185

Overgrazing of buffel grass pasture in the Brigalow Belt bioregion of central Queensland, Australia, led to invasion by Indian couch

Thornton, CM[1]; Elledge, AE[1]

[1] Department of the Environment, Tourism, Science, and Innovation, PO Box 3130, Red Hill, Rockhampton, Queensland, 4701, Australia

Key words: *Bothriochloa pertusa*; Brigalow Catchment Study; grazing land management; land condition; safe long-term carrying capacity

Abstract

Overgrazing, or failing to adjust stocking rates to match annual forage production, traps land in a cycle of degradation. From 2015 to 2024, two adjacent catchments in the Brigalow Belt bioregion of central Queensland were grazed by beef cattle. One catchment was stocked at or below the safe long-term carrying capacity. The other was stocked at the recommended stocking rate for newly established buffel grass pasture on recently cleared and developed brigalow land, which made no allowance for pasture productivity decline over time resulting in overgrazing.

The minimum ground cover in the catchment stocked at the safe long-term carrying capacity was 82% and end of dry season pasture biomass was always greater than 780 kg/ha. The proportion of buffel grass in this pasture averaged 93% throughout the study. In comparison, the overgrazed catchment had a minimum ground cover of 72% and end of dry season pasture biomass was as low as 46 kg/ha. At the commencement of this study, 88% of the overgrazed pasture was comprised of purple pigeon, buffel, and Indian couch grasses (54%, 27% and 7%, respectively). However, after 10 years, purple pigeon grass was almost absent and the proportion of buffel and Indian couch grasses in the pasture was 1% and 92%, respectively.

Overgrazing resulted in a decline in biomass, changed species composition, and the loss of the perennial, palatable and productive purple pigeon grass. Although ground cover initially declined as the tussock grasses disappeared, it recovered with Indian couch invasion. Previous research has shown that overgrazing also substantially altered catchment hydrology, with runoff and erosion more than tripling in the first five years. Conceptually, as runoff increases, the amount of rainfall stored in the soil for plant growth decreases, leading to lower ground cover and pasture biomass. Unless an intervention such as a reduction in stocking rate is undertaken, pasture utilisation will continue to exceed pasture production, and land degradation will continue.

Introduction

The Fitzroy Basin, in the Brigalow Belt bioregion of central Queensland, Australia, has been extensively cleared for agriculture. The dominant land use in the catchment is beef cattle grazing, accounting for 25% of the state cattle herd and 11% of the national herd. Land degradation in the Fitzroy Basin has occurred as a result of

continuous heavy grazing, just as it has in up to 35% of permanent pastures globally (Thornton and Elledge 2021). Reducing sediment loss from degraded grazing land in the Fitzroy Basin was a priority under the Reef 2050 Water Quality Improvement Plan (The State of Queensland 2018). Under the plan, the effects of hillslope grazing management on land condition and water quality were monitored at the Brigalow Catchment Study. This paper presents the longitudinal changes in ground cover, pasture biomass, and species composition under heavy grazing pressure compared to conservative grazing pressure.

Methods

This study ran from 2014 to 2024 (hydrological years), utilising two catchments of the Brigalow Catchment Study in central Queensland, Australia. The site has a semi-arid, subtropical climate with a long-term (1965 to 2023) average annual rainfall of 643 mm. Rainfall data prior to the commencement of the Brigalow Catchment Study was obtained from SILO (Queensland Government 2019). Soils in both catchments were dominated by Vertosols which supported native brigalow (*Acacia harpophylla*) woodland prior to clearing and development for improved pasture. The first catchment was a long-term conservatively grazed buffel grass (*Cenchrus ciliaris*) catchment of 12.7 ha. The second was a commercially grazed purple pigeon (*Setaria incrassata*) and buffel grass catchment of 12 ha that was subjected to heavy grazing from October 2014 onward. Both catchments were grazed by *Bos indicus* beef cattle breeds. Conservative grazing stocking rates were at or less than the safe long-term carrying capacity of the landscape, being 3.5 ha/adult equivalent animal. Heavy grazing stocking rates were about 2 ha/adult equivalent, which was the recommended stocking rate for newly developed brigalow land with no consideration for a decline in pasture productivity since clearing. Pasture biomass and species composition were estimated using the BOTANAL method of Tothill *et al.* (1978). Ground cover was assessed using VegMachine® (Beutel *et al.* 2019). A comprehensive description of the study and its associated data sets can be found in Thornton and Elledge (2021).

Results

The extreme variability of central Queensland's rainfall was experienced prior to and during this study. From 2010 to 2014, rainfall was above average, including the wettest (2011) and third wettest (2010) years on record at the Brigalow Catchment Study. From 2015 to 2021, rainfall was below average and included the driest year on record (2017). From 2022 to 2024, rainfall alternated between above and below average.

As a result of consistent above average rainfall from 2010 to 2014, both catchments had high biomass at the commencement of the study, with about 7,600 kg/ha in the long-term conservatively grazed catchment (Figure 1) and 6,900 kg/ha in the heavy grazing catchment (Figure 2). Ground cover was 92% in both catchments. Under conservative grazing, pasture biomass and species composition were dominated by buffel grass in all years (Figure 1). Purple pigeon grass was only observed on one occasion, and Indian couch grass (*Bothriochloa pertusa*) was commonly observed but averaged only 3% of total pasture biomass. Pasture biomass under conservative grazing always exceeded that under heavy grazing.

At the commencement of heavy grazing, purple pigeon grass accounted for more than 50% of the pasture biomass while buffel and Indian couch grasses accounted for 27% and 7%, respectively (Figure 2). Within three years, pasture biomass dropped to less than 10% of the starting biomass and averaged 9% for the remainder of the study. Three major shifts in species composition occurred over time: 1) the dominant purple pigeon grass was replaced by buffel grass; 2) buffel grass became co-dominant with Indian couch grass; and 3) Indian couch became the dominant grass (Figure 2).

Under conservative grazing, ground cover averaged 90% (82% to 94%), while under heavy grazing ground cover averaged 87% (72% to 97%). Periods of low ground cover in the heavy grazing catchment were associated with a shift in the dominant tussock grass, from purple pigeon grass to buffel grass, whereas the highest ground cover was during the dominance of Indian couch in the near absence of tussock grasses.

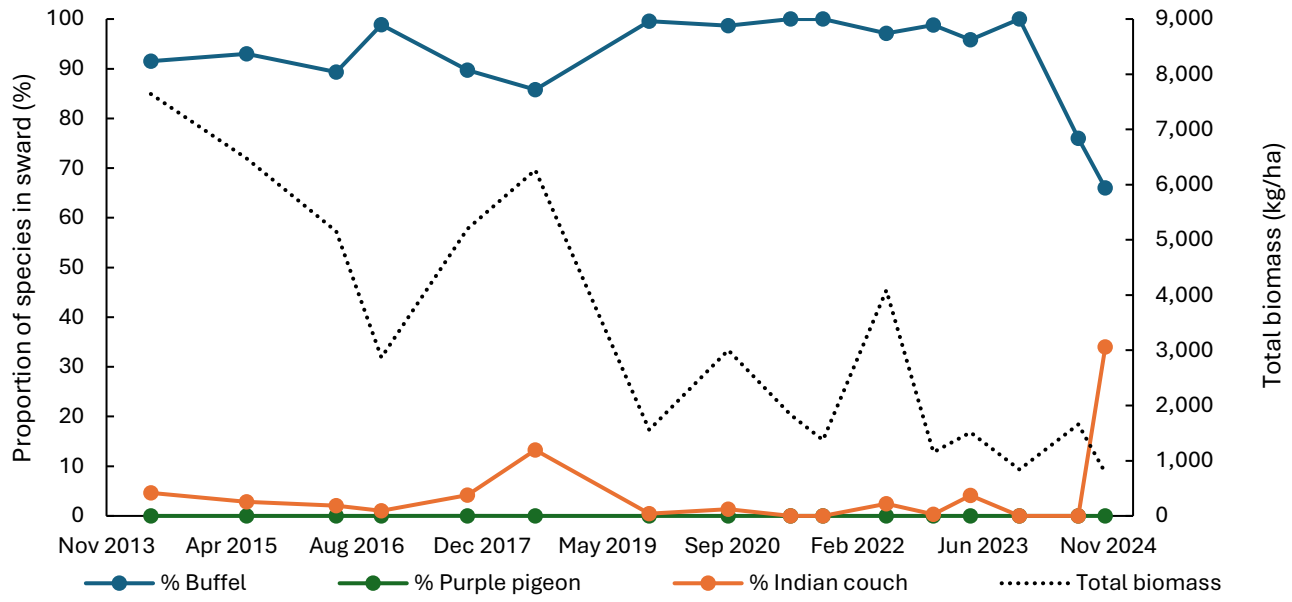

Figure 1. The proportion of buffel grass, Indian couch grass, purple pigeon grass and the total biomass of pasture under conservative grazing.

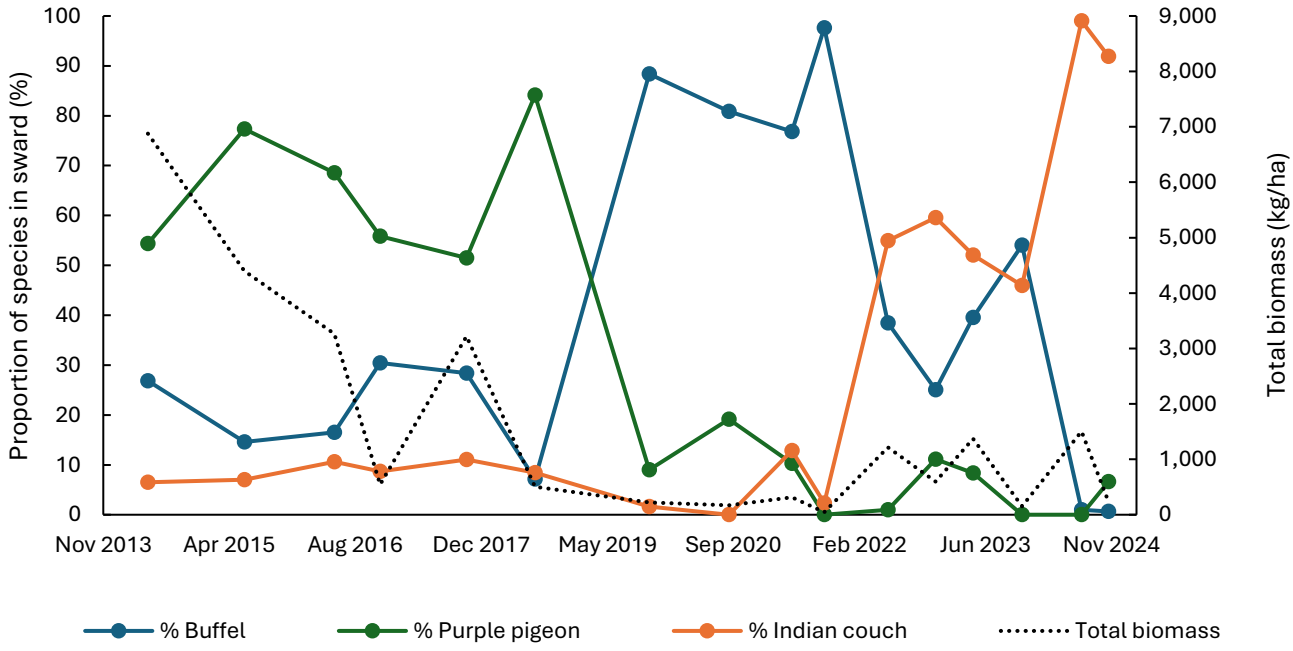

Figure 2. The proportion of buffel grass, Indian couch grass, purple pigeon grass and the total biomass of pasture under heavy grazing.

Discussion

This study was conducted during one of the driest periods in European history. Seven years of below average rainfall is atypical in the observed record, only happening twice since 1890. The previous occurrence was the Federation Drought which totalled an additional 100 mm of rainfall compared to the drought during this study. Drought was a substantial stressor to the pastures, as shown by the decline in yield under conservative grazing

well below the 3,000 to 4,000 kg/ha typically seen in that catchment (Radford *et al.* 2007). Failure to lower grazing pressure from 2023 onward likely accounts for the rapid decline in buffel grass, and the corresponding increase in Indian couch due to reduced competition.

The three shifts in species composition under heavy grazing likely occurred because of the cumulative stresses of drought and overgrazing, given that purple pigeon and buffel grasses have contrasting responses to these stressors. Purple pigeon grass is intolerant of continuous heavy grazing and will not survive (Scattini 2008). Conversely, buffel grass is very tolerant of regular grazing and will withstand considerable grazing once established (Skerman and Riveros 1990; Cook 2007). The two species also have quite different rainfall requirements. Purple pigeon grass is considered drought tolerant, but not as much as buffel grass which is considered the most drought tolerant improved pasture species (Cook and Clem 2000; Cook 2007; Scattini 2008). Purple pigeon grass is recommended for regions with annual rainfall greater than about 450 to 500 mm (Skerman and Riveros 1990; NSW Government 2012). In contrast, buffel grass is recommended for regions with annual rainfall greater than about 300 to 350 mm (Humphreys and Partridge 1995; NSW Government 2012). Annual rainfall was marginal for purple pigeon grass in three of the study years, whereas it was only marginal for buffel grass in one year.

The effect of heavy grazing was evident in the declining biomass of all three pasture species over time. While purple pigeon grass was no doubt stressed by record below average rainfall in 2017, it was able to respond to rainfall the following year and maintain a high proportion of the total pasture biomass. However, the combined effects of overgrazing and drought in 2019 to an already stressed plant caused a substantial decline in the proportion of purple pigeon grass in the pasture. The decline of purple pigeon grass likely provided buffel grass a competitive advantage, with buffel grass increasing to average more than 80% of pasture composition until 2021. At this point the proportion of buffel grass in the pasture dropped substantially, prior to a partial recovery, becoming co-dominant with Indian couch grass prior to the dominance of Indian couch grass.

Differences in palatability between purple pigeon and buffel grass may explain differences in initial pasture composition but are unlikely to have had substantial influence on the final pasture composition. Purple pigeon grass is typically considered less palatable than buffel grass, so may have received less grazing pressure, and hence accounted for more of the total pasture biomass during the high biomass period at the start of the study. However, when the proportion of purple pigeon grass in the paddock dropped abruptly in 2019, there was only about 220 kg/ha of feed on offer in a paddock stocked at about 1 ha/adult equivalent, which suggests palatability would have been a substantially lower concern for animals compared to simply finding enough forage to maintain intake.

Interpretation of ground cover without consideration of biomass and species composition provided an incomplete assessment of catchment and pasture condition. The decline in biomass and change in species composition when tussock grasses were dominant was reflected in low ground cover observations. Counterintuitively, the highest ground cover observation of 97% was the final sampling period, which yielded only 230 kg/ha of biomass from a sward containing greater than 90% Indian couch. This suggests that ground cover alone is a poor metric for assessing land condition when Indian couch is the dominant pasture species.

In contrast to changes in pasture composition and cover that occurred under heavy grazing, there was little change in pasture composition and cover under conservative grazing. This demonstrates that drought alone was not responsible for the changes in species composition under heavy grazing, as both catchments were subjected to the came climatic sequence. Heavy grazing was a key driver in the loss of valuable improved pasture species and the subsequent dominance of Indian couch in that catchment. This mechanism was illustrated under conservative grazing in 2024, when failure to lower grazing pressure resulted rapid decline of buffel grass, and a corresponding increase in Indian couch due to reduced competition.

The implications of heavy grazing extend beyond decreased biomass, changed species composition and the dominance of Indian couch in a formerly productive tussock pasture, as all these factors contribute to a decline in beef production (Stokes *et al.* 2023). Furthermore, from 2015 to 2018, heavy grazing more than tripled runoff, peak runoff rate and total suspended solids lost in runoff compared to conservative grazing (Thornton and Elledge 2021). Total nitrogen lost in runoff increased by a factor of 1.6 while total phosphorus loss increased by a factor of 2.6 (Thornton and Elledge 2021). The increased loss of rainfall as runoff and the subsequent loss of nutrients undermines the resilience of pastures to overgrazing and the invasion of Indian couch. Management practice change towards conservative grazing with consideration of safe long-term carrying capacity is essential to halt land degradation and begin improving land condition.

Acknowledgements

This study was funded by the Queensland Department of the Environment, Tourism, Science and Innovation, and the Australian and Queensland Governments Paddock to Reef Integrated Monitoring, Modelling and Reporting program. The study has continuously held approval to use animals for scientific purposes, currently granted by the Queensland Department of Primary Industries Animal Ethics Committee (SA 2024/12/969).

References

Beutel TS, Trevithick R, Scarth P, Tindall D (2019) VegMachine.net. online land cover analysis for the Australian rangelands. *The Rangeland Journal* **41**, 355-362.

Cook BG (2007) Buffel grass. Available at https://tinyurl.com/mud59ysc [Accessed 05 11 2024]

Cook BG, Clem RL (2000) Which grass for where? *Tropical Grasslands* **34**, 156-161.

Humphreys LR, Partridge IJ (1995) 'A guide to better pastures for the tropics and subtropics.' (NSW Ag: Newcastle)

NSW Government (2012) 'Pasture varieties used in New South Wales 2012-2013.' (NSW DPI)

Queensland Government (2019) SILO Patched Point Datasets for Queensland. Available at https://tinyurl.com/3h4zp2nh [Accessed 05 11 2024]

Radford BJ, Thornton CM, Cowie BA, Stephens ML (2007) The Brigalow Catchment Study: III. Productivity changes on brigalow land cleared for long-term cropping and for grazing. *Australian Journal of Soil Research* **45**, 512-523.

Scattini W (2008) Purple pigeon grass. Available at https://tinyurl.com/5n6teyat [Accessed 05 11 2024]

Skerman PJ, Riveros F (1990) 'Tropical grasses.' (Food and Agriculture Organisation of the United Nations)

Stokes C, Bartley R, Abbott BN, Hawdon AA, Kinsey-Henderson AE (2023) Long-term monitoring and modelling of pasture regeneration and water quality from a Bothriochloa pertusa site in the Great Barrier Reef catchments. *Rangeland Journal* **45**, 12-26.

The State of Queensland (2018) Reef 2050 Water Quality Improvement Plan 2017-2022. Reef Water Quality Protection Plan Secretariat.

Thornton CM, Elledge AE (2021) Heavy grazing of buffel grass pasture in the Brigalow Belt bioregion of Queensland, Australia, more than tripled runoff and exports of total suspended solids compared to conservative grazing. *Marine Pollution Bulletin* **171**, 112704.

Tothill JC, Hargreaves JNG, Jones RM (1978) 'BOTANAL - A comprehensive sampling and computing procedure for estimating pasture yield and composition. 1. Field Sampling.' (CSIRO: St Lucia, Qld.)