Pasture production and condition

Photo: Grant Stone

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Key findings

- Grazing is the main land use in more than 80% of Queensland and the state's grazing lands are a major natural resource. The livestock carrying capacity and condition of the pasture resource are affected greatly by year-to-year climate variability and, in particular, rainfall.
- Since 2001–02, much of Queensland has experienced continuing drought. The severity of the rainfall deficit over the six years from 2001–02 to 2006–07 has been generally amplified by high temperatures and evaporative demand. Derived indices of drought (moisture index, simulated pasture growth) suggest that the current drought is comparable in severity to the drought episodes of the 1990s and the Federation Drought (from approximately 1896 to 1903).
- The effects of severe rainfall deficit have led to reduced pasture and resource condition in several regions. Utilisation of pasture growth is considered high in areas where total grazing pressure (from domestic, native and feral grazing animals) is in excess of the capacity to support those animals in the long term and permit pasture to return to reasonable condition once the season breaks.
- While the grazing industry has reduced somewhat the impact of drought through advances in technology, the apparent retention of livestock numbers through the current drought has increased the risk of land and pasture degradation.

Indicators and summary of status

Indicator	Status of indicator
Pasture growth	Pasture growth averaged across the state for the period 1 April 2001–31 March 2007 was 29% below the long-term mean. [●]
Landscape function	Significant loss of landscape function has occurred in southern, south-eastern, far western, north-western and north-eastern Queensland. [●]
Weed invasion	Weeds of National Significance are increasing in abundance. [●]
Grass basal cover	Eastern Queensland grass basal cover is trending downwards. [●]
Grazing pressure	Grazing pressure was high: [●] • cattle number estimates were maintained (10.4–11 million head on pasture) from 2002 to 2007; • sheep numbers increased from 4.4 million in 2002–03 to 4.7 million in 2005–06; • macropod numbers still pose a significant addition to grazing pressure in selected areas, although numbers are reduced from those in the peak drought period (2002–03).

Land

Importance

Spatially, grazing represents the major land use in Queensland. Pasture production is strongly affected by climate and responds to temporal variability (year to year and decade to decade) in rainfall, temperature, humidity, sunlight and evaporative demand. Other important agricultural land uses (such as cropping and horticulture), as well as biodiversity and community wellbeing, are also strongly affected by variability in these climatic elements. In this discussion the focus is on the effects of climate variability on pasture production and condition.

Over the past six years, the state's extensive grazing lands have supported more than ten million cattle, five to seven million sheep and in some years at least twenty million native herbivores (macropods). Gross agricultural value from the meat and wool industries was forecast to be $3.7 billion for 2006–07 (DPIF 2007), representing about 35% of total gross value from agriculture. Climate variability and climate trends therefore have important implications for the economic value of the agricultural sector.

Rainfall variability in Queensland is strongly affected by the El Niño Southern Oscillation (ENSO) phenomenon and is measured and quantified by the Southern Oscillation Index (SOI). The current drought (2001–02 to 2006–07) is, in part, the result of the occurrence of three El Niño events (defined here as SOI ≤ -5.5 averaged for June to November) during 2002, 2004 and 2006. The lack of above-average rainfall (percentile 70–100) in the intervening years has resulted in an extensive six-year drought period comparable to historical drought episodes recorded in Queensland over the past 100 years.

Drought, or rainfall deficiency, can be defined as a protracted, abnormally dry period, when the water supply is inadequate for the needs of the user (Daly 1994; BoM 2007). Drought affects nature, industry, individuals and communities in different ways (conceptually, spatially and temporally) and therefore explicit definitions are available from the perspective of meteorologists, agriculturalists, hydrologists and sociologists (Daly 1994; BoM 2007). This report will describe pasture status in terms relative to the fields of agriculture and meteorology.

Pressure and condition

First, it is necessary to describe the year-by-year sequence of the current drought in terms of rainfall and modelled pasture growth. The calculation of historical pasture growth requires inputs of daily climate data of rainfall, maximum and minimum temperature, humidity, solar radiation and potential evaporation. The climate variable vapour pressure deficit (VPD), a measure of atmospheric humidity deficit, is important for evaporation and plant water use efficiency and was calculated from temperature and humidity.

The spatial pasture growth model AussieGRASS (Carter et al. 2000) uses a soil:water balance calculation that includes components such as runoff, drainage, soil evaporation, and tree and pasture transpiration. The model uses daily climate variables, and thereby accounts for the effects of within-seasonal rainfall variability. Seasonal rainfall totals alone account for only 40% of the measured variation in pasture growth in each growing season, whereas the soil:water pasture growth model (Day et al. 1997) accounts for more than 60–70% of the variation. The pasture growth model also includes a calculation of grass basal cover and hence carries a memory of the previous year's pasture growth into the calculation of current year's growth, which, for example, enables the model to simulate delayed recovery of growth from drought. Pasture values calculated from the model are expressed as standard units, which are kilograms of dry matter per hectare (kg DM/ha).

Since the previous reporting period (EPA 2003), historical climate data for the period prior to 1957 have been reconstructed for CLIMARC, a project for computerising the Australian Climate Archives, ‹www.bom.gov.au/climate/how/climarc.shtml›. Such data include the reconstruction of Class A pan evaporation (the estimate of potential evaporation) based on vapour pressure deficit and solar radiation (Rayner 2005). Further historical reconstructions will include the important effect of wind on potential evaporation (Rayner 2007).

Year-by-year drought sequence

The following description provides a year-by-year review of rainfall and pasture growth (see Figures 4.9, 4.10 and 4.19). The 12-month period from 1 April to 31 March is chosen to take in the main summer pasture growing season. This period aligns with El Niño/La Niña conditions (that is, ENSO, the major driver of climatic variability). In 2000–01, most of Queensland had well above-average rainfall and pasture growth. South-western Queensland experienced a series of relatively good years in the late 1990s, leading to a build-up of macropod numbers. The south-east corner of the state, however, had low rainfall and reduced pasture growth. The current drought sequence began in 2001–02 with extremely low rainfall along coastal Queensland and in areas of south-western Queensland.

In 2002–03, the drought extended across most of the state, with the exceptions of central Queensland and some parts of far western Queensland. In terms of pasture growth, the below-average rainfall in central Queensland was exacerbated by the previous year's low rainfall, while in the north-west, where there had previously been average rainfall conditions, below-average rainfall had less impact on simulated pasture growth.

In 2003–04, the majority of Queensland received average rainfall, but areas in the south-west and north-east (Burdekin catchment) received below-average falls. Areas of well below-average pasture growth were restricted to south-western Queensland, central Queensland and Cape York Peninsula.

In 2004–05, over 70% of Queensland had below-average rainfall, with only a small band of average conditions running through inland Queensland from the Gulf of Carpentaria to the New South Wales border. This pattern was reflected in pasture growth in many regions, with an amplified effect resulting from the rainfall deficit: for example, well below-average and extremely poor conditions occurred in south-western, central and north-eastern Queensland.

In 2005–06, much of the state experienced average rainfall conditions, but south-western and coastal north-eastern Queensland saw well below-average conditions. Very little pasture growth occurred in south-western, central and north-eastern Queensland and Cape York Peninsula, although large regions in the north-west and south-east had average pasture growth.

In 2006–07, above-average conditions occurred in northern and western Queensland, in part because of high rainfall associated with tropical cyclone Monica (19–21 April 2006). In contrast, rainfall in south-eastern Queensland was extremely low and very little pasture growth was simulated in southern and south-eastern Queensland. The pasture growth simulations for 2006–07 include the carry-over effect of soil moisture from tropical cyclone Larry in March 2006.

In summary, southern, south-western and north-eastern Queensland have had repeated years of rainfall deficit, which is reflected in the sustained poor pasture growth shown in Figure 4.9. The effects on the pasture resource of poor growth and extended use are discussed below.

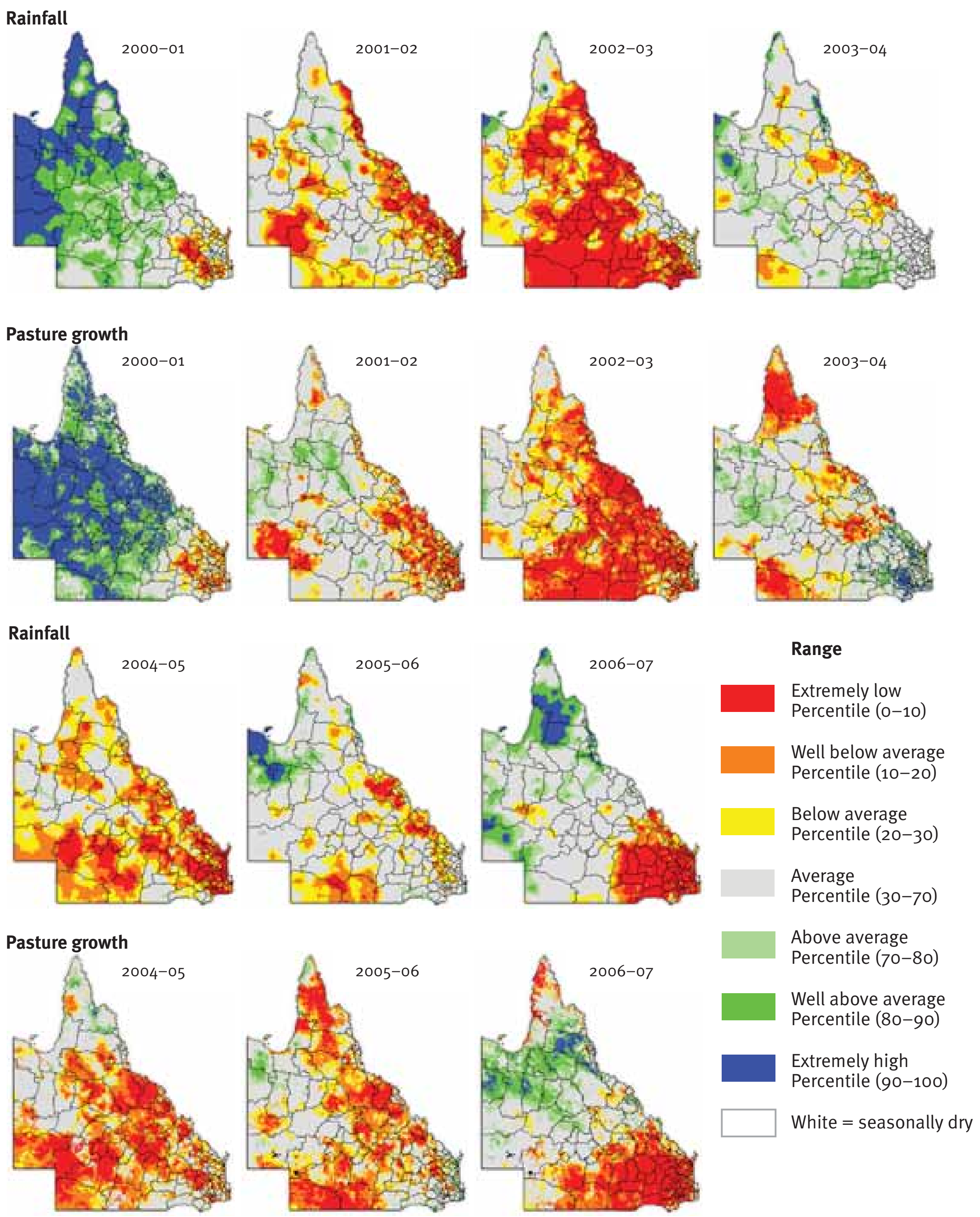

FIGURE 4.9 Annual (1 April to 31 March) rainfall and corresponding pasture growth percentiles for Queensland (2000–01 to 2006–07)
Source: DNRW

Trends in climate variables

Pasture growth results from soil moisture provided by rainfall along with other climate variables affecting plant water availability and water use efficiency. Thus, while rainfall deficit is the major cause of drought, other climatic elements (such as high maximum temperature, vapour pressure deficit and potential evaporative demand) can amplify the effects of lack of rainfall. In the following analyses, climate variables have been averaged across the state's main grazing/dryland cropping zones. Queensland's main dryland cropping and pastoral zone (south of 19° latitude and east of a line approximately from Cloncurry to Hungerford) represents approximately 60% (100 million hectares) of the state, but carries 80% of the state's livestock.

The historical records of climate variables (temperature, humidity and solar radiation) since 1957 (the commencement of data computerisation), along with pre-1957 weather station data (dating back to 1890) of lower density (and lower quality) represent these measurements. The Bureau of Meteorology also has a reference set of temperature data that has been corrected for changes in landscape position of weather stations (Torok and Nicholls 1996). The datasets used for this analysis are highly correlated with the Bureau of Meteorology reference set (McKeon et al. 1998; Rayner et al. 2004). Reconstruction of Class A pan evaporation from solar radiation (that is, cloud cover) and vapour pressure deficit, or 'synthetic' pan evaporation (Rayner 2005), was used to indicate trends in potential evaporation rather than using measured Class A pan evaporation. Rayner (2007) found that trends in measured Class A pan evaporation across Australia were correlated with local changes in wind run (daily average of wind speed), and these are likely to represent changes in instrumentation and/or exposure of the instruments (Nicholls 2006). Thus, the use of 'synthetic' pan evaporation in our analyses integrates trends in cloud cover, temperature and humidity in terms of potential evaporative demand.

Synthetic pan evaporation is regarded, however, as 'provisional' since corrections for changes in landscape position and instrument/measurement are yet to be developed. We present records and reconstructed variables prior to 1957, although it should be emphasised that only provisional comparisons can be made here. Corrections that would allow current conditions to be directly compared with historical conditions are yet to be developed. Thus, interim data are presented here with caveats stated, based on the view that the provisional data are of such importance that it would be an omission not to warn of the implications of this information.

It is also significant that Rayner et al. (2004) evaluated CLIMARC temperatures compared to the Bureau of Meteorology reference set (Torok and Nicholls 1996). The likely corrections to account for changes over time (that is, more than 100 years) suggest that corrected temperatures early in the 20th century were likely to be slightly lower (<0.5°C) than those presented here (Figures 4.11, 4.12 and 4.13).

Analysis of current drought in terms of climate variables

The current drought involves six years in which rainfall (averaged across Queensland grazing lands) has been below average and includes five individual years where it was more than 15% below average (Figure 4.10). In terms of rainfall for individual years, the worst year in the current drought sequence was 2002–03, when rainfall in the grazing lands was 39% below average. This year was not as extreme as the years 1982–83, 1951–52, several years in the period 1910 to 1930, or two 'back-to-back' extreme years in the Federation Drought, 1900–01 and 1901–02. However, as shown by the six-year running mean in Figure 4.10, the average rainfall for the full six-year period 2001–02 to 2006–07 is the lowest since the Federation Drought, which spanned seven years from 1896–97 to 1902–03. Given there has been a change in the number and location of rainfall reporting stations over the past 100 years (along with a range of options available in spatially interpolating rainfall for use in modelling), the current drought is regarded as being comparable in severity to the Federation Drought.

As stated in 'Climate and greenhouse' in Chapter 3, Atmosphere, Queensland minimum temperatures averaged for the 12 months from 1 April to 31 March increased during the 20th century. The highest annual minimum temperatures since 1957, the start of high-quality records, were recorded in 2005–06 (Figure 4.11). Annual maximum temperatures have also been high during the drought period: 2002–03 and 2005–06 had the highest maximum temperatures (Figure 4.12). The highest mean temperatures were recorded in 2003–04 and 2005–06 (Figure 4.13). Humidity content (expressed as vapour pressure) was exceptionally low in 2002–03, equivalent to the previous lowest 'dry' year in the 1982–83 drought (Figure 4.14). These temperature and humidity extremes were reflected in vapour pressure deficit, 2002–03 having the highest deficit, amplifying the effect of low rainfall (Figure 4.15).

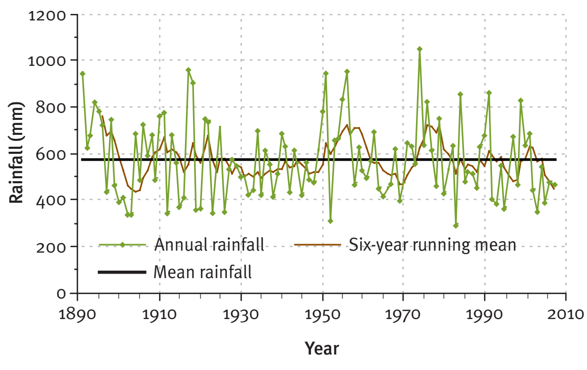

FIGURE 4.10 Annual rainfall (mm, 1 April to 31 March) averaged across Queensland's pastoral and cropping zone, mean rainfall (573.5 mm), and six-year running mean of annual rainfall
Source: DNRW

Land

Pasture production and condition

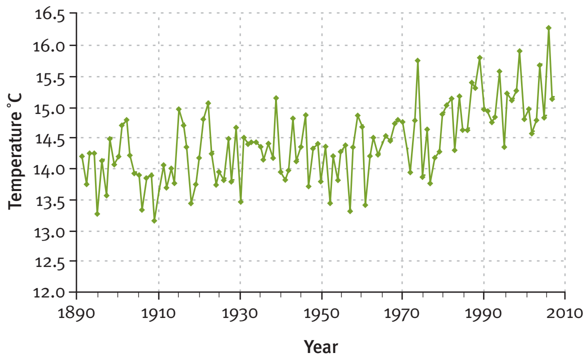

FIGURE 4.11 Annual minimum temperature (°C, 1 April to 31 March) averaged across Queensland's pastoral and cropping zone
Source: DNRW

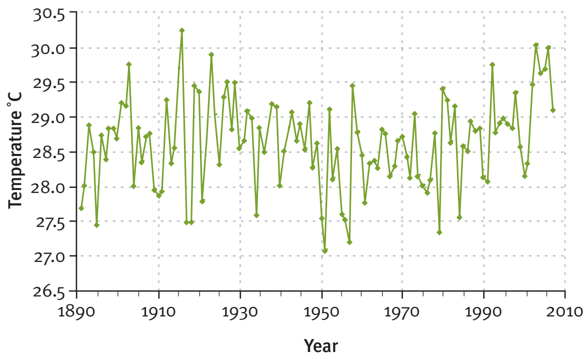

FIGURE 4.12 Annual maximum temperature (°C, 1 April to 31 March) averaged across Queensland's pastoral and cropping zone
Source: DNRW

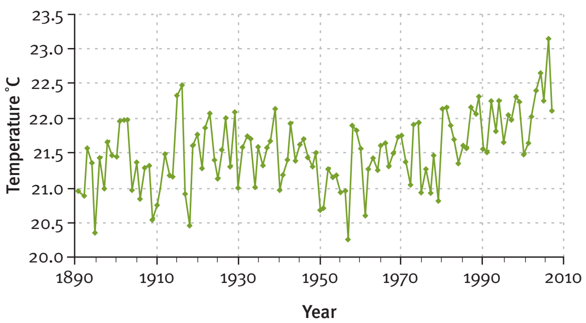

FIGURE 4.13 Annual mean temperature (°C, 1 April to 31 March) averaged across Queensland's pastoral and cropping zone
Source: DNRW

Potential evaporation estimates, or Class A pan evaporation (Rayner 2005), indicated high values for each of the years 2002–03 to 2006–07, comparable with the previous high value measured in the 1982–83 drought (Figure 4.16). The combination of low rainfall and high potential rates of evaporation (expressed as the ratio of rain to potential evaporation) indicated that the current drought is extremely severe (Figure 4.17). The six-year running mean in Figure 4.17 shows that the present trend is lower than that in any other period, including the Federation Drought period.

As explained above, the lack of high-quality records, which commenced only in 1957, prevents definitive comparison with earlier droughts such as the Federation Drought. As part of the CLIMARC project, Rayner et al. (2004) have reconstructed historical climate records (temperature, humidity, cloud cover), although corrections for changes in measurement procedures, landscape position and instrumentation are yet to be developed. Nevertheless, such corrections are unlikely to substantially increase historical temperatures for stations in rural Queensland (Rayner 2005). Thus preliminary assessment of reconstructed vapour pressure deficit and potential evaporation suggests that the current drought is comparable to the Federation Drought (if not worse) in terms of the ratio of rainfall to potential evaporation.

An alternative measure of moisture availability (to validate Figure 4.17) is the ratio of rainfall to vapour pressure deficit (Figure 4.18). Vapour pressure deficit is an important component of potential evaporation and has been calculated from historical temperature and humidity records. The moisture index calculated in this way (Figure 4.18) confirms the severity of the recent drought period when compared to historical values.

Simulated pasture growth

Pasture growth was calculated assuming a constant tree basal area (that is, tree density) and atmospheric carbon dioxide (CO_2) concentration, with no change in pasture composition, and using animal numbers reported in 2001. Since the late 1800s, CO_2 concentration has increased from 280 parts per million (ppm) to more than 380 ppm in 2006 (see 'Climate and greenhouse' in Chapter 3). The pasture growth model was calibrated using pasture data collected from the early 1990s to 2000. During this period CO_2 concentrations rose from 355 ppm to 372 ppm. The impact of historical changes of CO_2 concentrations on pasture water use and growth are yet to be modelled and are the subject of current research. Thus values of approximately 360 ppm are used in the simulations of pasture growth.

The pasture growth simulation integrates the effects on pasture growth of variability in climatic elements (rainfall, temperature, humidity, solar radiation and pan evaporation) along with animal consumption as a realistic 'feedback' mechanism on pasture growth.

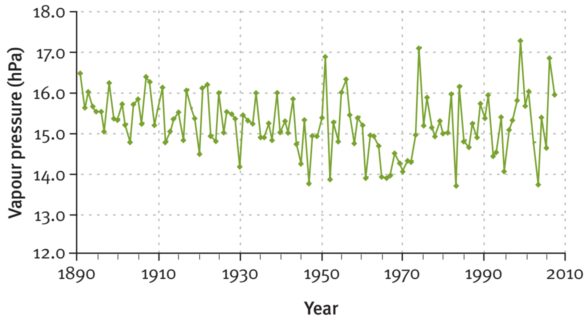

FIGURE 4.14 Vapour pressure (hPa, 1 April to 31 March) averaged across Queensland's pastoral and cropping zone
Source: DNRW

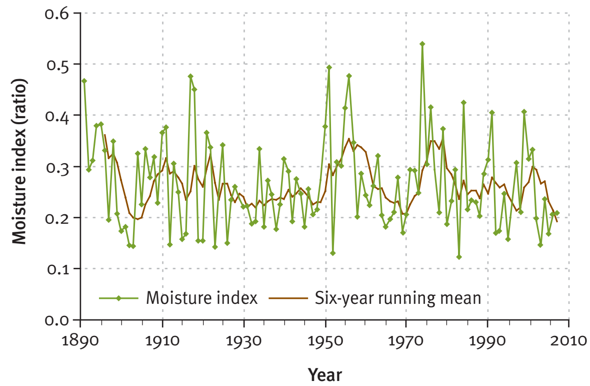

FIGURE 4.17 Moisture index (1 April to 31 March) averaged across Queensland's pastoral and cropping zone (calculated as a ratio of rainfall to synthetic pan evaporation), and six-year running mean of the moisture index
Source: DNRW

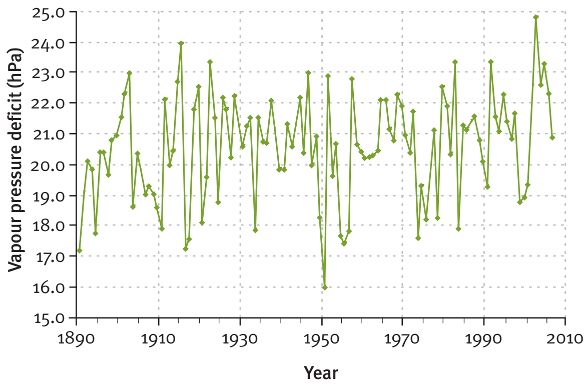

FIGURE 4.15 Vapour pressure deficit (hPa, 1 April to 31 March) averaged across Queensland's pastoral and cropping zone
Source: DNRW

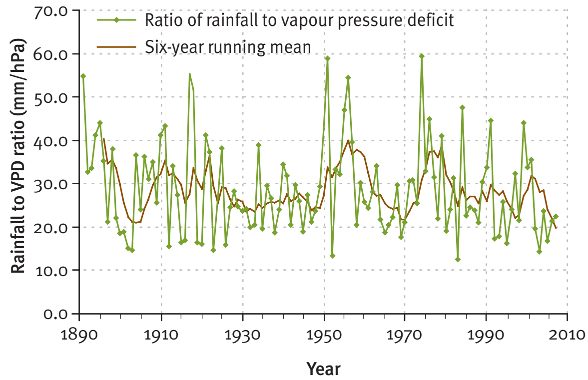

FIGURE 4.18 Ratio of rainfall to vapour pressure deficit (mm/hPa, 1 April to 31 March) averaged across Queensland's pastoral and cropping zone, and six-year running mean of the ratio
Source: DNRW

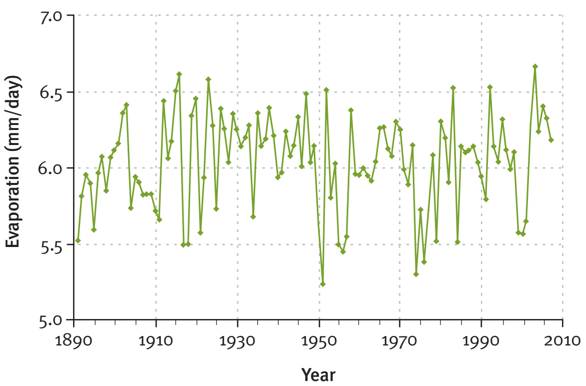

FIGURE 4.16 Synthetic pan evaporation (mm/day, 1 April to 31 March) averaged across Queensland's pastoral and cropping zone
Source: DNRW

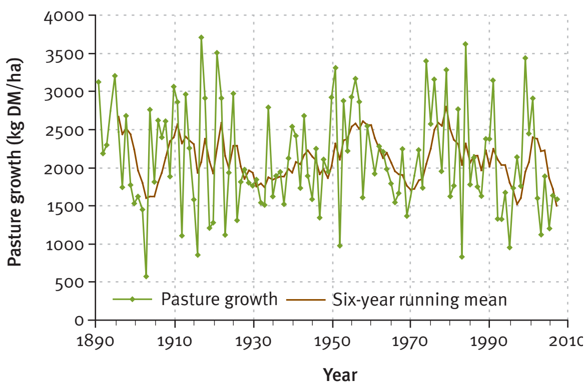

FIGURE 4.19 Pasture growth (kg DM/ha, April to 31 March) averaged across Queensland's pastoral and cropping zone, and six-year running mean of pasture growth
Source: DNRW

Historical variability in simulated pasture growth reflects the variability in rainfall (Figure 4.19). Temperature trends can have contrasting effects on pasture growth, on one hand increasing net photosynthesis (to a threshold of ~30°C), but otherwise increasing evaporative demand and reducing soil moisture availability and water use efficiency. The pasture model calculates the net result of these opposing temperature effects.

The time-series of simulated pasture growth shown in Figure 4.19 indicates severe droughts in 1902–03, 1915–16, 1951–52, 1982–83 and 1994–95. The most severe year of the current drought (2002–03) ranks as the eighth worst in terms of pasture growth. However, when the six years of the current drought period (1 April 2001 to 31 March 2007) are compared with all other six-year periods, the ranking is comparable with the 1990s drought (1991–97) and the Federation Drought. Pasture growth averaged across Queensland for the six years 1 April 2001 to 31 March 2007 was 29% below the long-term mean. In addition, each individual year of pasture growth was below the long-term mean. The six-year running mean in Figure 4.19 confirms that pasture growth for the current drought period is lower than that for any other six-year period (but similar to that in the 1990s six-year drought period).

Pasture utilisation

The pressure on the grazed resource can best be summarised by the ratio of animals to pasture growth. Pasture utilisation is the ratio between pasture consumption and pasture growth; this term explains effectively the grazing pressure on the pasture resource. High levels of pasture utilisation, especially under poor growing conditions, result in rapid decline in pasture basal cover (McKeon et al. 2004).

To calculate the state's pasture utilisation, pasture growth was calculated for the whole of Queensland to allow comparison with total livestock numbers retained in the state. Pasture growth was simulated at a 5 km resolution (Figure 4.20) across Queensland using the AussieGRASS model, which has been developed and validated over the past 20 years (Carter et al. 2000). There are limits, however, to our knowledge, our data resources and the rate at which that new information can be implemented and tested for use in analyses. As per the caveat given in the previous reporting period (EPA 2003), the major changes in vegetation affecting pasture productivity are not included in this analysis. They include vegetation thickening (Burrows et al. 2002); increase in buffel grass distribution (O'Rourke et al. 1992); tree clearing (various SLATS reports; Henry et al. 2002); and increases in herbaceous and woody weeds and other forms of land degradation (EPA 1999). Further research is required in this field to reconstruct historical vegetation change.

An estimate of numbers of domestic livestock impacting on Queensland pastures has been developed (G. Stone, pers. comm.) using (a) Australian Bureau of Statistics (ABS) census and survey data; (b) ABARE survey data; (c) livestock turnoff data; (d) feedlot statistics; and (e) monitoring sales and cattle movement data. From these estimates, a time-series of domestic livestock numbers (Figure 4.21) has been prepared to assess changes in grazing pressure (Stone et al. 2003; G. Stone, pers. comm.).

Pasture utilisation was calculated by first taking total grazing animal numbers expressed as adult beef equivalents (ABEs), then subtracting numbers of cattle that were held in feedlots (Figure 4.21). From this, a total demand for forage was estimated. Forage demand was divided by simulated pasture growth to give pasture utilisation (Figure 4.22). Average utilisation during the current drought was 13%, a value similar to that in the 1990s drought period (1991–92 to 1996–97). Figure 4.22 shows the pasture utilisation calculated for Queensland when estimates of feral grazers and macropod numbers are included from the AussieGRASS model.

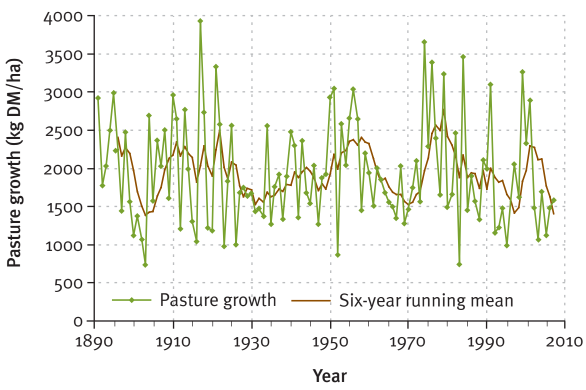

FIGURE 4.20 Pasture growth (kg DM/ha, 1 April to 31 March) averaged across Queensland, and six-year running mean of pasture growth
Source: DNRW

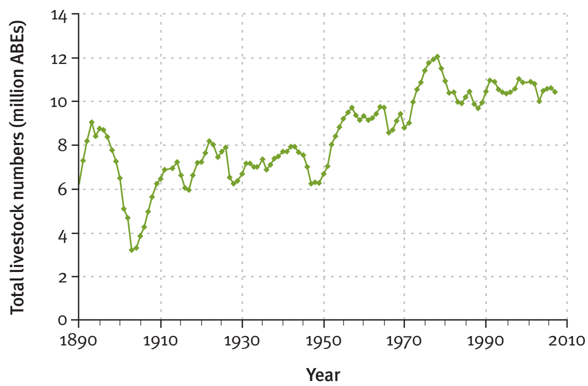

FIGURE 4.21 Domestic livestock numbers (beef cattle and sheep) across Queensland expressed as adult beef equivalents (ABEs)
Source: DNRW

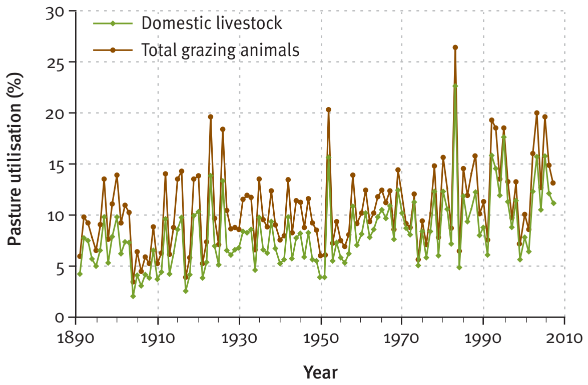

FIGURE 4.22 Pasture use (percentage utilisation, 1 April to 31 March) of domestic livestock (beef cattle and sheep) and total grazing animals (domestic livestock, macropods and feral grazers) averaged across Queensland
Source: DNRW

Grazing animal pressure

Assessing livestock numbers across regions and for the state is a difficult task. Because of the lack of data at a consistent spatial resolution, livestock numbers for the current drought have only been comprehensively assessed on an annual basis using the ABS agricultural census of 2001. For the years 2002 to 2005, total state numbers have been estimated from ABS/ABARE surveys; preliminary numbers were available for 2006 (ABS 2007) and numbers for 2007 were estimated from knowledge of previous numbers, seasonal conditions, livestock markets and turnoff (G. Stone, pers. comm.). These estimates suggest that, at a state level, cattle numbers have been maintained through the drought (that is, 10.4 to 11 million head on pasture), while sheep numbers declined from 8.7 million in 2000–01 to an historical low of 4.4 million head in 2002–03, but then rose to 4.7 million head in 2005–06 (ABS 2007). Severe drought in different regions such as south-western Queensland has resulted in low stock numbers, as reported anecdotally by graziers.

In contrast to the 1991–96 drought, a major feature of the current drought has been the relatively high prices received for stock, particularly cattle. These market opportunities have provided graziers with sufficient equity to respond to pasture feed deficits by arranging sales or agistment, thus reducing pressure on the pasture resource. Advancement in dry-feed supplementation, while a highly significant production and survival instrument for graziers, can potentially lead to problems if livestock are retained until perennial pastures are completely utilised or grazed beyond recovery.

In the previous reporting period, macropod numbers were conservatively estimated at over 20 million (EPA 2003). Recent reports suggest that, as a result of drought, macropod numbers have declined, which has been reflected in reduced pasture utilisation (Figure 4.22). Harvest quota estimates have declined by 45% since 2002 (DEWR 2007). The reduction in grazing pressure from macropods may facilitate the recovery of the pasture resource once rain occurs, although high macropod numbers may still pose a problem in some locations.

Feral and farmed goats should also be included in the total grazing pressure (TGP) calculation (Figure 4.22). In areas where feral goats had previously been harvested on an ad hoc basis (particularly south-western Queensland), buoyant markets and local slaughter facilities now provide the incentive for a feral/farmed goat industry to be run as a regular, profitable part of pastoral activities (Chapman 2003). Feral goat numbers are estimated in conjunction with macropod aerial surveys and farmed goats have been counted by ABS in recent years (2004 and 2005), but the limited time-series is not sufficient to judge trends for the period of interest (from 2000–01). In addition, because of the numbers of feral goats now being considered as 'farmed' goats, the numbers reported by ABS may falsely show an increasing trend.

In regions where rabbits are present, density is estimated to have increased by 50–100% since 2002 (D. Berman, pers comm.). This increase is most likely caused by the diminished effectiveness of the rabbit calicivirus in controlling rabbit numbers. In dry conditions the vector viability of the rabbit calicivirus is reduced. As a result, rabbits have continued to recolonise areas previously inhabited.

In terms of average rainfall, the six-year period ending March 2007 is comparable with 'six-year' periods in the long Federation Drought (that is, in the seven-year Federation drought there were two 'six-year' periods). In contrast to the Federation Drought, however, the three extreme drought years (2002–03, 2004–05 and 2006–07) were separated by years during which some areas in the state had average or above-average rainfall and pasture growth conditions. Thus, it would appear that during the current drought the pasture resource across Queensland has been able to carry the indicated numbers of domestic livestock (notwithstanding all other herbivores), through the movement of animals around the state from one area to another (for sales, agistment and slaughter).

Pasture condition

The major factors driving degradation and recovery processes in pastures are described in Stone et al. (2003) and McKeon et al. (2004), and include:

- climate variability;
- grazing pressure from domestic livestock and natural and feral herbivores; and
- grazing and vegetation management, including grazing management at a paddock scale, pasture burning and woody plant regrowth control.

The main degradation processes in grazing lands involve a decline in:

- composition of desirable (usually perennial) grasses and edible shrubs;
- soil surface protection (cover) and infiltration capacity; and
- soil fertility and capacity to store water.

Degradation may also involve changes in soil attributes that reduce pasture production (increased salinity, soil acidification) and increases in weeds and woody components that compete for water and nutrients. As discussed below, the term 'loss of landscape function' is used to integrate these components of degradation.

CASE STUDY: *Mitchell Grass condition*

Queensland's Mitchell grasslands represent 19% of the state's native pasture area. The climatic severity of the drought is highlighted by death (and variable recovery) of long-lived perennial grass tussocks, especially the Mitchell grass species in western Queensland (Orr and Phelps 2006). Individual Mitchell grass tussocks can live as long as 20–30 years, but sometimes as little as six years. During the current drought, some areas saw a period of fourteen months (November 2001 to February 2003) without significant rainfall. This was followed by 100–400 mm of rain received as patchy summer storm events in February 2003. Much of the Mitchell grass country did not receive further rain until January/February 2004, when 150–400 mm fell as summer storms (again with high spatial variability). In some areas tussocks failed to respond to February rains in both 2003 and 2004. Seed stores (and seed viability) to regenerate populations through recruitment have also been identified as a topic for investigation. The causes of widespread tussock death observed during the current drought are still being researched, although recovery has been observed recently in some regions. Similar concern was recorded regarding damage to Mitchell grasslands in the extended droughts of the late 1920s and early 1930s (Everist 1935; White 1935).

It is difficult to separate the natural and managerial components in resource deterioration. To determine the effect of climate variability, it is important to assess the pasture and land resource under similar climatic conditions (for example, after a sequence of drought years or favourable years). Comparison of the resource condition during the current drought with condition during previous droughts (for example, 1991–94) allows some assessment of trends to be made. The 1991–94 drought was concentrated in central and eastern Queensland. Western Queensland experienced severe drought in 1991, but had a substantial break in 1993.

The three-year period of above-average rainfall (1998–99 to 2000–01) over most of Queensland resulted in pasture production that was 46% above average (Figures 4.9 and 4.20). The climatic conditions in this period were suitable for placing the pasture resource in good condition. However, the above-average years also supported the build-up of livestock and macropods (EPA 2003). Pasture growth over the six years since 2001–02 has been 27% below average (using a six-year running mean from 2001–02). The retention of livestock numbers, as well as high native herbivore numbers at the start of the drought period, is likely to have increased the risk of conditions leading to decline in pasture condition.

The year-by-year sequence of climate variability suggests that the current drought is likely to affect pasture production and condition to a greater extent in some regions than in others. Areas of south-western Queensland, for example, have had extreme rainfall deficiency, poor pasture production and high total grazing pressure over the protracted period 2001–02 to 2006–07 and are now considered to be in poor condition.

Source: DNRW

Response

Climate variables and grazing pressure on the pasture resource have been analysed and discussed in this section. It suggests that pasture production and condition across the state compare (at least) with recent and historical severe protracted periods of rainfall deficit and deteriorating resource status. Without objective validation in the field, however, broad analysis of land condition by simulation can be misleading. Although Queensland's grazing lands occupy over 80% of the state and represent an important natural resource, no formal operational monitoring of pasture condition at permanent sites is carried out, as occurs in other states (Bastin and Watson 2006). Thus, assessment of pasture condition has relied on pasture scientists integrating their experience at a regional level to provide qualitative assessments (Tothill and Gillies 1992; EPA 2003). In the following review, we have followed this approach, drawing heavily on extensive field assessments and monitoring by DNRW officers over the 13 years since 1994 (Hassett et al. 2000, 2006).

Remote sensing of bare ground also allows objective assessment of change in surface cover where tree density is low, less than 20% tree foliage projected cover (Scarth et al. 2006). A preliminary assessment has been made using Landsat Thematic Mapper (TM) satellite imagery for the whole of Queensland since 1988. Average groundcover estimates in 2005 were similar to those made in 1996 at the end of the drought that started in 1991. A preliminary analysis (Figure 4.23) shows the groundcover estimate is very dynamic and ranges from 33% to 75%, with an average of 45% groundcover for the period 1988–2005. In relative terms, the years 1999 to 2001 show the potential for high groundcover across the state when beneficial climatic conditions are experienced. Conversely, on three occasions since 1988 average groundcover has been below 35%. When average cover is below the mean (that is, below 45%, as it was in 11 out of 18 years), areas of the state will be well below this value, indicating significant areas at risk of degradation from wind and water erosion. The analysis from Landsat TM averaged across Queensland matches AussieGRASS pasture cover simulations (using Bare ground index Version bi1), supporting the validity of the model in assessing changes in time and space, as discussed below.

An Australia-wide assessment of rangeland condition and trend is being made by the Australian Collaborative Rangeland Information System, ACRIS (Bastin and Watson 2006). As part of the ACRIS review, two independent assessments have been made by Queensland pasture scientists using: (i) subjective interpretation of AussieGRASS data simulation of pasture growth and utilisation; and (ii) repeated Rapid Mobile Data Collection (RMDC). The detailed findings and caveats to the interpretations for these two approaches are given in Hassett et al. (2006). The findings are summarised here for IBRA (Interim Biogeographical Regionalisation of Australia) regions.

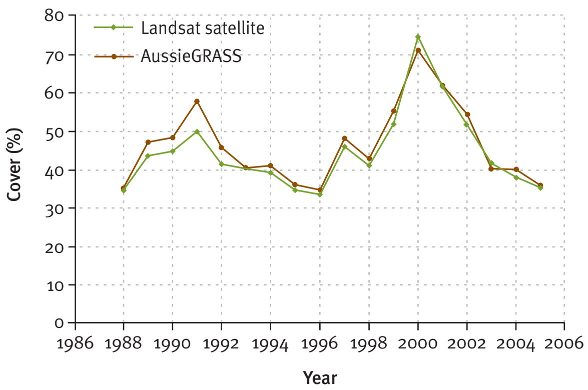

FIGURE 4.23 Groundcover (<20% tree foliage projected cover) for Queensland simulated from Landsat satellite imagery and AussieGRASS from 1988 to 2005
Source: DNRW

Subjective interpretation from AussieGRASS outputs

A key attribute of resource condition is the qualitative assessment of landscape function, where loss of function is indicated by a decline in composition of desirable (usually perennial) grasses and edible shrubs, soil surface protection (groundcover) and infiltration capacity, and soil fertility and capacity to store water. Landscape function has been assessed for identified important regions (such as south-west Queensland), where loss of function has occurred.

Subjective interpretation based on AussieGRASS data was undertaken for the period 1991–2005. Landscape function and trend (Figure 4.24) were inferred from monthly and annual time-series data of pasture growth, pasture utilisation, simulated cover and total standing dry matter (J. Carter unpublished data). High utilisation over extended seasons was assumed to reduce landscape function by removing perennial tussock grasses (particularly through reducing infiltration rates, increasing runoff/erosion, increasing bare soil evaporation and limiting the ability of the system to hold nitrogen) and was the main factor considered in estimating likely loss of function. A full description of the methodology, analysis and caveats to the interpretation can be found in Hassett et al. (2006).

Photo: Roslyn Charnock

Assessment of change in landscape function using on-ground visual interpretation

Landscape observations have been made while undertaking Rapid Mobile Data Collection (RMDC) since 1994 (Hassett et al. 2000, 2006). While landscape function 'state' was not formally recorded, the observer was astute in his interpretation of the state of the landscapes visited, has extensive practical experience, and has reliable recall supported by thousands of photographs taken at known locations.

In this interpretation, a map was constructed representing a subjective impression of where the most significant changes in landscape function had occurred (Figure 4.25). Areas representing change in landscape function were determined from yearly observations across much of Queensland, and are shown at a partial sub-IBRA scale. The initial assessment of these systems in 1994–95 was under climatic conditions somewhat similar to those in 2004 and 2005. Areas of change were then extrapolated to the full sub-IBRA scale. The frequency of surveys since 1994–95 in some regions was deemed too low to determine a change in landscape function. Like previous analyses (such as Tothill and Gillies 1992), the interpretation is subjective, but is likely to be more robust than interpretations made using other techniques, because a single operator (actively engaged in observation of the landscape) has made the estimates over the entire area over a considerable time span.

Both analyses (Figures 4.24 and 4.25) indicate areas of significant loss of function in southern and south-western Queensland. The second assessment (Figure 4.25) also indicated significant loss of landscape function in areas such as far western, north-western and north-eastern Queensland.

Although it was not possible to reliably separate the effects of climate from those of grazing management, several important features were noted. Fodder clearing in the mulga zone (south-west Queensland), which enables the retention of stock through drought, has maintained grazing pressure, particularly while pastures are recovering following rainfall, when they are most vulnerable to overgrazing. Given the length and severity of the drought in this region, as indicated by native tree death, careful management of grazing pressure will be necessary to aid pasture recovery. Regions such as Dalrymple Shire in north-east Queensland have demonstrated rapid recovery of pasture biomass once rainfall has occurred. However, this high variability in pasture yield (and species composition) does not necessarily demonstrate a sustainably grazed system. Periods of low cover as a consequence of high utilisation and drought continue to place the resource at risk and are contributing to soil loss, stream bank erosion and downstream risks (such as sediment affecting the Great Barrier Reef lagoon).

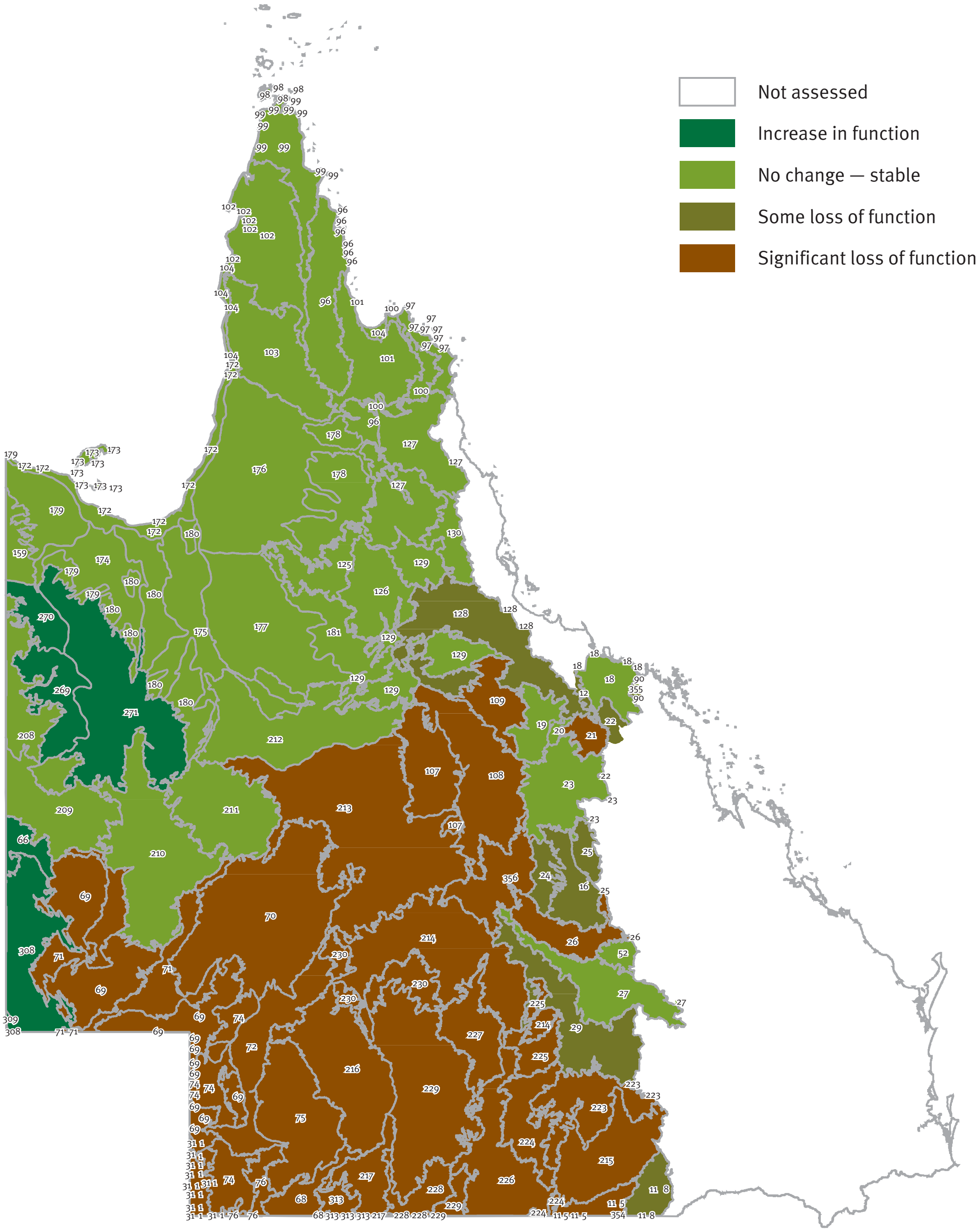

***FIGURE 4.24** Landscape function and trend from AussieGRASS outputs 1991–2005 (J. Carter)*
Source: DNRW

Repeated surveys using reproducible methods have given the general impression that invasion by weeds including parthenium, parkinsonia, prickly acacia and other Weeds of National Significance is increasing. Similarly, the impression was that in eastern Queensland grass basal cover is trending downwards, even in buffel grass areas. Other major concerns were that large numbers of domestic animals (including goats in western Queensland) were still present despite the severity of the drought, and that, with increasing pasture utilisation and more general use of supplementation, the pasture resource (particularly in south-western Queensland as of early 2007) remains under considerable grazing pressure.

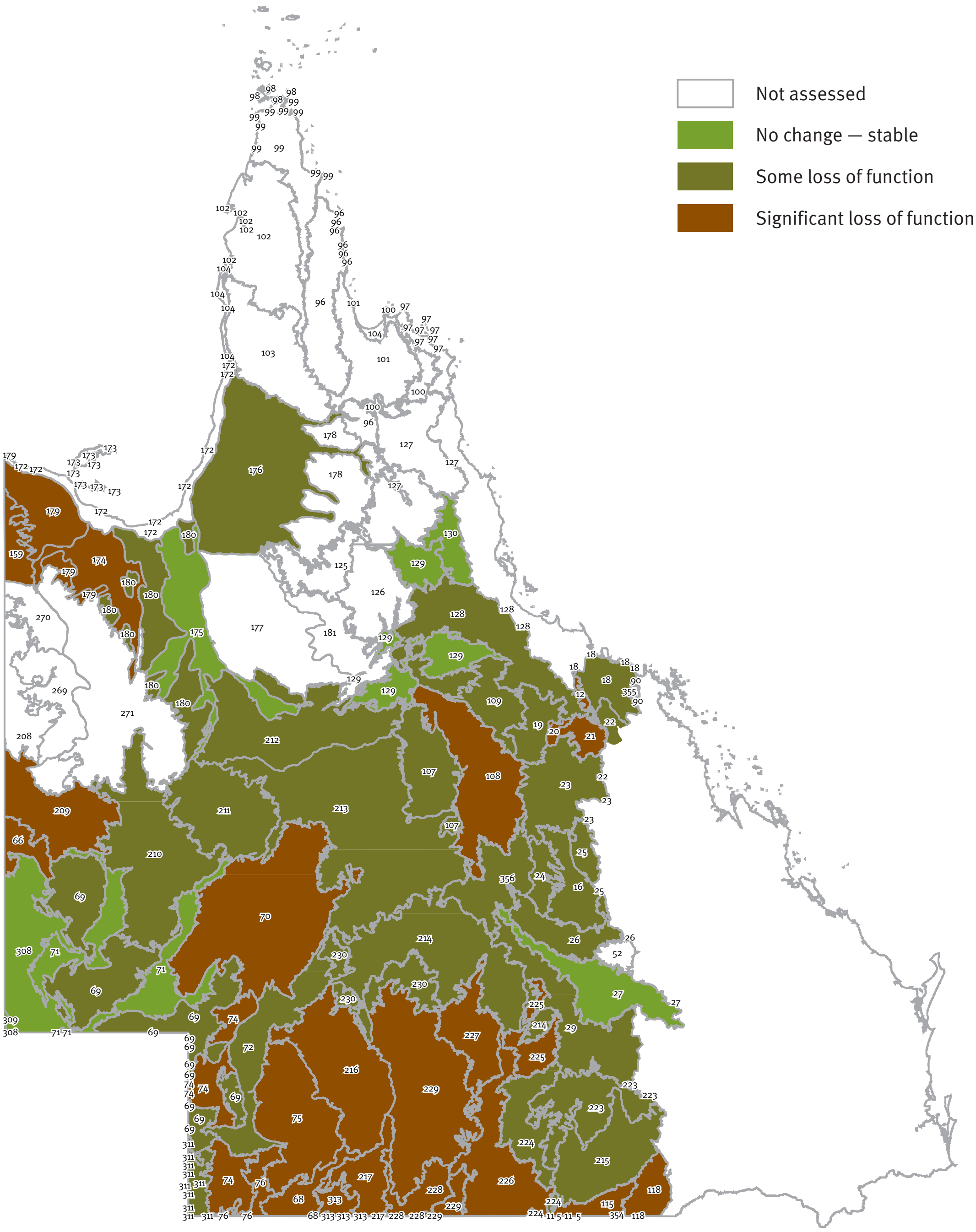

FIGURE 4.25 *Landscape function and trend from on-ground visual interpretation 1994–2005 (R. Hassett)*
Source: DNRW

Photo: Grant Stone

In the Burnett region, high pasture utilisation has resulted in low groundcover and increased the potential for land degradation during high-intensity rainfall events.
Photo: Grant Stone

Open woodland with high grass basal area and soil surface cover due to lower pasture utilisation. Risks to landscape function and biodiversity health are minimised.
Photo: Grant Stone

Conclusion

The above analysis reviewed components of pasture production for Queensland's grazing lands including climate variables, simulated pasture growth, estimated livestock numbers, inferred grazing pressure, and repeated surveys of selected areas to ascertain pasture condition. By historical standards, the current drought is extremely severe and is comparable to the Federation and the early/mid-1990s droughts. Climate indicators such as maximum temperature, vapour pressure deficit and potential evaporation suggest an increasing severity of drought since the start of reliable records (in 1957) and are consistent with general projections resulting from global warming and climate change considerations (Walsh et al. 2002).

Although the three years associated with El Niño events (2002, 2004 and 2006) had generally below-average rainfall and pasture growth, rainfall in the other years in different regions has provided sufficient pasture growth to maintain livestock (cattle) numbers. It appears that technological advancement, skilled management and transport efficacy have resulted in beef cattle numbers being relatively unresponsive to the recent effects of drought on a whole-of-state basis. Sheep numbers are very low, reflecting both drought and the economic trend of the industry, while the beef industry remains buoyant (in early 2007). It should be noted that even if domestic livestock were removed in areas where densities of macropods (and feral grazers) have been high (such as south-western Queensland), high pasture utilisation would have continued, to the detriment of the resource. The future vigour of the pasture resource will depend on how pasture recovery is managed—that is, the degree of grazing pressure applied after a break in the season.

It is not possible to conclude that the severity of the current drought is the result of climate change, or even that it is unprecedented when compared to the Federation Drought. Nevertheless, increased temperatures and potential evaporation rates, in combination with low rainfall and subsequent reduced pasture growth, provide a warning of what could occur in the future as temperatures continue to rise.

The success of the grazing industry in managing the drought is a credit to the experience, expertise and scientific support refined over 100 years. However, if retention of grazing animals in parts of the landscape results in irreversible long-term destruction of the resource, then the benefit of this hard-won success will not be available to future generations.

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