Case study: Grazing for climate resilience

The challenge

Maintaining access to high quality forage in the face of variable rainfall regimes is a challenge, particularly in the context of predicted increases in climate variability and, in many places, drying trends[1-3]. Pasture species vary in their ability to withstand prolonged dry periods, reflecting their rooting and water-use strategies[4]. However, since both drought and grazing reduce aboveground plant biomass[5,6], there is potential for additive effects on pasture productivity and persistence when drought and high grazing pressure co-occur. Knowledge of how species perform under different combinations of grazing and rainfall can guide decisions on stocking rates and timing under differing climate scenarios.

PACE: rainfall x grazing experiment

A field experiment was established at the Pastures and Climate Extremes (PACE) facility at Western Sydney University, Richmond, NSW (Fig 1). Perennial pasture species were grown under dry (578mm) or wet (1080mm) rainfall scenarios, with low (~12 weeks) and high (~4-6 weeks) frequency biomass removal (clipping), simulating differing grazing regimes. Rainfall treatments commenced in December 2022 and clipping treatments began in June 2023; data presented here are from June 2023 to February 2025.

Figure 1. *Temperate pasture swards at the PACE facility.*

Implications for grazing management under dry conditions

- Reducing the intensity of grazing (stocking rates and/or time on pasture) during dry years can be particularly beneficial for pasture performance during spring, when legume growth is most sensitive to water stress and defoliation.
- The combination of strong reductions in legume biomass and an increase in the amount of dead material under dry, frequently grazed conditions has implications for pasture quality (lower crude protein concentrations and digestibility), as well as quantity.
- Perennial herbs with deep taproots and large belowground carbohydrate stores, such as plantain, appear to be less affected by grazing and low rainfall than legumes and grasses, and may be a particularly valuable forage under drier conditions.

Six replicate plots per combination of rainfall x grazing treatments were sown with five perennial, temperate pasture species – two C_3 grasses, two legumes and a herb (Table 1).

Table 1. *Pasture species in the rainfall x grazing study*

Species	Common name	Cultivar
Medicago sativa	Lucerne	Sardi 7
Onobrychis viciifolia	Sainfoin	Othello
Dactylis glomerata	Cocksfoot	Convoy
Bromus catharticus	Prairie grass	Matua
Plantago lanceolata	Plantain	Grasslands Lancelot

Seasonal productivity responses to differing rainfall and grazing regimes

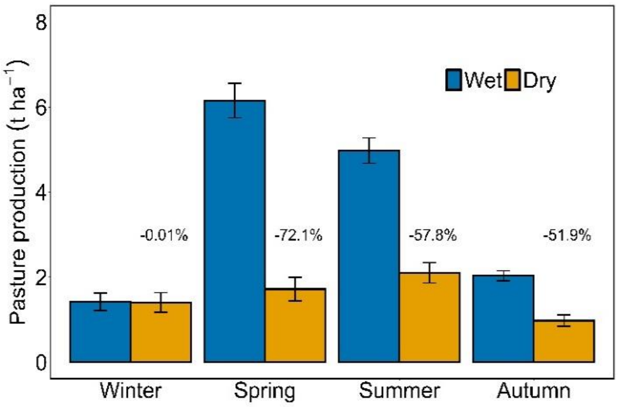

***Figure 2**. Mean seasonal pasture production (t ha^{-1} dry biomass ± standard error) under wet and dry rainfall regimes (winter 2023-summer 2024/5).*

Overall productivity for the 21 months was significantly reduced (-57.9%) under the low rainfall regime (dry: 5.71 tonnes/ha^{-1}), relative to high rainfall (wet: 13.5 tonnes/ha^{-1}). The biggest rainfall-related productivity decline was seen in spring (-72.1%). Biomass in dry plots was 57.8% lower in summer and 51.9% lower in autumn but was unaffected by rainfall regime in winter (Fig. 2). Legumes – the most abundant plant functional group – exhibited a stronger rainfall-related decline in productivity (-64%) than the other plant groups (Fig. 3). Grasses contributed <10% to total productivity and had a 56% reduction under low rainfall, while plantain was 32% less productive in dry, relative to wet, plots (Table 2).

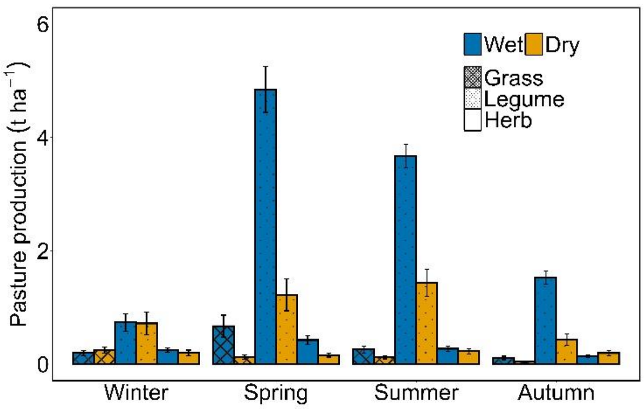

***Figure 3.** Pasture production (tonnes/ha^{-1} dry biomass ± standard error) by plant functional group under wet and dry rainfall regimes across seasons (winter 2023-summer 2024/5).*

While grazing can trigger compensatory growth, resulting in higher overall yields[7,8], it was found that more frequent clipping in fact reduced overall productivity by 27.9%, relative to less frequent biomass removal. The biggest reductions were seen in spring (-51.4%) and autumn (-24.1%), and there were minimal clipping effects during summer (-12.6%) (Figure 4). This suggests that frequent depletion of below ground carbon stores – which drive vegetation regrowth – is particularly detrimental during springtime for the species in this study.

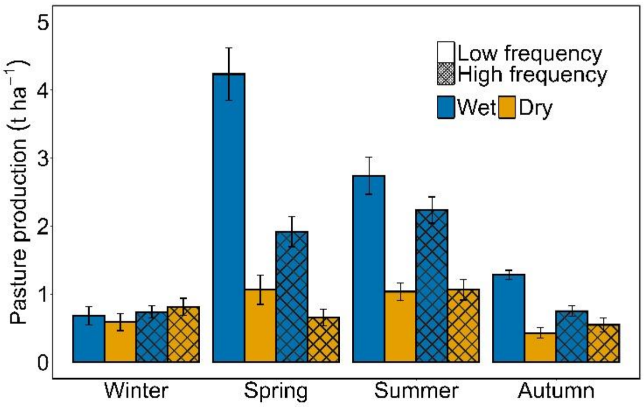

***Figure 4**. Pasture production (tonnes/ha^{-1} dry biomass ± standard error) under high and low simulated grazing (clipping) frequencies across seasons (winter 2023–summer2024/5).*

Interactions between grazing frequency and rainfall

Simulated grazing (clipping) and rainfall treatments interacted to affect sward productivity; high (relative to low) frequency clipping reduced overall productivity by 36.5% under high rainfall but had no significant effect (-3.2%) under low rainfall across the full 21-month study period (Table 2, Figure 5).

Figure 5*. Temperate pasture plots under (a) Wet and (b) Dry rainfall regimes with low-frequency clipping, or (c) Wet and (d) Dry rainfall regimes with high-frequency clipping.*

However, responses varied by season and across plant functional groups; during springtime, frequent clipping under low rainfall (Dry high-frequency (HF)) reduced biomass production by 84.5% compared to less frequent clipping under wet conditions (Wet low-frequency(LF)), with legumes experiencing the biggest reduction (-90%) during this period. Interestingly, more frequent clipping also increased (+81%) the overall amount of dead material under the low (dry) rainfall regime, with dead biomass representing 21% of total production in this treatment combination (Table 2).

Table 2. *Pasture production (tonnes/ha^{-1} dry biomass over a 21-month period) and treatment significance under Dry and Wet rainfall regimes, combined with high- (HF) and low- (LF) frequency grazing (clipping) management.*

Treatment	Total	Grass	Legume	Herb	Dead
Wet-LF	16.59^{a}	1.654^{a}	12.719^{a}	0.447^{a}	1.774^{a}
Wet-HF	10.54^{b}	0.707^{b}	7.323^{b}	1.586^{c}	0.924^{bc}
Dry-LF	5.806^{c}	0.413^{b}	4.376^{cb}	0.364^{a}	0.652^{c}
Dry-HF	5.619^{c}	0.616^{b}	2.813^{c}	1.013^{b}	1.178^{ba}
Rain	***	***	***	**	**
Grazing	**	*	**	***	ns
Rain*Grazing	**	**	*	*	***

*Within a plant category, mean values sharing a superscript letter in common do not differ significantly. */**/*** represent significant treatment effects at P<0.05/0.01/0.001, ns indicates not significant.*

Key findings

- Dry conditions significantly reduced productivity (-57.9%), relative to wet conditions, with the biggest yield reductions seen in spring (-72.1%).

- More frequent “grazing” also reduced overall biomass production (-27.9%), with legumes and grasses more strongly affected than plantain, particularly during spring.

- Summed over the full 21-month study, more frequent clipping resulted in a large decrease in productivity under wet, but not dry, conditions. However, springtime productivity was significantly reduced by more frequent clipping under low rainfall, with dry, frequently clipped plots producing 84.5% less aboveground biomass than their wet, less frequently harvested counterparts. Legumes, which represented approximately two thirds of total biomass, experienced the biggest declines when frequently clipped under dry conditions.

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