From the Ground Up

Supporting regenerative grazing practices

in the southern Rangelands of SA

Drought Resilient Soils and Landscapes Grant Program

LANDSCAPE SOUTH AUSTRALIA SA ARID LANDS

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Please reference as: SA Arid Lands 2024, From the Ground Up – Supporting regenerative grazing practices in the southern rangelands of SA, SA Arid Lands Landscape Board, Port Augusta.

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Acknowledgements : Dr Geoff Kew, Paroo Pastoral Company, Francesca & Jake Fennell, Field Systems

This report was produced by the SA Arid Lands Landscape Board as part of the Building Pastoral Sustainability Program. The report outlines results and outcomes of the 'From the Ground Up' Project, delivered by SA Arid Lands and funded by the Drought Resilient Soils & Landscapes Program through the Future Drought Fund.

Australian Government
Department of Agriculture, Fisheries and Forestry

Future Drought Fund

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Project background

This project has been delivered by the SA Arid Lands Landscapes Board, with a major component funded by the Drought Resilient Soils & Landscapes Program through the Future Drought Fund.

> The objective of the Drought Resilient Soils and Landscapes Program is to trial and demonstrate how scaling of particular practices (or combinations of practices) to improve management of natural capital can build drought resilience. Through this, the Program aims to create and communicate an evidence-base and case studies that contribute to scaling out the successful practices.

From the Ground Up builds on the success of the *Building Pastoral Sustainability Project*, with aim to support regenerative grazing practices in South Australia's rangelands to build drought resilience.

Eight demonstration sites across the SA Arid Lands region were established, with a focus on soil health, soil rehydration methods and grazing land management practices. The project has been a welcome addition to the region's land management programs, with growing interest from industry leaders for information on soil health and regenerative grazing practices in the rangelands.

South Australia's environmental trend and report card published in 2023 states that soil erosion risk in the southern pastoral region in the Flinders Ranges district and pastoral zone in the Murray River catchment has been worsening over the last five years. The report illustrates the impact of dry conditions on soil health and erosion risk, and further strengthens the importance of case studies, training and well-designed soil extension programs to support land managers with managing soil health.

Outcomes of the project have enabled ongoing engagement with grazing managers to continue to deliver extension support, and develop new projects to develop knowledge and skills in drought resilient grazing management practices.

Lance Mudgeway undertaking a Watercourse health assessment with landholders

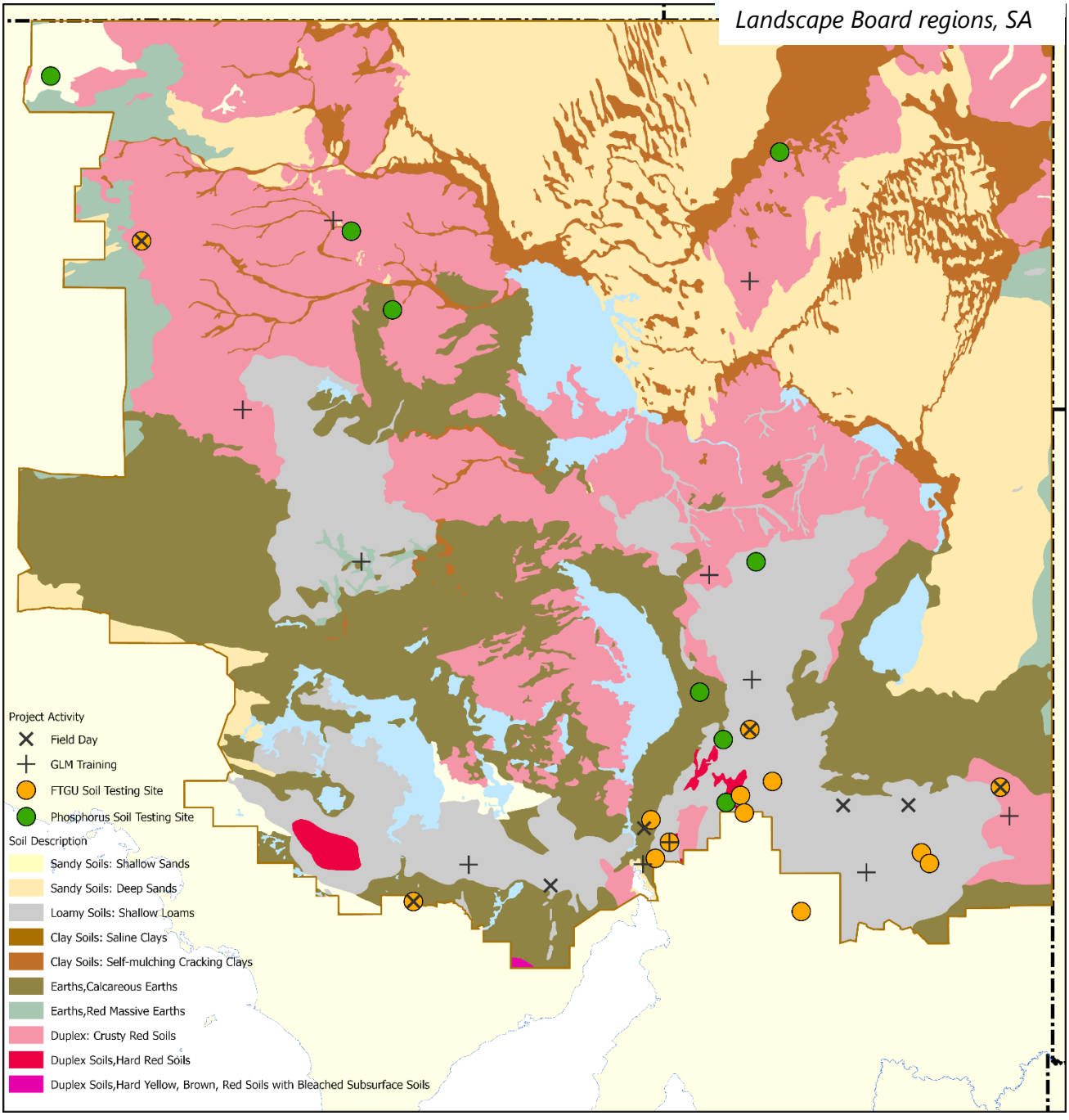
Focus area – regional map

The outputs of the From the Ground Up program focussed on three main areas:

- Demonstration sites – on commercial scale working pastoral properties
- Field days and peer-to-peer learning
- On-ground training

A copy of the Project Prospectus can be found in **Appendix A**

Landscape Board regions, SA



SA Arid Lands Landscape Board region with soil descriptions and project activity locations

Project collaborations & Acknowledgements

This project has enabled the collection and collation of large amounts of soil health data and associated knowledge from many disciplines involved in rangelands grazing management.

The project involved collaborating with external projects, service providers and experts aligned with advising or supporting the implementation of on-ground trials or training opportunities in the SA Arid Lands region. The following points also acknowledge the influence or input of complementary trials and work funded outside (or pro bono) of this projects funded scope:

- Extending the reach of **demonstration site knowledge** with the Rangelands Living Skin project participants from western NSW – sharing project information and trial site methodology. The Living Skin team supported property visits during a cross-border tour with land managers from this program footprint.
- **Native pasture nutrition** – Feed testing results from previous projects and studies were collated with data from this project to present a comprehensive pasture nutrition data base for the southern rangelands with pastoralists in the project footprint (sources of data include Outback Lakes Studies, PIRSA, Rural Solutions, Jodie Reseigh)
- **Soil biology** – Bern Doube from Dung Beetle Solutions has been a key supporter of the *From the Ground Up* project with the formal identification of opportunistic dung beetle collections made from the demonstration sites. Rebecca Greening completed an Honours Thesis "*Could livestock-associated soil microbes be affecting plant recruitment*" with the University of Adelaide at Koonamore Station. Rebecca is now designing a pHD project to continue this work.
- **Feedbase Monitoring** – Cibo Labs Pasture Subscription Key, [trials funded with a Cross Hub project involving 6 Drought Hubs] were implemented with 6 properties in the project footprint. Remote sensing monitoring of ground cover and feed base was ground-truthed and further analysed in this project on the Wintinna and Buckleboo demonstration sites.
- **Baseline Land condition assessment** – Establishment of AusPlots on Buckleboo and Wintinna Stations were undertaken to monitor species inventory and understand soil profile characteristics to depth. These sites were established by TERN (Terrestrial Ecosystem Research Network) and partly funded by Drought Hub program. Collaboration with Giles Forward from SA Dept. of Environment & Water to automate regional land condition assessment reviews (focusing on ground cover) for project footprint.
- **Livestock health measures** – Data review was supported by Deb Scammel (Lifetime Merino Ewe programs), Dr Caroline O'Connell (Adelaide Hills Mobile Veterinary Services) & Dr Colin Trengove (University of Adelaide). Pregnancy scanning of ewes at the Buckleboo Demonstration site was implemented by an externally funded project with Anne Collins.
- **Virtual Fencing Trial project** (and pHD project) with Megan Willis from the South Australian Research & Development Institute, with funding from the SA Drought Hub
- **Soils knowledge extension** with Dr Geoff Kew (Soils Extension Officer) Upper North Farming Systems, Field Systems & Soils Science Australia. Rebecca Greening (Uni of Adl) at Koonamore and Osborne Reserve. Hugh Pringle, Lance Mudgway & Mulloon Institute, Bush Heritage Australia.

- **Soil Phosphorus Deficiencies** tested by Dr Geoff Kew as part of a program funded by SA Drought Hub (Uni of Adelaide)
- **Grazing Land Management Training package**. Meat & Livestock Australia (MLA) were contracted to develop and deliver the Grazing Land Management training (GLM) program through their EDGE Training platform. MLA worked in alignment with staff and grazing specialists from NSW DPI, Jodie Reseigh PIRSA, Ron Hacker, Contour Consulting WA, Range IQ NT & Tanisha Shields - Agrista. This training program is now ready and available for delivery in regions across all southern rangelands regions (outside of initial project footprint.)
- **Weather Station Data & soil moisture probes** –This project used data collected from a weather station on-site at Wintinna Station (installed with external funding) and soil moisture probe technology previously installed on Buckleboo. Additional hardware and analysis was installed as part of this project to complement existing infrastructure, using the learnings from previous projects to refine tech success.

A special thanks extends to the staff and families of the Fennell Family & Paroo Pastoral Company for their commitment to the development of long-term grazing demonstration trials at Wintinna & Buckleboo Stations. Their input to project design, ability to manage expectations of trial measurements, involvement with data collection and dedication to sharing the work with the wider community has been instrumental to the delivery of this project.

Numerous landholders have hosted small scale trials, enabled soil collection and data review or have hosted of field days, sticky beak visits or training events. These properties include Narcoona, Wilkatana, Upalinna, Holowiliena, Corunna, Plumbago, Oakley at Craddock, Koonamore, Boolcoomatta, Bindarrah, Mt Eba & Nonning.

The success of this program also wishes to acknowledge the numerous volunteer-run community groups involved with hosting training events in regional locations, including Yunta Race Club, Stirling North Golf Club, Blinman Progress Association, Mungerannie Road house, Oodnadatta Race Club, Lyndhurst Community Hall, Coober Pedy Golf Club & Flinders Ranges Council.

Principles underpinning program design – regenerative grazing practices

Key Principles of Regenerative Grazing or Farming

1. Maximise plants' photosynthetic processes by ensuring significant leaf matter is available.

2. Increase the water cycle through slowing and holding surface water flow.

3. Increase the nutrient cycle from vegetative matter to soil, through regenerative livestock management and allowing for decomposition.

4. Increase plant and animal diversity in ecosystems (while decreasing any monoculture regimes.)

5. Understand the Human Social Element of land management by taking both oneself and the wider community on a regenerative journey.

These principles underpinned the development of demonstration sites, data collection and training provided over the duration of the *From the Ground Up* project. These key principles are globally recognised.

Regenerative grazing generally involves some form of rotational grazing with strategic rest. This means that pastures (grasses, shrubs or trees) are provided with the opportunity to grow leaf matter and establish strong root systems when there is adequate soil moisture available, without the pressure of defoliation (grazing).

Training & Soil Testing Sites

Field Day / Soils training sites	Grazing Land Management Training Delivery sites	Soil Testing Site properties funded by this project	Soil Testing Sites - funded by Phosphorus trials (Uni of Adl)
Narcoona	Stirling North	Clifton Hills	DeRose Hill
Buckleboo	Quorn	Boolcoomatta	Allandale
Wintinna (virtual)	Blinman	Oodla Wirra	Mt Lyndhurst
Upalinna	Lyndhurst	Manna Hill	The Peake
Koonamore	Bindarrah	Oulninna	Motpena
Corunna	Yunta	Quorn	Merna Mora
Plumbago	Mt Eba	Upalinna	Vesper
Boolcoomatta	Oodnadatta	Holowiliena	
	Coober Pedy	Oakley- Craddock	
	Nonning	Pine Grove	
	Mungerannie	Saltia	
		Wilkatana	
		Buckleboo	
		Wintinna	

Soil Monitoring – rangelands data set

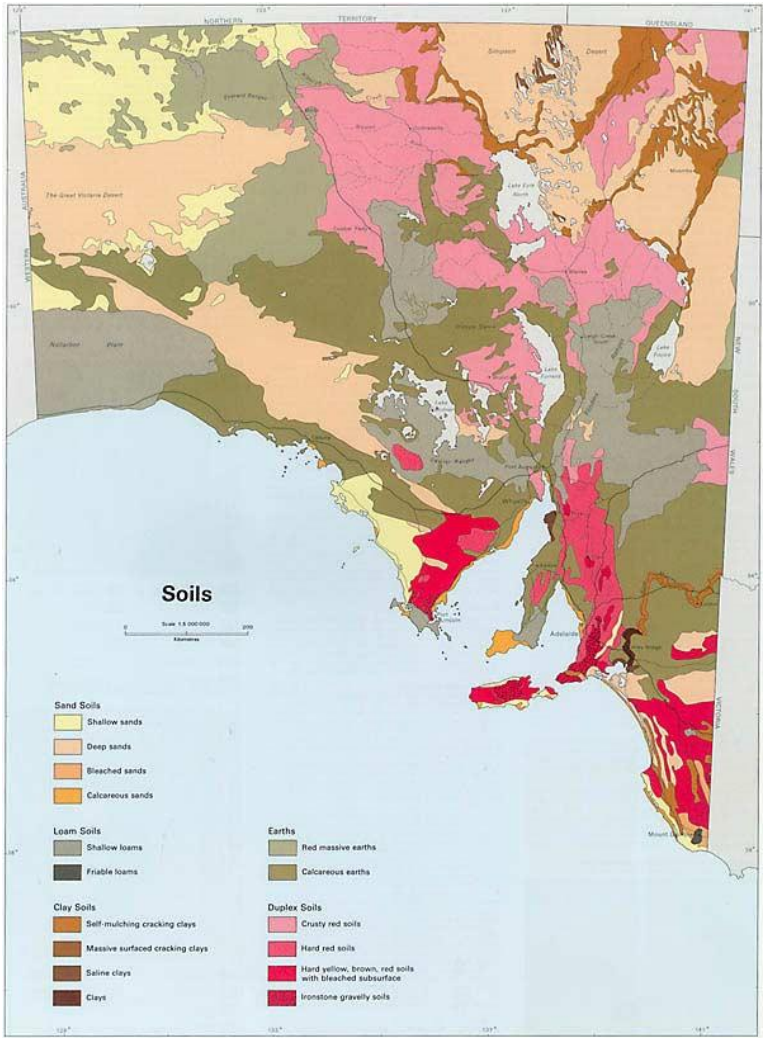
Valuable historic records and data sets of soil properties and characteristics exist for sites across Australia's rangelands, however these data sets are difficult to source and interpret without a well-designed and resourced soils extension program. The successional shift of new land managers and station lease owners in the pastoral lands of South Australia has seen a renewed enthusiasm and willingness to learn about soil health. Improvements in technologies and laboratory testing techniques has enabled *From the Ground Up* to test soil parameters with land managers, particularly with a focus on building soil carbon.

In the SAAL region, 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 put on assessing the landscape from a vegetation dominance perspective. Soil analysis in the pastoral area is generally sparse and land managers often lack the context of what the soil data means relative to other areas in the landscape.

With appropriate analysis, review of soil data and soil properties can tell us what has happened in the past and how changes in management can positively or negatively affect the soil & pasture resource.

This project enabled the construction of a contemporary soils data set from 14 properties across the SA Arid Lands region, with an additional data set from 7 pastoral properties (funded externally to this project.) A total of 200 samples were analysed and reviewed with 175 samples having comprehensive laboratory analysis conducted **(Appendix B).** 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



In addition to testing soils samples from sites of interest to pastoral land managers, results were used to showcase the influence of land management techniques on soil health. This data has been showcased at field days, demonstration sites and in project communications.




In summary, of the 200 soil test samples analysed by APAL Laboratories, the data set revealed the following observations:

Soil pH

pH is the measurement of Hydrogen ions (H+) in soil solution and is a key metric for assessing soil condition. Due to the nature of the landscape in the project footprint being in a very low rainfall environment, **the general trend of soil pH across the southern rangeland region is in the alkaline range (readings greater than pH 7.5).**

There were, however, **acidic soils located to the west of Coober Pedy in the strongly acidic range below pH 5** (CaCl). Examples of acidic soils were collected in the western part of Wintinna Staton – sites dominated by deep red sands.

Soil pH is largely are influenced by parent material. Generally speaking, clays and calcareous based soils are alkaline, sands are acidic. Soil organic matter management can influence soil pH to trend toward neutral (7) from either end of the pH scale.

Soil Organic Carbon

Organic Carbon (OC) is influenced by climate, soil type and management. The SAAL region has challenges around all three of those factors. The OC levels (Walkley and Black) from soils tested **ranged from 0.25% up to 1.5% with some outliers up at 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%.

Soil Organic Carbon

The range of typical soils Carbon measurements made across the project area varied from from 0.25 to 1.5 %.

The average Soil Organic Carbon measured during this project was 0.58%

Long-term monitoring at rest-based grazing trial sites

Soil Organic carbon is largely influenced by rainfall and soil type. To accurately understand the influence of transitioning grazing management to a rest-based system, will require a longer-term data set. This project has enabled baselining, and in the case of Buckleboo & Wintinna, two years of valuable data will enable a continuation of longer-term testing at permanent monitoring sites.

We understand from literature reviews that:

- erosion events remove topsoil which contains a bulk of the soils' organic matter. This can take years of good management to replace. This has significant influence on soil carbon stores.
- Micro-organisms breakdown soil organic carbon as an energy source – this occurs faster when the soil is moist and conditions are warm
- Gravel in soils will "dilute' the total carbon content of soils, soil type influences soil organic carbon totals (this needs to be taken into account when testing soils – particularly soils high in carbonates.)
- Total organic carbon influences many soil characteristic s including soil color, nutrient holding capacity, nutrient turnover and soil stability. These characteristics influence water holding properties and soil structure relevant to root growth.

Building soil carbon in rangelands soils is complex, and largely dependent on climatic variables – however data collected from paired 'treatment' sites across this project footprint suggest that soil conservation practices and considered long-term grazing management can have a significant impact on soil carbon stores at scale. An increase in soil carbon by as little as 0.1% in a paddock area can have profound impact on a soil carbon budget.

Influence of small changes in soil organic carbon

Assumptions made for calculation of soil carbon :

- the soil type has a bulk density of 1.4 gm/cm3
- management changes can increase soil carbon by **0.1% in top ten cm**
- management change and soil type is consistent across the site

10,000 x 0.1m depth x 1.4gm/cm3 x 0.1% = 1.4 tonnes/ha

One tonne of soil organic carbon is equivalent to 3.67 tonnes of CO2

Rangelands treatment sites illustrate small but stable increases in captured soil Carbon, the potential benefits are from the scale at which changes can be made. Many property areas with treatable scalds are in excess of 100 hectares in size.

This satellite imagery illustrates part of a historically scalded flood plain site on Koonamore Station. This area approximates 9 square kilometres. There are 100 hectares in a square kilometre, and the potential treatment area of this site is 900 hectares.

If soil health is improved, water capture restored and plant growth encouraged to improve Soil Organic Carbon (stable and long-term) by 0.1% - this area could benefit from a potential of 1,260 Tonnes of soil Carbon; or 4,624 CO2 Equivalents

Satellite imagery of degraded flood-out system - water running from Melton (south) to Koonamore Station (north)

Soil Salts

Salt contents ranged from **0.15 to 32 dS/m** (with outlier near salt lakes reaching 55dS/m) which indicates a strong variation in salt content in the landscape. All areas in the SA Arid Lands region need to be managed to address the salt accumulation potential at the soil surface which can then lead to scalding and reduced soil cover. Surface salt levels can be managed by improving soil water infiltration – both having a significant impact on seed germination and seedling establishment.

The soil profile at sites like the Wilkatana Range Paddock (Scald Site), indicated that salt levels are preventing plant growth beyond germination. Soils in this profile are hyper-saline below 20cm of depth, and improving rainfall infiltration will be critical to flush salts into the profile and enable soil structure and conditions to be more conducive to root development over time. This is likely to be a common issue at historically scalded sites in sodic soils.

Soil testing undertaken on footslopes of Arden Vale Range on Wilkatana & Narcoona Stations

Salty scalded project site on Wyndham Station, western NSW. This site is undergoing treatment regimes and detailed analysis as part of the Rangelands Living Skin program

Water Ponding

Trial results from the Rangelands Living Skin project, and anectodal observations made across sites in the SA rangelands indicate that managing **water ponding or slowing surface water flow** is critical in landscape rehabilitation. Allowing water to pool to a **depth of 100mm** is ideal to enable flushing of soil surface salts into the profile, allowing the long-term germination and establishment plant growth.

Summary of soil lab test results of soil samples collected from 200 sites across SA Arid Lands region over 2022/2024 project period.

	Min	Max	Average	Median
Salinity EC 1:5 dS/m	0.01	9.90	0.81	0.18
pH 1:5 water	4.86	9.47	8.05	8.42
pH CaCl2	3.96	8.50	7.45	7.86
Organic Carbon (W&B) %	0.14	2.49	0.59	0.46
Colwell Phosphorus	5.00	45.00	11.05	7.00
PBI + Col P	24.00	212.00	90.07	81.00
Colwell Potassium	67.00	1400.00	384.64	350.00
KCl Sulphur (S)	2.50	4700.00	130.38	8.00
Calcium (Ca) mg/kg	30.00	25400.00	3901.25	4460.00
Magnesium (Mg) mg/kg	10.00	1240.00	402.18	317.00
Potassium (K) mg/kg	46.00	1420.00	377.35	340.00
Sodium (Na) mg/kg	8.00	24900.00	933.89	195.00
eCEC	1.25	67.40	26.29	28.70
Calcium %	10.30	92.30	68.77	71.90
Magnesium %	2.40	29.70	12.79	10.90
Potassium %	0.30	16.00	5.12	3.90
Sodium %	0.20	53.00	9.38	3.80
Chloride	5.00	16000.00	912.87	77.00
Boron	0.10	18.00	1.97	1.00
Iron (Fe)	1.80	40.00	4.83	3.70
Manganese (Mn)	0.90	15.00	4.35	3.50
Copper (Cu)	0.11	2.50	0.77	0.65
Zinc (Zn)	0.08	13.00	0.34	0.18
ECe	0.15	55.04	9.40	2.14

Soil Monitoring – treated sites and case studies

Attempts to find 'paired' sites (same soil type and rainfall) of different soil management practices, disruptions or treatments in the project enabled capturing soil data to support practice-change at scale on pastoral lands in the project footprint.

Natural Surface Water Flows

Interrupting natural surface water flows (road or track incisions that divert water-flow) can cause severe 'droughting' of downstream flow-on areas. This landscape de-hydration process results in lowered water infiltration, germination, and perennial root development. Changing or interfering with natural surface water flows can significantly decrease organic carbon content, and in the case study sites where we were able to measure paired site comparisons (upstream and downstream of surface water flow disruption), we tested up to a 50% reduction in Soil organic carbon.

Influences of soil management on rainfall infiltration

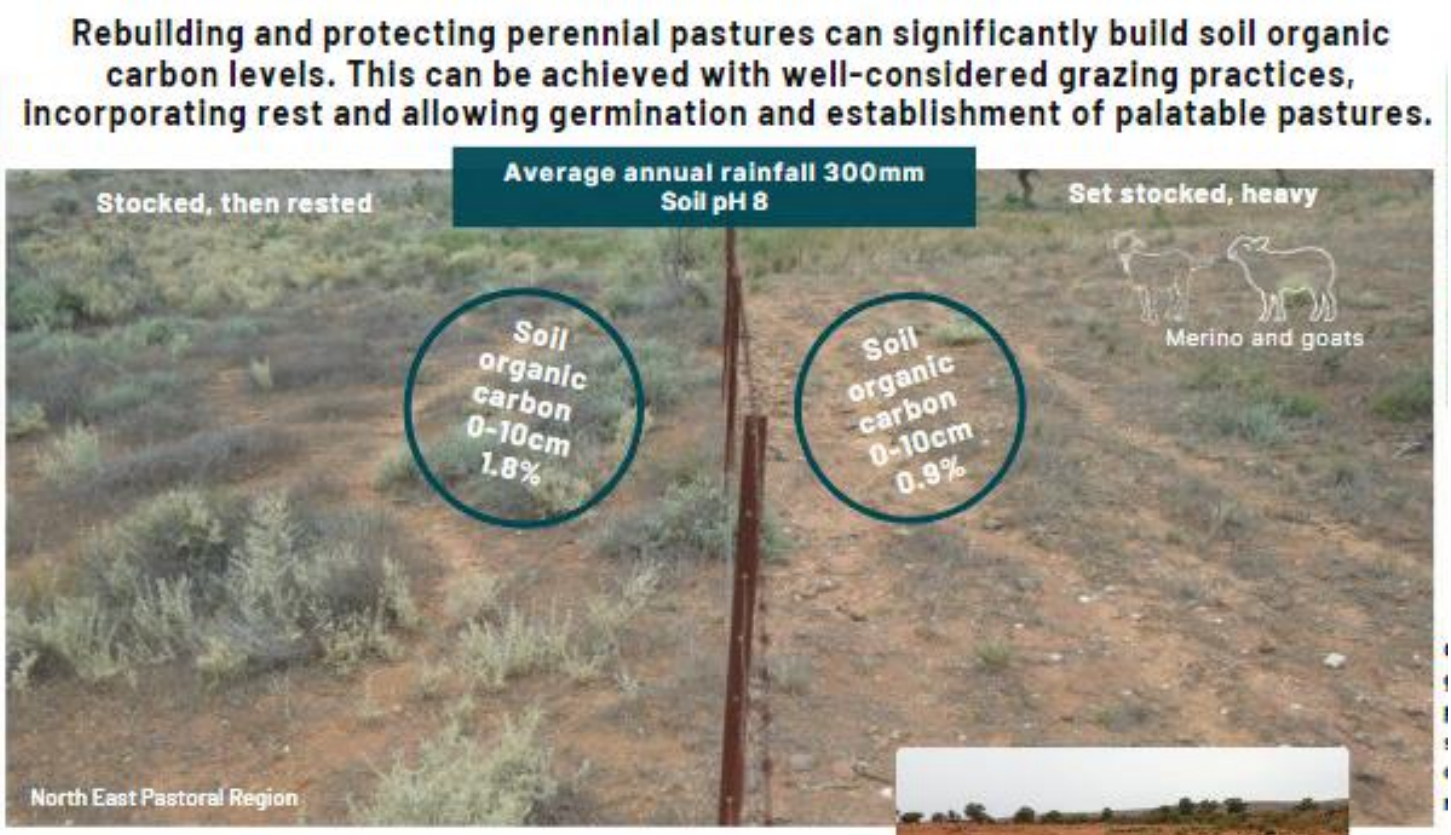
Allowing adequate water infiltration into the soil profile enables accumulated salts and minerals to flush and disperse throughout the soil profile. Methods and techniques (including ripping, contours & brush packing) employed to slow surface water run-off and enable infiltration, can reduce salt levels in the top 10cm of soil dramatically.

At the case study site on Boolcoomatta, soils were sampled from a degraded site that was hash-brushed to slow wind and water erosion, trap seed and soil drift and increase localised rainfall infiltration. Over a period of eight years, salinity levels have been decreased from 2.3 dS/m (highly saline) to 0.1dS/m (non-saline).

Pictured left, this site at a deep-rip treatment site on Holowiliena Station shows differences in soil properties. The soil moisture monitored in the deep rip line (left hand) is suitable for plant germination (left hand) while on the right – the non ripped soil is dry.

Grazing Management

Fenceline comparisons to analyse soil properties and comparing Carbon levels of long term heavy set stocking, with intermittent grazing revealed the influence of perennial shrub cover and root persistence on soil health. At case study sites, differences measured in Soil Organic Carbon were up to 1% greater in rested paddocks.



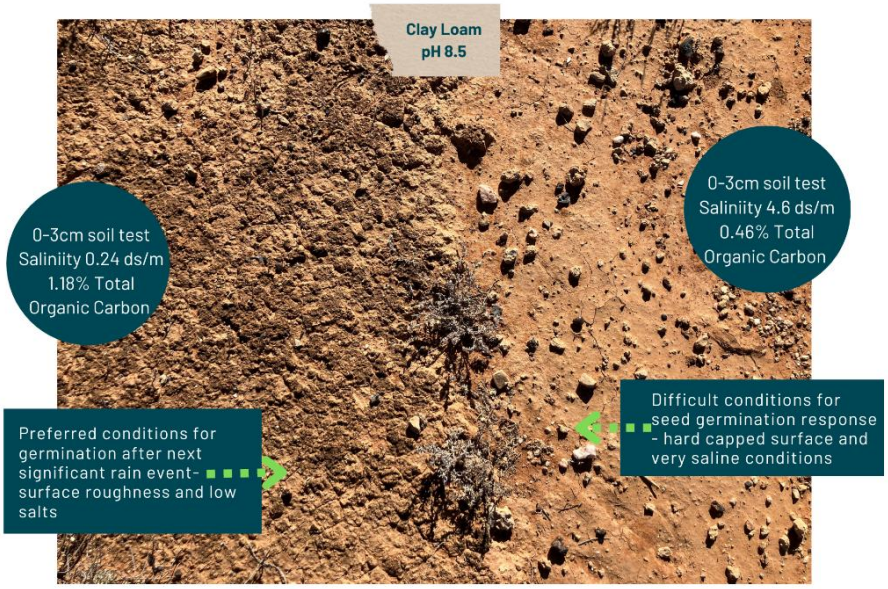
Livestock species and land type grazed can have an impact on land condition. The paddock on the left is grazed by sheep, and the right has cattle. Sheep have split lips which enables them to graze closely to the ground - without rest, perennial plants can be eaten-out of a paddock very quickly.

Further analysis of technologies like Virtual Fencing to enable rest-based management of large pastoral paddocks is being instigated as part of the demonstration trials at Wintinna Station. Numerous pastoral businesses have indicated interest in follow-up trial work to enable legislative approval. During the delivery of this project, Virtual Fencing was not available for commercial application in South Australia – due to legislative constraints.

Left - Wintinna Station heifers with Virtual Fencing collars

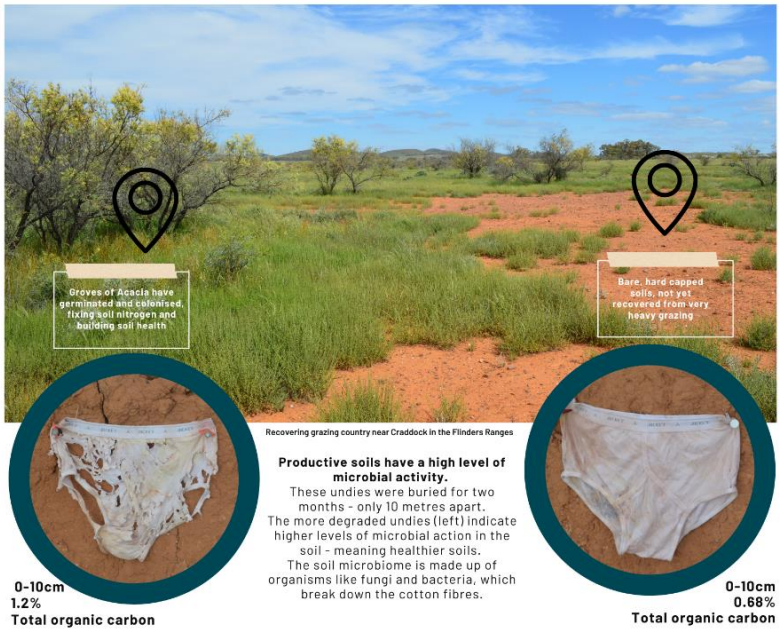
Soil Biology

Cryptogamic Crust – opportunistic sampling of crypto crust chemistry has illustrated significant differences in soil surface conditions conducive to germination and seedling establishment. At sites sampled, areas with intact biological soil crust (0 – 3cm depth) have more than double Organic Carbon than adjacent areas where crust has been removed (eroded.) Large differences in salts were also observed .

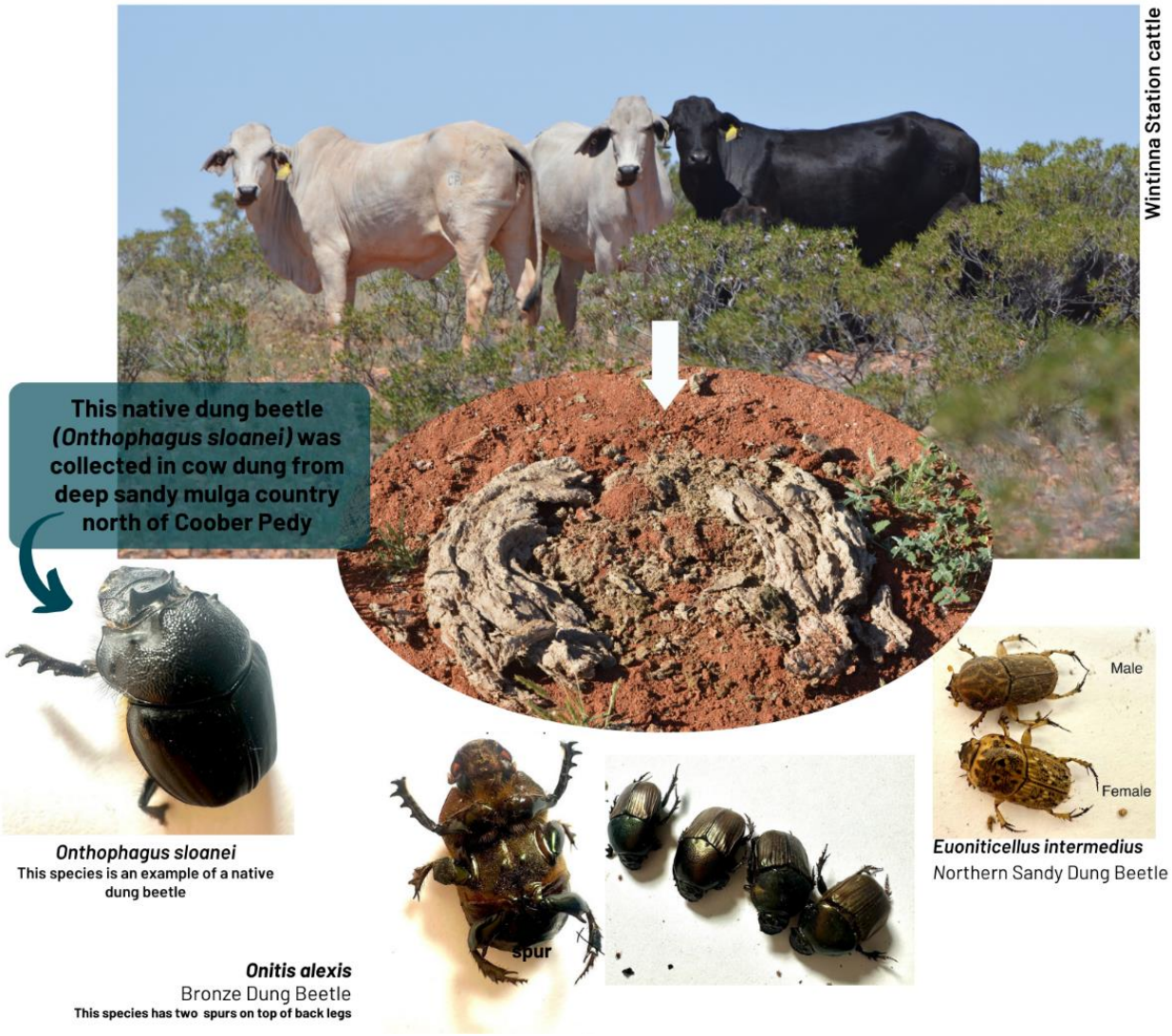


Soil sampled from Mannahill - North East Pastoral region

Cotton Undies Experiment– burying of cotton underpants to gain a better understanding of soil biology has attracted the attention & interest of land managers and NRM extension staff across the state. In the lead-up to field days and paddock walks, sites were sampled and cotton test undies were buried in a range of sites to test differences in soil biology. These visual tests enabled discussions about the influence of soil cover, surface water flows, soil rehydration and grazing management on soil health.



Dung Beetles – opportunistic collection and identification of dung beetles at demonstration sites with cattle was undertaken. A mix of native and introduced Dung beetle species were collected and identified with pastoralists and groups during field days to highlight the importance of healthy soil biota at all scales.



Dung Beetle Species	Locations Found
Euoniticellus intermedius	Quorn, Clifton Hills, Wintinna
Onitis alexis	Wintinna
Onthophagus sloanei	End Tank Wintinna,
Onitis aygulus	Clifton Hills, Port Augusta,
Onthophagus gazella	Clifton Hills, Quorn, Pandiburra Bore

Influence of perennial plant cover on soil temperature and infiltration

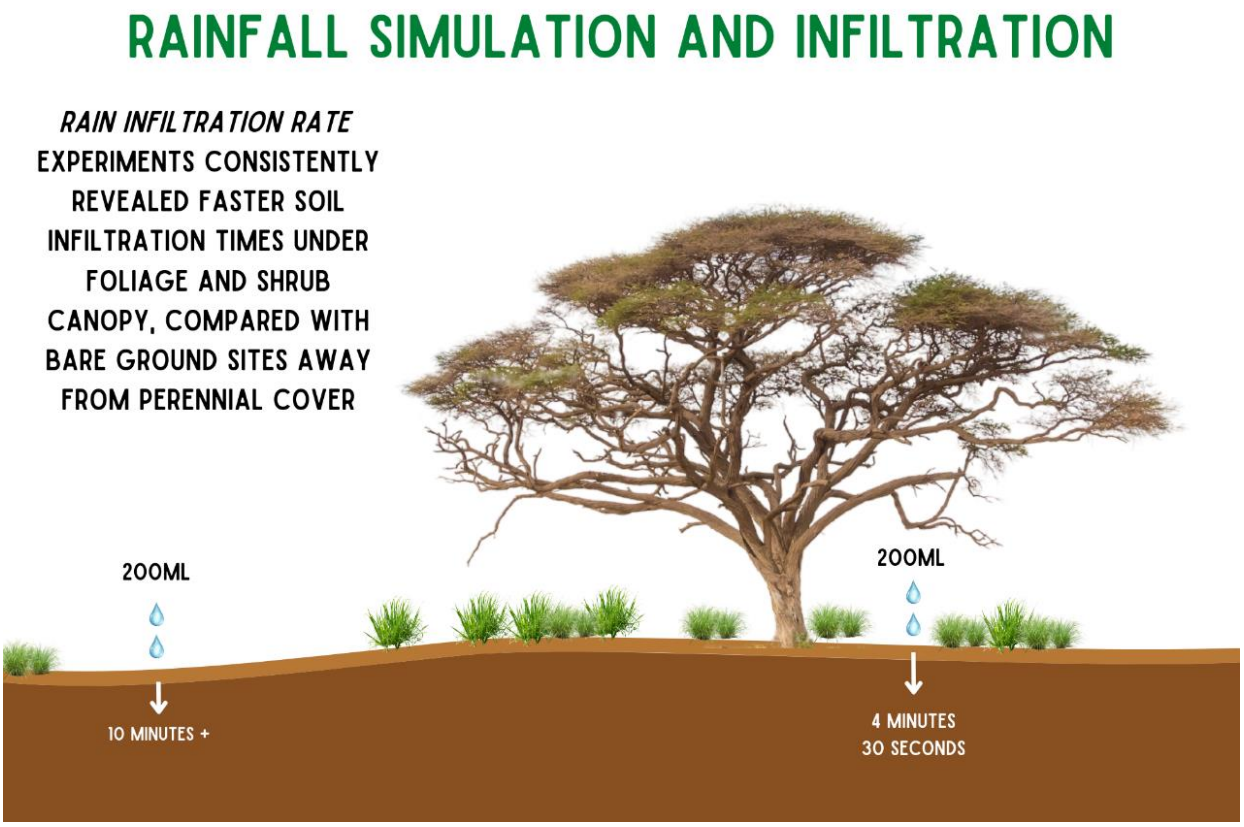
Soil moisture probes at Wintinna in a paired site (under Mulga and in an open area) indicate that soil temperatures (to depth of 10cm) are consistently up to 3 degrees Celcius lower under perennial shrubs.

Infiltration tubes were used to simulate a 25mm rainfall event, and timed at paired sites to compare soil and grazing management treatments and their impacts on rainfall infiltration. Simulated rainfall events measured under the canopy area of long-lived perennial shrubs was consistently faster than in open and exposed areas. The faster that water is able to infiltrate into the soil profile, the less likely that soil water run-off occurs (reducing erosion risk, and increasing water availability to plant roots.)

Influence of plant cover

The measurement of the infiltration of water in paired sites (with and without plant cover) consistently demonstrated quicker infiltration in areas with vegetative cover (more organic content in soil) 3 degrees cooler under perennial shrub cover.

Timed absorption experiment with pastoral participants (using water and dye) were implemented to demonstrate importance of soil health in a dry landscape – Koonamore Sticky Beak day

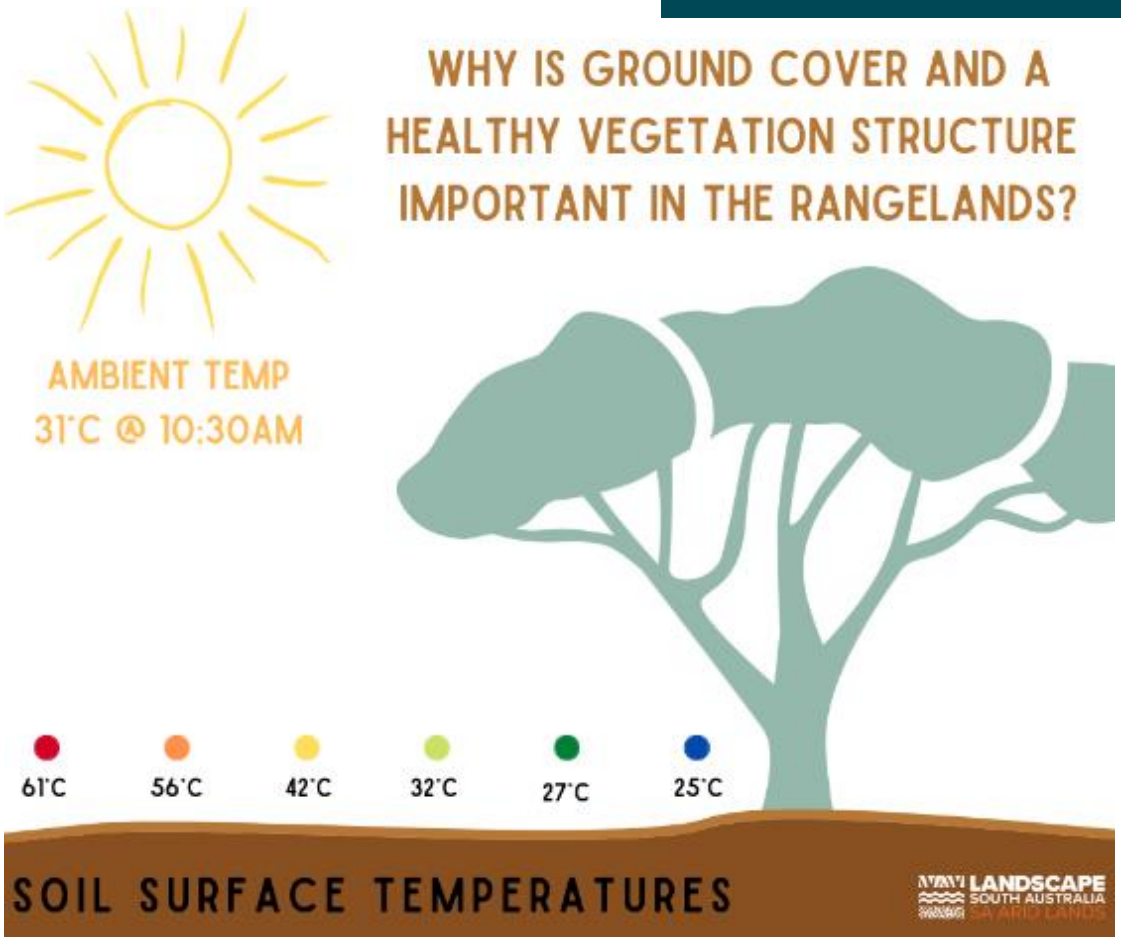


Soil Surface Temperature

Soil surface temperature monitoring with pastoralists on fixed transects away from perennial tree and shrub bases, illustrated drastic decreases in surface soil temperature influenced by canopy cover. For example, on a 22 degree Celcius day, the soil surface temperature under a large Acacia was 18 degrees C – in comparison to 43 degrees C, 10 metres away from tree base.

Influence of plant cover

Soil moisture probe data reveals the temperature of soil in the top 10cm in deep sandy country is consistently 3 degrees cooler under perennial shrub cover.



Surface soil temperature parameters measured near Oodnatdatta, GLM training day

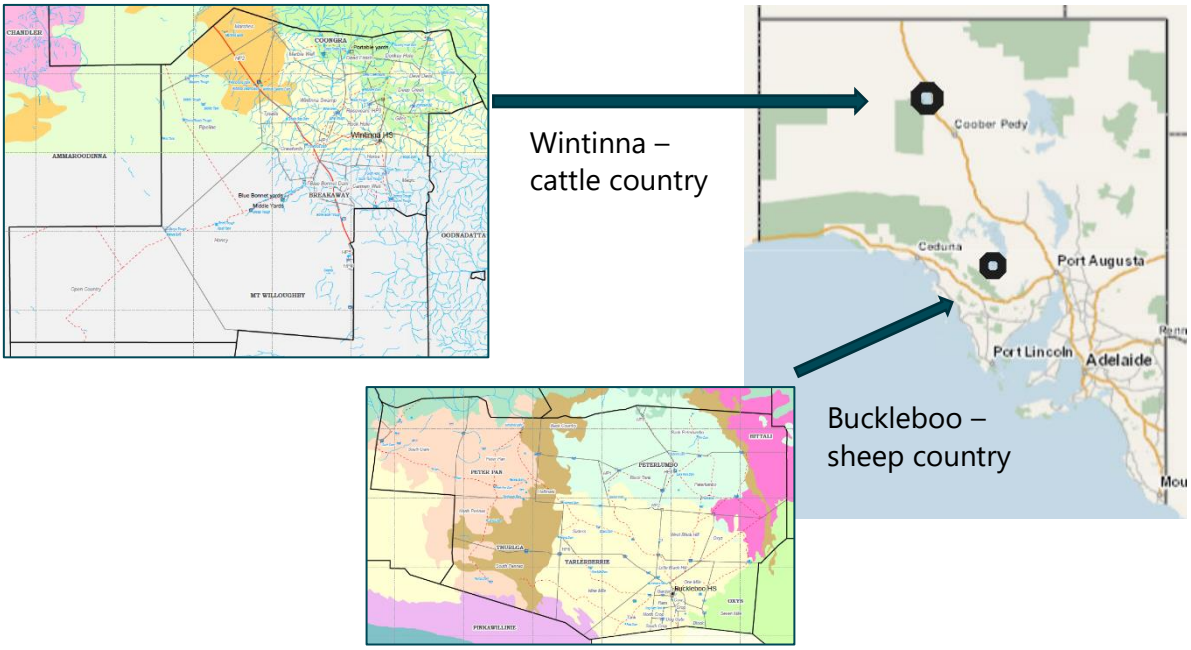
Influence of plant cover

Rebecca Greenings Honors Thesis research revealed that plants (grown-out in a green house in soil collected from open paddock areas) produced 60% less biomass than in soils from under shrubs – demonstrating the influence of perennial plant cover on soil microbial communities and soil conditions.

Nitrate Nitrogen, available Potassium and Sulphur levels were higher under the canopy. Appendix C

Rest-based Grazing Demonstration Sites

This project supported the development of long-term monitoring sites, and the deployment of technology and sampling techniques to monitor on-ground changes as a result of grazing practice change. Wintinna Station & Buckleboo Station were selected as suitable sites; as both properties had made **major management decisions to transition livestock grazing practices from set-stocking in paddocks – to a rest based grazing rotation**. The installation of grazing exclosures and collection of baseline soils data has been implemented to support long-term monitoring.



Wintinna Station – beef cattle

Buckleboo Station – meat sheep

Wintinna Station

Wintinna is 3,812km2 and lies 200km north of Coober Pedy in the Marla Oodnadatta district, running mixed breed beef cattle. The Wintinna Station demonstration site consists of a newly installed pipeline across the width of the 'Pipeline Paddock' (47,150 ha or 116,500 acres in size) on the western side of the property. Along the 21.8km long pipeline, water tanks have been installed to simulate a paddock rotation without the costly activity of installing new internal fencelines. The tanks and troughs are turned on and off in an east to west order, to move stock in a westerly direction over a period of two years.

The paddock is dominated by mulga trees (*Acacia aneura*), with a grassy understorey. Additional paddock areas (Deep Creek and Dead Finish Paddock) have been monitored to compare country type and additional trials including Virtual Fencing. Long-term monitoring photo sites have been established inside/outside of small grazing exclosures established in Pipeline & Deep Creek Paddock.

End Tank (deep sand country, Pipeline Pdk) right - Harrisons (heavy clays in Deep Creek Paddock)

Costs – Cattle fencing

Based on Jan 2024 costings – a 4 barb fence suitable for containment of cattle in far north of SA is **$4,700 / km** (including supply, freight, grader work and installation) shrub cover. Dividing large station paddocks into smaller areas to promote rest is currently cost prohibitive.

Buckleboo Station

Buckleboo is 1,011km2 and located 80km north of Kimba in the Gawler Ranges Region. The property runs Dorper meat sheep and has been divided into 6 large grazing areas (approximately 40,000 acres each in size) with the intent to rest each grazing area for a 15 month period.

The property is a mix of open low woodland mallee (*Eucalyptus brachyptera & Euc. Oleosa*) and Western Myall (*Acacia papyrocarpa*) interspersed with open chenopod shrubland (dominated by *Atriplex vesicaria*) and open annual grassland (*Austrostipa spp*.)

Sheep are run in a large single mob, and moved into a new grazing area every three months. Rams are managed in a controlled mating setting, with the intent for ewes to lamb into winter every year – making the most of ideal pasture conditions for lamb growth and maintained breeder condition.

Long-lived shrubs like *Eremophila alternifolia*, are extremely palatable to livestock and goats. Very few plants are able to establish beyond germination under constant grazing pressure. This photo was taken in Pennas Paddock and shows a respose to rest – basal resprouting is becoming obvious on palatable shrub species after a long history of over-grazing.

Set Stocking – a historic legacy

Paroo Pastoral Company were seeking alternative management approaches to help restore pasture health and improve ground cover. Their changes to management underpin a large-scale Carbon storage project registered with AI Carbon, encouraging the regeneration of tree and shrub species through the transition to rest-based grazing practices.

Pasture Monitoring

Pasture yields – measured as Total Standing Dry Matter (TSDM) were monitored across the two grazing demonstration sites at Buckleboo and Wintinna. Baseline data has been collected, however given the nature of climate variability in the rangelands region, it is too early to make conclusions about the impacts of changing management to rest-based grazing programs without a longer term data set.

Pasture Yield standards have been developed for Buckleboo in various country types, to support land managers to visually assess pasture cover. ***Appendix D.***

Examples of pasture yield ranges LEFT – 150 kg / ha *RIGHT – 1,000 kg / ha*

Analysis of livestock movements have been undertaken using the Pasture Subscription Key monitoring tools developed by Cibo Labs under a program funded with Meat & Livestock Australia. Analysis of this work is described in the next section of this report.

Nutrition – Native pasture samples of interest to pastoralists across the project footprint were taken opportunistically where possible. The data set was added to a compilation of historic pasture nutrition results to build an understanding of the resource base with pastoralist land managers and graziers. The data highlights the importance of pasture diversity, with particular attention to the value of highly palatable "decreaser species' – which are best managed and maintained with rest-based grazing practices. This data set was used during the delivery of grazing land management (GLM) training programs, and enabled participants to accurately develop a forage budget and grazing plans for their individual properties. All participants involved with training across the time-frame of this project were emailed a copy of the data sheets ***(Appendix E)***

Faecal analysis – A small number of cattle faecal samples from the Wintinna demonstration site were collected and tests undertaken in attempt to test sampling methodology and assess the suitability of NIRS analysis methods for pastoral situations. Given the limited amount of 'reference' material in labs due to the diversity and complexity of rangelands pastures, this trial was inconclusive.

Water quality – Water quality testing was undertaken on Wintinna Station to identify potential issues related to livestock health parameters, and align with pasture nutrition data. 2 bores and 2 surface water catch dams were tested, with no significant concerns measured. Of note, is the higher levels of Iron & Manganese in the dam water, likely to be a result of surface geology influence on

mineral levels in the water. The Yard Bore was also high in calcium carbonates (typical of local bore water.) Results illustrated in ***Appendix F.***

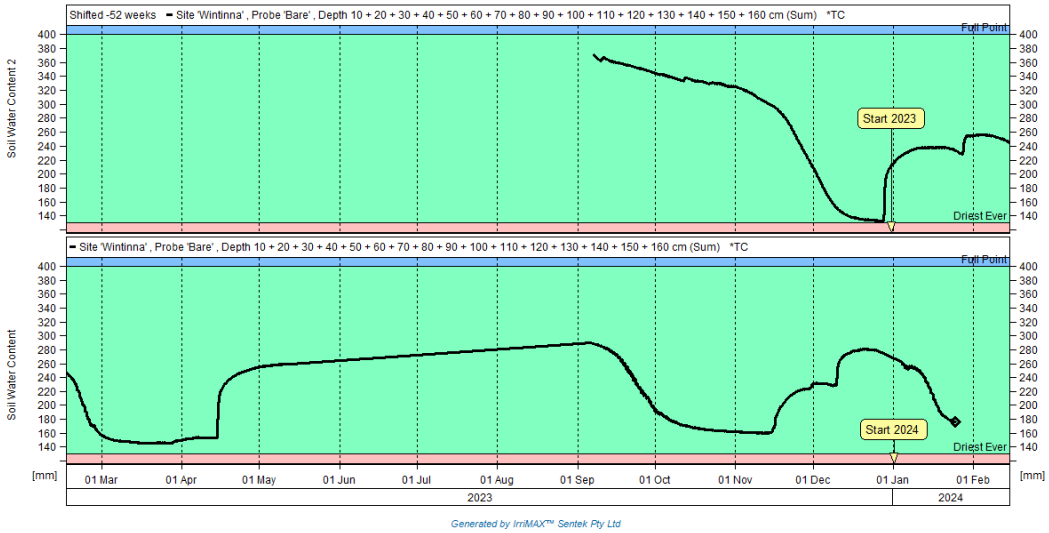
Measuring change on-ground in response to rest-based grazing practices

- Soil moisture probes

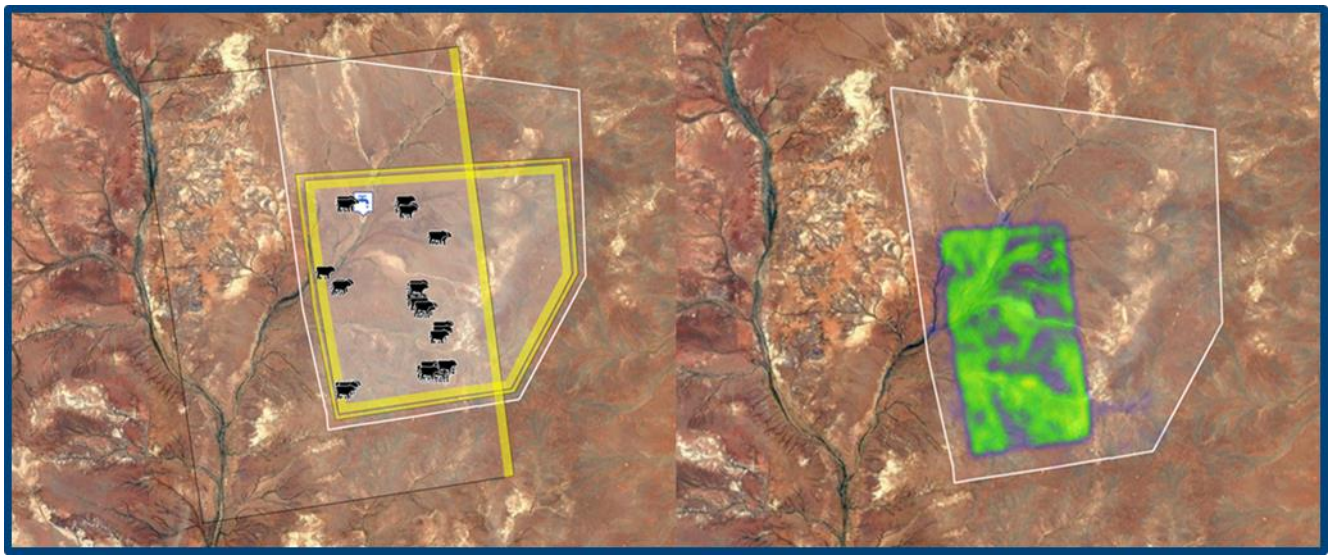
Paired site probes have been installed at the Wintinna weather station site in Middle Bore Paddock (*pictured right*), with aim to collect baseline data on soil moisture patterns and responses to rainfall events. The paired measures will allow monitoring the influence of deep rooted perennials (Mulga Shrublands) on soil moisture budgeting and pasture growth.

Paired site probes have been installed on Buckleboo (inside and outside of grazing exclosure) in attempt to measure long-term responses of deep rooted perennial pasture growth and root activity to grazing impact.

Data sets from the probes are still too "young" to make conclusive remarks about soil infiltration measured. Initial analyses indicate that perennial shrub cover significantly influences soil temperatures and soil water utilisation. The soil probes show promise to support pasture growth monitoring and planning long-term grazing programs by being able to estimate potential yield and pasture growth – particularly in the Bladder Saltbush pasture sites on Buckleboo. It is likely that the installation of this technology in its' current stage will be cost prohibitive for most pastoral businesses.

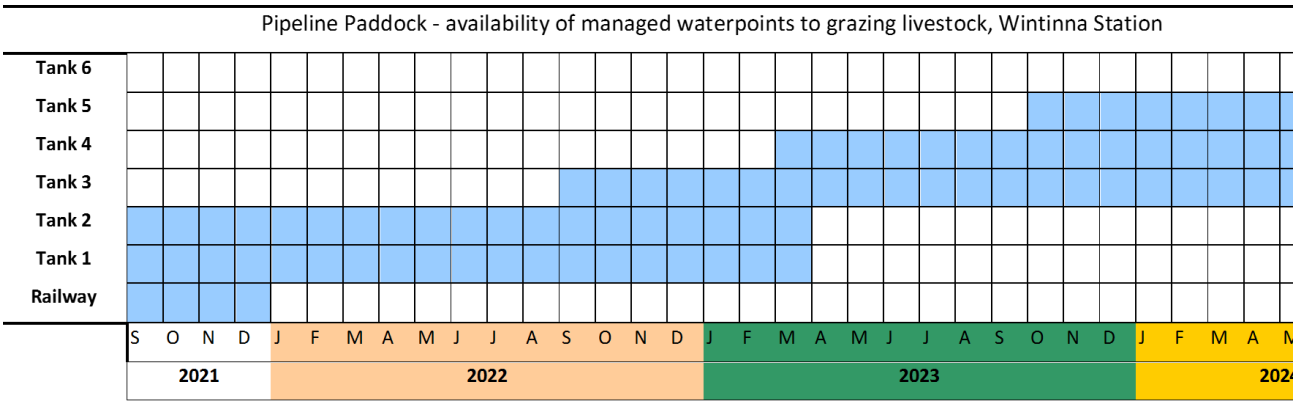


- Virtual fencing – an externally funded trial to implement virtual fencing technology was installed in Deep Creek Paddock on Wintinna Station; this has now been completed. Four major paddock moves were implemented to apply rest-based grazing management over a four month period. Further details on the project are attached in **Appendix G.**



Pasture Forage Budgeting & Ground Cover response – an externally funded project to trial accuracy of the Cibo Pasture Subscription Key on 6 properties was completed in 2023. Wintinna Station was one of the properties trialled. This data-set will continue to be reviewed over the next 2 years as cattle continue to be moved to the west of the paddock.

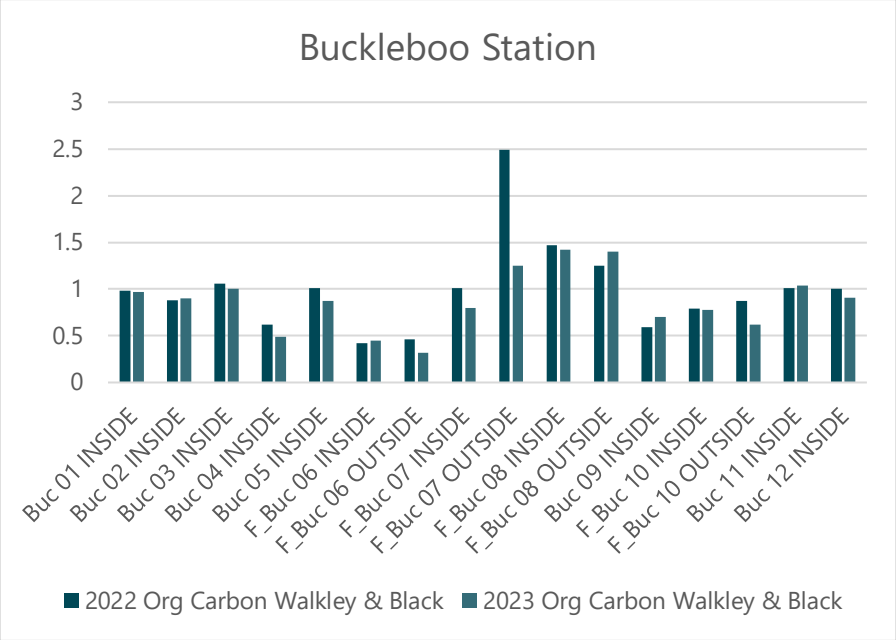
During the life of this project, Meat & Livestock Australia & Cibo Labs have developed and launched a national program to enable levy payers (all Australian commercial red meat producers) access to property scale mapping and feed base monitoring . The program is called the Australian Feedbase Monitor. This project has enabled collaboration with software developers to trial and promote the platform with producers to enable them to better monitor pasture growth trends and forward-plan grazing management strategies.



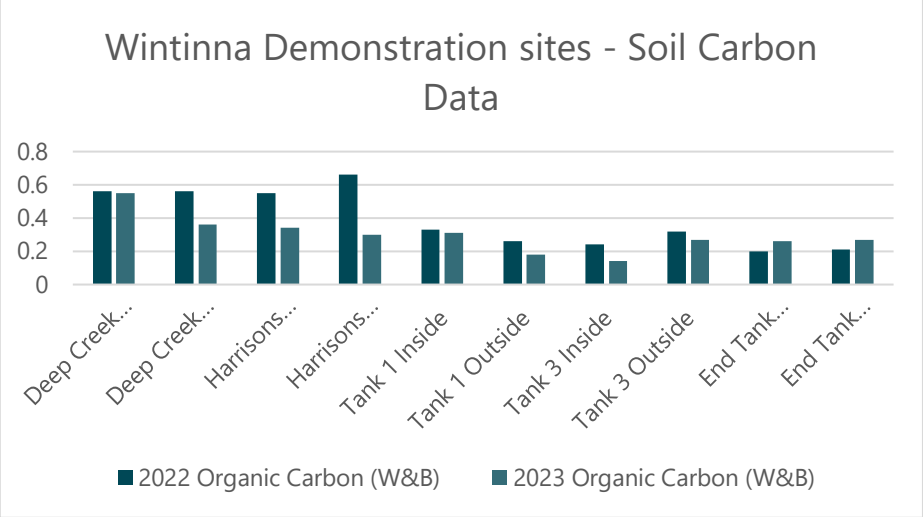
Soil Carbon

To date, there have been no significant changes measured in soil carbon profiles at the two major grazing demonstration sites at Wintinna & Buckleboo (2 years of data now collected.)

Soil organic carbon levels are considerably low in rangeland environments (compared to higher rainfall areas) and changes in carbon due to grazing management are difficult to detect with statistical confidence. OC levels are generally higher on Buckleboo (more rainfall) than on Wintinna.



Wintinna heavy clays hold more OC (Deep Creek & Harrisons paddock sites) than in sands (Pipeline paddock sites.) Stocking of paddock areas and drier conditions after 2022 sampling on Wintinna are likely to be the reason for slight decreases in SOC. A third year of data collection will enable confidence in finding SOC value trends.



Using technology to manage, monitor and understand livestock grazing behaviour

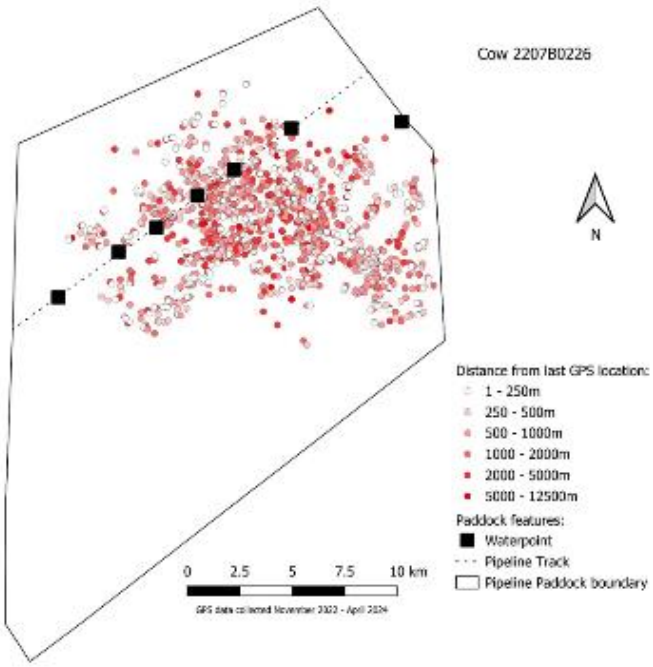
GPS Tracker Ear tags (Ceres Tags) were purchased and fit to a small sample-set of livestock on Wintinna and Buckleboo. This technology was chosen to trial in rangelands conditions, and to collect information relating to practice change; analysing how livestock are using country before and after pastures have been subjected to extended rest. Data was collated over an 18 month period and analysed to answer key site questions:

WINTINNA DEMONSTATION SITE OBJECTIVES

1.) Investigate the daily movement of cattle in relation to artificial water points and rainfall.
2.) Determine whether the use of artificial water points can be used to facilitate rotational grazing in a rangelands grazing system.
3.) Investigate whether cattle are moving around at night, and if so is it seasonal?
4.) Determine the longevity of Ceres tags on cattle in a heavily vegetated rangelands environment.

<u>Summary of results</u>

Review of the GPS data has enabled assessment of the movement patterns of cattle in relation to rainfall, artificial watering points and time of day:



- with movements largely focused around watering points (both natural and artificial) but exploratory movements also being made.
- the tags had the unexpected benefit of revealing 'hidden' water sources that appeared following rain.
- locations at night did not appear different to those during the day, suggesting cows do not use specific night 'roosts' but rest in the same places they graze and rest during the day.
- cows typically demonstrated lower activity when temperatures were either very cold or very hot.
- individual cows use the available space differently, with some individuals barely overlapping in range in a given month.
- The Ceres tags, although self-reported, appeared to be highly accurate.

(full report of findings captured in **Appendix H)**

BUCKLEBOO DEMONSTRATION SITE

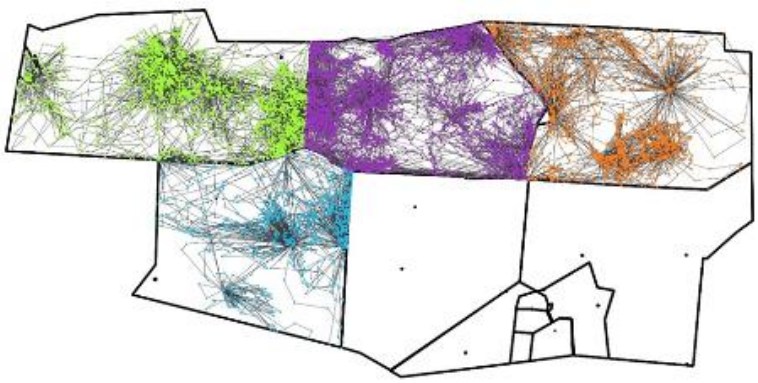
1.) Determine the time frame taken for sheep to 'spread out' when moved into a freshly rested paddock.
2.) Determine the average distance travelled by tagged sheep, and determine which individuals moved the most and the least, including whether lactation is correlated with shorter or longer distances.
3.) Determine whether there is difference in the daily distance moved by sheep between paddocks.
4.) Determine tag longevity for dorper sheep on Buckleboo Station.

Summary of results

Buckleboo Station has been divided into 6 large grazing areas (40,000 acres or approx.. 16, 187 ha each in size) and rested for a 15 month period. The combined GPS tag data from tagged dorper ewes was followed for the first four paddock moves:

- The GPS locations have revealed hotspots of activity, as well as highlighting lesser used areas within individual paddocks.
- Ewes quickly colonise a new paddock (in less than 48 hours)
- Environmental variables did not appear to have a strong effect on movement, except at extreme temperatures, however it should be noted that some rain was received in most months of the study.
- Age and breeding status also appeared to have no effect on the movement of dorpers.
- Ground-truthing of GPS locations may aid in flock management by revealing the features of preferred vs non-preferred areas within paddocks.
- Access to GPS tracked sheep movements of a small portion of the mob on a digital platform (aligned with the Australian Feedbase Monitor) enabled real-time decisions to aid more effective mustering and water trap management decisions (when to start moving mobs to the yards & how long to keep traps open.)
- Efficiencies gained by understanding where a small but seemingly representative portion of the mob were, enabled more effective mustering of expansive paddocks (fewer animals left behind after a paddock move.)

(full report of findings captured in **Appendix I)**



Monitoring Livestock Health

Opportunistic monitoring (largely visual based assessments) of livestock involved in the grazing trials was undertaken continuously throughout the project timeline.

Buckleboo Site

Ewes were mustered and processed (lambs tailed, castrated, weaned, older ewes culled) every three months, allowing close observations of overall mob health and productivity. There were no perceived disadvantages or negative impacts to livestock health related to transitioning mob management to a large flock grazed on a rotation.

In alignment with externally funded productivity trials, blood samples were taken from 40 ewes toward the end of the project. Analysis of results revealed no outstanding cause for concern. Of interest – some of the ewes sampled showed slightly elevated levels of Selenium & Calcium indicating these minerals are not a limiting nutrient in the paddocks that have been grazed. Blood tests also revealed low levels of Phosphorus and Sulfur, this is not unexpected given well-known Phosphorus deficiencies in pastoral country. Consideration may be given to future supplementation of livestock in this rotation design– and is a topic of on-going discussion with Paroo Pastoral staff and project collaborators. Full blood test results are included in **Appendix J.**

Anecdotal evidence supports that the transition to a rest-based and regular mob rotation has improved livestock behaviour traits. Due to regular handling and moving of sheep in the rotation, livestock are getting quieter. The rotation involves a regular pattern of animals being exposed to mustering, moving and then yarding; followed by a move to fresh rested paddock with ample pasture. Livestock handling patterns follow a work / reward pattern and establishes learned-behaviour traits that lead to lowered animal stress and 'compliance' with mustering and animal handling. Manager James Kerr has noticed significant changes in animal behaviour over the life of the practice-change. With particular note of animal temperament and ease of moving large mobs now becoming much quicker and quieter. Animals appear much less stressed when being moved and yarded, as they are handled and moved more regularly, older sheep in the mob know they will be rewarded with fresh feed and pick after yarding, younger sheep and lambs follow.

Wintinna Site

Cattle at the Pipeline trial were monitored regularly at waters and along the main access track on water-runs. A subset of animals were tagged with GPS ear tags, and observation of their movements regularly undertaken online. Over the project period, animals were mustered to castrate and wean calves every 6 months.

In August 2023, blood samples were taken from a subset of Heifers that were involved with the rotation trial undertaken with virtual fencing moves in Dead Finish Station, and a small set of bloods from livestock in the Pipeline Paddock moves. Animals in Pipeline Paddock have regular access to loose lick (including 20% Urea) and charcoal bins. The country type in Pipeline Paddock is Mulga Shrublands (over deep sands) and is the type of country considered deficient in Phosphorus – for this reason, livestock diets are supplemented with minerals at the water points. Heifers in Dead Finish paddock had no additional supplementation.

Veterinary analysis of animals and bloods sampled indicate no cause for concerns of animal health or welfare in either Dead Finish virtual fencing rotation or Pipeline water movement trials. All mineral levels appeared adequate, and supplementary mineral availability at Pipeline Water points is adequate. Of note, bloods indicate a potential worm burden in Pipeline paddock livestock, and veterinary advice questioned the impact of surface clay-pan water and it's potential link with internal parasite burden. This requires further attention.

Red cordial was sprayed around key sensory points at new yards and areas to encourage stock to move toward waters as they were turned on (influencing animal behaviour to be ready for stock moves)

Peer-to-peer learning

Field Days, Sticky Beak Days & Training Days

Three on-ground sticky beak days (Buckleboo, Koonamore & Upalinna); one virtual field day held online (on Wintinna Station – held virtually due to remote proximity of the property) and three on-ground training focussed field days (held at Corunna, Plumbago & Boolcoomatta Stations) were facilitated to visit demonstration sites and case study examples monitored through the life of this project. Prior to the events, baseline soil monitoring data from numerous sites around the properties were collected and analysed. The results, site history and soil testing demonstrations were shared to attendees during the field day events. This included data on carbon cycling, water infiltration and soil chemistry analysis.

In total, 324 individuals (excluding children) participated in one or more soils and grazing management focussed field days or training events held over the life of the project.

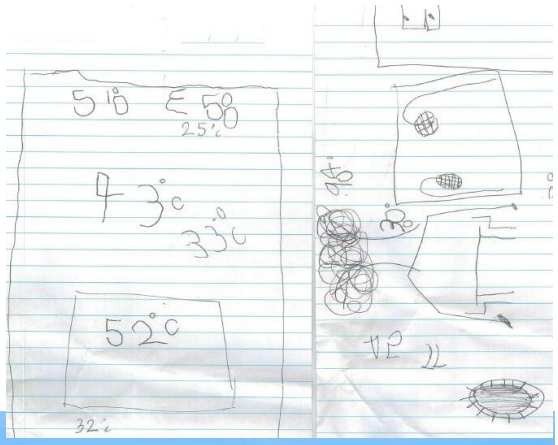
27 Participants (not all pictured) attended the Boolcoomatta Field Day, 2024

Of the participants, 169 work on or manage a pastoral property lease (pastoralists) and 22 were Graziers (freehold or perpetual lease grazing lands.)

14 of the participants were responsible for managing conservation land or estate in the arid lands region, and 30 lived in regional communities or managed small hobby holdings/rural blocks.

75 of attendees worked for an industry body (including stock agents, livestock groups) or in land management or extension. 14 attendees were researchers or academics. These individuals work with land managers and in their roles or circles of influence - their learnings are likely to have spread beyond the project footprint or 'captured' monitoring area.

Soil health focussed education events were also shared with school groups and local show days in the region (attendance data not captured.) Project results were shared over the life of the project with Sustainable Agriculture Extension Networks, and regular updates and data review with locally relevant communities of practice, district community groups and the SA Arid Lands Board.



Pictured right – Working with students from the Marree Aboriginal school involved measuring soil and surface temperatures around the campus. Students measured and mapped soil temperatures around the school grounds and then discussed soil health measures including the importance of shade, compost and litter cover.

Project Participation

324 participants involved with project events and demonstration site work

Participation Demographic break-down

- 169 pastoral land managers / owners
- 22 Graziers
- 14 conservation land managers
- 30 community reps/small block owners
- 75 industry reps or extension roles
- 14 researchers

**more than 55 children and family members were also involved with the projectct delivery (not recorded in project evaluations)*

From the Ground Up – Regen Grazing Bus Tour

Regenerative Rangelands

LANDSCAPE SOUTH AUSTRALIA SA ARID LANDS

BUS TOUR - 17TH TO 23RD MARCH 2024

This trip was co-designed with a small group of pastoralists from across the project footprint to enable peer-to-peer learning and visit sites of interest (particularly demonstration sites engaged with the Rangelands Living Skin research project) in western NSW. The focus of the trip was to explore and learn about the application of regenerative grazing methods and practices in semi-arid rangelands environments.

Collaboration with cross-border agencies and Communities of Practice and research networks were established and strengthened as a result of organising site visits and sharing of project results during this tour.

Some of these networks include:

Anne Brown & Millie Nicholls. Dr Sarah McDonald, NSW DPI, Courtenay Lallard, Paul Theakston, Craig Anderson & Brian Dohn from NSW Local Land Services, Bruce Maynard & Hugh Pringle. Greg Curran from Broken Hill Landcare, Nick Kentish, Dick Richardson, and George Millear also supported context for tour visits.

Site vists were hosted by Gus & Kelly Whyte at Wyndham Station, James & Kimberley McClure at Netallie Station, Luke & Sarah

Who was on the bus?

18 participants aged 25 to 72 – travelled 2,500km

Participants were collectively responsible for managing 1.8 million ha of pastoral and grazing country across SA rangelands.

5 demonstration sites on working pastoral properties in NSW were visited, involving engagement & networking with researchers, pastoralists, extension officers, animal health experts, soil scientists and ecologists.

Mashford at Katalpa Station and Andrew & Meagan Mosley at Etiwanda Station, Neil Sleep at Peterborough.

Resource Development

Following are examples of materials and resources developed during the period of this program. Most materials can be found through web-links on the SA Arid Lands Landscape Board website. These resources will be used in extension and one-on-one activities with pastoral land managers well beyond the life of this project.

Field Resources – made available to landholders	Training Resources	Fact sheets, printed materials, formal reports	Web-based media – short films
Soils testing field kit	**Grazing Land Management Training Manual**	**Virtual Fencing Case Study and Return on Investment publication**	**Boolcoomatta Landscape Rehydration Field Day**
Infiltration tube experiment	**Grazing Land Management Training Slide set**	**Native Pasture Nutrition Spreadsheets**	**Learning together - Soil rehydration**
Soil Your Undies experimental kit	**Land Condition Score cards**	**Animal behaviour tracking – Ceres Tag Report for Wintinna Station & Buckleboo Station**	**Wintinna Station Virtual Field Day**
Customised Station maps with Landsystem overlays	**Avenza Maps "how to" guide and info sheet**	**SA rangelands soils data report**	**Using technology to manage grazing in Pastoral Country**
"How to" Soil Identification booklets	**District Pasture Growth models covering southern Rangelands regions**	**Feed and TSDM cover assessment Photo Guide – Gawler Ranges (Buckleboo Station)**	**Monitoring Feed from Space**
Native Pasture Guide	**GIS layers of a fictional case study property– Wild Peach Downs**		**Tech and grazing trials in Pastoral Country**
Soils of the SA Rangelands – Brown Book			**Virtual fencing trial in the SA Arid Lands**

Southern Rangelands Grazing Land Management Course

Course & materials development

The development and delivery of this training in collaboration with Meat & Livestock Australia, was a major milestone for this project.

The Southern Rangelands Grazing Land Management Training Course and materials were co-designed with a team of rangeland experts including: Ron Hacker, Dionne Walsh, Deb Scammell, Jodie Reseigh, Trudie Atkinson and Tanisha Shields. Development of the training manual and work book activities was supported by Deb Scammell, Jodie Reseigh, Mitchell Plumbe, Ron Hacker, Holly Whittenbury, Liese Howard, Harriet Bawden, Andrea Tschirner and Liz Allen.

Materials and course content was designed with a focus on achieving foundational learnings across three main subject areas. Training was designed and delivered to include a mix of classroom, workbook and outdoor hands-on style learning activities:

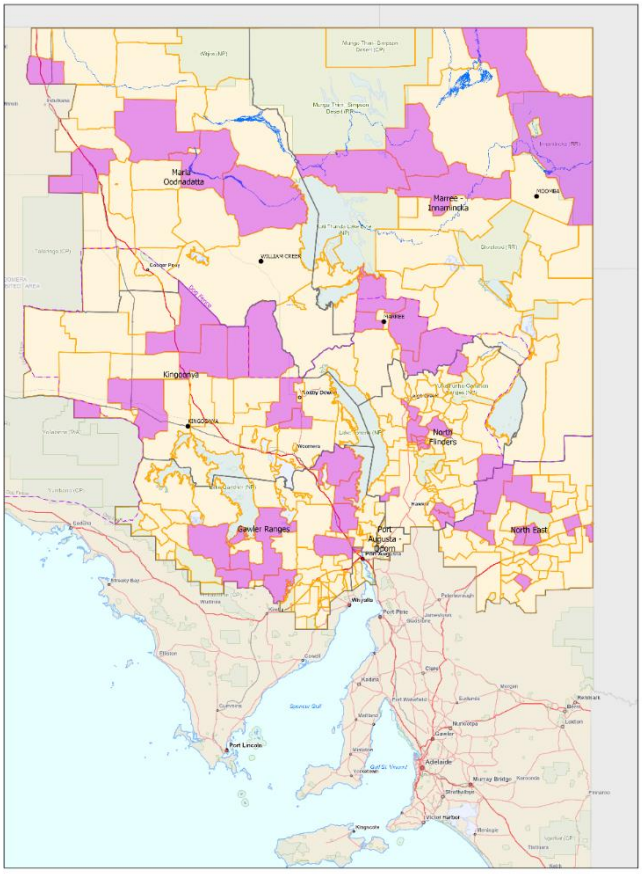
- **Nutritional requirements for animal production –** ruminant nutrition and calculating forage demand
- **Factors affecting forage production** – landscape function, soil and water cycling, land condition assessment
- **Grazing Management** – Carrying capacity and forage budgeting

The aim of the training day was to build the skills-base of pastoral land managers and graziers to monitor and improve land condition (with a focus on ground cover, biodiversity and drought resilience) into grazing practices.

Course materials that have been developed include a Participant Manual, Workbook, Pasture Growth Models, Case Study property maps (Wild Peach Downs north & south) and presenter Slide Sets. The Participant Manual is attached in **Appendix K.**

Course delivery

In total, **142 pastoralists/graziers** and **9 extension officers** working in rangelands environs attended the full day course. In addition, 30 children attended training days with their families.



Southern rangelands Training delivery team – Dionne Walsh, Tanisha Shields, Deb Scammel, Mitchell Plumbe & Andrea

Grazing Land Management Courses were attended by participants from 60 pastoral leases and 18 grazing properties from across the project footprint. Participants involved in the training represent a total management area of over 22 million hectares.

Mungerannie Roadhouse – 15th August 2023

Lyndhurst Town Hall – 17th Augusta 2023

Blinman Town Hall – 19th August 2023

The delivery team customised training content prior to each training event to ensure relevancy to each specific region. Customisation included changing livestock production figures relevant to stock classes and breeds carried in each delivery area, pasture growth models relevant to local climatic patterns and land systems & soil conditions. Customisation of each course, ensured relevancy to participants and resulted in positive feedback from participants. Participants also expressed gratitude in having delivery on-site (not having to travel to Port Augusta or Adelaide to attend training).

Bindarrah Station – 21st August 2023

Yunta RaceCourse – 22nd August 2023

Quorn Community Hall – 24th August 2023

Stirling North Golf Course – 25th August 2023

Mt Eba Station – 3rd October 2023

Oodnadatta Racecourse – 5th October 2023

Coober Pedy Golf Course – 5th October 2023

Nonning Station – 7th October 2023

Evaluation

The final report with Evaluation data and summaries in included in **Appendix L.**
Evaluation data was captured for each individual workshop. The overall value and satisfaction scores for the workshops were 9.1/10 and 9.4/10 respectively. An internal MLA KPI for producer adoption programs is to maintain satisfaction and value score >7.5/10, indicating that this course far exceeded that benchmark. Value scores were broken down by module (Table 5 of the Final Report compiled by MLA) showing a ratings difference of only 0.1/10 between each module. This is quite significant in demonstrating the relevance of all three course modules and the consistent quality of delivery.

The "Intention to implement change" was measured at 92% of participants, this is considered a highly positive result. Further insight to this figure is provided in Table 4 of the final report, where the most common intended change to implement (at 64% of participants) was to assess land condition of paddocks.

From GLM participant feedback evaluation, documented areas of interest and willingness to practice or change included:

- Past management strategies, photo monitoring.
- Photo points.
- Consider use photo points to monitor land condition.
- Working on decision making process.
- Review water management.
- Monitor water quality.
- Take more notice of 3P species in pastures.
- Use app for photo monitoring.
- Few more photo points around.
- Carry out land condition scores.
- Set up photo points for long term monitoring, use more surface water and less bore water where possible.

Project summary

What worked well?

- Having access to a formally trained Soils Scientist in an allied program (Dr Geoff Kew) meant we could deliver extension activities and set-up demonstration sites in a much faster time frame as soon as the project was approved with DAFF.

- Working with partners and external collaborating bodies helped develop material and research based outputs with integrity. Of particular note is the Virtual Fencing Trial with SARDI, and MLA on the development and delivery of the Grazing Land Management Training package and program roll-out.

- Thinking outside the box (or State boundaries) - Developing a training product and associated resources that can be shared across state boundaries (Southern Rangelands Grazing Land Management Training package) and beyond the life of this project. Linking with the Rangelands Living Skin project has supported many aspects of this project – finding useful resources and experts on rangelands and pastoral management subject matter outside of our patch, that is up-to-date and relevant in a contempory setting.

- Having a 'hands-on' approach to looking at and monitoring soil health during field day and training events. All participants were encouraged to get their hands dirty, and to learn processes of identifying texture, slaking properties and soil chemical properties (like pH & Salinity) to understand key management principles. Allowing room in the budget to resource field day events with books and learning materials to give to interested participants to take home or borrow added value to these days (especially books and guides on soil health).

- Working with post-graduate students on specific studies that complemented demonstration site work was unintended in the planning phase, but has positive outcomes for many reasons including:

- Supporting the succession and interest of young researchers in the rangelands region (there is currently a serious shortage of young and mid-career scientists in this field).

- Approaching conventional or tradition problems with a new focus – particularly access to emerging technologies like LoWaRan Tower capabilities, meta-genomics testing (Megan Willis, Rebecca Greening, Sam O'Connell).

- Peer-led learning that continues "behind the scenes" of this project, including new connections with Young in Soil Science SA group.

- Approching specialists "outside of our field" to engage with pastoralists. For example, extension specialists experienced in low rainfall broad acre cropping or from interstate to work in a pastoral region. These specialists were able to bring a fresh set of eyes to our region, and an alternative interpretation of the challenges we are hoping to over come to help co-design management approaches or practice changes.

- Engaging the 'next-gen' of pastoral land managers in field based events – especially the Regenerative Rangelands Tour in western NSW. The undies experiement and informal colleciton and identification of Dung Beetles at project sites attracted the attention of station and community children, kids participation at field days and site visits was not recorded in the evaluation process, but was significant.

What was challenging?

- Fitting everything we wanted to do into less than 2 years!

- Producing communications products to a high standard in a short time frame toward the end of the project.

- Finding and sourcing presenters to deliver workshops or training in timeframes that are also suitable for pastoral participants (working around regional mustering/shearing/community events.)

What would we do differently?

- Engage communications experts / content creators earlier in the project to support co-design of fact sheets and case study content.

- Engage more University students and Supervisors, or research institutions to support longer-term on-ground monitoring (particularly to monitor grazing practice based animal production parameters.)