Herd effect and deep ripping to restore claypans in western New South Wales rangelands

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Abstract

Historic soil degradation, primarily due to overgrazing and drought, has led to the widespread formation of bare, scalded 'claypans' throughout the rangelands of south-eastern Australia. Mechanical interventions such as ripping and water ponding have been used to restore claypans over the last ~70 years, with varying success. Strategic management of livestock to restore degraded land has increasingly gained attention in recent decades as an alternative to resource-intensive mechanical restoration methods or complete destocking. This study compared the effects of intense cattle impact (~400-600 cattle held overnight on 0.5 ha of claypan + hay) with deep ripping (a single tine, to 30 cm depth with one meter row spacings) across three replicate claypans on 'Bokhara Plains' in the semi-arid rangelands of western New South Wales (NSW), Australia. Two years following the interventions, results show a significant increase in plant cover (up to 50%) and diversity for both the cattle and ripping treatments, compared to the control (initially 0% cover), and a reduction in salinity of the upper soil profile. Differences in vegetation cover between the cattle and ripping treatments were less obvious, though there were differences in plant composition with higher species richness under the cattle treatments at some replicates. These results demonstrate the effectiveness and need for targeted management to restore scalded areas and regenerate land condition in rangeland grazing systems.

Introduction

Historic soil degradation, primarily due to overgrazing and drought, has led to the widespread formation of bare, scalded 'claypans' throughout the rangelands of south-eastern Australia (Cunningham 1987). These soils are often saline and dispersive, with sealed surfaces that constrain plant emergence, water infiltration and nutrient cycling. With no or little vegetation growth or cover, they are vulnerable to wind erosion and unable to support livestock production, and even under conservative grazing management, many have failed to recover naturally. Increasing water infiltration (and the subsequent benefits this brings by leaching salts and reducing salinity), surface soil roughness and niches for seed to establish is required to effectively restore degraded scalds (Cunningham 1987, Green 1989).

In extensive rangeland grazing systems of semi-arid NSW, Australia, this has historically often been achieved through mechanical interventions including deep ripping, furrowing or water ponding (e.g., see Cunningham 1967, 1970, Green 1989; Wakelin-King 2011). 'Herd effect', is purported to achieve similar benefits through intensive trampling (hoof action) of livestock to break the soil surface and provide the addition of nutrients and seed through livestock dung and urine (Savory 1989). However, the use of strategic livestock management (herd effect) to restore degraded land has not been scientifically trialled in NSW rangelands.

This trial sought to understand how deep ripping or high density and intensity grazing by cattle for short durations (herd effect) affects the restoration of soil and pasture on degraded scalds in north-western NSW.

Methods

The trial was located on 'Bokhara Plains', approximately 30 km north of Brewarrina, NSW Australia (29º40'29"S, 146º56'37"), on the Barwon River floodplain, Wongal Land System (Walker, 1991). The climate is semi-arid, with an average annual rainfall of 385 mm and a summer dominant rainfall pattern. Soils on Bokhara Plains are predominantly grey vertosols. Vegetation is comprised of open woodland and grasslands, with isolated whitewood and coolabah and understorey of Mitchell grass (*Astrebla* spp.), Native millet (*Panicum decompositum*), forbs, annual and perennial subshrubs (*Atriplex* spp., *Sclerolaena* spp., *Maireana* spp., *Rhagodia spinescens*). Across Bokhara Plains, and the broader landsystem, there are large areas of scalds, characterised by very low vegetation cover and saline and sodic soils. Three scalded areas across different paddocks (4 – 10 km apart) on Bokhara Plains were selected as replicates of the trial. Each replicate claypan was divided into ~0.5 ha plots which were randomly assigned one of the following treatments: 1) herd effect (cattle); 2) ripping; and 3) control (no treatment). Further detail on treatments is provided below.

Herd effect treatment

At replicates 1 and 3, cattle (400-600 Livestock units, LSU) were held overnight on plots three times between May 2022 and April 2024. At replicate 2, cattle (680 LSU) were held on the plot for two hours in April 2022 (one time only). Prior to introducing cattle, on each occasion two large haybales were spread throughout the plot to introduce organic material and increase activity and movement of livestock in the plot. Each replicate experienced animal impact at a different timepoint.

Ripping treatment

In each replicate, a single tine behind a tractor was used to rip to depth of ~30cm, in a spiral formation. Each rip line was approximately 1 m apart. Replicates 2 and 3 were ripped in April 2022, while replicate 1 was ripped in September 2022 (the same time that cattle initially impacted the herd impact plot).

Vegetation and soil monitoring

In April 2022 (prior to installation of treatments), April 2023 and June 2024, ground cover (percent cover of plant, litter, cryptogam, coarse woody debris, dung and bare ground), herbage mass and plant composition (percent cover by species) was assessed in 0.25m^2 quadrats every 10 m (replicates 1 and 3) and 15 m (replicate 2) along three transects in each treatment plot (7 quadrats per transect, 21 quadrats per plot). At five permanent locations in each plot, all species within a larger 5x5m quadrat were identified. In June 2024, seven soil cores were collected along each transect and composited by depth 0-5cm, 5-10cm, 10-20cm and 20-30cm. Salinity (electrical conductivity, ECe) was assessed through laboratory analysis (Shaw 1999; Rayment and Lyons 2011; Method 5A2b and 3A1) to estimate effects of treatments on soil salinity.

Results

Vegetation cover was greater under the cattle treatment relative to the control at two of the three replicate scalds, while the ripping treatment had a positive effect across all three scalds (Fig. 1). Compositional differences between the three treatments were most apparent in the third replicate, which included a greater proportion of native perennial grass (e.g., *Eragrostis setifolia, Sporobolus caroli, S. actinocladus, , Tripogon loliiformis)* and non-native perennial grass *(Lolium perenne*, assumed to be imported with the hay) cover in the cattle treatment than the ripping and control treatments. Species richness was greater in the cattle treatments at the first and third replicates, while the control and ripping treatments had similar richness values to each other across all replicates (Fig. 2). Two years post cattle and ripping treatment, salinity (EC) of the upper soil layers (0-20cm) at replicates 1 and 3 was lower under cattle and ripping, while differences at replicate 2 were smaller and constrained to the 0-5 cm surface layer (Fig. 3).

Discussion

Both ripping and high intensity animal impact for a short duration in combination with additional organic material (hay) had a positive impact on the restoration of degraded scalds across Bokhara Plains, increasing ground cover and plant diversity and decreasing soil salinity. The greatest response (including a reduction in the amount of bare ground and >50% increase in plant and litter cover) was apparent at the third replicate where cattle had impacted the area overnight three times in the two years prior to the final monitoring occasion. Replicate 2 experienced the least cattle impact, with only two hours of cattle impact in April 2022, more than two years prior to final sampling, and had the smallest response, similar to that of the control treatment. This variability in response highlights the potential role that the timing, duration and frequency of animal impacts to achieve desirable results and suggests achieving greater disturbance by holding livestock for longer (overnight) is more effective than one-off, very short periods of time.

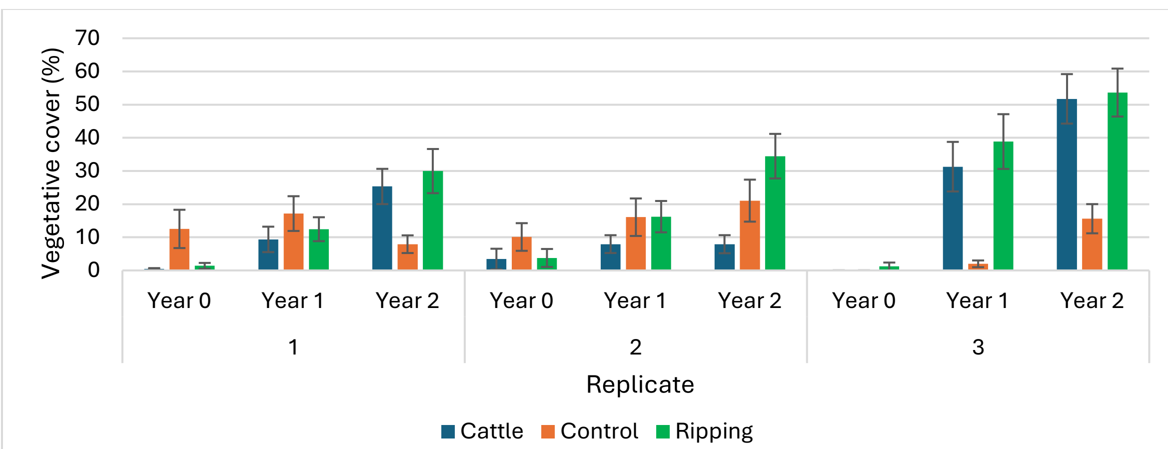

Fig 1. Average vegetative (plant and litter) cover for cattle, ripping and control treatment plots across three replicate scalds, measured prior to trial installation in April 2022 (Year 0), April 2023 (Year 1) and June 2024 (Year 2), ± 1 standard error.

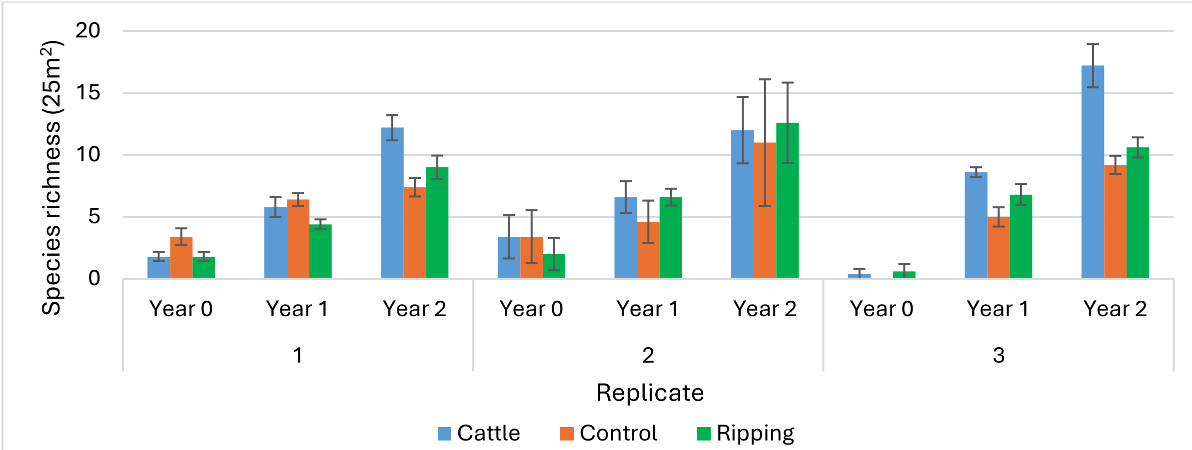

Fig 2. Average species richness (number of plants per $25m^2$) for cattle, ripping and control treatment plots across three replicate scalds, measured prior to trial installation in April 2022 (Year 0), April 2023 (Year 1) and June 2024 (Year 2), ± 1 standard error.

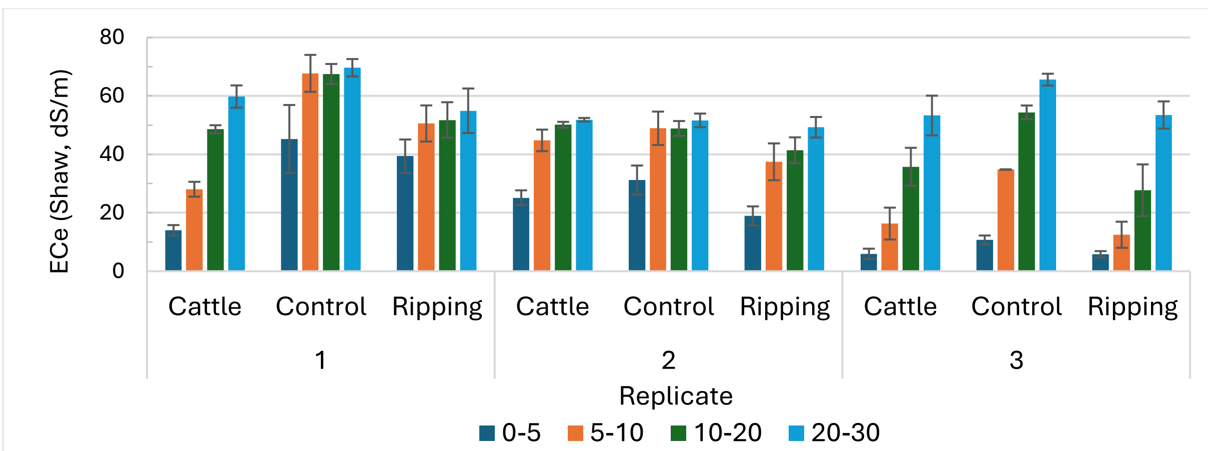

Fig 3. Electrical conductivity (ECe, Shaw 1999) of soil profile layers (0-5cm, 5-10cm, 10-20cm, 20-30cm depth) for cattle, ripping and control treatment plots across three replicate scalds in June 2024, two years after treatment, ± 1 standard error.

There are few published studies on the use of herd effect to restore degraded rangelands, and no studies we are aware of compare with mechanical restoration methods such as ripping. However, positive results observed in this study are similar to those reported by Barnes and Hibbard (2016), where forage growth was significantly greater one year following animal impact in night pens. The benefits of ripping to rangeland restoration have been documented throughout the world (e.g., Jones 1966; Miyamoto et al. 2004), however, long-term effectiveness of these treatments is often dependent on soil type (Friedel et al. 1996). The application of high-density animal impact in this study was in conjunction with addition of organic material (hay) and we are therefore unable to separate the potential impacts of herd effect and the organic material. Seed from the hay likely contributed to a proportion of plant growth observed within the herd effect treatments (e.g., *Avena sativa* and *Lolium perenne*). Studies in Australia have documented beneficial effects of addition organic materials to create patches for resource capture and germination of perennial grasses (e.g., Bean et al. 2015).

The decrease in surface salinity under the cattle and ripping provides improved conditions for plant establishment and growth, providing a positive feedback cycle as increased plant cover further reduces the draw of salts to soil surface. Periods of above-average rainfall over the duration of the trial also resulted in some improvement in the control areas in 2023 relative to that recorded in 2021, however this increase was generally greater in the cattle and ripping treatments.

These results demonstrate the effectiveness of targeted management actions in restoring scalded areas on the Darling Riverine Plains. For long term remediation of these sites, it will be important to sustain the changes that have been achieved so far by continuing to carefully manage grazing pressure of both domestic and unmanaged herbivores. Further research examining the impact of timing of animal impact (i.e, in dry versus moist conditions), duration and frequency of impact, with and without addition of organic material, and combinations of both mechanical and animal impact is recommended, alongside continued monitoring of the trial site to understand long-term benefits of the management interventions.

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