



Empowering pastoral landowners through soil understanding and land management strategy

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Key words: participatory research; soils; pastoralism

Abstract

Rangeland soils in Australia are diverse and integral to the country's vast arid and semi-arid landscapes, covering approximately 75% of the continent (DAFF 2024). These soils are typically shallow, often but not always nutrient-poor, and have low organic matter due to the region's low rainfall, high evaporation rates, and sparse vegetation. Rangeland soils are commonly prone to erosion and salinity, especially when vegetation cover is disturbed. Despite their limitations, these soils support unique ecosystems and are used for extensive grazing, playing a critical role in Australia's agricultural and ecological systems. Sustainable management practices are essential to maintain their productivity and prevent degradation. Education, training, and support for pastoral land managers in the soil sciences is pivotal to protecting and enhancing rangelands systems, especially given the frequency and intensity of rainfall events that are predicted with future climatic variability. Shifting the focus of rangelands management back to the fundamentals of understanding soils from a whole of landscape perspective and adopting a “from the ground up” approach to pastoral productivity is re-empowering a new generation of pastoral land managers with knowledge and confidence to adopt regenerative land management tools.

Introduction

The South Australian Arid Lands (SAAL) Landscape Board region covers over **400,000 square kilometres**, making up more than half of South Australia (SAAL 2024). Characterized by expansive plains, low-lying scrublands, and distinctive ecosystems adapted to harsh conditions, including hot dry summers and cold winters, this vast area includes some of the driest climate zones and most ecologically significant landscapes in the state. Despite the challenging environment, the southern rangelands are rich in biodiversity and offer opportunity for productive grazing systems.

Comprehensive soil testing across rangelands regions can be expensive and, outside of crop production systems in more reliable rainfall regions, have largely been an uncommon practice. There are very little agronomic inputs or interventions that can be administered to rangelands soils to alter soil chemistry or initiate soil structural change in a cost-effective manner, and for this reason it is uncommon for intensive testing or review of soils to have been undertaken. However, rangeland managers can learn and derive value from agronomic and environmental soil testing practices and other areas of formal soil science. This paper highlights the importance of understanding soil fundamentals to make more informed and effective land management decisions through exploration of datasets and techniques employed to engage pastoral land managers in the process of understanding rangelands soils.

Methods

The project has involved the design, implementation and delivery of extension programs focussing on collecting and analysing soil data from southern rangelands regions of Australia. This involved collaborating with land owners, pastoral station managers, Government and non-government organisations and experts aligned with advising or supporting the implementation of on-ground soils focussed trials or training opportunities in the SA Arid Lands region. The program also reviewed data that was collected from complementary field trials and soil sampling work funded outside of the original projects funded scope.

Soil Sampling

This project enabled the construction of a contemporary soils data set from the SA rangelands region and a total of 200 samples were analysed and reviewed with 175 samples having comprehensive laboratory analysis conducted (SAAL 2024). Soil testing parameters also included measuring soil temperature, biological activity and infiltration rates in the field with land managers. Laboratory results were independently analysed to consider:

- Typical ranges of Soil Organic Carbon across the SA pastoral zone (and causes of outliers)
- Characteristics of southern rangeland soils (chemical & physical traits) that influence the ability to manage regeneration of degraded grazing land
- The potential of different soil types to regenerate, and where to focus management efforts to gain the best outcomes
- Influence of soil health on pasture growth and livestock production parameters

Demonstration sites

In addition to testing soil samples from a range of land systems and rainfall zones, sites of specific interest to pastoral land managers were also tested. Results were used to show case the influence of land management techniques on soil health at demonstration sites on commercial-scale pastoral and rangeland properties, enabling the construction of a soils data set from a total of 21 pastoral leases across the SA Arid lands region. The data has been showcased at field days, demonstration sites, in project communications and on social media channels.

Previous research has shown that engaging land manager participation in scientific research is integral to raising awareness, building knowledge and leading to practice change (Pino et al 2022). At nearly all sites, data was collected with and alongside pastoral land managers. Where possible, qualified soil scientists were engaged to attend field visits. Collaboration with soil scientists and extension personnel with backgrounds in intensive agriculture and broadacre cropping allowed for the application of a broad scope of skills, technologies and backgrounds outside of the normal scope of rangelands ecology. The cross-sector collaboration proved invaluable to further investigating data sets and improving understanding of soil chemical processes and plant growth responses when analysing laboratory data and visiting sites to consider soil property constraints by bringing a different lens to the approach.

Where possible, samples were taken at paired sites, using fence line or track boundaries where areas with identical soil type and rainfall could be compared. Comparisons of soil sample sets at sites where rehabilitation techniques (including water slowing techniques, brush packing to increase rainfall infiltration or differences in grazing management) were undertaken to measure the range and differences of soil properties caused by management inputs or techniques.

Extension activities and land manager engagement

A range of extension tools and facilitation techniques were employed to engage land managers in understanding local rangelands soils through a variety of workshops and field day events. All events were designed to provide as much practical, “hands-on” learning as possible. Design and delivery of field trips, tours and training days took participant experience and demographic background into account. Adult learning

styles were considered carefully during event design, with special attention given to constructing activities and content delivery to focus on kinaesthetic, interpersonal learning types using varied instructional methods (Burns, 1995).

Out-of-classroom demonstrations were employed as much as possible, encouraging the group to collect data and measure soil properties in the paddock. These soil properties included measurement of pH, salinity, soil texture and colour, water infiltration rates and soil temperature. To create engaging dialogue, a fundamental soil property principle was described (for example, the influence of soil organic matter on soil structure) then participants were asked to estimate the measure or impact of an application of management inputs to the concept and collect data in teams. By engaging small groups to apply the experiment or collect data, a competitive element was added to increase engagement from the group. This form of engagement works well with pastoral audiences. Retention of knowledge and learnings about soil properties was enhanced by paying special attention to participants response and engagement and allowing flexibility to change demonstration approaches if needed.

Soil biological indicator trends were monitored using the ‘Soil Your Undies’ technique (DeBruyn 2018). Cotton underpants were buried at demonstration sites up to two months in advance of field days at the site. Participants were asked to uncover the buried material and share observations with the group. Cotton underpants were consistently more degraded in healthier soil patches (aligned with higher Organic Carbon (OC) and perennial plant cover) at all paired trial sites. As soil biology is expensive and difficult to measure with laboratory sampling methods, this form of experiment was a powerful and cost-effective tool, using a novel approach to educate land managers, integrating visual interactive assessment, humour and science.

Results

Numerous soil parameters were measured from laboratory test sets (SAAL 2024), for the purposes of this paper, data analysis will focus on a sub-set of parameters of interest to pastoral land managers.

Soil Organic Carbon

Organic Carbon (OC) is influenced by climate, soil type and management. The SAAL region has challenges around all three of these factors. The OC levels (Walkley and Black) from soils tested ranged from 0.25% to 1.5% with some outliers up to 2 to 2.5% OC. The average OC% was 0.58% and half of the samples were below 0.45% OC. The level of detection for OC% as a Walkley & Black analysis is 0.25%.

Building soil carbon in rangelands soils is complex and largely dependent on climatic variables and soil types, however data collected from paired treatment sites across the project footprint suggest that soil conservation practices and rest-based grazing management can have a significant impact on soil carbon stores at scale.

Soil Salinity

Salt content of the top 10cm of soil profiles across the pastoral soils data set, measured as Electrical Conductivity E_{Ce}, ranged from 0.15 to 32dS/m (with an outlier in salt lake country reaching 55dS/m). All areas in the southern rangelands need to be managed to address the salt accumulation potential at the soil surface, which can lead to scalding, plant species decline and reduced pasture growth. The data sets at paired sites consistently demonstrated that improving soil water infiltration, and maintaining soil cover reduces salt accumulation in topsoils, which is critical for seed germination and seedling establishment.

Soil water infiltration and surface temperature

Opportunistic testing of soil surface temperatures along transects with different vegetation cover parameters were particularly impactful in group training exercises during paddock walks. Using a digital infrared thermometer, participants were asked to monitor and record soil surface temperatures with and without perennial plant cover. The presence of large perennial shrubs and ground cover influenced soil surface temperatures by up to 32 degrees Celsius – being the difference between extremes in soil surface temperature recorded across a short gradient. Participatory data collection in ‘real-time’ enabled strengthened learning

outcomes. The same approach was made with testing differences in simulated rainfall infiltration experiments (NQ Dry Tropics 2019). Differences in soil water infiltration times ranged significantly according to soil type, with the most significant differences being measured in paired treatments sites that had undergone mechanical intervention, such as deep ripping.

Project participation

In total, 324 individuals participated in one or more soils focussed field days over the two-year life span of the funded project. This included on-ground field days, training days, a virtual field day and a week-long bus tour into western New South Wales. Of note was the attendance (not captured in attendance data) of more than 55 children to the events. Designing and facilitating inclusive events (families encouraged to attend events) is important in a region where childcare is limited, and all family members are involved with the day-to-day activities of a pastoral business.

The outcomes of a week-long facilitated inter-regional tour with twenty pastoral participants, continues to be monitored. All participants engaged in the learnings have committed to undertaking practice change since returning to their home properties. Participants on the tour alone are collectively responsible for managing 1.8 million hectares of pastoral and grazing lands in South Australia. Follow-up interviews with participants have recorded changes which include transition to changing livestock enterprise make-up, installation of major soil conservation works, successful enrolment in post-graduate study in soil biology and the acquisition of grant funds to undertake large-scale land rehabilitation works.

Discussion

South Australia's environmental trend and report card published in 2023 states that soil erosion risk in the southern pastoral region of South Australia has been worsening over the last five years (DEW 2023). The report illustrates the impact of dry conditions on soil health and erosion risk, and further strengthens the importance of understanding the fundamental of soil properties through case studies, training and well-designed soil extension programs to support land managers with regard to managing soil health.

In the southern rangelands, especially in pastoral areas where the land area under management is vast, it is often considered that the soil "is what it is" and focus is given to the landscape from a vegetation dominance perspective. Soil analysis within the pastoral industry is generally limited and land managers often lack the context of what the soil data means relative to other areas of the landscape. Supporting pastoralists to adopt strategic soil sampling regimes, and appropriate analysis to target an improved understanding of the soil properties that are driving high and low performing production zones is a critical step forward.

Water and where it goes, defines what grows; Land managers adopting a strong understanding of the soils influence on landscape hydrology and water movement within the soil profile are recognising they have impact and control to redefine soil management in the rangelands, for future productivity and environmental gains.

Acknowledgements

This project was delivered by the SA Arid Lands Landscapes Board with major funding provided by the Drought Resilient Soils and Landscapes program through the Future Drought Fund and has enabled the collection and collation of large amounts of soil health data and associated knowledge from many disciplines involved in rangelands grazing management.

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