640

Establishing perennial pastures at Yalda Downs, western NSW

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Abstract
The rangelands of NSW depend on rainfall driven native pastures to support privately managed grazing operations. The Perennial Pastures, Resilient Rangelands project aims to improve drought resilience by managing for biodiverse pastures with a focus on establishing and managing perennial species. Utilising a community of practice approach, landholders near White Cliffs collaborated with scientists and advisors to identify priority areas for restoration and implement innovative strategies to increase key perennial species. The group selected a stony plain on Yalda Downs north of White Cliffs and the landowner agreed to implement a demonstration site to trial regeneration strategies chosen by the group. Water ponding has been successfully demonstrated to improve scalded soils with low water infiltration, providing opportunities for seedling establishment leading to increased vegetation cover and plant diversity. However, establishment of key perennial grass and shrub species in these ponds is often limited. At Yalda Downs ripping, seeding of perennial grass and shrub species, and grazing exclosure treatments within water ponds were established in August 2023. Multiple rainfall events in early 2024 assisted with the early germination of perennial species (inc. *Astrebla spp*., *Panicum decompositum*, *Chloris truncata)* in the seeded treatments. The effectiveness of this trial is being monitored and species counts have shown establishment of sown seed and additional perennial species.

Introduction
Perennial species are important in the rangelands for both sustainability and productivity, protecting the soil surface during dry periods and being able to persist through dry seasonal conditions. A combination of prolonged droughts and high levels of total grazing pressure has resulted in considerable land degradation, including soil erosion and a loss of productive palatable, perennial species over extensive areas in western NSW rangelands (Green, 1989).

Regeneration strategies are often required to improve water infiltration and encourage seed germination and survival in degraded landscapes (Gintzburger, 1987; Kinloch and Friedel, 2005). Water ponding, water spreading and diversion banks have been used throughout Australia as an effective restoration method. Productivity has been reported to double within areas that have been water ponded compared to uneroded

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areas on the same soil (Cunningham, 1974a). Ripping and furrowing can encourage plant establishment by collecting moisture, litter, seed and reduce soil water evaporation (Gintzburger, 1987; Green, 1989; Rorive and Bainbridge, 1993). Attempts to rehabilitate semi-arid woodlands in Australia by reseeding bare areas with grasses have often been unsuccessful, and limited by seed supply (Broadhurst et al., 2015). Many studies concluded there is adequate seed naturally available to facilitate regeneration in the landscape. In addition, changes to grazing management can promote desirable plant species. In western NSW rangelands a tactical grazing approach is recommended (Hacker and McDonald, 2021) and resting after a major rainfall event allows establishment of key species (Hacker and Tunbridge, 1991; Sparrow *et al*., 2003). The aim of this study is to trial if ripping, seeding and grazing exclosure within ponding banks increase palatable perennial species density and diversity.

Methods

A demonstration site was established in 2023 located on an eroded and scalded area of Yalda Downs, ~60 km north of White Cliffs in far west NSW, Australia (30°18'28"S 143°01'28"E). The site is gently sloping, located in the Oakvale land system (Walker, 1991) with vegetation historically being primarily *Astrebla* (Mitchell Grass) grassland and chenopod shrubland, although very few perennial grasses were present. The climate is arid with an average annual rainfall of approximately 200mm.

One hundred and forty eight water ponds were established in July 2023 across ~80ha of predominately bare, stoney ground within a large (10,069ha) paddock on Yalda Downs. Ponds were constructed with a 12H Caterpillar (CAT) grader with a 14ft blade and rippers attached on the back, creating a bank ~0.5m high, ponding up to 10cm of water.

Five ponding banks of similar design were selected for monitoring in three replicate areas (15 ponds total), each receiving a different treatment:

1. Control (P), ponding only, without rip lines along the base of the pond
2. Ripping (PR), ponding with rip lines along base of pond
3. Ripping and Seeding (PRS), ponding with rip lines and seed added to ripped lines
4. Ripping and grazing exclosures (PRC), ponding with rip lines, and a 6 x 24m cage established at base of pond
5. Ripping, seeding and grazing exclosure (PRSC), ponding with rip lines and seed added to rip lines, and a 6 x 24m cage established at the base of the pond

Ripping treatments

Using a 12H Caterpillar (CAT) grader, 5 tines ripped the soil to ~30cm depth, with rows ~30cm apart, total 2m width, at the base on the topside of the ponding bank.

Seeding treatments

A list of desirable perennial species was generated for the site in collaboration with the Community of Practice and advisors. Not all desirable species were able to be sourced. Seed species sown included: *Cloris truncata, Astrebla lappacea, Astrebla pectinata, Pancium decompositum, Einadia nutans, Rhagodia spinescens, Enchylaena tomentosa, Atriplex semibaccata, Atriplex vesicaria* and *Atriplex nummularia*. For treatments with seed, seed was spread throughout the whole pond. Seeds were sown by hand, walking the length of the pond distributing seed evenly.

Cage treatments

A 6 x 24m cage was erected at the base of the pond, running parallel to the pond bank, constructed out of 5mm wire, 150mm x 100mm mesh, 1100mm high. Cages were erected in March 2024, to exclude the treatment area of being grazed by livestock and unmanaged herbivores. Although the paddock had been destocked of livestock between the time of ponding, sowing seed and the erection of the grazing exclosures.

Vegetation monitoring

At each ponded treatment (P, PR, PRS, PRC, PRSC), a permanent 20m transect was established at ~3m from the centre (top) of the bank, running parallel to the bank, with a star picket post at each end and a cattle tag denoting the treatment name and transect start. For treatments with exclusion cages, the transect was located inside the cage. The start and end points of each transect were marked on GPS and photo points (portrait and landscape) established at each transect.

Baseline monitoring of treatments was undertaken in August 2023, approximately 1-3 weeks after construction of the ponds and prior to any rainfall following the ponding. Measurements were repeated in September 2024.

Percent cover of each species present, herbage mass and percent cover of ground cover components (plant, litter, cryptogram, rock, course woody, dung, bare) was estimated in ten 0.5 x 0.5m quadrats along each 20m transect. The number of key perennial plant species within each quadrat was also recorded. All species one meter either side of the transect (40m^2 total) were identified, and the number of individual plants of key perennial species within this area counted.

In April 2024, ~7 months after seed was sown, establishment counts of the sown species were undertaken by recording the number of individual plants rooted within 0.5m either side of the 20m transect (total area 20m^2).

Mixed effect models using the lme4 package in R (Bates et al. 2015; R Core Team 2021) were used to test the impact of treatment on plant and litter cover and herbage mass (log+1 transformation applied), with replicate and pond included as random effects. Anova was performed to test for significant differences between treatments (P<0.05).

Results

Rainfall

Summer rainfall recorded near the site resulted in totals of 54mm in December 2023, 98.5mm in January 2024 and 101mm in February 2024.

Groundcover and biomass

Overall, in September 2024, approximately 12 months after establishment of the trial, there were no significant differences in vegetative (plant+litter) ground cover (P = 0.132), with considerable variability depending on the pond and replicate (Fig. 1a). Herbage mass was significantly higher in the PRS treatment than the PR treatment (P = 0.043), but there were no other significant differences between treatments (P>0.05, Fig. 1b)

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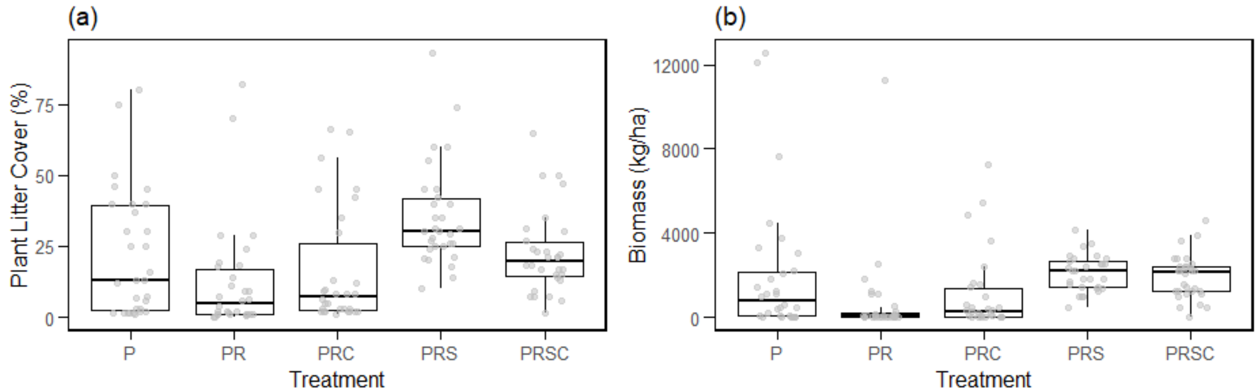

Fig 1. Boxplots of a) vegetative (plant + litter) cover and b) herbage mass across treatments in September 2024. P = ponding only, PR = Ponding and ripping, PRS = ponding, ripping and seeding, PRC = ponding, ripping and grazing exclosure, PRCS = ponding, ripping, seeding and grazing exclosure.

Species establishment

The seeded treatments (PRSC and PRS) saw *Chloris truncata* being a dominant species of sown seed with a ~9 plants per m^2 established, followed by a large count of *Panicum decompositum* and *Astrebla spp.* (Fig. 2). Other sown species, including *Einadia nutans, Rhagodia spinescens, Enchylaena tomentosa, Atriplex semibaccata, A. vesicaria* and *A. nummularia* were not present in transects in April 2024, and still had no to very low counts on assessment in September 2024.

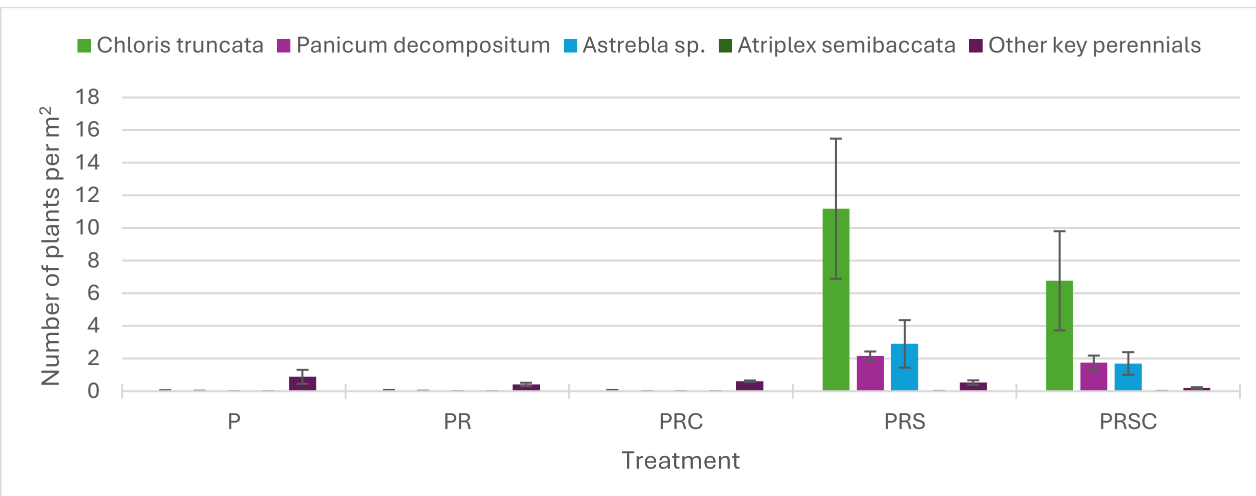

Fig 2. Average number of individual plants per m^2 of sown perennial and other perennial species recorded in different treatments in April 2024 (± 1 standard error) P = ponding only, PR = Ponding and ripping, PRS = ponding, ripping and seeding, PRC = ponding, ripping and grazing exclosure, PRCS = ponding, ripping, seeding and grazing exclosure.

Discussion

Summer rainfall in January and February of 2024 provided a germination opportunity for the seed that was sown the previous spring and continued favourable conditions throughout 2024 alongside the water ponding resulted in an increase of ground cover (>10%) in all treatments.

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It has been well documented that supply and access to native species seed for large restoration projects can be limited and not efficient economically, however in this trial the treatments without seed showed a low response in perennial germination and ground cover compared to the treatments that had been seeded. Six different suppliers were required to source the quantity of seed necessary for this trial, and due to limited availability, we were unable to ensure local provenance, as would be preferable (Broadhurst *et al.* 2017). Access to limited species can also have an impact on the project outcomes and overall restoration (Broadhurst *et al.*, 2015; Broadhurst *et al.* 2017). This demonstration site used 13.51kg of seed and included differing rates of 10 different species of perennial grasses and shrubs. Although there has been success in germination and establishment of some species in the seeded treatments, the efficiencies in accessing the seed along with the economic investment should be considered alongside the risk of relying on the rainfall. By targeting seeding within water ponds this risk was reduced by increasing water availability for seed germination and establishment. Targeted seeding such as this may be a more practical and efficient approach to restoring perennial species in degraded landscapes more broadly in NSW rangelands. Early results (12 months from seeding) did not find an increase in ground cover, biomass or species germination with the removal of grazing (cage treatments). However, as the paddock was initially destocked, and later grazed by only 8 cattle, and with a favourable season reducing pressure from unmanaged herbivores within the ponded trial area, this was to be expected.

The ponding and ripping combination treatment (PR) had the lowest levels of ground cover, biomass and species establishment particularly in comparison to the ponding treatment alone (P). This was also evident when a cage was added to the treatment (PRC). Studies have shown that the effectiveness of ripping is highly dependent on the soil type and annual rainfall. Friedel at al. (1996b) found that soil disturbance techniques such as discing and pitting in the Northern Territory were successful when there was no more clay than a sandy loam.

When considering the efficiency of regeneration methods, it is important to consider the economic trade-offs and treatments across a large scale (Friedel at al.,1996b). The success of water ponding and seeding is evident in this trial however the cost relative to benefit of seeding is still in question on a broad scale application. The success of ripping should be considered alongside other treatments and soil types while a longer timeframe is required to assess the impact of the exclosures to control grazing.

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