# Summary

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## Introduction

Droughts are inevitable in Australia's rangelands. Yet, despite the physical hardship, the social heartbreak, the animal suffering, the financial and economic consequences, and the environmental damage we know for certain will occur, we appear to be surprised by the next inevitable drought.

The work in this report has been motivated by the proposition that Australia's rangelands used for livestock grazing will be better managed for future climatic variability (and climate change) by better understanding the mistakes and successes of the past. Since 1956 Australia's rangelands have carried 8–14 million cattle and 18–40 million sheep (National Land and Water Resources Audit 2001). The benefits to Australia of improving our management of the rangelands, especially during drought, are immense – over 3.2 million km$^2$ of rangelands (more than 43% of Australia) are used for livestock grazing and much of this area has been affected by degradation to some extent.

The manifestations of land and pasture degradation, described in Chapter 1, are the loss of 'desirable' (in terms of providing feed for livestock) perennial grasses and shrubs, the resulting increase in soil erosion (both wind and water-driven), soil structural decline and infestation of woody weeds. Perennial species (usually grasses but also palatable shrubs in some areas) are the key to economic and resource sustainability. They not only provide drought forage in variable rainfall climates such as Australia's, but they also protect the soil surface, play an important role in nutrient cycling and maintaining soil 'health' (e.g. soil organic matter), and in some areas provide fuel for burning to help control woody weeds.

Excessive grazing pressure and climatic variability interact to cause the loss of 'desirable' perennial grasses and shrubs. Results of grazing trials and grazier experience have shown that the combination of heavy utilisation and drought during what should have been the normal growing season results in the loss of 'desirable' perennial plants. The loss of perennial cover leads to increased soil erosion, and reduced fuel to support pasture burning, with resultant woody weed infestation and further pressure on the grazed resource. Recovery of vegetation generally requires sequences of above-average rainfall years and low grazing pressure to allow plant populations and perennial root systems to build up.

In Chapters 1 and 2, this report describes eight major degradation episodes from across Australia's grazed rangelands (Table 1). Drought is an important component of these episodes, revealing the extent of degradation and also contributing to further degradation. The purpose of describing these episodes is to derive an understanding of what caused land and pasture degradation, and what actions and information sources are needed to prevent future episodes. Recovery sometimes occurred decades after the degradation episode, although it has not been possible to quantify the extent to which initial productivity and resource condition have been restored. In episodes where there has been considerable loss of soil and/or woody weed increase, irreversible change may well have occurred and the return to initial productivity for grazing is unlikely to occur. The report is not intended as a history, but uses the review of previous histories (e.g. Condon 2002) to help interpret the causes of degradation.

The initial review of these degradation episodes and subsequent partial recovery confirmed the obvious. Year-to-year variation in rainfall was a major factor driving both degradation and recovery. However, it is simplistic to focus on the lack of rainfall as the major cause of the degradation episodes. Some

**Table 1.** Regional degradation episodes in Australia's rangelands as described in detail in Chapter 2. The extended drought period associated with each degradation episode was calculated using regional rainfall for a standard 12-month period from 1 April to 31 March (Chapter 1). The first year of the extended drought period was the first year in which rainfall was less than 70% of the mean. The drought was considered broken when average to well above-average rainfall occurred. For Episode 5 which involved woody weed infestation in the 1950s, the impact was not revealed until the later drought period of the 1960s.

| Episode | Degradation episodes | Extended drought period |
|---|---|---|
| 1 | 1890s in western New South Wales involving soil erosion, the impact of woody weed infestation, rabbit plagues, substantial financial losses and financial hardship resulting in the Royal Commission of 1901 (Anon. 1901, Noble 1997a) | 1898/99 – 1902/03 |
| 2 | 1920s–30s in South Australia involving substantial loss of perennial vegetation and soil erosion (Ratcliffe 1936, 1937) resulting in government legislation for regulation of carrying capacity (Donovan 1995). Western New South Wales was also affected | 1925/26 – 1929/30 |
| 3 | 1930s in Gascoyne region of Western Australia involving substantial loss of perennial shrubs, soil erosion and animal losses documented in the Royal Commission of 1940 (Fyfe 1940, Wilcox and McKinnon 1972) and subsequent inquiries (Jennings *et al.* 1979) | 1935/36 – 1940/41 |
| 4 | 1940s in western New South Wales involving substantial dust storms and animal losses graphically portrayed in Russell Drysdale's paintings and Keith Newman's newspaper reports (Condon 2002) and supporting the need for government action (Beadle 1948) | 1941/42 – 1944/45 |
| 5 | 1950s in western New South Wales involving large increases in woody weeds resulting in reduced carrying capacity and income in the 1960s (Anon. 1969, Hodgkinson *et al.* 1984) | 1964/65 – 1967/68 |
| 6 | 1960s in central Australia involving wind and water erosion resulting in extensive surveys and re-assessment of carrying capacity (Condon *et al.* 1969a, 1969b, 1969c, 1969d, Purvis 1986) | 1958/59 – 1965/66 |
| 7 | 1960-70s in south-west Queensland involving soil erosion and woody weed infestation resulting in the government-sponsored South-West Strategy supporting review of recommended carrying capacities and property amalgamation (Warrego Graziers Association 1988, Johnston *et al.* 1996a, 1996b) | 1964/65 – 1967/68 |
| 8 | 1980s in north-east Queensland involving soil erosion and loss of 'desirable' perennial grasses, resulting in extensive government-sponsored surveys (De Corte *et al.* 1994) and dramatic grazier response (Landsberg *et al.* 1998) | 1984/85 – 1987/88 |

commentators, even today, view it as the sole cause. However, drought on its own does not cause degradation of the scale described here. Drought has been a feature of Australian landscapes for tens or hundreds of thousands of years. The rangeland ecosystems of Australia have adapted to drought and have probably weathered droughts far worse than have been encountered since European settlement (e.g. Hendy *et al.* 2003).

The main feature of degradation in the documented episodes was the carrying of too many animals, for too long, on areas especially under stress from drought. This highlights that the major management issue in natural grazing systems is managing stock numbers. The challenge is to optimise economic performance, yet at the same time matching stock numbers to available feed (e.g. Bartle 2003a, 2003b) and reducing resource degradation risk. This must be done within a highly variable and unpredictable environment in terms of rainfall and prices. Furthermore, the 'animals' can include domestic livestock, native herbivores (such as kangaroos), and feral herbivores (such as rabbits and goats). A problem that graziers have in managing grazing pressure is that they only really have good control over domestic livestock.

This report considers factors that led to the excessive grazing pressures which resulted in degradation. For each of the eight degradation episodes, various factors are considered. They include the rise in livestock numbers and also rabbit and kangaroo grazing pressure. This was due to several factors including years of high rainfall prior to the droughts, government policy at the time to ensure the land was fully stocked, over-expectation of the carrying capacity of the land, and a physical and/or economic inability to destock the land quickly when feed ran out.

The socioeconomic and biophysical contexts within which degradation occurred are also reviewed. Global economic and political forces had major impacts on prices, which were a significant factor in managing stock numbers. Over time, animal husbandry and disease management have improved and livestock were selected for better adaptation to the environment. Improvements in technology have had contrasting impacts. For example, under drought conditions stock can be kept on the land for longer, whilst improved roads and better transport services have made it easier to destock animals when grazing pressures become too high.

Individual property managers make the day-to-day decisions about how many of their animals should run on a piece of land and to a lesser extent what effort can be expended on feral and native herbivore control. No amount of government policy, and no amount of improvements in seasonal climate forecasting, will be of use without individual managers appropriately responding to the conditions. However, managing grazing enterprises is complex. For example, Chapter 4 analyses the history of two western Queensland properties and highlights the difficulties in making correct management decisions when faced with a range of uncertainties in climate and finances. Chapter 4 also provides a property perspective in which we can better understand the regional scale histories found in the review of the eight degradation episodes.

As will be described later, a number of commonalities emerge from the histories we present. The fact that there are common issues arising from these episodes, spaced over nearly a hundred years and across Australia's rangelands, strongly suggests that there are indeed lessons still to be learnt.

## The eight degradation episodes

The eight degradation episodes include examples from all the rangeland States and the Northern Territory (Table 1). They are not the only degradation episodes to have occurred since settlement, but were chosen because they were well documented in a range of sources including Royal Commissions, personal accounts, newspaper records and government reports.

These sources provided us with the context for the social, political, animal welfare, economic and environmental issues from the time, as well as with data on changes in stock numbers and commodity prices, and assessments of the extent of degradation. We then combined this information with time series of climatic forcings, rainfall and simulations of historical pasture growth using present-day methods to build up a composite picture of each degradation episode and the factors that led to it.

'Drought' was the major issue for people at the time of the episodes, and hence it was the starting point of our analysis. However, in most cases the sequence of dry years, ranging from two to eight years, exposed and/or amplified the degradation processes that were already in train. The evidence for degradation is unequivocal. The accounts from the time are graphic in their descriptions of the physical 'horror' of bare landscapes, erosion scalds, gullies and dust storms. Subsequent observations documented the environmental and economic damage caused by woody weeds, loss of palatable perennial species and soil loss, and highlighted the animal suffering through deaths or forced sales. For example, Webster (1973 p.150) reported that more than 100 million sheep died in 'the eight severe droughts that have affected the Australian pastoral industry since 1880'. Importantly from the human perspective, several accounts have described the financial and emotional plight of graziers and their families during drought, leading to abandonment of properties or, sadly, deaths (e.g. Ker Conway 1989, McDonald 1991). Studies during the recent 1990s drought in Queensland and New South Wales confirm the hardship that drought causes (Stehlik *et al*. 1999).

## Climate forcings

Imagine the benefits to Australia if these episodes could have been prevented or at least minimised through forewarning. Seasonal forecasting based on a sound understanding of the climatic drivers of rainfall in the rangelands provides opportunities for alerting us to potential future degradation episodes.

This report examines current knowledge of a number of phenomena that affect climate variability in Australia's rangelands. These influences are complex and current climatological research has shown that there are significant climatic signals at timescales from about biennial to decadal and multi-decadal (White *et al*. 2003). The best known of these is the El Niño – Southern Oscillation (ENSO) phenomenon (Pittock 1978, Partridge 1991, Allan *et al*. 1996b). ENSO has a well-described dominant effect on year-to-year variability in Australia's rangelands (Lindesay 2003).

El Niño years, when the eastern Pacific is anomalously warm, are generally associated with an increased chance of below-average rainfall, especially in Queensland and New South Wales, and to some extent through central Australia and the Western Australian rangelands as well. In contrast, La Niña years, when the eastern Pacific is anomalously cold, provide an increased chance of above-average rainfall in the same areas. The Southern Oscillation Index (SOI) is a widely available and simple measure for summarising ENSO patterns. Winter/spring SOI values below 'minus five' reflect El Niño years and values greater than 'plus five' reflect La Niña years (e.g. Clewett *et al*. 1991, Allan *et al*. 1996a).

When we started assembling the history of the various degradation episodes in 1996, our purpose was to understand the major climate drivers that had led to the extreme wet and drought sequences, with particular attention to ENSO. At that time, the first research on the effects on Australian rainfall of inter-decadal signals in the Pacific Ocean was being done (Power *et al.* 1999). We have built on the analysis of Power *et al*. (1999) to place the historical degradation episodes in the context of what has happened in the Pacific Ocean on decadal timescales. Measures of the inter-decadal oscillation have been developed by the UK Meteorological Office (Inter-decadal Pacific Oscillation, IPO) and the University of Washington (Pacific Decadal Oscillation, PDO). Both ENSO and the IPO/PDO were shown to be associated with the large year-to-year variation in rainfall and pasture growth across much of Australia's rangelands.

The interaction of ENSO and the IPO/PDO adds to the complexity of understanding rainfall variability. A major finding was that, in eastern Australia, the impact of La Niña years has been greatly enhanced when the inter-decadal component of the Pacific Ocean variability was in a mode characterised by a very large wedge-shaped body of cold water dominating not only the equatorial region of the eastern Pacific, but also extending into the extra-tropical regions of the northern and southern hemispheres (IPO cool). However, the interaction of inter-decadal indices and El Niño varied considerably with location across the rangelands (Chapter 1).

Indices of the IPO/PDO were *warm* for most of the period from 1925 to 1946 and *cool* for most of the period from 1947 to 1976, and hence provide supporting evidence for the shift in climate regimes that has been identified as a contributor to the recovery of vegetation, for example, in western New South Wales and South Australia. In eastern Australia and to a lesser extent other regions, the major periods of potential pasture recovery have been associated with the *cool* phase of the IPO/PDO when sequences of above-average rainfall years have occurred (mid 1950s, early 1970s, and perhaps late 1990s). Most of the degradation episodes occurred when the IPO/PDO indices were *warm* or neutral when the chance of 'drought-breaking' (above-median) rainfall was not as high as the *cool* phase.

The various Pacific Ocean indices such as ENSO and IPO/PDO account for only 20–40% (Crimp and Day 2003) of the year-to-year variability in rainfall in the regions of major influence (e.g. in Queensland). A small proportion (23%) of years in the extended drought periods in eastern Australia (Table 1, Chapter 1.2.3) were associated with El Niño. Thus the impact of sequences of non-El Niño drought or dry years in the historical degradation episodes has been more devastating than isolated El Niño droughts and hence the lack of predictive capability remains a serious limitation to our capacity for useful climate risk assessments. It is plausible, however, that at least some of these droughts were due to the inherently chaotic nature of the atmosphere, and events of this kind may be essentially unpredictable. There is clearly a need to research other causes of rainfall deficit. Nevertheless, whilst there is still some way to go to provide adequate climate risk assessment, we believe that the understanding of Pacific Ocean effects on rainfall is useful for climate risk management, especially interpretation of why sequences of wet or dry years occur.

While there has clearly been a statistical association between rangeland rainfall variability and the IPO/PDO, and an association between IPO/PDO and the impact that ENSO has had on Australia, the dynamics of the IPO/PDO are not yet fully understood. It is not clear if these associations are causally related, nor is it clear if the IPO/PDO is predictable or persistent on decadal timescales. Frustratingly for rangeland managers and scientists alike, the various components of the climate system operating at different timescales are yet to be unravelled. At the time of writing (2003) we cannot even be certain what stage the late 1990s/early 2000s are in terms of inter-decadal variability (e.g. Mantua and Hare 2002). What is clear, however, is that the impact that ENSO has had on Australia has waxed and waned from decade to decade and from generation to generation. This variability can manifest itself in many forms, e.g. in a reduced number of La Niñas and/or El Niños occurring in a given decade. Given the anthropogenic changes occurring in the climate system there is uncertainty as to the direction and magnitude of future inter-decadal variability of this kind (e.g. Walsh *et al.* 1999, Cai and Whetton 2000). It is hoped that current research into the IPO/PDO will ultimately underpin improved seasonal to inter-annual climate forecasts, and answer the questions of how well we will be able to foretell that a particular decade will exhibit an increased frequency of El Niños or La Niñas or that a particular decade may be more climatically primed to be at greater risk of a degradation episode.

The understanding of these climatic forcings has provided the opportunity to develop climate forecast systems. For example, forecast systems based on the SOI or sea surface temperatures (SSTs) (McBride and Nicholls 1983, Stone *et al.* 1996, Drosdowsky and Chambers 1998, Drosdowsky 2002) now allow climate risk assessment based on historical rainfall data. The National Climate Centre of the Bureau of Meteorology (BoM) provides three-monthly forecasts based on SSTs (http://www.bom.gov.au/). The Queensland Centre for Climate Applications (QCCA) also provides historical probability analyses based on SOI phases (Stone *et al.* 1996) (http://www.LongPaddock.qld.gov.au/). However, the use of information relating to possible decadal and inter-decadal signals for forecasting is still in the experimental stage (e.g. White *et al.* 2003). Similarly Global Climate Models representing many of the physical processes in the climate system have only been operational since 1998 (Goddard *et al.* 2003, http://iri.columbia.edu/climate/forecast/net_asmt/) and hence are still establishing a 'track record'.

If the 'character' of climate variability of the last hundred years is unchanged in the future then, in the working life of a property manager, for example 40 years, an average 10 El Niño years and nine La Niña years are likely to be experienced, as well as extended periods of inter-decadal variability (15 – 20 years). The success of the property enterprise in terms of finances, satisfaction and resource condition will depend on how well climate variability on these different timescales has been managed for. However, not every 'El Niño' has resulted in a drought year nor has every drought been due to 'El Niño'. Thus a major problem for communication is that the current (2003) public emphasis on El Niño will obscure the importance of managing for non-El Niño related drought years.

Since the 1980s, seasonal rainfall forecasting has concentrated on ENSO-related indices (SOI or SST anomalies). However, the analysis and extended drought periods reported in Chapter 1 indicate the importance of the 'neutral SOI' years in contributing to the regional extended drought periods. Forecasting of rainfall anomalies in this 'year-type' provides a major challenge for further research into better forecasts.

The future behaviour of the climate system is complicated by the possible presence of changes due to anthropogenic influences (e.g. increasing greenhouse gasses, ozone depletion, aerosol emissions, land use change) together with naturally occurring inter-decadal variability. Frustratingly, the implications of global warming for rainfall variability remain largely uncertain, and hence analysis of anthropogenic and naturally-occurring influences on rangeland rainfall and pasture growth is an important area of current and future research.

## Price variability and other factors influencing the degradation episodes

Variability in rainfall and pasture growth were major factors in each of the degradation episodes presented. However, variability in prices paid for wool and meat also contributed to the degradation outcomes by affecting not only the build-up in numbers, but also the timing and extent of destocking when seasons became dry. For example, wool prices declined by 30% from 1890 to 1894 during a favourable climatic period in eastern Australia. Wool prices increased at the onset of the drought (1897 to 1900) and then halved again in 1901 at the peak of the drought in western New South Wales and south-west Queensland. Sustained price recovery did not occur until after 1904. Similarly wool prices fluctuated in the 1920s, increasing rapidly from 1922 to 1924, then falling by 25% in 1925, and further declining during the years of the Great Depression (early 1930s) with extended drought periods in western New South Wales and South Australia. Similarly, beef prices dropped sharply by 80% in the mid 1970s. Such rapid declines in the prices received by property managers 'encouraged' them to retain stock in the hope that prices would improve. When these periods of relatively low prices coincided with drought conditions such as in the late 1890s in western New South Wales (Episode 1), 1926 to 1930 in eastern Australia (Episode 2) and the mid 1930s in Western Australia (Episode 3), the conditions were set for grazing pressures to be greatly increased and degradation to be exacerbated.

The description of the degradation episodes also highlights the effect of government policy on degradation. In South Australia and Western Australia, governments demanded certain levels of minimum stocking or infrastructure development to discourage squatters or speculators (Donovan 1995, Tynan 2000, Watson, 2002). The wish to provide land for soldier settlers after both World Wars led to the subdivision of large properties into smaller blocks, many of which proved to be too small to provide viable incomes once commodity prices declined, and were consequently overstocked (Drysdale 1995). However, in some regions such as south-western Queensland, surveys have indicated that degradation can be severe across all properties regardless of size (Mills *et al.* 1989).

## The importance of management

Managers make the day-to-day decisions that either prevent or accelerate degradation (Wilcox 1988) and promote or inhibit recovery. Learning from the experiences of individual pastoral managers is therefore critical. Those graziers whose experiences have been recorded (e.g. Chapter 4; Anon. 1951, Lilley 1973, Purvis 1986, Lange *et al.* 1984, Landsberg *et al.* 1998, Lauder 2000a, 2000b, Stehlik 2003, Wahlquist 2003) emphasise the adoption of conservative stocking rates and/or highly responsive stock management as strategies to prevent degradation and promote pasture recovery when the opportunity arises. However, the historical degradation episodes show that some graziers have felt compelled, presumably by property size and economics, to push the pasture resource to (or even past) its limit. Nevertheless, it is hard to imagine that any manager, if forewarned of a potential degradation event, would take the risk of animal losses, financial cost, and environmental damage by not reducing stock numbers early.

Degradation alerts will therefore be critical in the future to give managers time to make decisions that will minimise the impact of grazing. Alert systems, based on seasonal forecasting, coupled with stock number data and simulated pasture production, are under development in the Australian Grassland and Rangeland Assessment by Spatial Simulation (AussieGRASS) project (Carter *et al.* 2000; http://www.LongPaddock.qld.gov.au/). Simulations of pasture biomass and growth enable an alert to be triggered under conditions likely to result in loss of soil cover, i.e. when high grazing pressure is likely to occur during times of low pasture growth. The objective is to accurately assess animal numbers so as to quantify grazing pressure in real time and to use seasonal climate forecasting systems to calculate probabilities of future pasture growth.

The compilation of long-term records can provide a basis for analysing the impacts of climate variability on grazing enterprises. It also provides a context for examining which grazing management options were successful in the face of variability and which, in hindsight, were mistakes. An example of this approach is found in Chapter 4 for two sheep stations in Queensland that have been successfully managed over very long periods. These two examples demonstrate that, at the property level, lessons were indeed learnt from experience. Managers improved their ability to contend with highly variable climatic and price environments.

## Commonalities to emerge: an opportunity to learn

No two droughts and no two degradation episodes are the same, but some commonalities emerge from the eight episodes. It is this repetition of factors, common to events in different places and at different times, that suggests we may reduce future impacts.

1. There was a general over-expectation of safe carrying capacity by managers, investors and governments.
2. Stock numbers and other herbivores (e.g. rabbits, kangaroos and goats), and in some cases woody weed seedlings, increased in response to a period of mainly above-average rainfall that preceded the drought/degradation episode.
3. These above-average years coincided in eastern Australia with the cool phase of the IPO/PDO (early 1890s, 1916–18, early 1920s, mid 1950s, early 1970s, and perhaps late 1990s).
4. Intermittent dry seasons or years resulted in heavy utilisation, damage to the 'desirable' perennial species, and ultimately the grazing land resource. This led to the rapid collapse in the capability of the land to carry animals at the onset of drought.
5. Extreme utilisation in the first years of drought by retaining stock caused the further loss of perennial species, exacerbating the effects of drought in subsequent years.
6. Rapid decline in, or generally low, commodity prices resulted in some managers retaining stock in the hope of better prices or the fear of high cost of restocking.
7. Continued retention of stock through a long drought period compounded damage to the resource and delayed recovery.
8. The sequence of drought years resulted in rapid decline in surface cover, which revealed the extent of previous resource damage and further accelerated degradation processes.
9. In eastern Australia, drought sequences have occurred more often when the IPO/PDO 'indices' were in the *warm* phase.

10. Government surveys, inquiries and Royal Commissions were held during or following drought sequences and documented the economic and environmental damage.
11. Partial recovery occurred during sequences of above-average years sometimes decades after the major degradation episode.

### More work to do

The major issue raised by the historical degradation episodes is to what extent they could have been avoided or at least mitigated by better pasture or grazing management. During the severe drought periods of the degradation episodes it was debated whether the apparent soil erosion and loss of 'desirable' perennial shrubs and grasses were the result of the extremes of climatic variability or caused by too many animals. One approach to the debate is to build computer models that represent the impact of climate variability and stocking rate decisions on the pasture resource. In Chapter 3, we present modelling studies for 'desirable' shrub populations in the North East District of South Australia and the Gascoyne region of Western Australia. The simulations highlighted the deleterious impact of high stock numbers and intermittent drought periods on the loss of palatable shrubs. The decline in shrub density was less severe when conservative stocking or responsive tactical stocking decisions reduced grazing pressure on shrubs in critical years. The simulation studies support the view that, for Episodes 2 (South Australia) and 3 (Gascoyne, Western Australia), the severe drought periods revealed and also amplified previous reduction in shrub density. Thus, the simulations suggest that much of the degradation could have already occurred by the time of the episodes described in this report. They also suggest that, with the benefit of hindsight, much of the loss of shrubs and resulting soil loss was avoidable. Chapter 3 also describes the remarkable increase in shrub density in the Gascoyne during the late 1990s in association with well above-average rainfall. The future management of this valuable vegetation resource will demonstrate whether or not managers have learned from history.

Of course, science on its own will have minimal effect in contending with the next inevitable degradation episode. Governments, government agencies and the community need to be prepared for drought. Individual land managers need to be prepared and supported to make the decisions that will ameliorate the impact of the factors leading to degradation. In simple terms, this means the removal of an appropriate number of animals (domestic, feral and native) from the rangeland resource at critical times whilst not jeopardising financial viability (e.g. Stafford Smith and Foran 1992).

This report is, of course, incomplete. It considers eight degradation episodes, but Australia's pastoral rangelands have suffered through more episodes than these. The rangelands have also experienced widespread degradation outside these episodes. Background processes leading to degradation can occur continually and hence 'eternal vigilance' in terms of grazing management is required.

Work remains to fully document the histories of individual properties, to tease out the mistakes and successes of individual pastoral managers and families. The degradation episodes themselves are not yet fully documented. As the work continues we hope that further historical accounts from these times will emerge, adding to our understanding.

## Current and future challenges

Better natural resource management decisions are made when managers: (1) understand a problem; (2) have the motivation to adopt a changed practice; and (3) have the capacity to implement it (Gordon *et al.* 2001). While these three principles were developed to represent the decision making of individual land managers, we believe the same principles apply equally well to land administrators and policy makers.

The documentation of the causes of the degradation episodes and consequent human and animal hardship should provide sufficient motivation to want to do things better in the future. We have also discussed the capacity to change, specifically, the use of more accurate and timely forecasts, and more responsive grazing management decisions.

We believe there are three components to preventing degradation of the grazing resource:

1. better resource management, particularly grazing and fire management, by individual managers to help prevent degradation (Campbell and Hacker 2000);
2. government policies and administration which value the responsibility of managers to make day-to-day decisions on their properties as well as providing them with the tools to help improve those decisions (Stafford Smith 2003); and
3. alert systems, at both local and regional scales, that use improved climatic understanding and resource monitoring to provide warnings of the potential for degradation episodes (Carter *et al.* 2000).

Only with these three things in place is preventative action possible and likely to occur.

It would seem debatable what 'better grazing and fire management' actually is, especially where the climate has such high year-to-year and decade-to-decade variability, and has uncertain future climate trends. Nevertheless, graziers, their advisers, scientists and governments have all expressed views over the last hundred years on how to best manage the grazed resource (e.g. Donovan 1995, Hacker and Hodgkinson 1995, Johnston *et al*. 2000, Lauder, 2000a, 2000b, Bartle 2003a, 2003b). These views include risk averse strategies (e.g. Purvis 1986, Landsberg *et al*. 1998), preventative and early action prior to and at the onset of drought (Childs 1973a), responsive stock adjustment during drought (Johnston *et al*. 2000, Bartle 2003b), tactical rest to aid recovery (Lauder 2000b), and monitoring for compliance with legislation (Donovan 1995, National Land and Water Resources Audit 2001) and/or commercial advantage. The above list (which is by no means exhaustive) represents an impressive knowledge base gained from hard-won experience and scientific testing. We would be foolish not to use it and continue to build on it to manage for future climate variability.

The need may be more urgent than we think. A series of not unexpected good seasons in Queensland (1999-2001, positive SOI and mainly *cool* PDO) supported an increase in beef cattle numbers (11.3 million in 2001 from 8.5 million in 1988) to levels last seen in 1978 (11.0 million). Although sheep numbers (9.7 million) were relatively low, kangaroo numbers were estimated (Anon. 2003, Kelly 2003) to be very high compared to historical estimates since the 1970s ( 24 million, A. Pople pers. comm.). The retention of high stock numbers in some regions through the dry years of the late 1970s and 1980s contributed to the pasture deterioration and degradation described in Chapter 2 as the 8th Degradation Episode. Will the early 2000s also be documented as a degradation episode?

We are currently presenting the findings from this report '*Learning from History*' to graziers, grazier organisations and government agencies. The presentations continue to outline the potential risk for another degradation episode as the inevitable dry period which began in 2001 was exacerbated by the 2002 El Niño.

Is the 9th degradation episode being prevented? It is too early to tell.