Rainfall and soil water content at a native pasture site near Barraba, New South Wales; 2003–2008

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Abstract. *Annual average rainfall at the site (1900–99) was 634 mm, but there was substantial inter-annual variation. From June 2003 to March 2008, monthly rainfall was below average for 64 per cent of the time and total soil water content (mm, 0–2.1 m) ranged from 378 to 472 mm. Over the 58 months that the site was monitored, the soil profile wet on eight occasions and dried nine times, although most of the change in soil water content occurred at a depth of 0–0.7 m. While there has been a recent substantial La Niña event, with over 375 mm of rainfall received at the site in summer 2007–08, total soil water content in early April 2008 was 412 mm, which is about the lower limit for pasture growth. Above average rainfall would be required in autumn–winter 2008 to wet the soil profile to a depth of 2.1 m.*

Introduction

The La Niña event in the Pacific Basin in summer 2007–08 was forecast to persist until the end of autumn 2008 in southern Australia (Bureau of Meteorology 2008). This strongly indicated an easing of the recent drought conditions on the North-West Slopes of New South Wales (NSW). While this is good news for producers, and summer 2007–08 has provided some of the highest rainfall totals across the district for many years, now is a good time to reflect on just how dry and wet our soils have been, and what effect different rainfall events may have had on soil water content (SWC).

Logically there is a relationship between rainfall and stored soil moisture. However, the relationship is not constant, since rainfall effectiveness depends on the intensity of rainfall and the infiltration capacity of the soil. Similarly, for plants to be able to respond to rainfall they need to be actively growing. However, not all of the water in the soil profile is available for plant growth. Plant available water (the water that most pasture plants can use) is held at a tension of up to −1500 kPa, beyond this level it can only be extracted by plants such as shrubs and trees. Soil water can also be unavailable to plants if it is stored below the root zone. To better understand the relationship between rainfall and SWC we have been continuously monitoring a native pasture site near Barraba, NSW since 2003. Both rainfall and SWC data have been collected to demonstrate the cycle of profile wetting and drying in relation to the different rainfall events from June 2003 to March 2008 and to indicate the depth of wetting of the soil profile that has occurred.

Methods

These studies were conducted at a native perennial grass site located at 'Springmount' (30° 34'S; 150° 38'E; 510 m above sea level) 20 km south-east of Barraba on the North-West Slopes of NSW. This site has been described in detail by Lodge *et al.* (2003a) and these authors also reported on the SWC (mm, 0–2.1 m) for the period September 1997 to September 2001. Briefly, the pasture was dominated by the native perennial grasses redgrass (*Bothriochloa macra*) and wiregrass (*Aristida ramosa*) and was located on a red Chromosol (Isbell 1996) soil.

Neutron moisture meter (NMM) access tubes were installed to a maximum depth of 2.1 m in spring 1997. SWC was estimated by a NMM (CPN503DR–Hydroprobe, Boart Longyear Co., Martinez, Ca.), with readings (16 s count time) taken at depth increments of 0.2 m between 0.2 and 2 m depth. Details of the aluminium access tubes, their installation and the calibration of the NMM were given by Lodge *et al.* (2003b). For the NMM, linear regression was used to determine the relationship between probe count and θ_{vol} (R^2=0.73, n=193). Procedures for determining soil water retention curves and soil bulk density (Mg/m^3) were described by Lodge *et al.* (2003b). The minimum total SWC (0–2.1 m) for pasture growth at this site, determined by the long-term drought analyses of Lodge and Johnson (2005) was 410 mm. Weather data (rainfall, ambient temperature, solar radiation, relative humidity, wind speed) were recorded at 30 minute intervals from an on-site automatic recording station (Tain Electronics, Melbourne). Long-term (1900–2006) daily interpolated weather data for the site latitude/longitude coordinates were from the SILO Data Drill (Jeffery *et al.* 2001).

The rainfall and SWC data presented in this paper were collected over five years from June 2003 to March 2008, including the recent drought period. NMM data were from one access tube in each of the three replicate plots of the 6 wethers/ha grazing treatment. Treatments were discontinued in spring 2001 and since that time plots have been intermittently grazed with both sheep and cattle. SWC data were collected at approximately 3-week intervals from 19 June 2003 to 20 July 2006 and then approximately every 12 weeks to February 2008, with the final measurement being taken on 1 April 2008.

Results and discussion

Long-term average (LTA, 1900–1999) annual rainfall for the site was 634 mm. Average annual rainfall was 597 mm from 1900–1949 compared with 672 mm from 1950–1999. A feature of the rainfall distribution (Figure 1) was the high inter-annual variation with there being few periods with high annual rainfall over consecutive years, and most of these were in the 1950s and early 1960s, the 1970s and the 1990s.

Annual rainfall was above the site LTA in 2004 and 2005, below the LTA in 2003 and 2006 (Figure 1) and about average in 2007 (data not shown). Monthly rainfall was below average for 37 of the 58 months (64 per cent of the time) from June 2003 to March 2008, most notably for 7 and 5 consecutive months from February 2004 and January 2005, respectively (Figure 2a). Monthly rainfall was >100 mm in 9 months and >150 mm in 4 months (January and December 2004, February 2006 and December 2007). Months with rainfall >100 mm generally occurred in summer, except for June and November 2005 (108 and 111 mm of rain, respectively).

Total SWC (0–2.1 m) ranged from 378 mm in April 2005 to 472 mm in September 2005 (Figure 2b). This upper value for SWC was substantially lower than the highest value recorded for this soil (583 mm) in September 1998 (Lodge *et al.* 2003a). SWC was less than the minimum value for pasture growth (410 mm, Lodge and Johnson 2005) in summer 2003–04, autumn-winter 2004, summer-autumn and winter 2005 and 2006 and autumn 2007 and 2008 (Figure 2b).

For the soil profile there were eight main wetting and nine drying cycles (Figure 2b) with the soil wetting from: January–February 2004 (37 mm), April–September 2004 (45 mm), November–December 2004 (46 mm), June–September 2005 (91 mm), February 2006 (50 mm), May–July 2006 (52 mm), May–August 2007 (21 mm) and November 2007–February 2008 (45 mm); and drying from: July–December 2003 (–62 mm), February–April 2004 (–51 mm), September–November 2004 (–19 mm), December 2004–April 2005 (–77 mm), September 2005–January 2006 (–85 mm), February–May 2006 (–47 mm), March–May 2007 (–34 mm), August–November 2007 (–12 mm) and February–April 2008 (–46 mm).

From 2 June to 14 July 2005, there was a total of 155 mm of rainfall and total SWC increased by 80 mm (a conversion efficiency of rainfall to soil water of 52%). In contrast, 187 mm of rain fell from 2 to 23 February 2006, but total SWC only increased by 50 mm (27% efficiency).

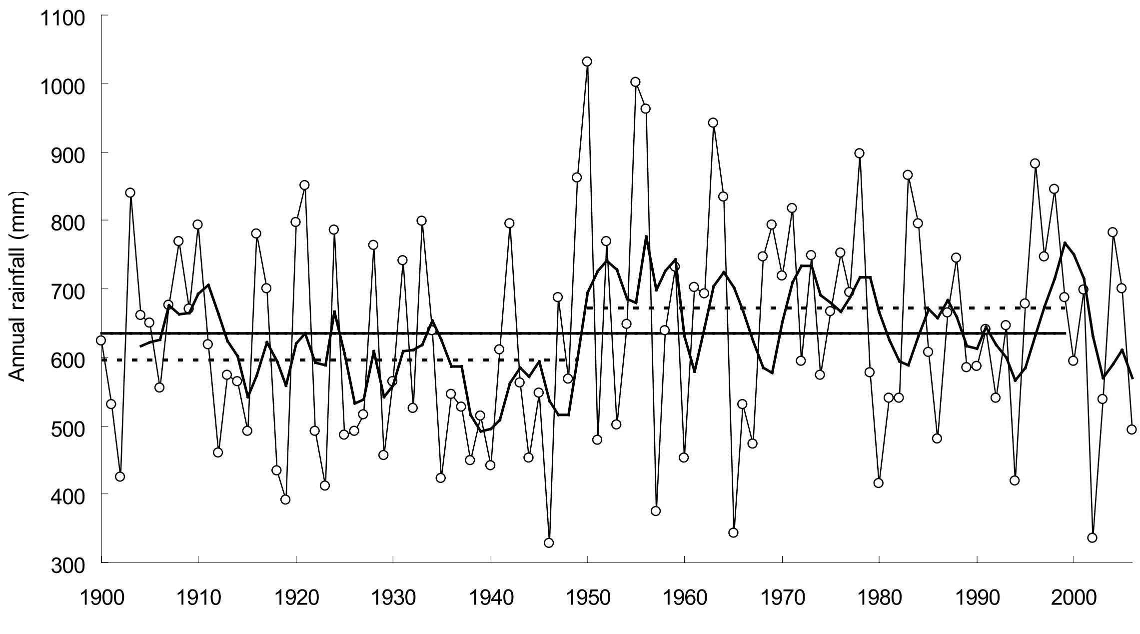

Figure 1. Total interpolated annual rainfall (mm) at the native pasture site each year from 1900–2006 (open circles), together with the 5-year rolling average. Horizontal lines represent the mean annual rainfall (mm) for the periods 1900–99 (solid line), 1900–49 (broken line) and 1950–99 (broken line).

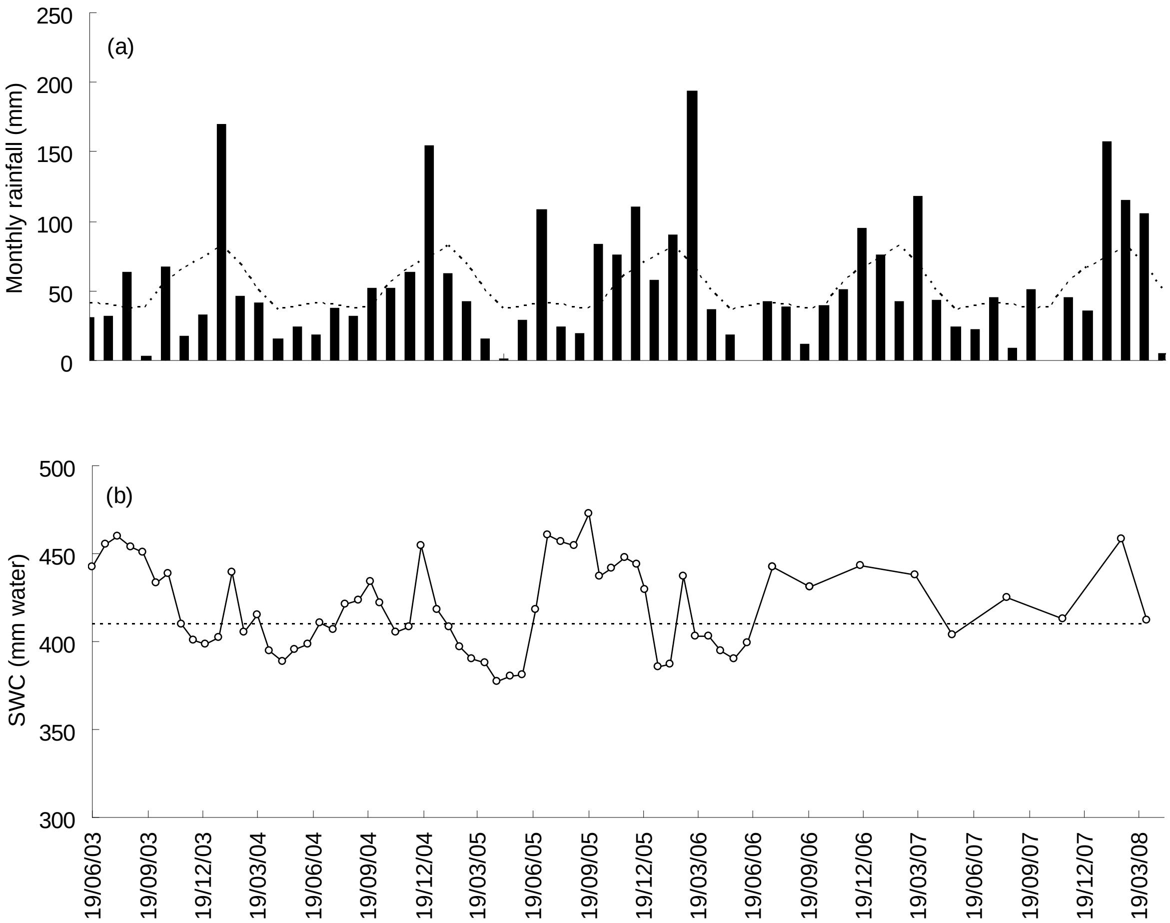

Figure 2. (a) Monthly rainfall (mm, vertical bars) at the native pasture site, together with the long term average (mm, broken line), and (b) total SWC (0–2.1 m, open circles) at the native pasture site from June 2003 to March 2008. The broken horizontal line indicates a SWC of 410 mm.

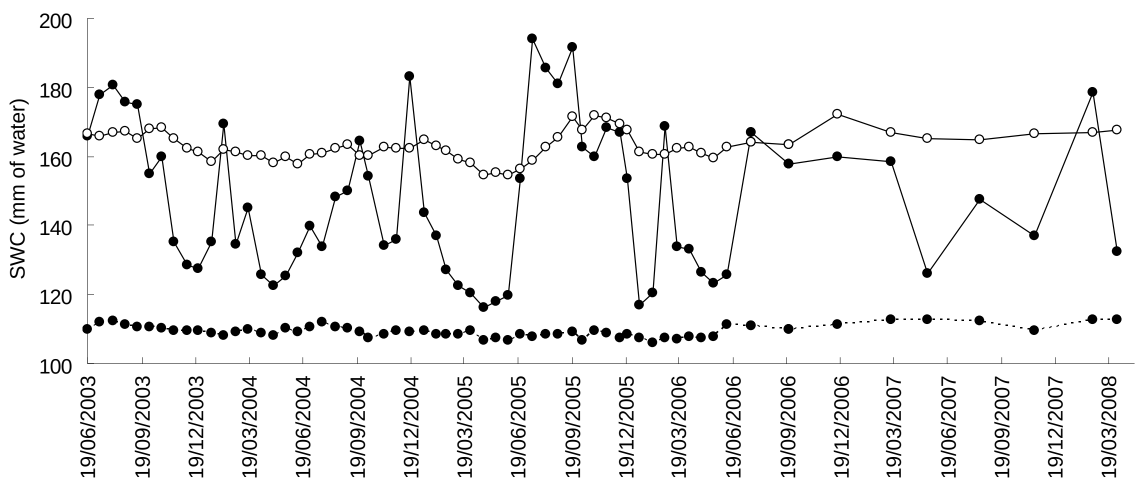

Figure 3. SWC at soil profile depths of 0–0.7 m (filled circles, solid line), 0.7–1.5 m (open circles) and 1.5–2.1 m (filled circles, dotted line) at the native pasture site from June 2003 to March 2008.

Soil profile wetting and drying in response to the rainfall events from June 2003 to March 2008 mostly occurred at a depth of 0–0.7 m, with the overall change in SWC being <20 mm at a depth of 0.7–1.5 m and <7 mm at the 1.5–2.1 m depth (Figure 3). For this site, mean root depth was 1.3 m with >60% of roots being at a depth of <0.3 m (Lodge and Murphy 2006). The apparent lack of response in SWC at depth in relation to rainfall indicated by the NMM measures was in agreement with continuously recording gypsum blocks at a depth of 2 m in the profile which also showed no marked changes in SWC flux over time (G.M. Lodge, unpublished data). The highest increase in SWC occurred from 2 June to 14 July 2005 (74 mm) at a depth of 0–0.7 m (Figure 3), with 92 per cent of the increase in total SWC occurring at this depth. Despite receiving over 375 mm of rainfall in summer 2007–2008, total SWC on 1 April 2008 was 412 mm and at about the lower limit for pasture growth. For soil profile wetting to occur to a depth of 2.1 m, rainfall would need to be above average in autumn and winter 2008.

References

Bureau of Meteorology (2008) ENSO Wrap-up. Available at: http://www.bom.gov.au/climate/enso/

Jeffery SJ, Carter JO, Moodie KB, Beswick AR (2001) Using spatial interpolation to construct a comprehensive archive of Australian climate data. *Environmental Modelling & Software* **16**, 309–330.

Isbell RF (1996) The Australian Soil Classification. (CSIRO Publishing: Collingwood, Australia)

Lodge GM, Murphy SR, Harden S (2003a) Effects of grazing and management on herbage mass, persistence, animal production and soil water content of native pastures. 1. A redgrass-wallaby grass pasture, Barraba, North-West Slopes, New South Wales. *Australian Journal of Experimental Agriculture* **43**, 875–890.

Lodge GM, Murphy SR, Harden S (2003b) Effects of continuous and seasonal grazing strategies on the herbage mass, persistence, animal productivity and soil water content of a Sirosa phalaris – subterranean clover pasture, North-West Slopes, New South Wales. *Australian Journal of Experimental Agriculture* **43**, 539–552.

Lodge GM, Johnson IR (2005) Using long term model simulations of soil water content of grazed pastures to predict the onset of drought on the North-West Slopes of New South Wales. In 'Proceedings of the 20th Annual Conference of the Grassland Society of NSW'. (Ed. HL Davies) pp. 112–115. (NSW Grassland Society Inc.: Orange)

Lodge GM, Murphy SR (2006) Root depth of native and sown perennial grass-based pastures, North-West Slopes, New South Wales. 1. Estimates from cores and effects of grazing treatments. *Australian Journal of Experimental Agriculture* **45**, 337–345.