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Put your money where success has been – a rapid review of interventions to improve pastoral land condition in the southern rangelands of Western Australia

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Abstract
The paper reports on a six-day study trip of rangeland regeneration efforts implemented between 1984 - 99 in the Goldfields Region of Western Australia (WA). Results of land regeneration efforts have been influenced by the extent and severity of degradation, fragility of soil type, episodic flooding and drought, and the degree of total grazing pressure (TGP) control. Locally endemic plant species fared better than sown native species. The long-term effect of cultivation has been variable as have the benefits of shallow water ponding. The benefit of any cultivation has depended on the proximity of seed source areas of native species. Plant establishment has been improved where the water ponding has made the surface soil more sodic and cracked. Deeper, longer-lasting ponding behind bulldozer-built banks has been effective in rehabilitating rangelands. A small study of fracturing hardpan with explosives has shown benefits. Measurement of Mulga (*Acacia aneura*) trees planted in water-ponded areas has allowed an assessment of mean annual increments of carbon that could inform future carbon farming initiatives in the rangelands.

Introduction

The WA Department of Primary Industries and Regional Development (DPIRD) Southern Rangelands Revitalisation Program (SRRP) supports pastoralists to improve land condition for livestock production. The SRRP is reviewing rangeland regeneration efforts to understand their short and long-term effectiveness, which will benefit pastoralists and other rangeland uses. The southern rangelands of WA have experienced long term degradation, with a mean of 25% in poor condition, and one per cent being severely degraded and eroded (SDE) (DAFWA 2017). More productive types of pastoral land have a greater proportion of degradation, reducing productivity and profitability. Government and land managers have spent decades trying to improve land condition on this very small area of SDE to the detriment of focusing on the management of the whole landscape. The best publication from WA on mechanical range regeneration remains Addison (1997). This bulletin describes many of the cultivation techniques used in the Goldfields and was informed by experience gleaned from sites such as those visited in this study.

The Goldfields has seen many changes over the past thirty or so years. Many pastoral leases are now held by mining companies and overseas financial interests with fewer owned by family entities. Climate change is leading to higher mean temperatures throughout the year, lower winter rainfall with increased occurrence of drought, and more intense rainstorms and, therefore, more flooding events (BoM 2024). There were several areas with mature dead Mulga, which is attributed to severe drought and high temperatures experienced in 2019 (Paul Axford, pers. comment). The feral goat eradication program (1993-8) temporarily reduced grazing pressure. Wild dogs and dingoes are no longer controlled and effectively ate the local sheep industry, driving the change to cattle production. Dogs, dingoes and an extended dry period (2019 – 2023), have greatly reduced grazing pressure by native and feral species. On our 1,000 km trip through the Goldfields, we saw a total of four kangaroos. Many pastoralists have entered into carbon farming projects based on the regeneration of above ground biomass.

Methods

Prior to our 6 day tour (21 – 26 October 2024) we obtained whatever old research plans, site assessments, reports, monitoring records and relevant papers we could find. A desktop assessment used time lapse remote sensing images to detect change, confirm locations to visit, and inform rapid assessment methods (Table 1).

Table 1. Range of rapid assessment techniques employed

Types of assessment / measurement employed	How assessments were used
Visual observations	Assess persistence of earthworks and influence on regeneration
Time lapse remote sensing	Assess direction of change
Photographs with GPS locations	Current condition and allowing for future re-assessment
Photos of monitoring sites	Present reassessment (need original monitoring photos)
Drone footage	Gradations in cover and soil conditions - for future detailed assessment
Report soil surface changes	Assess effects of water on cultivations and ponding banks
Soil penetrometer tests	Assess any long term benefits of cultivation
Plant species, locations and sizes	Assess effects of water ponding on plant establishment and growth
Trial plant / species survival	Assessment of plant species that established and matured
Native plant colonisation	Effects of cultivation and proximity to seed source areas
Cross section across ponds	Measure land slope and bank height
Canopy and height measurements of Mulga trees of known age	Assessments of annual increments in above ground biomass & carbon content that might inform future carbon farming and water ponding initiatives

Results

We assessed regeneration sites on 5 leases, one in the Southern Goldfields where the Mallen niche seeder was trialled, and 4 in the north-eastern Goldfields which variously received broad scale disc pitting, chisel ploughing, seeding, grader built banks and dozer built banks. Photo records show all the sites prior to treatment were in poor condition or SDE. Project files consistently identify a common purpose of demonstrating methods to rehabilitate degraded and eroded areas. North-eastern Goldfields rainfall in the year of assessment was greater than the median and above average. For the 6 years prior, it was below the median and average.

Cultivations and soils

Soil cultivation aims to provide a seedbed for plants to establish, and can extend winter and summer growth periods by increasing the amount and longevity of water infiltrating the rooting zone. Our penetrometer tests showed infiltration benefits from initial cultivation had been lost. On disc pitting cultivation from 1985, 14 pitted sites had a mean penetrometer depth of 6.8cm compared to 20 non-pitted sites that had a mean depth of 6.2cm. Disc pitted sites from 1984 on a more alluvial site adjacent to a waterway showed mean (n= 10) penetrometer readings of 8.2cm (pitted) and 4.6cm (non-pitted).

Most sites in the north-eastern Goldfields were on hardpan plain land units with shallow, restricted soil depth over hard pan. These areas once supported preferential grazing. (The Nambi site in Humpy paddock was an alluvial plain that exhibited saline and/or sodic conditions.) These are some of the most challenging areas to rehabilitate. Soil profiles commonly contained ironstone gravel. As cultivated soil fretted or eroded away, gravel was left behind on the soil surface.

Plant establishment

Fencing off trials from all forms of grazing is essential, as is fence maintenance if long term observations are to be made. The exclosures on Mungari (near Kalgoorlie) and Sturt Meadows (Browns Paddock) have remained stock proof, which allowed us to make some observations. Accessions of *Atriplex amnicola* (573, 577, 580, 586, 588 and 949) planted on cultivation by a Mallen niche seeder (Malcolm and Allen 1981) in the Browns Paddock exclosure established well, but were only assessed in 1985, the year they were planted. Judging by remains of stems, a few of each accession (4 to 12 plants) lived a long time, but eventually succumbed to local conditions. Alternatively, plants of some species sown by a Mallen niche seeder at the Mungari exclosure on Gumland Land System in a slightly wetter, more sheltered site have survived or have completed their life cycle and produced seeds. However, plants have not spread away from the cultivated lines.

Surviving examples of the species sown on Mungari include *Atriplex vesicaria, A. bunburyana, A. nummularia,* and *Maireana pyramidata*. Other species have since established inside the exclosure, including *Cratystylis subspinescens, C. conocephala, Eremophila scoparia, Maireana georgii, Ptilotus exultatus, P. obovatus* and *Aristida contorta*. This and other locations where native species established on cultivated areas close to native seed sources may reflect that successional processes cannot be bypassed entirely by cultural interventions (Hacker 1989).

Different forms of ponding banks

'Accidental' shallow ponding in the Mungari exclosure caused by cultivation on the contour by the Mallen niche seeder, has made the soil more sodic and has increased cracking. This has caused a dense establishment of the colonising species mentioned above.

Grader-built ponding banks were established on Sturt Meadows around 1985-86. In the large catchments, such as flow through Browns and Top Bullock paddock on Sturt Meadows, overtopping runoff has washed away much of the soil from the grader-built banks, leaving a gravelly strew and a bank with minimal elevation (5-20cm). Most ponds remain bare, but, in places sufficient soil moisture has been retained to allow the establishment over time of a range of native species. As an example, along a 250m length of bank we found 8 *Acacia aneura* (Broad leaf), 1 *A. aneura* (Narrow leaf), 7 *A. craspedocarpa*, 6 *A. tetragonophylla*, 2 *Senna* spp, and 1 each of *Eremophila fraseri, Marsdenia australis* and *Solanum lasiophyllum*.

We visited bulldozer-built banks at Melita and Sturt Meadow Stations. The Melita banks were designed and supervised by John Law to reduce erosion and rehabilitate the area by impeding runoff and increasing soil infiltration. An explanation is provided in Law 1993. The work was a collaboration between the mining industry, pastoral industry and government. One of the first changes attributed to the banks was increased aquifer recharge. This caused Heron Well on the east side of the highway that that had been dry for a long time to start producing water again (John Law, pers. comment). Of the interbank areas, the banks decreased the length of slope for all locations typically increasing the stability of soil surfaces and vegetation density. The banks caused water ponding for approximately 5% of the overall area. This varied between interbank areas from less than 5% to up to 25%. Ponded areas experienced the greatest increase in vegetation density and size. It has taken several years before the banks have started to show their benefit. This was partly due to feral goat grazing some years ago (Jim Addison, pers. comment). Remote sensing scenes of the banks from April 2005 and July 2024 show a great improvement in the cover by native plants, particularly Mulga and halophytes (Fig. 1). Plants near the bank were twice as tall as those further away and had more than double the canopy area.

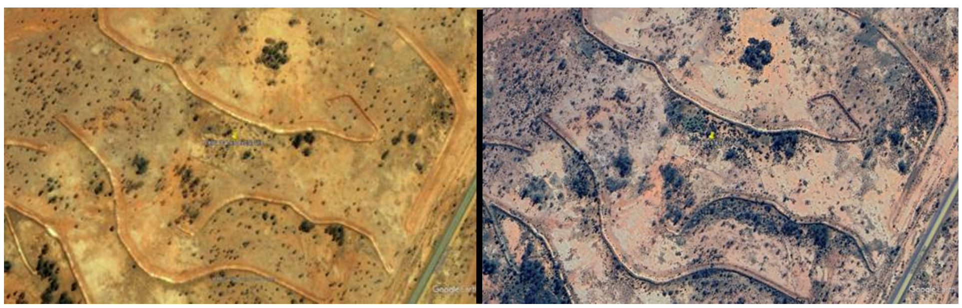

Fig 1. Centre of Melita 'Big Banks' system. Google Earth images in April 2005 (left) & July 2024 (right)

The bulldozer-built banks / ponds at Sturt Meadows were constructed as part of a research program of a consortium of Japanese universities. Here local trees (*Eucalyptus camaldulensis, A. aneura, E. salubris*) were planted in 1999 to assess growth rates. The site was on hardpan on severely degraded land that had been part of a stock route. On one research site the hardpan under all but one of the ponds (Pond 5) was fractured using explosives (Shiono et al. 2007). While many trees in all the other ponds have continued to grow, most trees in Pond 5 are dead. So, fracturing the hardpan (with explosives) will assist aquifer recharge, plant establishment, root penetration and plant nitrogen nutrition. Landscape rehydration works can be sub-surface as well as on the surface!

Based on an assessment of annual increments in above ground biomass and carbon achieved from Mulga trees of known age within ponding banks at Sturt Meadows, we estimated that a Mulga tree density of 10 trees/ha growing within ponding banks could sequester 0.4-3.0 tonnes C/100ha/yr. A density of 40 trees/ha within ponding banks might sequester 1.6-12.0 tonnes C/100ha/yr.

Discussion, Conclusions and Implications

Obtaining regeneration records was challenging and when available, mostly hard copy held variously by the Department, former Department staff, and lessee. Located records will be digitised before more records are lost. Some records may be found in journals (e.g. Williams 2002).

Of the areas that 39 to 41 years ago received cultivation, seeding, or grader banks, many have sustained minimal regeneration. It is hypothesised some initial plant germinations did not persist due to either degraded soils and landforms, limited natural seed sources, seasonal conditions, grazing impacts, or a combination of these. The data to explain the relative importance of ecosystem drivers was limited. The big banks sustained the greatest regeneration. The cost of bulldozer-built ponds might be hard to justify. However, where they have multiple uses (aquifer recharge, carbon farming, range regeneration) they may be of economic benefit, especially where pastoral and mining interests work together for mutual benefits.

Ongoing management and TGP control are essential. Wild dog predation has reduced grazing pressure from kangaroos and goats. This may assist control of TGP to improve outcomes from future regeneration events. Regeneration work should be preceded by investigating soil conditions (e.g. hardpan presence and depth, salinity and sodicity) and catchment characteristics. Addison (1997) contains some guidelines for cultivation under various soil conditions. Cultivation should be proximal to native seed source areas to extend the regeneration of native species while foregoing the expense of seed of less well acclimatised species. Grader-built banks are likely suited only to small catchments with controllable runoff to prevent overtopping.

Many regeneration efforts focus on the most noticeably degraded areas where recovery is slowest (Hacker 1989, Addisson 1997). Improvements to grazing systems and strategically located works (mechanical and land management) to arrest the progression of erosion into better condition asset areas, may provide a faster and greater return on investment. Short funding periods of up to three years acted against effective holistic planning and implementation which requires a long term (20-30 year) program.

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