, as implied by the significance of the epoch variable, and the trend in Plant Cover Index described earlier. Considering the severe degradation in the early part of the century, the improvement might even be described as dramatic, but whether land condition has improved to a level acceptable to all interested parties is another question. An attempt to put these questions in perspective will be made in Chapter 9 in a final discussion of the methods developed during the project, the nature of the data, its limitations and application.

CHAPTER 8

THE MARREE SOIL CONSERVATION DISTRICT

8.1 INTRODUCTION

Following the development and application of the methodologies in the North East Pastoral SCD, the same approach was attempted for the Marree SCD. The differences between the two areas are highlighted in Chapter 2, but in summary, the Marree area is much larger, more remote and the vegetation is much more ephemeral. In contrast to the vegetation in the North East Pastoral SCD which can all be described as chenopod shrubland, there are four major land types in the Marree SCD - sandhills, gibber, river country and saltlakes, each with a distinctive vegetation cover.

The greater size and remoteness of stations in the Marree SCD has a significant influence on the lifestyles of people living there and the management practices employed. In particular, there are less internal fences and stock are often mustered by plane or helicopter. Communication is largely by 2-way radio (UHF) and the flying doctor radio (HF). Water runs (travelling to and checking each watering point) by car can fill a whole day; mustering cattle (eg. for branding or sale) can take several days, requiring those involved to camp out on site due to the distances involved. Although advancing technologies are speeding up these processes, they are still fairly large scale activities and management decisions need to be more long-term than on the smaller, more southerly stations.

An important feature of the Far North of the state is the presence of the 'Dog Fence' (**Plates 8.1 and 8.2**), a dingo proof vermin fence running roughly east-west across the state. To the south of the fence, dingoes (wild dogs) have been destroyed. The fence was formed in the 1940's by joining together the northern fences surrounding the outer vermin proof districts. Most of the Marree SCD (including all of the stations examined in this project)

Plate 8.1: A gate in the Dog Fence on the road to Muloorina Station.

Plate 8.2: Looking east along the Dog Fence, to the right of plate 8.1.

lies above, or 'outside' the Dog Fence and thus is inhabited by dingoes. For this reason, sheep grazing has been abandoned and cattle are run.

The remainder of this chapter describes an attempt to apply the 'classification scale' method developed for the North East SCD to the Marree SCD in order to examine historical changes in land condition.

8.2 METHODS

The initial steps of the project were as follows:

1. Collection of historical and current records on land condition and related factors
2. Development of a classification scale for the Marree SCD

If these were successful, then data could be analysed as for the North East SCD.

8.2.1 Collection of historical and current records

A letter and questionnaire was sent to all pastoralists in the Marree SCD in March 1995. Responses were received from fourteen of the twenty one stations approached (**Table 8.1; Map 5**).

Table 8.1: List of responses from lessees in the Marree SCD.

OWNERS/MANAGERS	STATION(S)
Jimmy Crombie	Alton Downs & Andrewilla
Kevin Oldfield	Clayton & Saltapurina
Gwynne Hughes / Tom McKay	Clifton Hills, Goyder Lagoon & Kanowana
David Brook	Cordillo Downs
Sharon Oldfield	Cowarie
George, Daryl and Sharon Bell	Dulkaninna & Corryanna
Paul and Debbie Broad	Etadunna, Peachawarinna, Kirrakirrinna & Pt Cannatalkaninna
Michael Brazel	Gidgealpa
Graham Morton / Greg Campbell	Innamincka
Pam and Martin Reick	Merty Merty
Malcolm and Colleen Mitchell	Muloorina
Mary Oldfield and James Oldfield	Mungeranie & Waukatana
Ron, Jennifer, Marcus and Catherine Hyde	Quinyambie
Michael Sheehan	Woolatchi

These stations were visited during the course of two, four week field trips in June and August of 1995. Information was collected as for the North East Pastoral SCD. Historical records were collected or copied, however there were fewer such records available on stations in the Marree SCD. Anecdotal information was recorded from discussions with pastoralists and many photos were taken during extensive trips over the stations.

8.2.2 Development of a classification scale for the Marree SCD

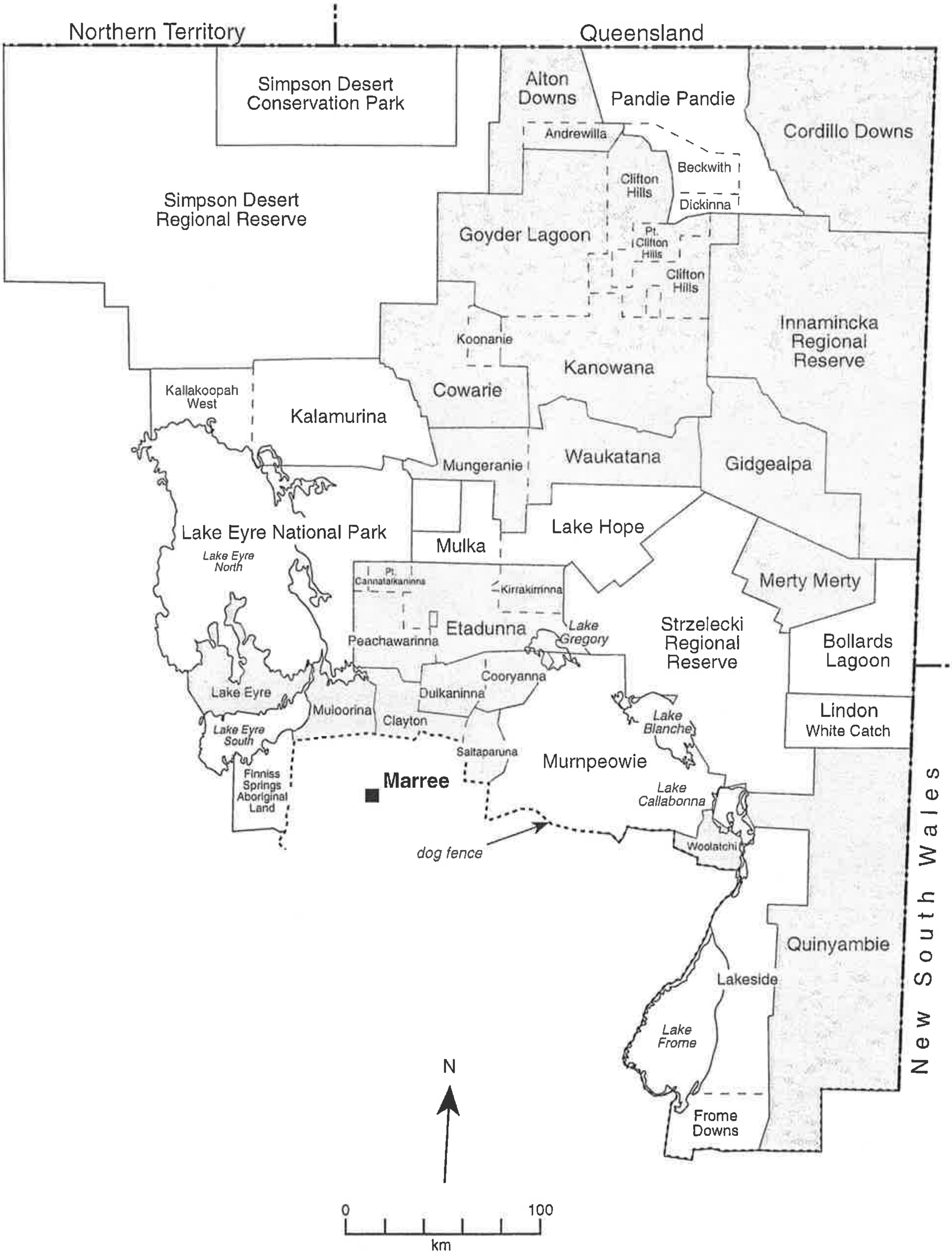
It was soon evident that a single classification scale could not be developed due to the heterogeneity of land types in the area. For example, the condition class assigned to 50% cover on a gibber plain, with naturally sparse vegetation, would be quite different to that for 50% cover on a fertile river flat. Nevertheless, since the scales are nominal, I believed that separate scales for the 4 land types could be used in conjunction to describe land condition for the whole are, provided the scales were the same size (ie. had the same number of points).

As much information as possible was collected for the Marree area, and attempts were made to define land condition scales, in the same way as described for the North east Pastoral SCD, for each of the different land types. The main land types were sandhills, gibber plains, channel and flood plain country and areas adjacent to saltlakes.

8.3 RESULTS

8.3.1 Application of 'classification scale' methodology

Unfortunately, the methodology developed for the NEP SCD could not be adapted and applied to the Marree SCD. The main reason for this was insufficient records, in particular insufficient spatial distribution of records. Most records collected were relevant to the areas surrounding the homesteads. Given the large size of the stations, and the relative heterogeneity of land types, the combined data for a station yields little information on land condition for the station as a whole. Clifton Hills station, for example, is nearly the same size as the entire North East Pastoral SCD. Therefore using information from the homestead to describe the station would be akin to using information from Olary to describe the whole North East Pastoral SCD.



Map 5. Stations in the Marree Soil Conservation District, showing those involved with this project (shaded).

It also became clear that analysis of any trend in condition would have proved difficult. Rainfall records, for example, were too few and unrepresentative for any attempts to assess the impact of rainfall on condition. As elsewhere in the arid zone, rainfall is often patchy and varies widely depending on locality. The few recording stations at homesteads are unlikely to be representative of the surrounding areas. Another confounding factor is the flooding of the river systems due to heavy rainfall in catchments outside the study area (in south-west Queensland). In these circumstances it is possible for drought conditions to prevail in one area, alongside an area supporting lush vegetation. In such a vast area, stock numbers are also probably less reliable than in more closely settled country. Similarly the numbers of feral horses (brumbies) camels and donkeys, all of which contribute to the grazing pressure are undocumented and unknown.

I persisted with the work in the Marree SCD until field work was complete, in part because the idea for this work was initially suggested by pastoralists in this area; but part way through the field work it was clear that use of the methods developed for the North East Pastoral SCD were not applicable to the larger and relatively poorly documented Marree district. Nevertheless, aspects of the data collected and comments from pastoralists should be valuable for design of future work in the area. A summary is presented in the following pages.

8.3.2 Information collected

While the intended research could not be attempted for the Marree SCD, a certain amount of other important information was collected that is worth reporting.

Response of the land systems to grazing and rainfall

The four main land systems in the Marree SCD (described in Chapter 2), all respond differently to grazing and climatic influences.

- Sandhills - After rain, feed comes up more slowly than on gibber, but is usually thicker and covers the entire sandhills (George Bell *pers comm*). This is good fattening country, but cattle cannot be left there too long because feed runs out suddenly (David Brookes *pers comm*).

- Gibber - Generally supports the least vegetation of all the land types. After rain, plants come up quickly but patchily - usually where stones have been removed eg. crabholes, stock pads, roadsides (George Bell *pers comm*). Smaller rainfall events are best utilised by the gibber country due to runoff and collection in claypans. This is considered the hardiest of the land types because there is little erosion unless the stones are removed, and some pastoralists suggest that cattle cannot survive on this country long enough to degrade it (Pam Reick *pers comm*).
- Floodplains - There are intricate systems of channels and floodplains associated with the Diamantina and Cooper River systems and during times of high rainfall either in the far north east of SA or in QLD, literally hundreds of square miles of country is flooded (Ratcliffe, 1936). Most of the water floods out over the country, and relatively little makes it to the rivers' end, Lake Eyre. The state of the country on these floodouts depends heavily on when the floods occur, and in particular on how susceptible they are to flooding ie. depending on their situation, some plains get flooded every few years, while others will only go under water during very large floods. This affects the soil types in these areas and hence the vegetation.
- Saltlakes - These are usually dry and only contain water after large rainfall events. Immediately surrounding areas usually support perennial shrublands including samphires and these 'green up' after rain.

The transition zones between these land types are very abrupt (**Plate 8.3 and 8.4**). Therefore the management of each paddock often involves consideration of multiple land types.

Vegetation

The vegetation in the Far North-East of the State strongly contrasts with the chenopod shrublands, primarily because of the prominent ephemeral component. Most trees are confined to riversides and run-on areas. Shrubs or subshrubs are common in some of the land types, but a feature of all areas is the strong contribution of annuals and ephemerals to the vegetation. Many of the grasses and shrubs may not necessarily be annuals, but without rain they die back to dry butts, and after rain they regrow and 'green up'. As a consequence, changes in land condition appear to be much more closely related to rainfall than in the NEP SCD. In chenopod shrublands, a sparse stand of vegetation is generally

Plate 8.3: Transition zone between gibber and floodplain in the Marree SCD.

Plate 8.4: Transition zone between sandhill and gibber in the Marree SCD.

assumed to have suffered from overstocking by stock and/or rabbits. However in the Marree area, a poorly vegetated area is just as likely to be a consequence of low rainfall as overgrazing by stock or rabbits. During dry times, annual and ephemeral plants die and also a large amount of the plant material on perennial species. A common perception (of pastoralists) is that much of what stock eat would die off anyway if it was not utilised, and thus often cattle are making use of a temporary food source. Therefore, unless the natural dieoff of vegetation during droughts is considered to result in 'bad condition', then in the Marree area, plant cover is not a good indicator of land condition.

Also, in the far north country, soil erosion and drift cannot be viewed in the same light as in the chenopod country as they are a part of the natural cycle of change - the land is continually changing as basins and channels are eroded, and deposits are made on dunes or floodplains (Fatchen, in print). The wind is continually shifting and re-shaping the sand dunes and while the overall change is hard to see, the land is in a continual state of flux. Land degradation, therefore, needs to be measured not as the presence of erosion, but as an increase in the rate of erosion.

The Marree Soil Conservation District is an area of contrasts. Stock useage of the vegetation has always been on an opportunistic basis because the land fluctuates so dramatically as a result of climatic influences on the vegetation. It is quite an ephemeral area and there is a lot of natural fluctuation in the vegetation. Because of this, it is said to be not very stable, but it is very resilient in that it responds to advantageous conditions with remarkable vegetation germination and growth.

Mining

Mining is a lot more prevalent in the Far North area, especially around Moomba (**Map 3**). The effect of mining operations on the surrounding areas comes from a number of sources:

- Roads - around Moomba, there is an increase in the number of built up roads for the transport of trucks and other mining vehicles (especially on Gidgealpa and Innamincka stations).
- Borrow pits (**Plate 8.5**) - roads are built up using clay dug out from areas nearby. This leave holes in ground and while these are disturbed areas (and usually eroded; *pers obs*), they usually collect water and support ephemeral vegetation after rains.

- Pumps (**Plate 8.6**) - numerous 'nodding donkeys' are scattered over Gidgealpa, Innamincka and Merty Merty stations, used for bringing up oil and gas. The areas surrounding these pumps are cleared to a limited distance.
- Waters (**Plate 8.7**) - water that is brought up with the oil is drained into nearby evaporation ponds, some of which stock (and other herbivores) can use.
- Seismic lines (**Plate 8.8**) - there are many cleared lines in the area, forming a grid pattern, along which geological testing has been done. These used to be cleared completely with a dozer, but now vegetation is flattened with a roller, and large or important trees are avoided.

All of these factors have an effect on the surrounding land condition, although mining companies are continually working to reduce the impact of their operations on the environment and rehabilitate areas after use.

Additional herbivores

The extent of grazing by herbivores other than domestic stock also needs to be taken into account in any future analysis of land condition. Besides cattle, additional herbivores which are not as prevalent in the NEP SCD area are caterpillars, galahs, corellas, horses and feral donkeys and camels (see **Plates 8.9-8.11**) - all of which contribute to the consumer impact on the vegetation. One pastoralist mentioned shooting 500 brumbies and 200 donkeys in a 100 square mile paddock in 1960 and trucked 1500 brumbies off of another water point in the following 12 months (Kevin Oldfield *pers comm*). Feral horses, donkeys and even camels are not as prevalent now, as they can be economically herded and trucked off for sale in Adelaide markets (and camels overseas).

Historical Information

Before the introduction of trucks and road trains for stock transport, drovers walked stock from Queensland to Adelaide along a stock route, which ran roughly along the Birdsville track (see **Map 3**). The country along the stock route was usually very bare (George Bell *pers comm*). When the stock route was in use, there used to be more dust storms which many believe were largely due to the effects of the tens of thousands of head of cattle that ate the vegetation and destroyed the soil surface as they travelled through. There are many stories about the old stock routes and drovers, especially about Sidney Kidman who, at one

Plate 8.5: Example of a 'borrow pit' on Innamincka Station.

Plate 8.6: SANTOS oil production well near Moomba, SA.

Plate 8.7: Evaporation ponds containing water brought up during mining of oil and gas.

Plate 8.8: Evidence of an old seismic line.

Plate 8.9: Brahman cattle on a station in the Marree SCD.

Plate 8.10: Large flocks of corellas on Moomba - Innamincka road.

Plate 8.11: Catepillar sac on a gum tree lining the Strzelecki creek, Innamincka Station.

stage or another, held most of the leases in the Marree SCD and was known as 'The Cattle King' (Bowen, 1987).

The first invasion of rabbits to the Far North East has been recorded by Harry Ding (year unknown):

> "In 1895 the imported rabbits reached the Cooper and bred in millions, and ate all the surface feed and then dug out the roots so that there was nothing to hold the sand. When the water holes dried up they died in the troughs and soaks and thousands had to be thrown out." (p.14).

Over the ensuing years the impact of the newly arrived rabbits, along with overstocking (especially along the stock route) and a string of droughts had a devastating effect on the land. By the 1930s and 40s, when the condition of the North East Pastoral SCD country was at it's worst, the Far North was in a similar state:

> "The great majority of the cattle stations in this country were in 1935 carrying no stock at all, and many have been deserted.....It is from this country that the material for the most sensational (but substantially accurate) reports of drift and "the sand menace" has been derived - reports of homesteads completely smothered, and the beds of rivers drifted up until the tops of the coolabahs on their banks are just visible above the sand. It was also to this area that a member of the State Pastoral Board referred when he stated that the Far North properties had passed beyond hope of redemption, and the urgent problem was to prevent the better rainfall areas suffering a like fate.
>
> "The present condition of the Far North cattle country is pitiable. The Cooper, and its branch the Strzelecki, have not flowed since 1918. Moreover, the courses of both rivers have been so altered by deep drifts that is seems possible that their floods will never be able to reach the lakes again. The properties dependent on the Diamantina have not been so unlucky, for floods, though of less frequent occurrence, have not failed altogether. They alone, of all the stations in the country traversed, were carrying stock in 1935 - but they are only two in number, and their cattle could be counted in hundreds." (Ratcliffe, 1936; pp.41-42).

Tales of the infamous dust storms largely originate from these times:

> "Dust storms really intensified following the long 1930s droughts. Even the Cobbler sandhills of the Strzelecki Track were reasonably negotiable previously. Then for about the next twenty years dust storms became a way of life along the Birdsville Track and district, sometimes continuing for three of four days." (Litchfield, 1983; pp.73).

These dust storms continued until the 1960s, then their frequency and intensity decreased - "Jan 1994 was bad, but nothing like the 60s. In the 60s, the place was rippling sand drift" (Kevin Oldfield *pers comm*). Photographs available from this period show many areas were more devoid of vegetation than they are now (**Plates 8.12 and 8.13**).

Several pastoralists I spoke to believe their land is looking in better condition than 30 years ago (which is when many bought their properties) and most of these people mention putting in large numbers of water points, say 14 where there were only 2 or 3 when they got there (David Brookes, Ron Hyde and Kevin Oldfield *pers comm*). These observations are supported by those of one pastoralist who has been in the area 60 years - George Bell of Dulkaninna station. He believes that the bush feed (cotton bush and saltbush) has grown a lot over the last 20-30 years. Also, a number of photographs were available from the 1960's and where they could be re-taken they either showed no change in vegetation cover, or an improvement over the last thirty years (**Plates 8.12 and 8.13**).

A detailed account of most aspects of pastoral country in the Marree SCD is included in a booklet currently being published by the Marree Soil Board (author Fatchen) titled 'More than meets the eye'.

8.4 DISCUSSION

While there are a reasonable number of historical records available for the Far North East of South Australia (eg. Litchfield, 1983), there was not enough to construct a quantitative scientific history on changes in land condition.

a)

b)

Plate 8.12: A watering point on Muloorina Station, taken in a) the 1960s and b) 1997. Courtesy Sharon Bell.

a)

b)

Plate 8.13: Dulkaninna waterhole, taken in a) 1950 and b) 1997. Courtesy Sharon Bell.

Although it was not possible to construct a land condition graph for this area, anecdotal evidence at least suggests that the trend has been similar to that for the NEP SCD. What records and histories do exist indicate that the condition of the land deteriorated (more so in dry years) until it reached its low around the 1920-40s. Once again, anecdotal evidence, photographs and personal observation have shown that it has since improved. According to pastoralists, this improvement has been especially evident since the 1974 rains which undoubtably gave the vegetation a boost - particularly with respect to the recruitment of perennial shrubs and trees.

The main conclusion to be drawn from this section is that pastoral land in South Australia cannot be thought of as "all the same". Some areas are as different from one another as they are from the coastal, agricultural regions. Consequently, stocking, land management and legislation issues need to all be adapted to each particular type of pastoral land.

CHAPTER 9

FINAL DISCUSSION

9.1 INTRODUCTION

This final chapter contains a broad summary of the work done for this thesis in an attempt to place the outcome in perspective. The methods and results are discussed in terms of the initial aims and expectations from both my point of view and those of the pastoralists who initially proposed the project. Some suggestions are made on the direction of future historical research in this area.

9.1.1 Historical research

Standard treatments of the history of pastoralism in South Australia often emphasise the degradation which occurred in the early part of the 20th century, a consequence of a number of factors which combined to deplete the vegetative cover over large areas to the point where unstable soils and drift were commonplace. These conditions stemmed from a mixture of early optimism about the carrying capacity of the land, on the part of both government and industry, inappropriate grazing systems such as shepherding, economic necessity, and in some cases, indifference to the impact of high grazing pressure on lands which were implicitly, if not officially, considered wastelands. In addition to the tendency to overstock to recover rent or investment, the pressure on the land was exacerbated by poor transport systems which delayed removal of stock at the onset of drought, and limited waters which concentrated large numbers of stock on areas inadequate to support them. The outcome prompted several Royal Commissions on the state of the pastoral industry in its early years.

Even with as little information as this, any reconstruction of the history of these areas is almost inevitably led towards the conclusion that the condition of arid pastoral lands has declined from some undisturbed state in pre-European times to a low in the years following settlement, and has since recovered to some extent. That the land has shown some improvement in the last few decades might be concluded, rightly or wrongly, simply from the decline in public outcry about the state of the northern country. While the state of rangelands in South Australia is still the subject of serious debate, the urgency that led the CSIR to send Francis Ratcliffe to assess the extent of erosion in the North East in the 1930s has abated. However, it is possible that current forms of degradation are less dramatic than the aforementioned dustorms of the 20s and 30s, and thus less easily identified by the general public.

The Plant Cover Index (PCI) derived from information compiled during this project was designed to quantify the changes in land condition identified from a variety of historical sources, and in general, the trends in PCI correspond to the sequence of events outlined above. Of course, the close correspondence between PCI and conventional assessments is not surprising, in light of the fact that the sources of information are similar, and quite likely not independent. Nevertheless, since this project was done without deliberate reference to the details of previous studies, the results are independent in that sense.

Though never used as a means of outward pressure, one of the clear expectations of the Pastoralists in the North-east, who initially proposed the idea for this project, was that the outcome would confirm their view that land condition is improving. In terms of broad-scale changes in plant cover at least, the PCI graph implies much improved land condition over the last 30 years. Since the 1960s, the PCI has remained above 3, and well above the values for the early years of the century. At face value, the results do suggest that pastoralists have some justification for their opinions, but nevertheless can only provide a general guide to land condition and trend for the following reasons.

The shape of the trend in PCI with time was discussed earlier, but it is worth stressing the point that a given value of the index does not necessarily represent the same land condition in detail. This situation arises because some of the cover classes encompass more than one combination of cover and species composition. For example, an index of say 3.5 at one time might represent the weighted sum of classes of cover including both soil drift and good perennial cover, whereas the same index at another time might represent good cover made up solely of short-lived vegetation. Land condition was defined in terms of soil stability and vegetative cover, irrespective of the species. Hence, the observed recovery of the plant cover index, in the last few decades, to levels equivalent to those in the 1880s does not necessarily imply equivalent land condition. While some areas may have improved in plant cover, that cover may be composed of unpalatable species, short-lived species, or at least have shifted from its former species composition. As discussed earlier, perennials may have the capacity to respond rapidly to favourable conditions, but in fact, the most likely explanation of the correlation between rainfall and PCI in this study is the effect of rainfall on the annual and ephemeral components of cover in the current landscape. There is little evidence of any long term trend in the rainfall data which would support the view that rainfall alone has been responsible for the difference between land condition in the early and latter parts of this century.

There is no doubt that the situation is not perfect. Some stations are managed better than others due to differences in perspective, knowledge and finance. According to Donovan (1995), for example, the Pastoral Board imposed a destocking order on a lease in the North East as recently as early 1995. For whatever reason, instances of degradation still occur. The PCI also says nothing of the indigenous wildlife covered by the 1989 Pastoral Land Management and Conservation Act, a major concern for some sections of the community.

In general, however, land management practices have improved with more stability in the industry as well as access to better transport and modern technology. Pastoral land now rarely changes hands, in direct contrast to the rapid turnover in the late 19th century, allowing the accumulation of experience and knowledge of the land. Today, stock can be bought, sold and moved much more easily. While droughts are still a time of hardship and increased land degradation, most pastoralists interviewed in this study stressed the importance of two major improvements in current management - better transport and the introduction of polypipe - which allow better use of the land. The polypipe, in particular, has provided the opportunity of developing new waterpoints, appropriately located in the paddocks, while the improvements in transport have allowed a more rapid response to drought. These two features, more than any other, have given managers more options and greater flexibility, which is vital in the unpredictable conditions of the arid zone.

9.1.2 Analysis

The biggest impediment to identifying the causes of change in land condition in a study of this kind is the enforced reliance on correlation. Any conclusion on causes would have to rely on a very strong correlation between plant cover and one or more of the most likely causal factors. In the end, the data was inadequate. It is quite likely that the improvements seen in management practices are responsible for the observed changes in plant cover since the 1950s, but there was no evidence from this analysis, except by default, to suggest that these were the main reasons. In any case, it is still true, even had one or more correlations been very strong, that such evidence does not constitute proof. The best that evidence of this kind can provide is directions for future experimental research.

9.2 FURTHER RESEARCH

In hindsight, the aims of this project would have been better served if I had concentrated only on the North East Pastoral SCD. The expectation that both areas managed by the interested parties be covered was unrealistic. Coping with the sheer size of the Marree SCD, equivalent in area to the State of Victoria, left too little time to investigate potential avenues of research which presented themselves as the work proceeded.

For example, one useful line of research might be an analysis of the amount of dust in fleeces. Figures for dust loading were apparently published until recently (Lange, 1993) According to Lange, pastoralists could pick the overstocked stations simply by reading the wool yields. In his words, it was simply a matter of which clips carried the most dust. A study of this kind might well provide supporting evidence for the results obtained here.

A more difficult, but equally useful corroboration of this work might be found in a history of subdivision and waterpoint development in the North-east. Smaller paddocks with appropriately placed water points to encourage more even grazing have been suggested as important features of well managed stations (Lange *et al.*, 1984) Again, data of this kind would potentially correlate well with historical condition. In this case, however, it is difficult to see how the benefits of cumulative waterpoint development could explain the rather large fluctuations of the Plant Cover Index in recent decades.

The introduction of polypipe has been generally thought to have had a positive effect in spreading out the grazing pressure. However, it has also increased the area of stock impact. It would be worthwhile to examine the effect of spreading out the grazing pressure to larger areas on the biodiversity and conservation of both flora and fauna.

As suggested above, such correlations can only provide some insight into the factors which affect land condition.

9.3 CONCLUSIONS

Donovan (1995) in his concluding chapter says:

> "Certainly there is subjective evidence to suggest that dust storms and sand drifts are not so prevalent in the rangelands as in earlier periods." (p.213)

The approach used here has some limitations imposed by the data, but nonetheless has provided a quantitative analysis of the historical record, which strongly supports the above statement. The classification developed in this project is robust and repeatable, and can be used with confidence provided the user is aware of its limits and the potential biases. Application of the procedures to other areas will depend on the availability and amount of reliable data, as it has done here.

Given that my task in this project was to stand back from the political and social debate about rangeland condition, some time has been spent, throughout this thesis, pointing out the limitations of the information that could be used, the methods developed and the subsequent results. In the sense that little can be said about the details of condition and trend from this approach, those limitations are substantial.

This is not to say, however, that historical research of this kind has no place in the assessment of past and present land condition, or the way people view the current state of the rangelands. In a paper describing what might be seen as the state of the art in the management of chenopod shrublands, Lange *et al.* (1984) point out that none of the key principles under discussion demonstrate that the outcome is a direct result of their management system. In the face of virtually impossible experimental conditions for conclusive evidence, they were forced to rely on correlation to support their belief in the system. This reliance is no less inescapable in historical research and future studies will no doubt resort to correlation to support any findings.

Progress in understanding the impact of past management practices is probably best achieved through a combination of historical research as described in this thesis and the suggestion above to make better use of existing data on waterpoints, dust loadings in wool clips, and any similar sources which can be identified. Data for the future seems assured if the will exists to continue the assessment procedures laid down in the current Act. The monitoring involved in such assessments would be much more valuable if pastoralists were involved in the process, as has been done in Western Australia (Holm*et al.*, 1987). Another valuable exercise would be to commence building up some sort of quantitative record of the numbers and/or effect of rabbits on a regular basis so that they can be included in future time series analyses.

There is no doubt, for whatever reason, that some improvement in land condition has occurred, but it is worth recalling that changes in land condition, like the establishment or loss of perennials, which may alter the face of the landscape for a very long time, can occur quickly in the arid zone. In one such instance on a well managed station in the north-west of the State, only a few days were required before a flock of young, inexperienced sheep, which hung in the corner of a paddock, destroyed the saltbush in a mixed stand of perennial chenopods (Lange & Coleman, in prep.). Recent views on rangeland management in the literature (Westoby *et al.*, 1989) also emphasise timing and flexibility rather than a fixed policy, a view which would presumably require much more day to day input from management than traditionally expected.

With these cautions in mind, it is perhaps fitting to end with another quote from Donovan (1995; p.213), the most recently published history relevant to rangelands in South Australia:

> "Pastoralists certainly believe that practices have improved greatly despite critics who believe that the country continues to be degraded. The answer lies somewhere in between these views".

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APPENDIX A

REFERENCE PANEL ORGANISED BY THE SA FARMER'S FEDERATION

The following people were on a reference panel set up for the purpose of discussing ideas for the research. Those who were available met with myself either in person or by phone link up approximately once every 2 months for the first 18 months of the project.

• Malcolm MITCHELL	Marree Soil Conservation Board
• Maurice FRANCIS	North East Pastoral Soil Conservation District
• Sharon OLDFIELD	SAFF member, Zone 15
• Rick PEARSE	SAFF member, Zone 16
• Andrew NICOLSON	SAFF Pastoral Task Force
• David MOYLE	Nature Conservation Society
• Peter DAY	SAFF Supervisor
• Martin ANDREW	University of Adelaide Supervisor

APPENDIX B

LETTER AND QUESTIONNAIRE SENT TO ALL PASTORALISTS IN THE NORTH EAST PASTORAL SCD

To: Pastoralists in the North East Soil Conservation District
From: Nicola Barnes
Date: April 1994
Subject: SA Farmers Federation / National Landcare Masters Project.
"Range condition in the South Australian Arid Pastoral Zone: historical trends and management practices."

Dear [lessee/manager's name]

I am writing to let you know about this project, to introduce myself and to seek your assistance in locating the information I need to assist the project.

Project origin

This project was initiated by the SA Farmers Federation after receiving support at a zone 15 meeting for a proposal to quantify how land condition had changed since early this century. Some people in the community at large believe that land condition in the arid zone is bad and getting worse - that pastoralists are continuing to degrade the land. However, most pastoralists believe that land condition was worst last century/early this century and is now improving under modern management.

What is lacking is the objective information to set the record straight.

This project aims to provide an objective assessment of changes in land condition by combining scientific and pastoral backgrounds experience to provide an unbiased account.

The SA Farmers Federation (through Peter Day) organised funding from the National Landcare Program to obtain this information, and the idea was developed into a Masters project, with supervision from Associate Professor Martin Andrew at the Roseworthy campus, University of Adelaide. I was appointed to carry out this work, from March 1994. I have a science degree with honours in botany, during which time I received a good general background on pastoral areas by studying and researching plants on Middleback Station.

Objectives of this project

This project seeks to draw on all possible sources of information (especially station records, old diaries, old photos etc, but also Government files and published literature) to document the changes in land condition since the arrival of white man.
This will involve developing a standardised method for utilising records and photographs, and to convert their information into a useable form. In this way I will be able to integrate information from a variety of sources, in a way that may be repeated in the future.

I will focus on two pastoral areas and subsequently identify the major influences on change in the land condition since early this century (or as far back as possible). The two target areas are first, the North East Pastoral and later, the Marree Soil Conservation District.

However, just documenting the changes is one thing. Discerning the causes of change is another, important component. These will include weather (droughts, floods), rabbits, and sheep and cattle grazing pressures.

Thus, there are 2 parts to the project:

1. Constructing a history of the land condition.
2. Constructing a history of influential events over the same time span.

I will be collecting as much information as possible from various sources held in Adelaide, however a major part of the project is the collection of knowledge and records from the people on and from stations.

This project runs for two years; it will finish with a written thesis and reports for SA Farmers Federation as well as the North East Pastoral and Marree Soil Boards.

The potential sources of information with which you might be able to help are:

* photos (past and present)
* rainfall records
* family diaries
* stocking rates
* history of fencing plans, water points etc
* information on droughts/floods/fires etc
* anecdotal - people's experiences
* temperature records
* station records
* wool clip records
* information about feral animals
* commissions of inquiry

I shall also be grateful for your ideas on other potential sources of information.

I am planning to visit the North East area around June - July, during which time I hope to visit everyone willing to help me with this project.

If you have any information or ideas which you think would assist this project and are willing to lend your assistance, please return the attached questionnaire.

During the visit I will be collecting information and I hope to be relocating old photo points etc. I will be bringing a portable photocopier and a camera with me to copy valuable records.

If you wish to discuss any aspect of the project, I would be very grateful if you would contact me at any of the addresses below:

During this project, I will mostly be working from my home -

42 Verdun St
Beulah Park SA 5067
ph: (08) 333 0100

I can also be contacted through the Roseworthy Campus (University of Adelaide) -

Dept of Environmental Science and Rangeland Management
Roseworthy Campus
Roseworthy SA 5371
ph: (08) 303 7897
FAX: (08) 303 7956

or via Peter Day -

SA Farmers Federation
122 Frome St
Adelaide SA 5000
ph: (08) 232 5555
FAX: (08) 232 1311

Any information is greatly appreciated. Thankyou for your time.

Nicola Barnes

"RANGE CONDITION" QUESTIONNAIRE.

To give me an idea of the types of information you may have available, would you mind filling out this questionnaire and returning it in the envelope provided, as soon as possible. Thanks.

1. Name of person(s) completing this questionnaire:

   Name of station owner and station manager (if different from above):

   Name of station(s):

   Contact Details - phone:
   FAX:

2. Do you have any photos which I could borrow or copy? (if "yes", a brief description would be helpful - eg. what are they of, are they dated, are they relocatable, how many are there etc).

3. Do you have any documentation of past events which I could look at and/or copy? (eg. management records, diaries, information of stock sales, wool clip, fencing layout, rabbit plagues etc).

4. Are there any other persons who may also have information about your station(s), that I could contact? (including past owners/managers).

5. Would you mind if I accessed the Pastoral Management Branch's files on your lease(s) and/or paddock maps? (Any information gained would be used for general statements only).

6. How may years does your knowledge of the station(s) extend for?

7. Do you know of any other forms/sources of information that may help me in my study?

8. I would like to visit you at your station(s) around June-July. Will you be available then? If so, when would be the best time, and would you mind if I camped on your property during my visit?

Please return to Nicola Barnes.

APPENDIX C

EXAMPLES OF INFORMATION COLLECTED DURING THIS PROJECT

Two basic rules were applied to information collected during this project. For inclusion in the final data set, the information had to refer to:

1. **an identifiable location at paddock scale, or finer -** Information on the condition of the 'station' as a whole was considered too coarse and unreliable, because of the potential for focus on a particularly good or bad area in the mind of the observer. At the other end of the scale, information referring to land condition in the immediate vicinity of homesteads, watering points and yards was also specifically excluded.

2. **an exact date (year) for the event or the condition of the land being described -** "In the 1920's" was not considered reliable enough. In most cases, people struggled to remember the exact year in which events took place, and hence the information was excluded.

The information was then examined further for reliability, in particular the likelihood of bias. Anecdotal information was one of the least reliable sources, and was only used when it provided specific details, (eg. Rabbit plague in a particular year). Even then, such information was double-checked with other people and, where possible, independent references, such as rainfall records or stocking rates.

Following are some examples of descriptive information from a variety of sources, along with an indication of whether or not the information was used in this project. These examples are short extracts from often longer passages, and are thus out of context, but still serve to give the reader a general idea of the variety in the information collected, as well as the 'quality' required for inclusion in the data set.

SOURCE	INFORMATION COLLECTED	USED IN DATA SET?
Lease Dockets	"Minor rabbit activity was noted"	NO
	"..lease looking in very good order.."	NO (too vague)
	"Clover flourished in creeks, several patches 2-3 feet high … bush looked fresh and had good green shoot."	YES
	"Rabbits were seen in moderate numbers. Several kangaroos and emus were sighted."	NO (too general)
	"Annual feed … is extremely good ... heavy density cover over the entire run. The perennial species are in good condition, most species at a flowering stage, no grazing pressure of perennials was sighted or envisaged."	YES (evidence of close observation)
	"… lease was denuded of perennials many years ago and is now only a grass proposition."	NO (too general)
	"… lease is extremely dry."	NO (too general)
	"… the sparse bush was fresh and herbage of all varieties covered the area."	YES
"Thirty years with men" by Harry Ding	"The fence was built while rabbits were infesting the Cooper country. When a migration of rabbits decided to head south again, they were said to have piled against the fence in millions. I did not see it, but I can remember not being able to walk near watering places in SA without stepping on starving rabbits."	NO (no date or specific location)
	referring to a station in the north east - "The area was 2,980 sqare miles … The greatest number of sheep shorn in any one year was 146,000 in 1918. The lowest annual rainfall was 95 points in 1940 and the greatest fifteen inches in 1921."	YES
"The story of the drought" by E. Whitington	"During the succeeding thirty years [post 1865], however, the bush, especially adjacent to the permanent waters, has undergone a terrible ordeal, and in some cases the country is bare for miles around."	NO (no specific location or date)
	"Crossing the railway line we met lambing ewes nearly five miles from water, and with hardly any vegetation"	YES
	"Again it was another chapter in the story of "eaten-out" country."	NO (too vague)
	"Mr. Treloar has had a battle with the rabbits. 'They ate us out in 1886 and 1887.'"	YES

*Note - station names/localities are omitted to preserve privacy.

The key words on which the decision was made are underlined. For example, the "good order" referred to in the second row of the table is not a detailed enough description, and there is no way of telling what is being referred to. On the other hand, the reference to 146,000 sheep shorn in 1918 (10^{th} row of table) is a valuable piece of information.