'POONUNDA'

Carbon & Natural Capital for Resilient Farming Systems

Status & Opportunities

Prepared by Daniel Hanisch (Project Manager/Ecologist – RegenCo)

for Ryan & Ellie Oates (Trading under "JM & JC Oates"),

Primary Industries & Regions SA (PIRSA), and

Upper North Farming Systems (UNFS)

May 2025

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WHAT ARE WE DOING TODAY

Australian Farmers have been working the land for centuries, each generation motivated to leave the land more resilient, productive, and profitable than how they found it. It's this spirit of being stewards of the land that inspires Regenco's mission; we exist to help farmers sustain the land that sustains Australia. This generation, and every generation to come.

We value and respect this expertise that comes from years of working the land. So, we built a natural capital business that complements farmers existing land management practices. As a group of pastoralists, grazing land management specialists and scientists with over 100 years combined experience working with the land, we have first-hand experience of the unique challenges farmers face. We listen to what farmers want and work in partnership to create mutually beneficial land management plans that help them make the most of their land. One that maximises their profits and productivity, while regenerating the land. It's an investment in our farmers, and our future.

A future that's good for producers, paddocks and the planet.

Regenco, value that grows.

‘POONUNDA STATION’

Carbon & Natural Capital for Resilient Farming Systems

Status & Opportunities

Dear Ryan and Ellie, Primary Industries & Regions SA (PIRSA), and Upper North Farming Systems,

We are grateful firstly for the opportunity to be involved, and secondly for your contribution of time and resources to help us develop this report.

The broader PIRSA program that funded this project was an important investigation into identifying where environmental market opportunities align with improving productivity, profitability and resilience to a changing climate. Based on our findings in this report, we believe there are clear opportunities for the Oates’ enterprise to deliver subtle management changes that can drive both economic and environmental improvement, while continuing to maintain agricultural production into the future.

This important case study highlights ways in which other landholders in the region could consider the value of natural capital and environmental markets being integrated into their current enterprise mix. While each enterprise and its landholdings is unique, there are some valuable take-away messages in this report for other regional businesses, which are highlighted in the executive summary, climate resilience being key.

We have to expect that the future is not going to be a simple repetition of the past- either for markets or the environment. Taking on board the findings of this report will stand the Oates (and other landholders in the region, and indeed across the State) in a much stronger position to capitalise on opportunities that emerge, while keeping a key focus on agricultural production and the financial drivers of their business.

We wish you well in the implementation of the aspects of this report that you see having significant positive impacts for your business, and standby to provide any further assistance you require moving forward.

Dr Tim Moore
Head of Science and Strategy, RegenCo
Greg Noonan
CEO and Managing Director, RegenCo

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Contents

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1. LANDSCAPE & CLIMATE CONTEXT

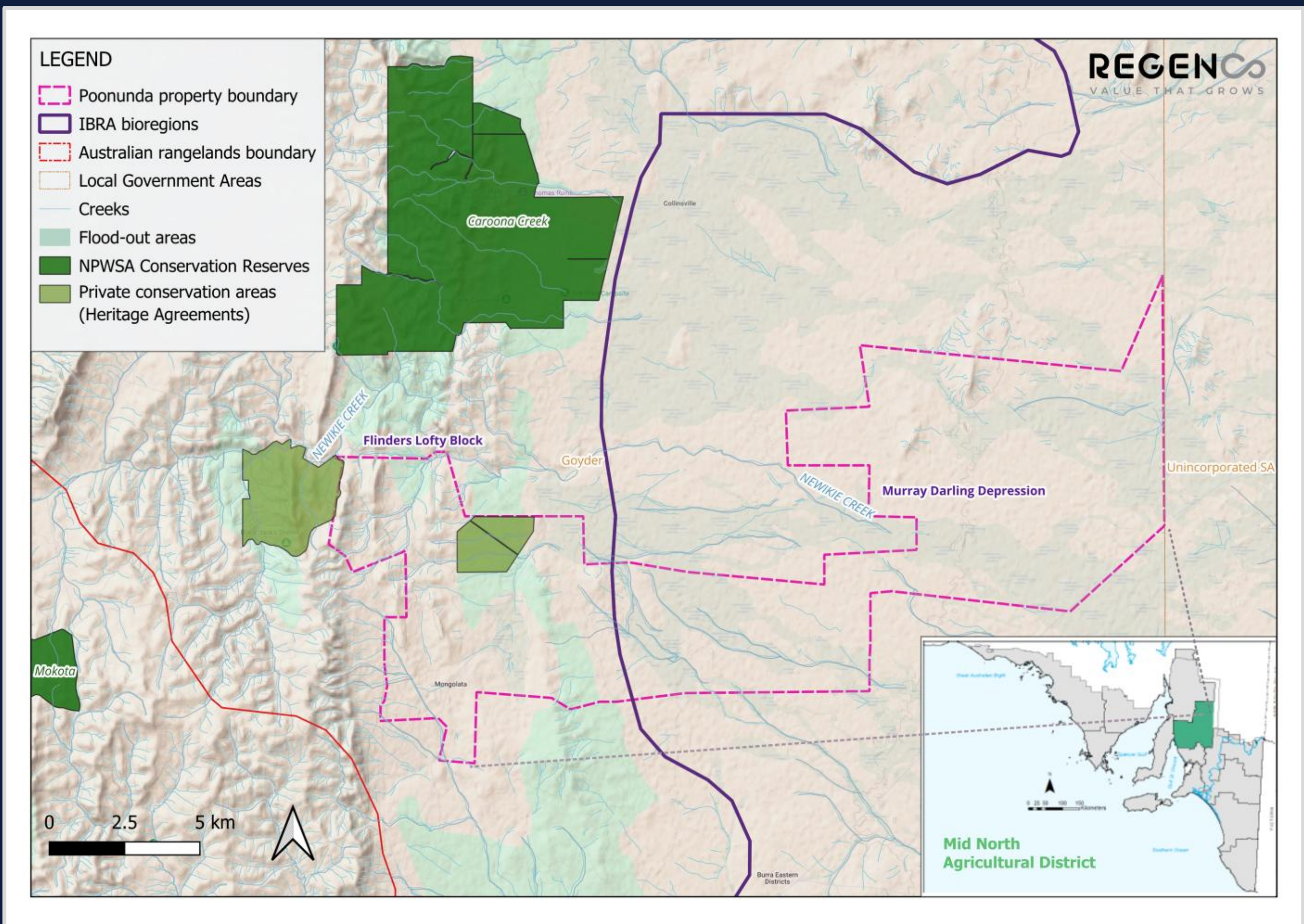
LANDSCAPE CONTEXT – REGIONAL SETTING

Poonunda is a 16,650 ha sheep grazing operation on the eastern side of the Northern Mount Lofty Ranges (Burra Hills) approximately 20 km northeast of Burra, South Australia, in a locality known as Mongolata. Historically, some parts of the property were cropped but this land use was abandoned decades ago.

From west to east, the property starts in higher rainfall country (350 mm) on the eastern slopes of the ranges (Flinders Lofty Block bioregion) but then descends to a wide depositional plain (Murray Darling Depression bioregion) with low annual rainfall (230 mm). Both these bioregions belong to the Mediterranean Forests and Woodlands & Scrub biome, where clearing for agriculture has been widespread and, generally, only fragmented vegetation remains with only 9% under protection. The status of these regions is Critical/Endangered, according to WWF.

The boundary of the Australian Rangelands, roughly following the Goyder Line which demarcates the reliable rainfall region for cropping in South Australia, also occurs only 2 km to the west of Poonunda.

As such, Poonunda can be regarded as occurring in ecologically transitional country - where diversity of plants, birds and other biota is often maximised - as well as agriculturally transitional country - where cropping ceases to be viable and low intensity grazing of native shrublands becomes preferred practice. This ecotone is very obvious on the ground, with the vegetation transitioning from mallee-dominated woodlands with grassy or shrubby understorey in the west, to chenopod shrubland in the east.



Regional physiographical context of Poonunda Station

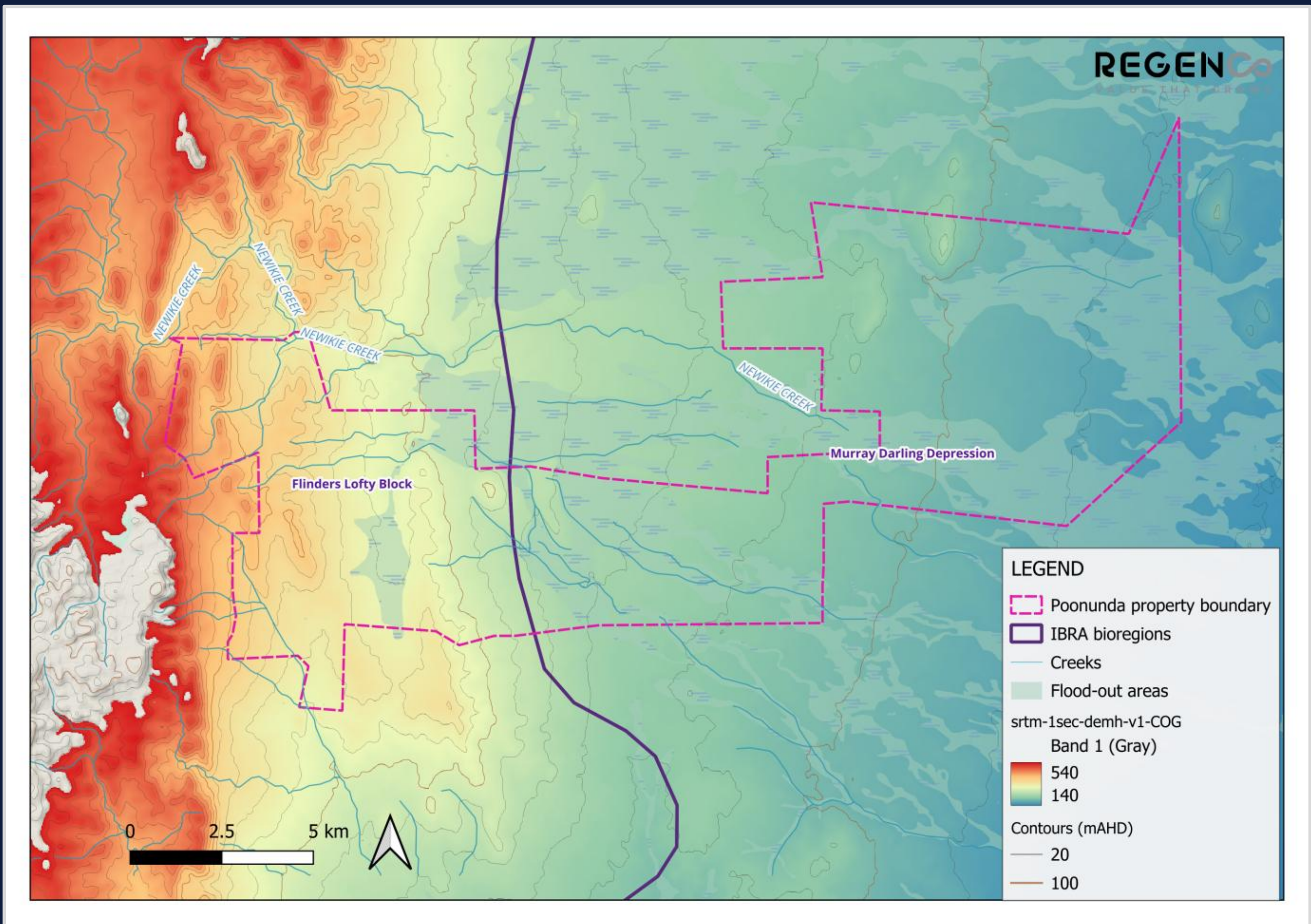
LANDSCAPE CONTEXT – TOPOGRAPHY & HYDROLOGY

Poonunda lies at an altitude of 510-170 mAHD with the highest altitude parts on the western border of the property, on the partially cleared and modified eastern slopes of the Burra Hills. The topography from the western boundary trends down to an intermontane swale (Shamrock), then rises over another low ridge covered with mallee woodland before descending from the Flinders Lofty Block to the Murray Darling Depression Bioregion and a wide alluvial saltbush plain, which gently slopes down into the Southern Olary Plain and to its lowest point on the property in the south-east corner.

Although only receiving about 230-350 ml of rainfall, with the annual average decreasing from west to east, Poonunda has some noteworthy hydrological features owing to its receiving position in the landscape (i.e. outflow plains and foothills). Several ephemeral creeks, some with deep meandering gorges, run off the eastern slopes of the ranges and infrequently flood-out onto the eastern plain.

Of particular note, Newikie Creek is a locally significant watercourse whose headwaters occur in the north-west of Poonunda. This creek is ephemeral and rarely flows but has a semi-permanent spring on Poonunda's northern boundary, which is fed by infiltration of rain on the adjacent ranges into local groundwater systems. The creek passes through mallee woodland and chenopod/black bluebush shrubland, running north of the property after leaving the ranges before turning south-east and re-entering the eastern plain of Poonunda, which is belongs to the Murkaby Land System. In heavy rainfall conditions, Newikie Creek floods out in this part of the property over a wide area.

The current PMP for Poonunda notes that historical overgrazing and poorly devised infrastructure have created several problems for the hydrological integrity of Poonunda, resulting in scalded soils incapable of absorbing water, landscape dehydration and erosion. Landholder efforts to rehabilitate areas through ripping are showing encouraging results.



Elevation & hydrological features of Poonunda Station

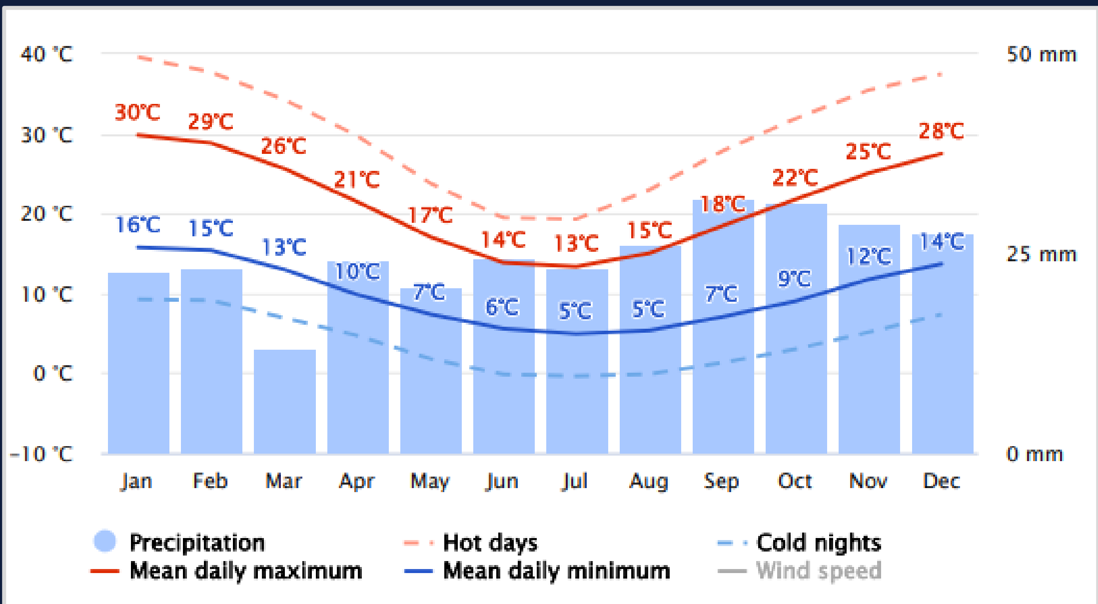
CLIMATE CONTEXT – TEMPERATURE & WATER BALANCE

The climate experienced by Poonunda, and the local region in general, is classified as semi-arid, generally receiving rainfall of 250-350 mm per year. The nearby ranges receive slightly more rainfall on their peaks, at about 350-450 mm per year.

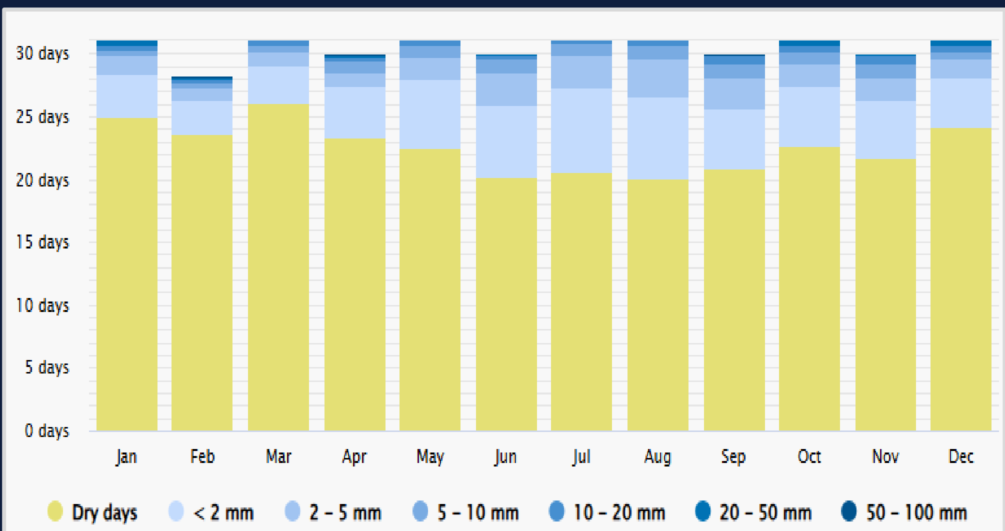
The long-term rainfall pattern favours winter-spring rainfall, however this has shifted towards a heavier summer rainfall pattern and reduced winter rainfall in the past two decades, such that rainfall is now more even throughout the year. Rainfall is poorest on average in March, raising risk of feed shortage before the autumn rains arrive.

Average maximum summer season temperatures are high (high 20s to low 30s) and maximum winter temperatures are mild (low to mid teens), while overnight average minimums are 5-6C and sometimes fall below zero.

Total annual pan evaporation is about 1900 mm, peaking at 10 mm per day in January.



The "mean daily maximum" (solid red line) shows the maximum temperature of an average day for every month for Mongolata. Likewise, "mean daily minimum" (solid blue line) shows the average minimum temperature. Hot days and cold nights (dashed red and blue lines) show the average of the hottest day and coldest night of each month of the last 30 years.
Note the very high hot day average from November to February (over 35C) and the very low cold night minimum from June to August (0C). (Source: Meteoblue website)



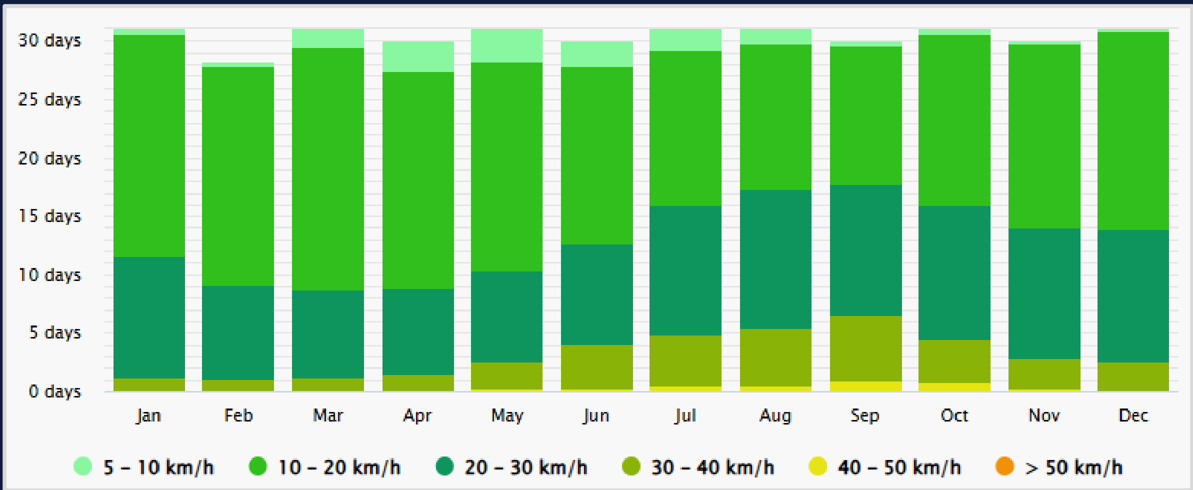
The precipitation diagram for Mongolata shows on how many days per month certain precipitation amounts are reached. Note that rainfall days are lowest in late summer-early autumn, with the larger precipitation events generally occurring autumn-early summer. (Source: Meteoblue website)

CLIMATE CONTEXT – WIND SPEED, DIRECTION & SEASON

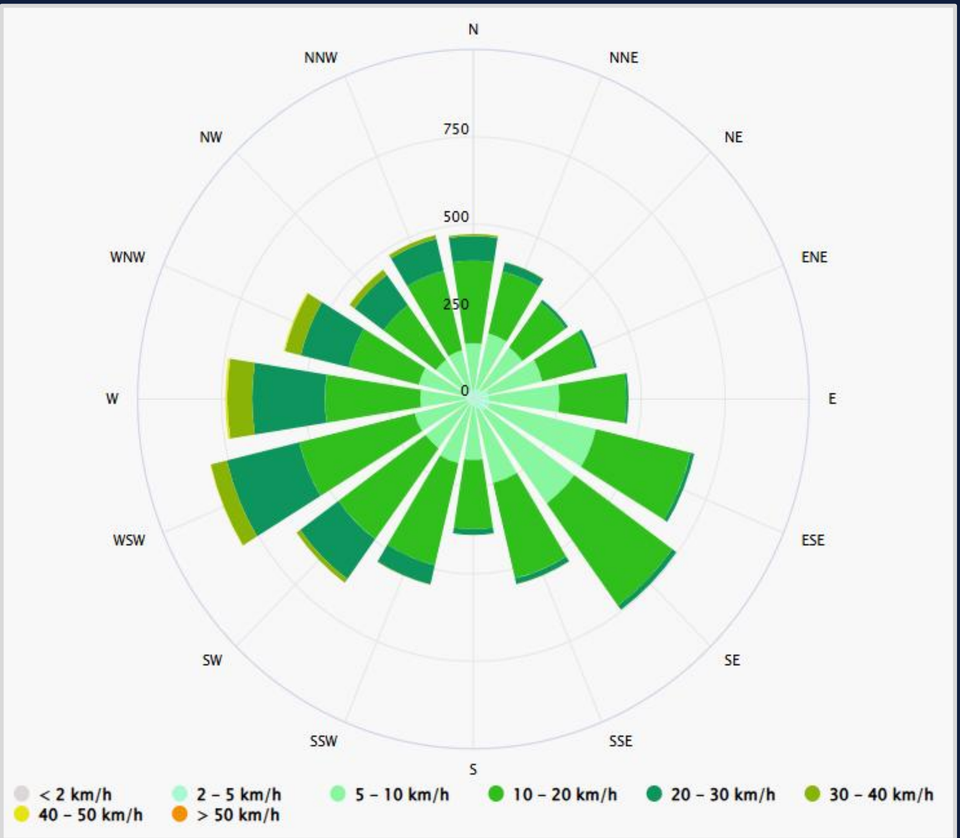
The Mid North Agricultural District of South Australia is a windy part of the state, and the area around Poonunda is no exception, with the period from July to December being a period of particularly strong winds, before easing in late summer.

September is when wind speeds generally peak, while Autumn is the time of year with most gentle winds.

Wind direction is primarily from the west/south-west, especially when winds are strong (more than 20 km/h). Although a large proportion of annual winds also blow from the south-east, these tend to be more gentle breezes. Strong hot winds (up to 40 km/h) will sometimes blow from the north-west, especially from Oct-January.



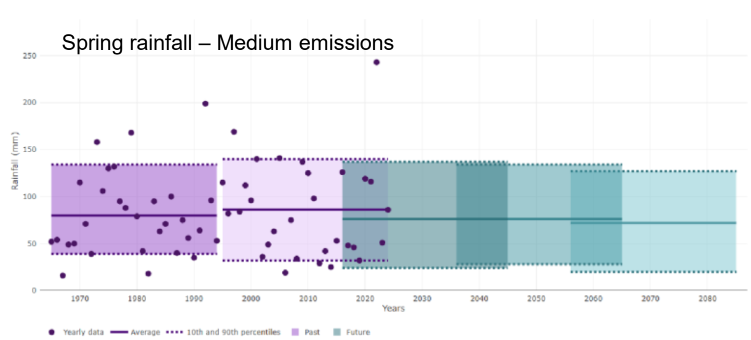
Wind Speed: The diagram shows the days per month during which the wind reaches a certain speed at Mongolata. Note that the windiest time of the year coincides with the wettest time of the year (Aug-Dec) and overlaps with the coldest time of year (Jun-Aug). (Source: Meteoblue website)



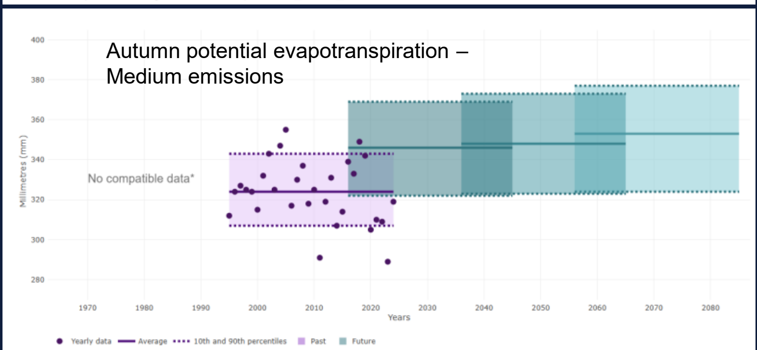
Wind Direction: The wind rose for Mongolata shows how many hours per year the wind blows from the indicated direction and at what speed. Note that almost all winds greater than 20 km/h, and all winds greater than 30 km/h, blow from a westerly direction (SW to NW) (Source: Meteoblue website)

CLIMATE CONTEXT – WATER BALANCE TRENDS

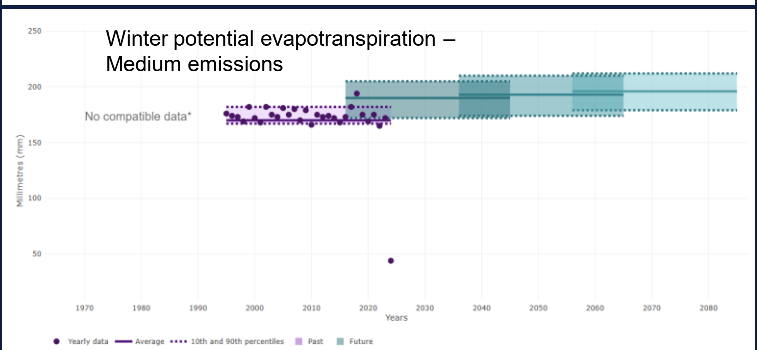
The My Climate View website provides regional level climate projections under climate change scenarios for primary producers. For the Mongolata region, rainfall projections suggest a 10 mm decrease in Spring rainfall when comparing the 1995-2024 period to projected rainfall in 2050, as indicated in the first graph below. Rainfall in all other seasons is projected to remain steady. The website also provides projections for evapotranspiration to 2030, 2050 and 2070 based on medium emission climate change model scenarios. All projections for evapotranspiration are for an increasing trend, suggesting a worsening water deficit. Particularly noteworthy are the large increases in evapotranspiration in the next ten years or so under the influence of climate change.



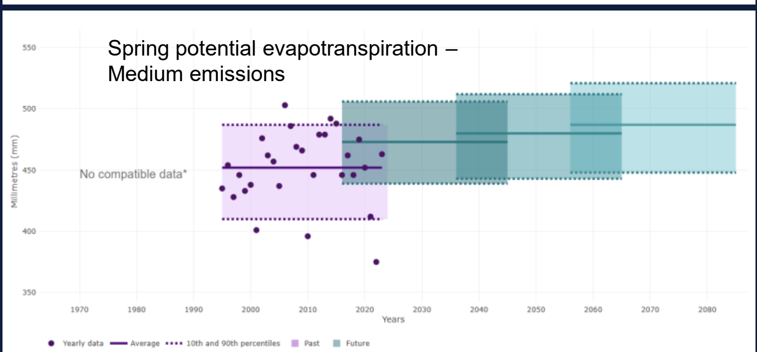
Past		
1965–1994 average: 80 mm	1995–2024 average: 86 mm	
Future		
2030s average: 76 mm	2050s average: 76 mm	2070s average: 72 mm



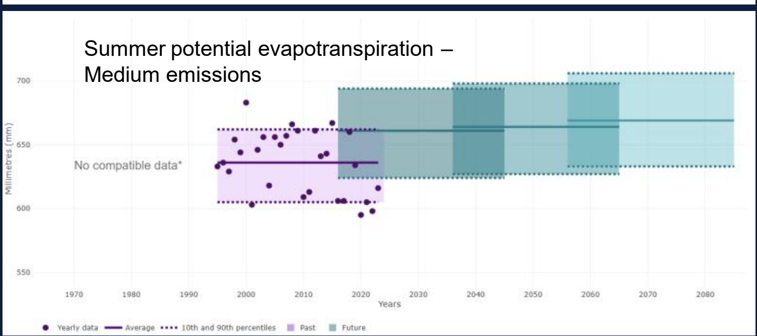
Past		
1965–1994 average: No compatible data*	1995–2024 average: 324 mm	
Future		
2030s average: 346 mm	2050s average: 348 mm	2070s average: 353 mm



Past		
1965–1994 average: No compatible data*	1995–2024 average: 170 mm	
Future		
2030s average: 190 mm	2050s average: 193 mm	2070s average: 196 mm



Past		
1965–1994 average: No compatible data*	1995–2024 average: 452 mm	
Future		
2030s average: 473 mm	2050s average: 480 mm	2070s average: 487 mm



Past		
1965–1994 average: No compatible data*	1995–2024 average: 636 mm	
Future		
2030s average: 661 mm	2050s average: 664 mm	2070s average: 669 mm

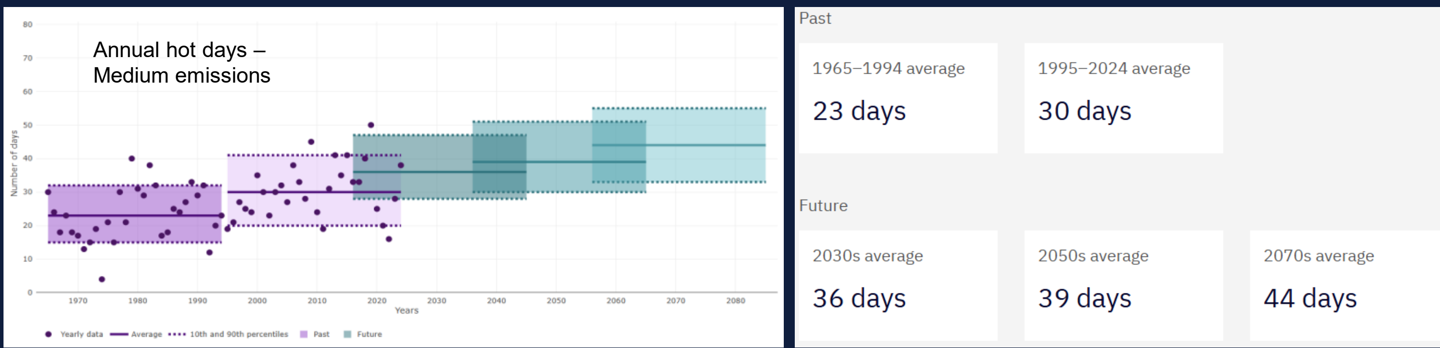
CLIMATE CONTEXT –HEAT STRESS RISK

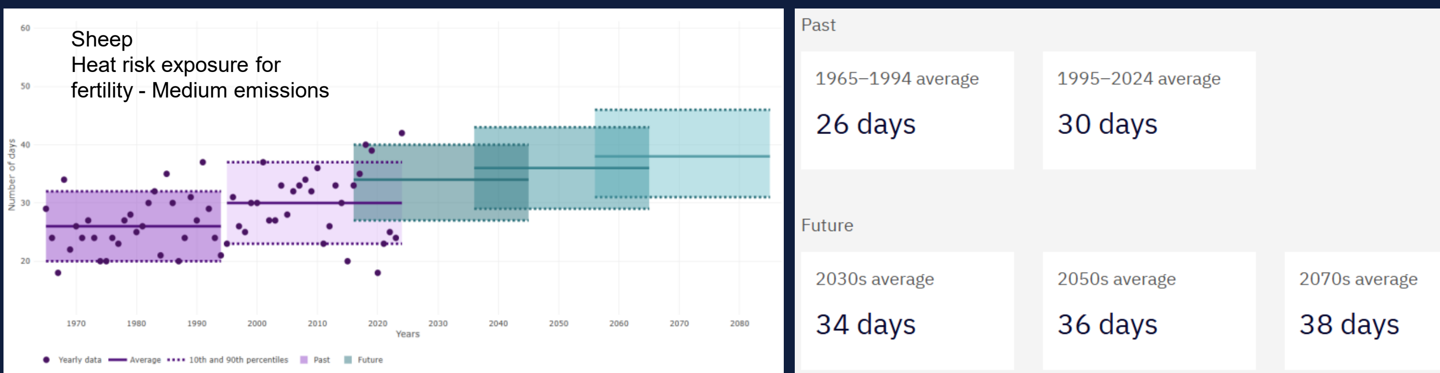
For well-fed, adult animals, the effects of higher temperatures are substantial. For example, sheep with a full fleece will often increase their respiration rate when the temperature reaches 18–21°C.

The graphs for the Mongolata region below are taken from My Climate View.

The first graph indicates the number of annual hot days (more than 35C) during the 1965-1994 and 1995-2024 periods, showing that the average number of hot days has increased from 23 to 30. The graph also provides projections for annual hot days to the 2030s, 2050s and 2070s based on medium emission climate change scenarios. All projections suggest that annual hot days will continue to increase up to an average 44 days per year by 2070 – almost twice the 1965-1994 figure.

The second graph shows the number of days per year that are potentially harmful to sheep fertility due to excessive heat. The data are restricted to 15 January - 15 June each year, which is the period identified as the main lambing time around Mongolata. Unsurprisingly, the current and projected trends follow much the same increasing pattern as those presented in the “Annual hot days” graph.





Why does it matter?

Heat stress reduces sheep fertility and lambing rates. Hot conditions can reduce the production and quality of ram semen while ewes’ fertility cycle can lengthen reducing the number of opportunities to fall pregnant. Further, heat stressed ewes can have higher embryo mortality in early pregnancy and lower foetal weights. Collectively these affects can lower productivity.

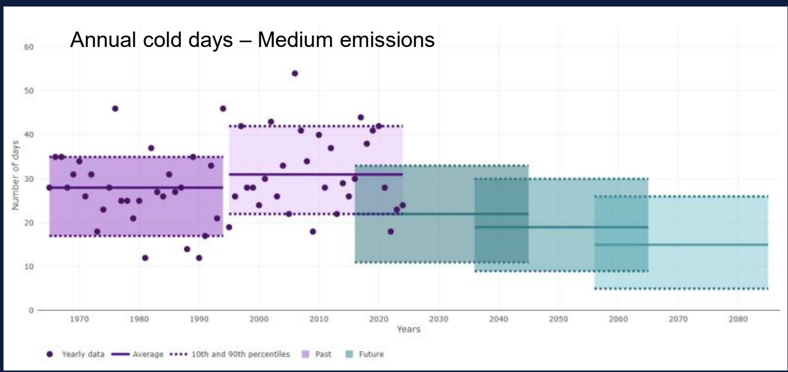
CLIMATE CONTEXT – COLD EXPOSURE RISK

The graphs below are taken from My Climate View for the Mongolata region.

The first graph indicates the number of annual cold days (with minimum less than 2C) during the 1965-1994 and 1995-2024 periods, showing that the average number of cold days has increased from 28 to 31. The graph also provides projections for annual cold days to the 2030s, 2050s and 2070s based on medium emission climate change scenarios. All projections suggest that annual cold days will decrease to an average 15 days per year by 2070.

The second graph shows the number of days per year that are potentially harmful to lamb survival due to cold exposure (minimum less than 2C and at least 1 mm of rain). The data are restricted to 1 March – 31 August each year, which is the period identified as the time when, generally, lambs are young and vulnerable in the Mid North district. The data suggest little change, with only a small drop in cold exposure days from a current average of 1 to 0 days by the 2070s.

Wind chill is also a major risk when considering cold exposure. For example, a 10 km/hr wind at sheep height can lower the effective temperature from 10 to -3°C. The lack of a wind chill factor in this analysis likely causes an underestimate of the true risk of cold exposure, especially as July & August are two of the coldest, wettest and windiest months near Mongolata.

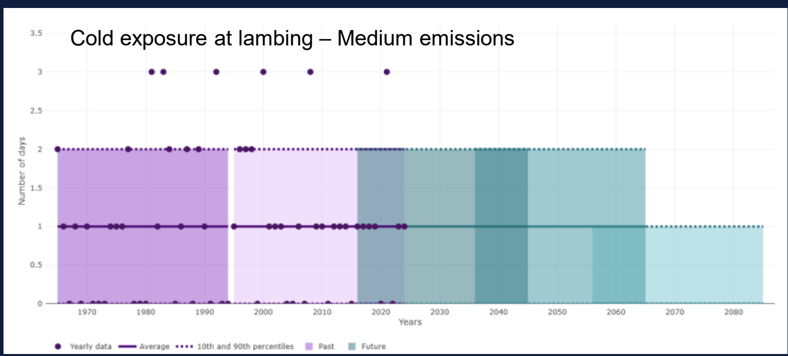


Past

1965–1994 average	1995–2024 average
28 days	31 days

Future

2030s average	2050s average	2070s average
22 days	19 days	15 days



Past

1965–1994 average	1995–2024 average
1 day	1 day

Future

2030s average	2050s average	2070s average
1 day	1 day	0 days

Why does it matter?

Cold exposure can lead to lamb mortality, reducing productivity. Rainfall events combined with cold temperatures are used to represent potential cold exposure.

2. NATURAL CAPITAL ASSESSMENT

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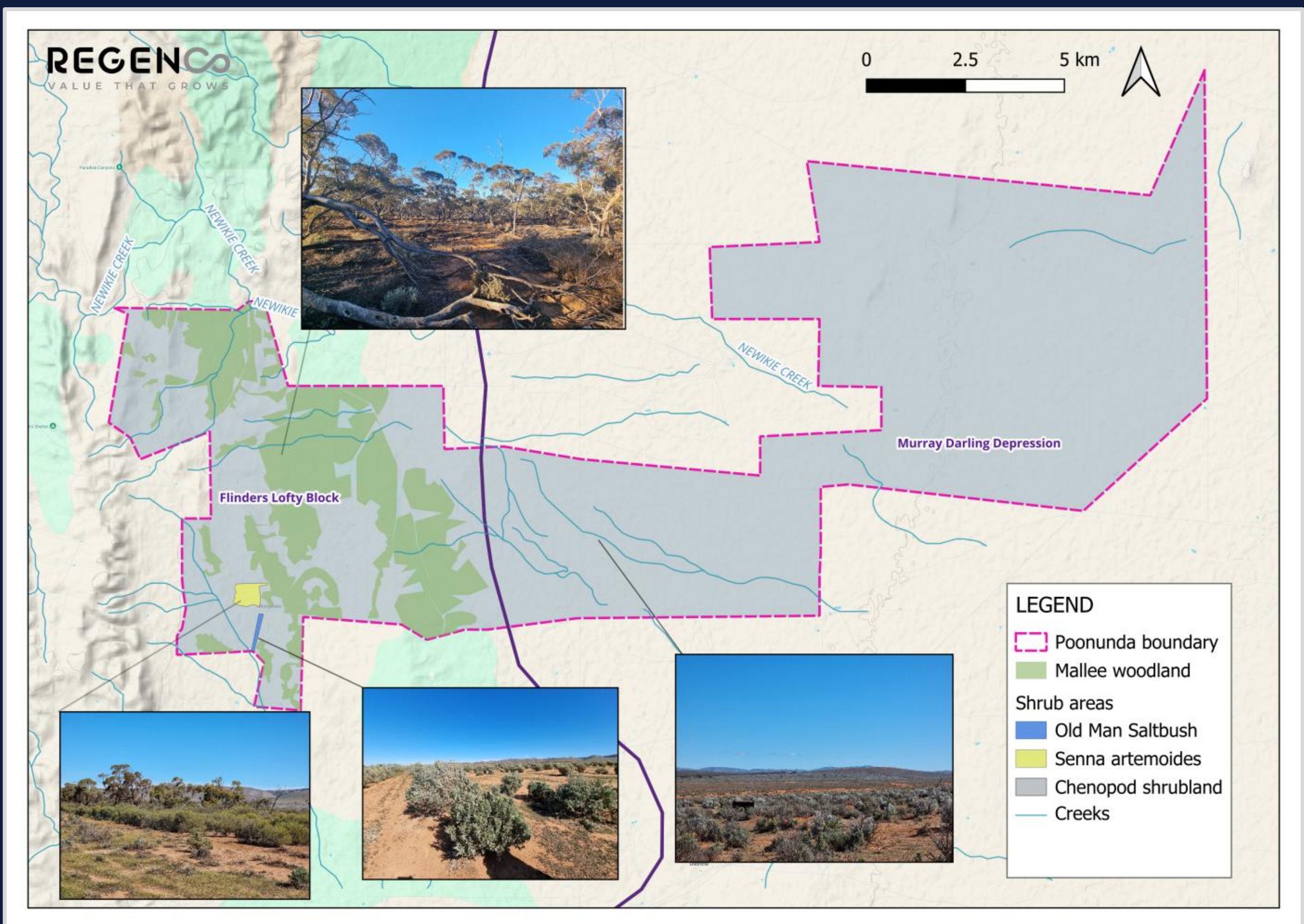
WOODY BIOMASS CARBON ASSESSMENT

- Embedded carbon and sequestration rates on Poonunda in woody vegetation biomass were assessed and estimated using the Australian Government's official carbon model – FullCAM.
- There is a 40 ha block of regenerating *Senna artemoides* shrubland near the Poonunda homestead, estimated to be about 15 years old. Based on the literature (e.g. Williams *et al*, 2023), 40 hectares of this shrubland would contain about 676 tCO_2e-. Assuming it takes 25 years to reach maturity, this block would be sequestering 27 tCO_2e-/yr on average. The embedded carbon in this vegetation is estimated to currently be **405 tCO_2e-**.
- The landholders have also planted a 9 ha block of Old Man Saltbush, which is about 10 years old. For the purposes of this exercise, we adopt a conservative estimate of 1 TCO_2e-/ha/yr for this planting, which means the total sequestration of this block would be 9 tCO_2e-/yr. At 10 years of age, the embedded carbon in this vegetation is estimated to currently be **90 tCO_2e-**.
- The total area of remnant mallee woodland on the property is 2350 ha, which FullCAM models to contain 147 tCO_2e-/ha, assuming an age of 90 years. The embedded carbon in this woodland is estimated to currently be **345,450 tCO_2e-**.
- The vast majority of the property, about 14,310 ha, is chenopod shrubland. A study by Henry et al (2015) was used to derive an estimate of biomass carbon content of 6 tCO2e-/ha for this vegetation. Therefore, the embedded carbon in the total area is estimated at **85,860 tCO_2e-**
- Given the above, woody biomass carbon stocks on the property total **431,805 tCO_2e-**



Areas of existing woody vegetation on Poonunda Station

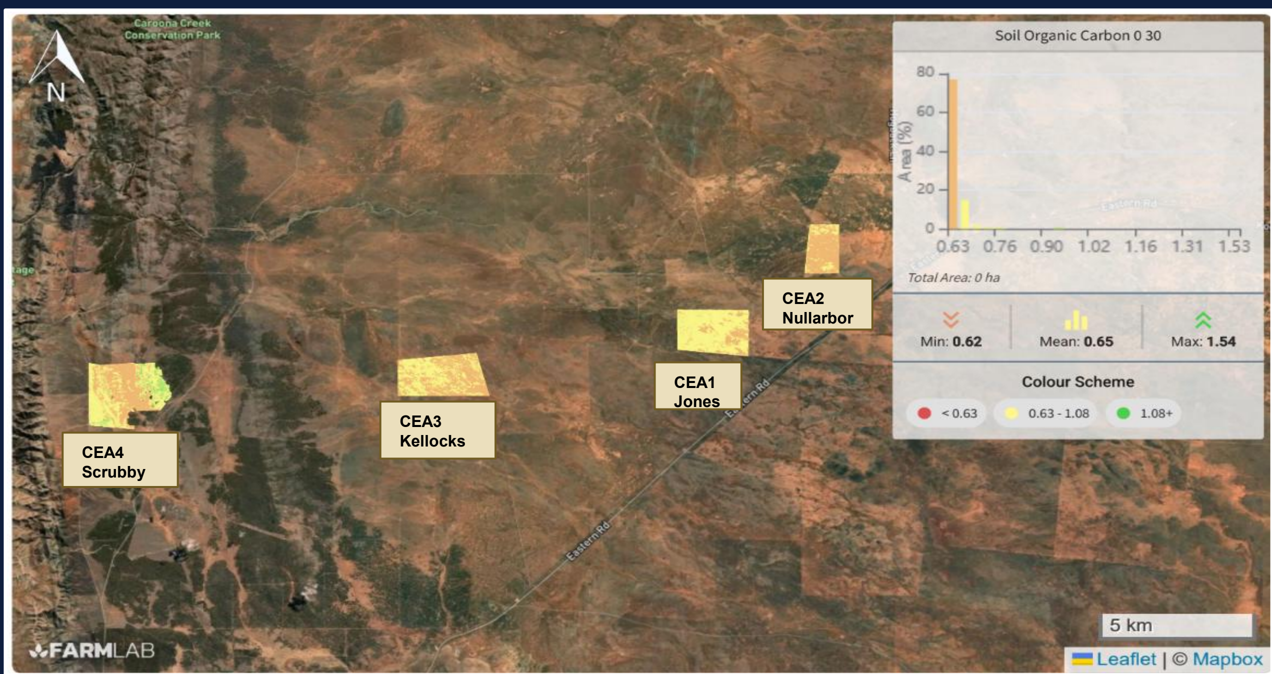
SOIL CARBON ASSESSMENT

- The soils on Poonunda are mostly a calcareous loam (sandy to clay) texture. In the Mid North District, there is an increasing trend in surface SOC content from sand to clay loam textures, with pasture soils having higher SOC concentration than crops (Schapel et al, 2024).

Ag District SOC Benchmarks							
Texture	Count	Mean %	25%	40%	50%	60%	75%
Sand							
Loamy sand	41	0.78	0.51	0.62	0.66	0.85	1.00
Sandy loam	188	1.25	0.85	1.09	1.21	1.33	1.57
Loam	539	1.45	1.10	1.27	1.40	1.50	1.70
Clay loam	1346	1.50	1.18	1.33	1.45	1.54	1.71
Clay	1005	1.46	1.10	1.30	1.40	1.50	1.72
Weighted Mean (all texture)	3119	1.45	1.11	1.29	1.40	1.50	1.69

Table 2: Soil organic carbon benchmarks based on soil test data for the Mid North agricultural district

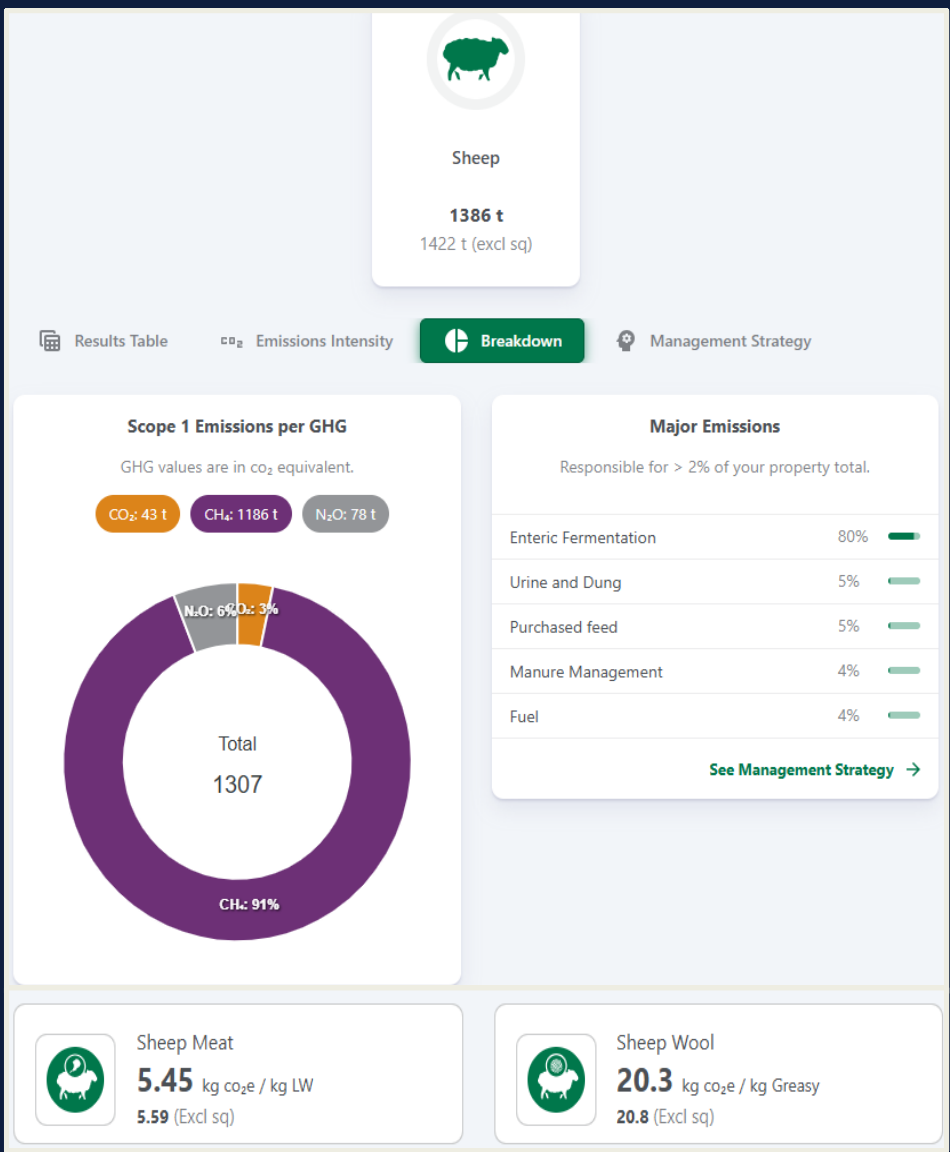
- The PMP developed by Hugh Pringle (2022) identified a historical degradation of soil through poorly conceived infrastructure and excessive grazing. Several areas of severe scald and erosion have been identified in the document.
- In March 2024, the soils on Poonunda were sampled in accordance with the Emission Reduction Fund soil method, *Estimation of Soil Organic Carbon Sequestration using Measurement and Models) Methodology Determination 2021.*
- Carbon in the soil was sampled to 0-30 cm and 0-100 cm depth at 127 sample points across 3 strata of four Carbon Estimation Areas (CEAs) across 1,330 ha). Samples were analysed by APAL.
- Soil organic carbon (SOC) was found to be quite consistent across the property, with average concentration of **0.44%** from 0-30 cm depth. CEA1, located in a Newikie Creek flood-out area, did stand out as having the highest SOC concentration with 0.68%. CEA2, by contrast, located in the more western part of the Newikie Creek flood-out in the Murkaby land system, has been degraded by track and fenceline gutters interfering with sheet flow. This CEA only had a SOC concentration of 0.37%. The highest scoring samples (up to 1.54% SOC) were taken from CEA4, located in the higher rainfall western part of Poonunda in proximity to mallee scrub.
- Total SOC Stock across the whole CEA area was found to be about 14 tSOC/ha. This equates to 52 tCO_2e^-/ha or **68,740 tCO_2e-** across the whole CEA. If we extrapolate these CEA figures to the whole property, we can roughly estimate that the stock of soil carbon on Poonunda Station to 30 cm depth is **860,545 tCO_2e-**.
- According to work by the SA Govt., these results would put Poonunda's SOC % generally below the 25th percentile for soils in the Mid North District (noting that the District figures are for 0-10 cm soil depth). This suggests that opportunities exist to increase SOC, which would most likely be realised by restoring natural hydrology and managing grazing pressure. If %SOC in the top 30 cm of the CEAs was increased to reach the 25th percentile figure for sandy loam (0.85%), this would increase the amount of SOC by about 17,350 tSOC in the CEAs (approx. **63,676 tCO_2e^-**).



Soil sampling CEAs and carbon content for Poonunda Station

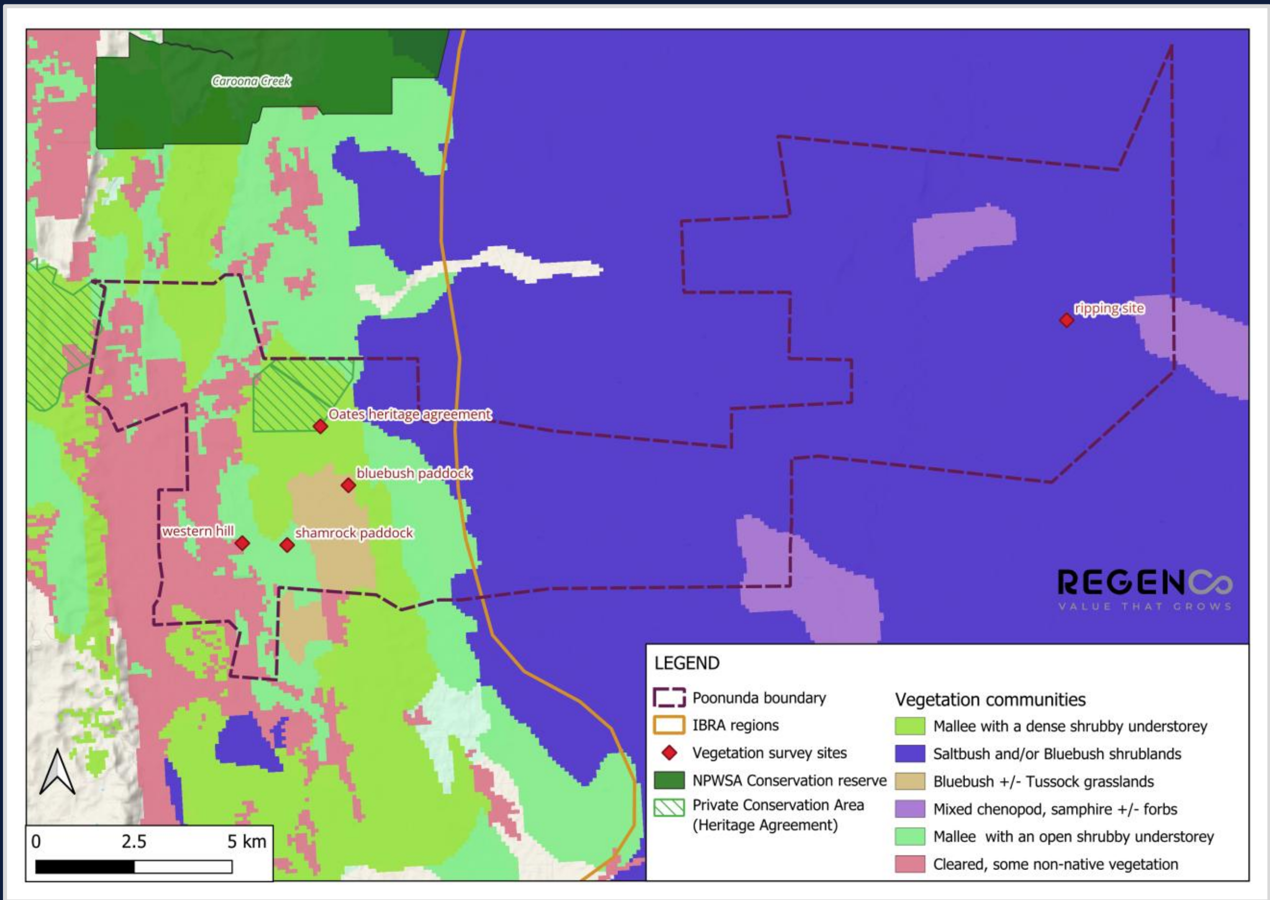
CARBON FOOTPRINT ASSESSMENT

- The carbon footprint of the Poonunda operation was assessed using the MLA Carbon Calculator. This assessment included upstream Scope 3 emissions but not downstream Scope 3 emissions (i.e. value stream emissions were accounted for until the point at which product leaves the farm gate).
- Total gross farm emissions was found to be reasonably low at **1422 tCO_2e^-/yr.** Net emissions were **1386 tCO_2e^-/yr** (i.e. after subtracting the carbon sequestered by regenerating shrubland areas less than 25 years old) . Older vegetation is not able to be counted in carbon accounting balance sheets.
- Emissions intensity for sheep meat production was **5.59 $kgCO_2e^-$/kg liveweight** and for wool production it was **20.8 $kgCO_2e^-$/kg Greasy**. This compares favourably to an Australian industry-wide benchmark for sheep meat of 6.8 $kgCO_2e^-$/kg LW and for wool of 24.4 $kgCO_2e^-$/kg Greasy. After carbon sequestered by regenerating vegetation was added to the equation, emissions intensity was lowered to 5.45 $kgCO_2e$-/kg LW (meat) and 20.3 $kgCO_2e^-$/kg Greasy (wool).
- By far the greatest source of emissions was in the form of methane from enteric fermentation and animal waste, at 91% of total CO_2e^- emitted. Only 5% of total emissions came from purchased feed and 4% from diesel use.



VEGETATION CONDITION ASSESSMENT

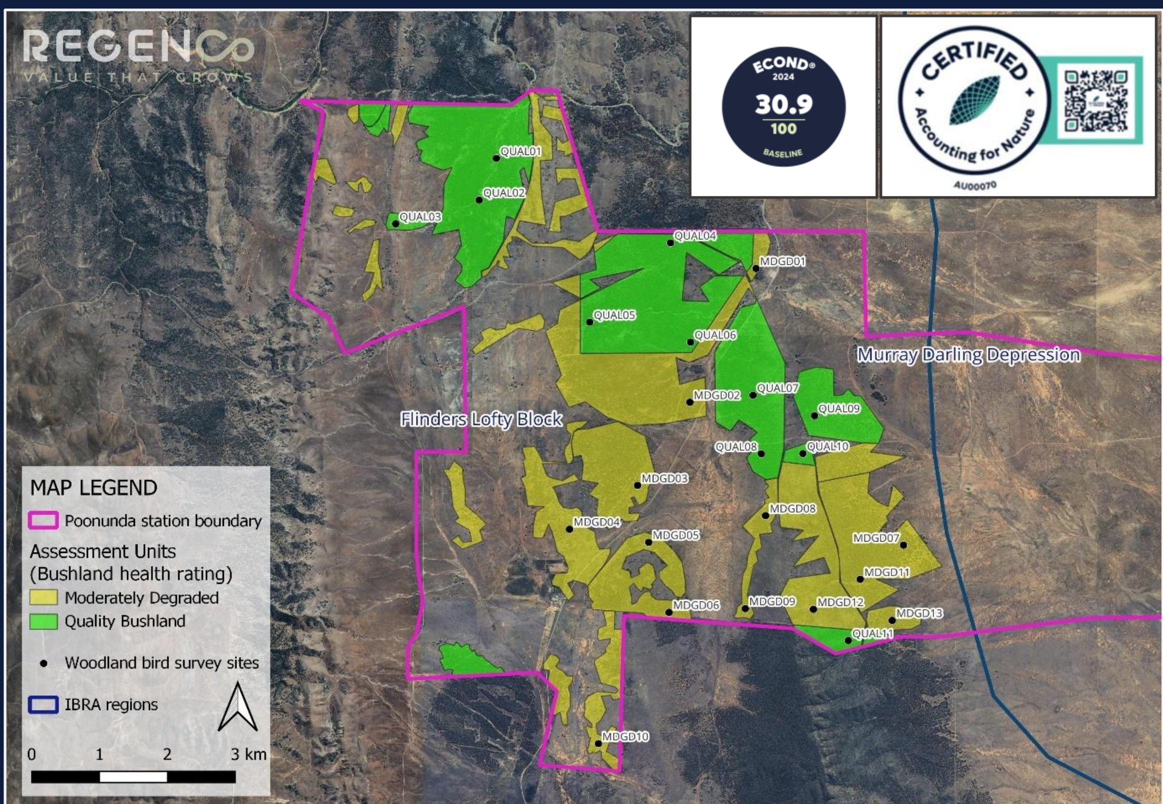
- The condition of the vegetation communities at Poonunda was assessed using the “Significant Environmental Benefit” (SEB) survey method.
- Five survey sites were assessed across the property. Four were located in the Flinders Lofty IBRA region (Mongolata IBRA Association) and one in the Murray Darling Depression region (Florieton IBRA Association). The sites were selected to reflect the diversity of vegetation communities at Poonunda, as can be seen on the map below.
- All four sites in the west of the property achieved reasonably high biodiversity scores between 55 and 65. The highest valuation biodiversity score of **65.4** was achieved in the property’s Heritage Agreement area, which has been put aside for private conservation. This reflected the good condition of the vegetation, especially the understorey, in this area, as well as the fact that only 12% of native vegetation is protected in the Mongolata Association, scoring a high 1.05/1.25 for landscape context. The “Western Hill” site had the best diversity, with 23 native species and three introduced, reflecting both the higher rainfall near the western boundary, and the recovering condition of the area after having been historically cleared.
- The “Ripping site” (**26.32**) in the east of the property scored much lower than those in the west. This site is located in an area where interruption of sheet flow from creek flood-outs has caused severe degradation of chenopod vegetation and soils. The landowners have ripped the area to enable seeds to settle and germinate in the scalded soils.
- Though no sites were assessed on the eastern slopes leading down to the eastern plain, it was apparent that the mallee in this area was in relatively poor health, with many individuals dead or dying, and the understorey sparse and in poor condition. It is suspected that a combination of dry conditions in recent decades and reasonably heavy grazing have impacted the area.



Broad vegetation communities of Poonunda Station

WOODLAND BIRD ASSESSMENT

- The condition of the woodland bird community at Poonunda was assessed using the Accounting for Nature (AfN) method, *A native woodland bird assessment methodology for diverse regenerating farmlands* (AfN METHOD F-02).
- 24 survey sites were assessed across two condition-defined strata in the mallee woodland in the western part of the property (Flinders Lofty bioregion). Sampling density was sufficient to produce a “Moderate (80%) Accuracy” account.
- The condition (Econd®) for the Woodland Bird asset in its entirety was scored as **31/100**.
- The Econd® of the two individual assessment strata were: ‘Moderately Degraded' - 26; and ‘High Quality Bushland’ – 37.5.
- Econd® scores for individual survey sites ranged from 8 to 56. Site QUAL04 , located in the property’s private conservation area, was easily the highest scoring site, with 12 species recorded, 9 of which were small-bodied natives (small-bodied species are indicative of a healthy community).
- Two EPBC-listed species were observed: the Endangered sub-species of Hooded Robin and the Vulnerable Southern Whiteface. Four species listed as Rare in SA were recorded during the survey: Hooded Robin, White-winged Chough, the south-eastern subspecies of Jacky Winter, and Chestnut Quail-thrush.
- The EPBC-listed Threatened Ecological Community (TEC), *Mallee Bird Community of the Murray Darling Depression Bioregion*, has been shown to be present* within the Environmental Account Area. Following the Approved Conservation Advice for this TEC, one "mallee specialist" species (Chestnut Quail-thrush) and two "mallee dependent" species were recorded and, therefore, the community is present in "Category B" (highest quality) condition.
- In total, **40 native bird species** were recorded of which 24 were small-bodied
- An ongoing environmental account for woodland birds has been registered and certified by AfN.



Woodland bird survey sites and Assessment Units based on woodland condition at Poonunda Station

*Note the Malle Bird TEC is present in terms of the biotic requirements but, strictly speaking, not in terms of location since, by the definition of the TEC in the Approved Conservation advice, the site must be located in the Murray-Darling Depression Bioregion for it to be present.

3. KEY OPPORTUNITIES: PRODUCTION, CLIMATE RESILIENCE & NATURAL CAPITAL BENEFITS

PROPERTY MANAGEMENT PLAN (PMP)

The current Poonunda PMP identifies long-term grazing and poorly designed infrastructure as key degrading factors for the property's natural resource base and productivity. In particular, landscapes have been degraded near permanent water sources, where vegetation has sometimes been replaced by bare and sealed (scalded) soil surfaces. Similar degradation of soils and vegetation is seen downslope of where "road rivers" have formed. A major concern is the decline and deterioration of groundwaters for stock, particularly in the western part of the property.

The Oates family's vision for Poonunda is a drought resilient and profitable property with:

1. Secure water during periods of high demand
2. Landscapes that absorb rainfalls and produce productive and persistent pastures
3. Habitat that is good for humans, their livestock and wildlife
4. Continuously improving management through lessons learnt.

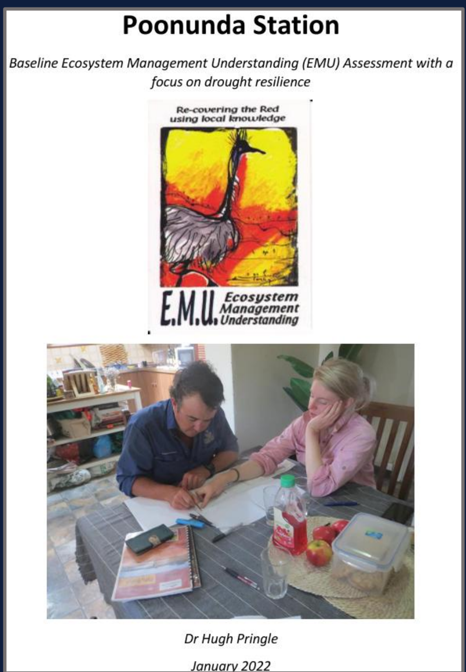
Recent actions to improve management of the natural resource base and maintain profitability through drought include:

- The building of a four-pen confined livestock facility to fatten weaners and cull ewes
- Contour and scald ripping to regenerate vegetation and hold water to allow infiltration
- Ripping of gully erosion heads to avoid gully development and landscape dehydration

Grazing management is also identified as a general issue, in terms of matching stocking rate to feed on offer, recovery period and landscape diversity. The PMP suggests consideration of trials to return key palatable perennial shrubs to the farm landscape.

The PMP also states that the Oates see Poonunda as a place where their business can co-exist with wildlife and that a regenerative basis to future planning and management should increasingly align habitat values for livestock and wildlife.

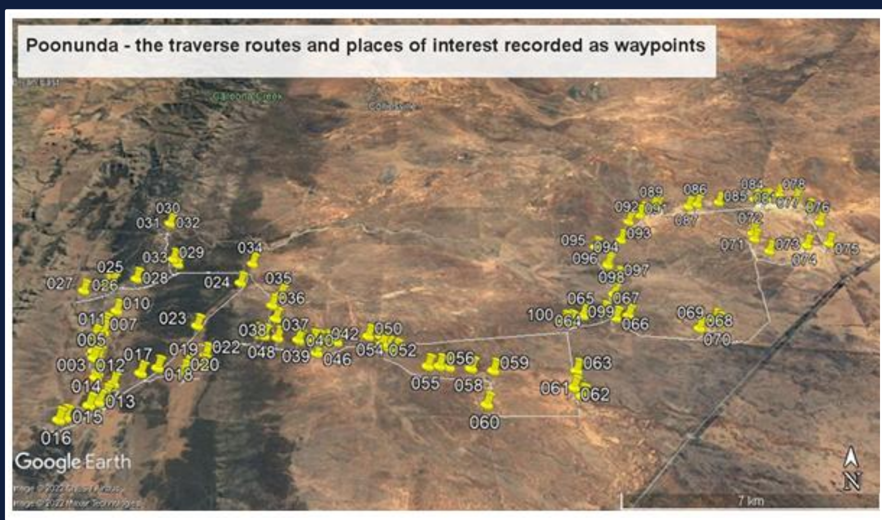
The following pages of this report look at how the actions and ambitions currently underway, planned and/or identified in the PMP can support improvement of Natural Capital on Poonunda and how associated carbon and biodiversity projects may be leveraged to expand and expedite PMP delivery while enhancing farm productivity, resilience to climate change and biodiversity.


Poonunda Station

Baseline Ecosystem Management Understanding (EMU) Assessment with a focus on drought resilience

Dr Hugh Pringle

January 2022



TREE SHELTERBELTS & BLOCK PLANTINGS

Production System Benefits

The climate information provided above shows that a major risk to the Poonunda operation is posed by climate, which is already challenging for sheep production and will only become more so under projected changes. Shelterbelts are a significant tool for mitigating these risks.

Wind chill: The information below, taken from a South Australian Government factsheet, is highly relevant to Poonunda and the opportunity presented by shelterbelts to improve weight gain and survival, particularly in late winter when rain and wind chill are a major risk.

The benefits of shelterbelts

Research has shown the beneficial effects of shelterbelts on farm productivity.

The main benefits for landholders in southern Australia are:

1. Young lambs with shelter have a greater survival rate than those without.
   - Shelterbelts can increase survival of young lambs in their first 48 hours from 84% to 93% for single lambs (Bird et al, 1984).
   - The increase in survival is even larger for twins, where shelterbelts have been shown to increase survival from 56% to 78% (Bird et al, 1984).
   - The bottom line $: For a flock of 2,000 ewes where half have a single lamb and half have twins, these percentages mean an extra 530 lambs surviving per year!
2. Shelterbelts can reduce water loss in pasture plants particularly in spring and summer, which extends growing conditions.
   - Although there can be a loss of productivity close to a shelterbelt, gains in productivity have been shown in plant production at a distance of 2-18 times the height of the shelterbelt into the paddock.
   - This positive effect is due to wind speed reduction and temperature modification resulting from the shelterbelt.

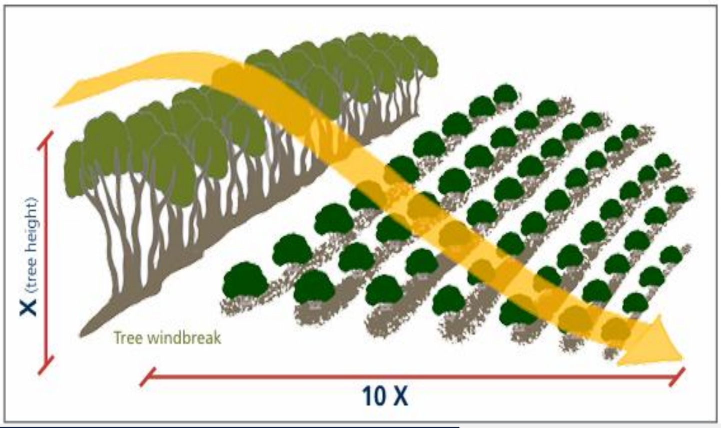


Figure 1. Protection offered by shelterbelts. *(adapted from the Goolwa to Wellington Local Action Planning Association Inc. Shelterbelt factsheet)*

Exposure can be fatal for lambs

Research on Kangaroo Island found that winds as light as 8 km per hour, in combination with 0.25-5 mm of rain per day, significantly increase mortality in Merino and Corriedale lambs. Higher winds (24-56 km per hour) combined with more than 5 mm of rain per day increased lamb mortality in Merinos by over 50% (Obst and Day, 1968).

Newborn lambs are most at risk. Further research on Kangaroo Island found that in the first six hours after birth (critical post-birth period), lamb losses were 5–10% if there was no rain and wind was less than 8 km per hour. However when wind was greater than 18 km per hour and more than 1.5 mm of rain was received in the critical post-birth period, lamb losses could exceed 70% (Obst and Ellis, 1977). In 2012, lamb deaths from exposure made the headlines, and it was estimated that up to 15 million lambs are dying within 48 hours of birth in Australia every year (The Australian, 2012). This results in large financial losses to sheep producers each and every year.

Post-shearing is a time of risk

For 14 days after shearing, adult sheep can be at risk of hypothermia if exposed to cold winds and rain. Sudden adverse weather events and unseasonal cold weather are the main cause of stock losses post-shearing. In South-West Victoria for example, unseasonal cold weather in March 1983 caused around 30,000 sheep to perish when a storm resulted in wind speeds of 32 km per hour, rainfall of 42 mm and a temperature drop to 16°C (Bird et al, 1984).

Wind affected pastures

Research indicates that high wind speeds increase water loss through transpiration in grasses and clovers leading to a reduction in growth (Radcliffe, 1983). In extreme cases, damaging winds can cause physical damage to plants through mechanical agitation (Sturrock, 1981).

Liveweight gain and heat stress: Goulburn Broken Catchment Management Authority also produced a factsheet that highlighted the value of shelterbelts to improving sheep liveweight gain, wool production and health under conditions likely to provoke heat stress, as below:

Shelter benefits:

- Ewes exposed to 32+°C after joining have a 40.7% fertilisation success
- Heat stress reduces conception rates in sheep. Refer to figures shown below

Breed	Sheltered (marked per ewe lambed)	Unsheltered (marked per ewe lambed)	Difference Extra Lambs/100 ewes
Merino	126%	102%	24
Coopworth	157%	139%	18

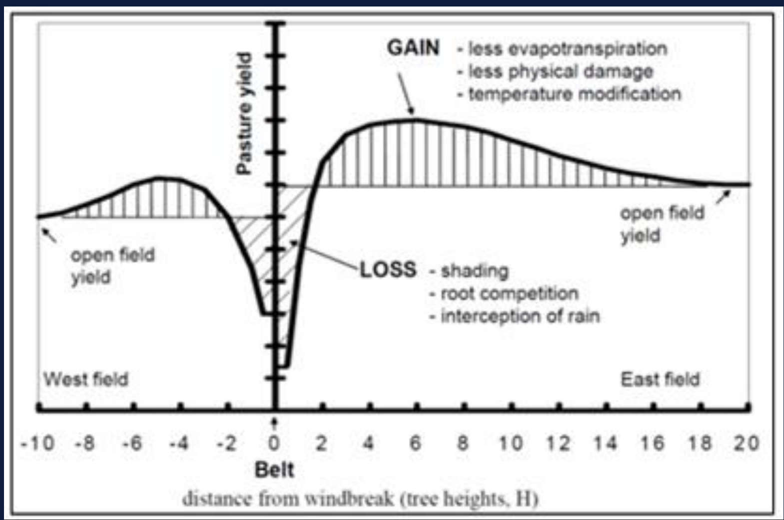
- ✓ Shelter increases pasture growth by 10% and sheep require 10% less pasture to maintain body heat in cold conditions when shelter is available. The combined effect of these benefits is expected to generate on average an extra $0.93/DSE per year.
- ✓ Heat load reduction on ewes at joining and lambing results in lambs with faster growth rates and more wool during their first 16 months of life. Heat stress reduces wool growth by reducing feed intake.
- ✓ Sheltered sheep showed a 31% increase in wool production and a 21% increase in live-weight in a five year trial.
- ✓ Sheltered off-shear wethers require only 1/3 the supplementary feed as unsheltered stock.
- ✓ Heat stress is detrimental to ram fertility, ovulation rate and conception in ewes and foetal development.

TREE SHELTERBELTS & BLOCK PLANTINGS

Production System Benefits

Pasture production: The Basalt to Bay Landcare Network collated a document titled "*The Economic Benefits of Native Shelterbelts*". This included information about the benefit of shelterbelts to pasture production, as follows:

- Shelter improves plant growth and increased pasture and crop production, by reducing moisture loss from soils and transpiration in crops and pastures.
- Sheltered pastures lose 12mm of water less than open pastures during the spring growing season.
- On one farm sheltered areas had a 20% increase in average annual pasture growth.
- Major gains in decreased animal stress and greater pasture production in winter can support an extra 1-3 sheep/ha.
- Gross value of pasture output is at its highest level when the proportion of tree area on a farm is at 34%.
- There is growing evidence that soils around trees contain elevated amounts of organic material and a higher nutrient status, thereby promoting pasture growth.
- There is no major evidence to indicate a large effect of shelter on pasture growth. Losses in the competitive zone are matched by an equivalent gain in the sheltered zone.



Estimated economic benefits: The Basalt to Bay collation also included an analysis by Patrick Bird (1996) of the estimated percentage gains and associated economic translation of several of the benefits outlined above. These benefits were estimated for two different spacings of shelterbelts – 250 m and 500 m, as below.

Table 1. Expected benefits from shelterbelts at maturity

Benefit	Belts 500 m apart	Belts 250 m apart
Wind speed reduction:	33%	50%
Improved plant growth: resulting in extra production (gross margin $ per ha)	+ 10% + $16	+ 20% + $32
Reduced maintenance energy requirement of stock: resulting in extra production (gross margin $ per ha)	+ 10% + $16	+ 17.5% + $28
Improved lamb survival (extra % units weaned): resulting in extra production (gross margin $ per ha)	+ 5% + $3	+ 5% + $3
Reduced losses of shorn sheep (ave. annual %): resulting in extra production (gross margin $ per ha)	+ 0.5% + $1.50	+ 0.5% + $1.50

Benefits from shelterbelts at maturity (Source: Bird 1996).

Note: As these estimates were devised 30 years ago for SW Vic. sheep farmers, the applicability of the economic estimates to the Upper North District in 2025 may be tenuous. Nonetheless, they provide a guide to the scale of benefits offered.

TREE SHELTERBELTS & BLOCK PLANTINGS

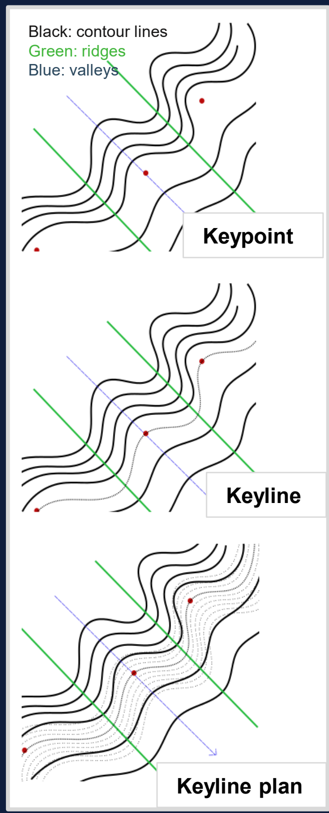
Production System Benefits

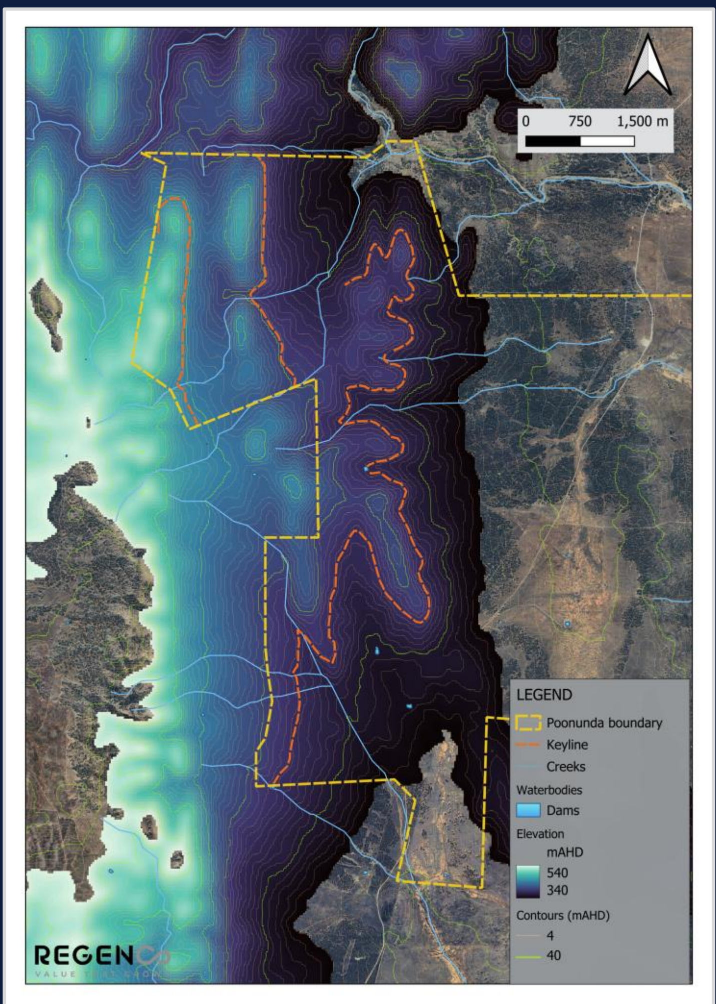
Water management: Poonunda has some steeper, higher rainfall country at its western end. The current PMP notes that there has been a decline of water availability from long-standing sources in this area. There are also some eroding gullies that have a dehydrating effect on the landscape.

Strategic planting of shelterbelts, along with plowing of keyline contour furrows that hold and spread water in this area may enable rehydration of the downslope landscape and replenishment of groundwater. Implementation is as follows (see schematic to right):

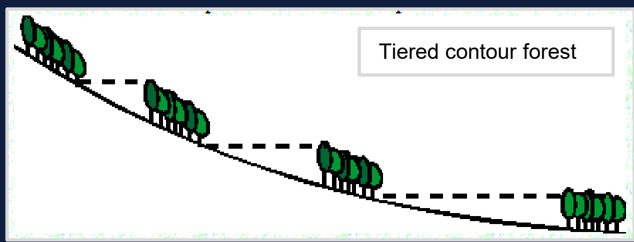
1. Locate the Keypoint: The Keypoint is the key element, found slightly downhill from the valley's break-of-slope.
2. Identify the Keyline: The Keyline runs through the Keypoint, guiding the design.
3. Utilize Parallel Lines: Drawing lines above and below the Keyline on maps helps plan water and planting systems.
4. Implement Keyline Plowing: Plowing along parallel lines to the Keyline helps water move from valleys to ridges.

This rehydrates ridges and keeps water higher in the landscape for longer. The intent is to promote water infiltration which will benefit revegetation efforts and reduce erosion/soil loss.





Elevation of west Poonunda Station and indicative keylines



The map to the left shows indicative keyline locations for the western portion of Poonunda. RegenCo believes there is potential to spread, slow and hold water in this part of the property by planting shelterbelts in locations downslope and parallel to the keylines. This could potentially be designed as a tiered contour forest (as above) with tree belts interspersed with pasture.

Above the keyline, parallel rows of fodder shrubs interspersed with pasture could further slow and spread water flow, as well as providing a forage attraction for stock to climb into the uplands. In doing so, the sheep will cycle fertility (in their dung) back to the top of the slope, as described by Natural Sequence Farming theory.

See this animation video by the Mulloon Institute for a general idea of what the vision would be for the keyline shelterbelts, as well as in-channel options for water management.

TREE SHELTERBELTS & BLOCK PLANTINGS

Natural Capital Benefits

Although Poonunda is relatively well wooded, opportunities do exist to add planted belts of and blocks of mallee and mixed species woodland to the higher rainfall areas in the west of the property, where historical clearing has occurred. The next section of this report (4. *Project Proposal & Business Case*) presents a design and business case for a potential shelterbelt and block planting project of about 400 ha. This is intended to provide an example around which discussions can occur about matters of cost/benefit and optimal size/configuration of a tree planting project. A planting project of this scale will improve the Natural Capital of Poonunda in a number of ways that will add to, interact with and enhance the potential production benefits described on the previous pages:

Vegetation biomass carbon – The proposed shelterbelt and block plantings are modelled to sequester carbon at an estimated average annual rate of about **1,540 tCO_2e^- /yr** over 25 years, accumulating about **38,500 tCO_2e^-** in that timeframe.

Soil carbon – The shelterbelts will help to increase soil carbon on Poonunda both directly, through reduced erosion and increased addition of carbon in leaf litter, and indirectly, through provision of microhabitats with lower wind and higher soil moisture allowing higher groundcover to be maintained and loss of soil carbon by exposure to be reduced.

Vegetation condition – The shelterbelts will enhance the condition of the existing native vegetation by increasing biodiversity and connecting large areas for enhanced genetic flow and self-organization. The block plantings are proposed to be established on hill tops and include palatable species that have largely been removed from the local region, such as she-oak (Casuarina), Christmas bush (Bursaria) and wattle species. Protection of these areas with kangaroo-proof fencing to facilitate high-level control of grazing pressure and maximise biodiversity and health of the ground layer vegetation, may be worth considering.

Woodland Birds and other fauna – Restoration promotes recovery of woodland birds in agricultural landscapes (e.g. Bennett et al, 2022) and connectivity is key to this. The proposed shelterbelts will greatly enhance connectivity between large blocks of mature mallee woodland in the west of the property, including connecting the very important habitat of the Heritage Agreement area on Poonunda through to that on the neighbouring property, and also to a vegetation corridor that runs through to Caroona Creek CP. It is proposed to make corridor plantings at least 30 m wide to enhance their habitat value. One study referred to by Basalt to Bay found that an average shelterbelt (3 rows/12m wide) can promote 12 species of woodland bird; if widened to 25m (7 rows) the number rises to 17. Bird diversity will also be enhanced by high floristic diversity and structural complexity of shelterbelts (Bonifacio et al, 2011) and by linking to the stands of existing mature vegetation (Haslem et al, 2020). By bolstering populations of woodland birds, along with other fauna such as pollinating and predatory insects, ecosystem services to adjacent pastures, such as pest insect control, will be enhanced. The block plantings will be an important driver for increasing fauna biodiversity, as the bird and insect species that inhabit corridor plantings are known to be substantially different from those that inhabit large blocks of vegetation. Also, the block plantings would include plant species that are now locally uncommon, as described above.

Water – The plantings, especially the keyline contour plantings, will help to keep the water that would accumulate and flow into valleys from rapidly moving into creeks and potentially causing soil erosion. Instead, the water will be spread from valleys to ridges, slowed and held longer and higher in the landscape. This will enable an improvement in soil health and soil carbon, which will in turn enhance water holding capacity of the landscape. It is anticipated that this will enable rehydration of the landscape and replenishment of groundwater and wells. It has also been shown that woodland trees enhance water infiltration in fragmented agricultural landscapes, reducing "ecosystem leakage" and potential soil erosion in intense rainfall events (Eldridge, 2005). Trees also act as ecosystem pumps that drive the small water cycle. With Poonunda stretching such a large distance to the east, it is possible that the plantings could create a small increase in rainfall volumes reaching the eastern parts via the additional moisture the trees would put into the atmosphere by evapotranspiration.

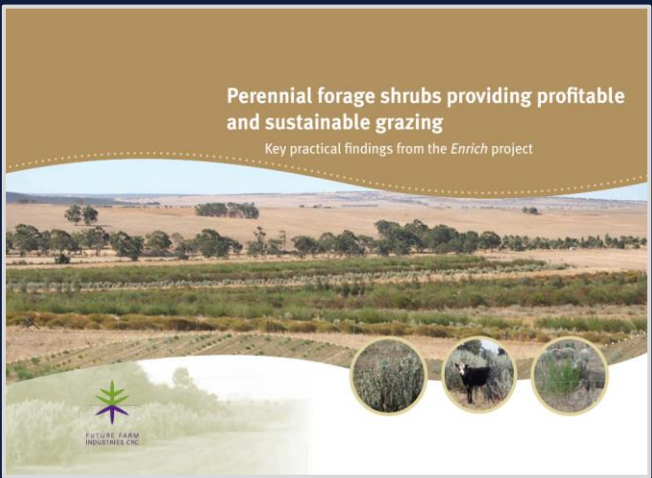
PERENNIAL FODDER SHRUBS

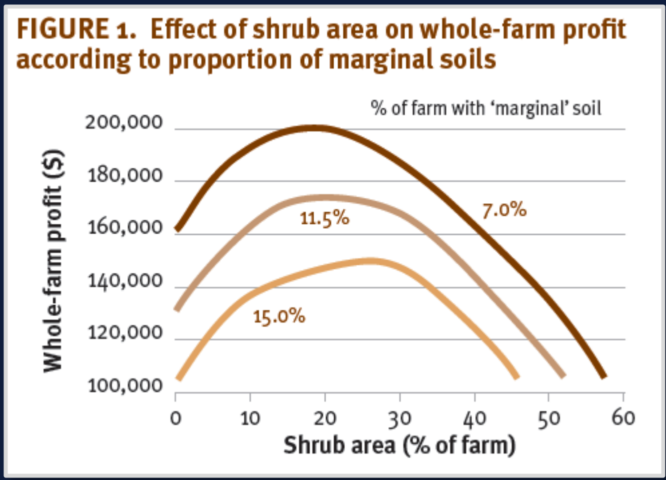
Production System Benefits

The *Enrich* research project conducted in the 300 – 350 ml rainfall zones of SA, WA and NSW (including sites in the mid/upper North of SA) was initiated due to an emerging awareness that prolonged drought and changes in rainfall patterns were making land use dominated by cropping and annual pastures unsustainable, especially in medium to low rainfall areas. These events presented an opportunity for large-scale change to livestock industries, where blending feed production from woody and herbaceous perennials with traditional pastures could become the preferred productive and less risky land use for the future.

Enrich looked at some guiding principles for incorporating forage shrubs into grazing systems, including the optimal area of a farm established to forage shrubs; grazing time for optimal use; scale and layout; plant establishment and productivity; and nutritive value traits of various species.

The headline finding was that "*For a 'typical' farm in low-medium rainfall crop-livestock zones of Southern Australia, inclusion of perennial forage shrubs at about 10-20 % of farm area can increase profit by 15-20 %*"





While Poonunda is well vegetated with perennial fodder shrubs, especially on the eastern plain, the farming system could still benefit from adding a variety of shrub species to the mix, some of which have likely been eliminated from the property by historical overgrazing.

The *Enrich* project examined 101 species with potential for use as forage for livestock in semi-arid Australia, not just for palatability but also:

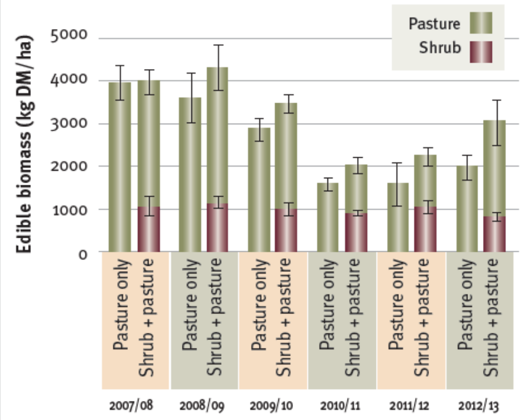
- Edible biomass
- Plant growth over time.
- Growth form and height.
- Re-growth after grazing.
- Nutritive value (protein fibre, minerals).
- Effects on rumen fermentation (gas production to indicate digestibility).
- Bioactivity — pattern of rumen fermentation end products including methane, ammonia, volatile fatty acid composition.
- Bioactivity — anthelmintic properties.

Production System Benefits

Forage production:
During six years of research under *Enrich*, greater annual productivity was achieved with the addition of forage shrubs:

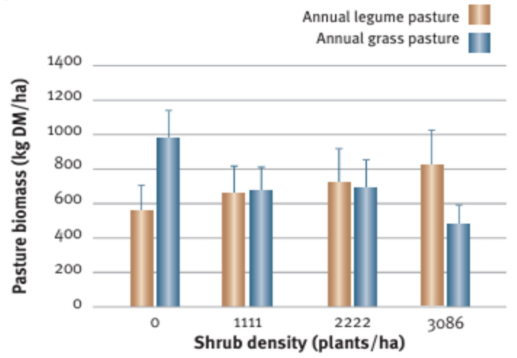
- Forage shrub production was stable from year to year and contributed around 1000 kg/ha. This 'extra' tonne in autumn is higher in crude protein and mineral content than the inter-row pasture of annual plant species, which are dead at this time of year. Animals can only utilise fibre in senesced pasture and crop stubbles if they have a source of nitrogen. Forage shrubs provide this useful dietary complement.
- Demonstrated the growth of annual pasture legumes is not compromised when grown alongside shrubs. While annual grass production is reduced with high shrub density, at moderate shrub density (for example, <1000 shrubs/ha), the loss of grass biomass is compensated by the increase in shrub edible biomass.
- Shrubs reduce supplementary feeding during summer/autumn feed gaps, and are particularly valuable forage in winter if there has been a late seasonal break and pasture growth is slow.
- Shrubs may enable deferral of grazing other paddocks at the break-of-season, allowing better winter pasture establishment.

FIGURE 2. Annual forage production measured as spring and autumn annual pasture biomass and including autumn shrub biomass for the shrub and pasture system*



* Shrubs were planted at a density of 2066 plants/ha

FIGURE 3. Effect of shrub density on inter-row pasture biomass

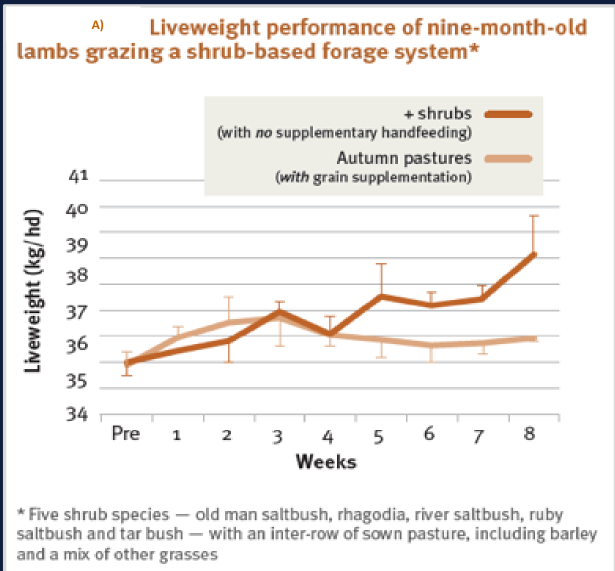


- The shade provided by shrub species can create favourable soil moisture conditions through reduced evaporation and lead to better pasture survival in conditions such as false breaks. Annual pasture species remain green for longer at the end of the cooler growing season when afforded some protection by shrubs.
- During winter, minimum temperatures are higher within shrub stands and frosts are less common.

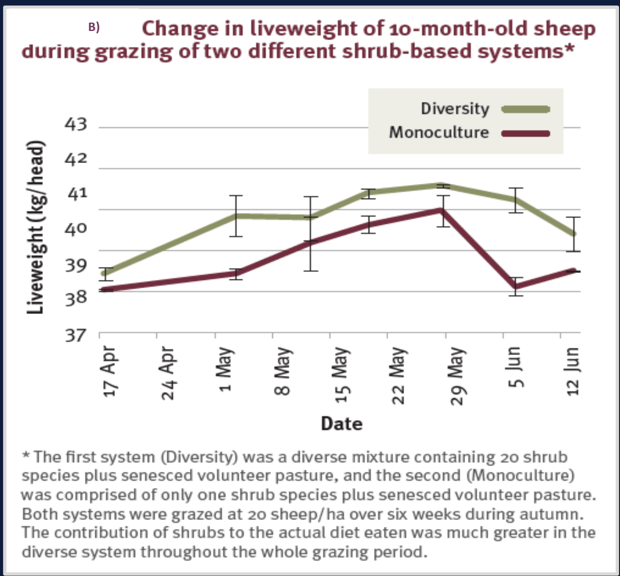
Shelter and shade: *Enrich* found that rows of a mixture of tall and shorter species are the best way to achieve even permeability and adequate height. Using just tall species can lead to increased wind speed under trees where livestock have grazed all the lower branches. *Enrich* listed the following species as suitable for shelter provision, with species also providing good shade indicated by an asterisk. Note, the listed species are not necessarily all suitable for planting at Poonunda. Seek local expert advice.

Shorter	Medium	Tall
Atriplex nummularia (old man saltbush)	*Acacia ligulata* (sandhill wattle)	*Acacia loderi* (nelia)*
Atriplex rhagodioides (silver saltbush)	*Acacia oswaldii* (Oswald's wattle)*	*Acacia neriifolia* (oleander wattle)
Rhagodia parabolica (mealy saltbush)	*Acacia saligna* (golden wreath wattle)*	*Acacia pendula* (myall)*
Rhagodia preissii (mallee saltbush)	*Allocasuarina verticillata* (drooping sheoak)	*Geijera parviflora* (wilga)*

PERENNIAL FODDER SHRUBS



* Five shrub species — old man saltbush, rhagodia, river saltbush, ruby saltbush and tar bush — with an inter-row of sown pasture, including barley and a mix of other grasses



* The first system (Diversity) was a diverse mixture containing 20 shrub species plus senesced volunteer pasture, and the second (Monoculture) was comprised of only one shrub species plus senesced volunteer pasture. Both systems were grazed at 20 sheep/ha over six weeks during autumn. The contribution of shrubs to the actual diet eaten was much greater in the diverse system throughout the whole grazing period.

Production System Benefits

Liveweight gain:

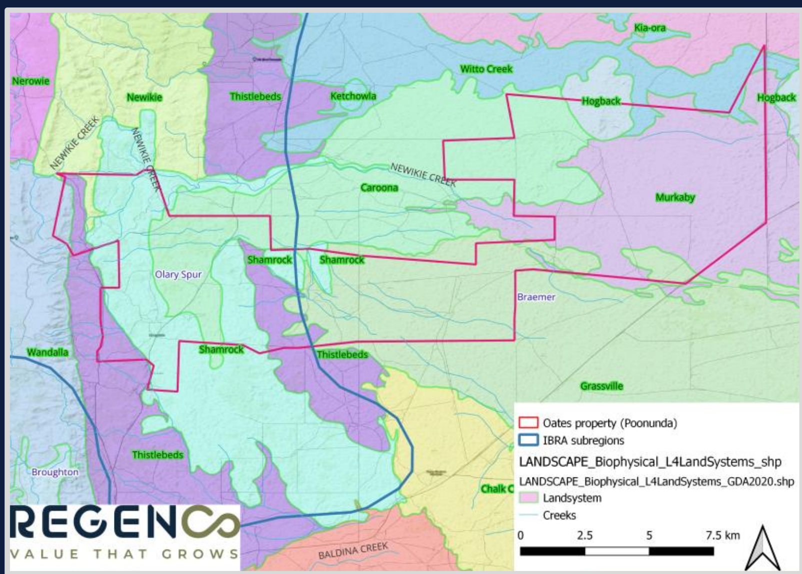
Enrich examined and compared the liveweight gain of lambs grazing a) a shrub-based forage system vs autumn pastures with supplementary grain, and b) a diverse shrub-based system vs one with only one shrub species. The study found that weight grain was greater in a) the shrub-based forage system and b) the diverse system.

Given the wealth of information gathered by *Enrich* on a variety of shrubs, it is recommended that the landholder considers desired traits for shrubs in their forage system and incorporates a diversity of shrubs in any future plantings. Plantings of shrub rows could be made parallel to keylines, as suggested on page 23, or potentially located in the historically cropped 'Shamrock' area.

The booklet *Perennial forage shrubs – from principles to practice for Australian farms* provides an easily accessible resource for understanding the attributes and assisting selection of 10 of the most likely forage shrubs for semi-arid grazing systems. The detailed final project report for *Enrich* can be found here.

Restored hydrological and ecosystem processes:

The PMP for Poonunda includes several recommendations for restoring landscape hydrological processes degraded by roads and infrastructure, as well as overgrazing. This has created scalds where all the bluebush, blackbush and other fodder have been removed and are unable to recolonise, especially across about 1500 ha of the Murkaby Land System in the Newikie Creek flood-out area. In these locations, restoration of hydrological processes, recovery of perennial shrubs, reinstatement of intact and resilient ecosystem processes, and improved agricultural productivity go hand in hand.



Land systems of Poonunda Station (Murkaby System in the east)

PERENNIAL FODDER SHRUBS

Natural Capital Benefits

As with the potential tree plantings, fodder shrub plantings would support Natural Capital gains, which will, in turn, interact with and bolster farm system productivity and resilience:

Vegetation biomass carbon – A study of carbon mitigation using Old Man Saltbush plantings (Walden et al, 2017) was undertaken at six sites in southern WA, SA and NSW with similar climate to the western end of Poonunda. The study found that OMS plantings sequestered between 0.2-0.6 tC/ha/yr, which equates to 0.73-2.2 tCO_2e^-/ha/yr. The sequestration potential of other high biomass fodder shrubs is likely to fall in a similar range. Regeneration of saltbush and chenopod shrubland in the Murkaby Land System area is estimated to sequester **0.3 tCO_2e^-/ha/yr** over 20 years (see Henry, 2015). Across the estimated 1500 ha of scalded land, this would equate to about **450 tCO_2e^-/yr.**

Currently there is no Australian method that lends itself to generating carbon credits from forage shrub plantings or low shrubland regeneration, but the sequestered carbon could potentially be used to inset against farm emissions for carbon neutral claims.

Soil carbon – Read et al (2012) studied soil carbon sequestration following hydrological restoration in the rangelands of NSW, finding a 29% increase in soil carbon density to 30 cm over a period of about 5 years. Sampling of soils in the scalded area of Poonunda by the current project found SOC stocks of about 12 TSOC/ha (30 cm). While rainfall in the Read et al (2012) study area is likely to have been somewhat higher, the Murkaby Land System is in a flood-out area and, therefore, the same 29% increase is applied to estimate soil carbon potential. This equates to an increase of 3.5 TC/ha over the 1500 ha of scalded area, which translates to about **19,157 $TCO2e^-$** for the whole area.

Establishment of fodder shrub corridors would also help to increase soil carbon on Poonunda through provision of microhabitats with lower wind speeds and higher soil moisture allowing higher groundcover to be maintained and loss of soil carbon by exposure to be reduced. The *Enrich* project also found that nitrogen-fixing legumes tend to grow well as a companion pasture to fodder shrubs, and the presence of shrubs brings increased nutrient cycling with companion pastures having higher levels of phosphorus and potassium. Therefore, soil nutrient constraints to pasture growth many be overcome in the inter-row of a diverse fodder shrub system, resulting in greater SOC being generated.

Carbon footprint – Poonunda's carbon footprint shows that by far the largest source of its carbon emissions is enteric methane production in sheep. Fodder shrubs present an opportunity to reduce emissions from this source by including tar bush (*Eremophila glabra*). Tar bush, a local shrub species has been shown to influence the conditions and fermentation profiles in the rumen, such as producing less methane (waste) when digested compared with other forages. Laboratory tests indicate reductions in methane production of more than 80% (Durmic et al, 2022). This would equate to an emission reduction of about **940 tCO_2e^-/yr** at current Poonunda stocking rates. Tar bush has also been able to mitigate acidosis in sheep rumen.

Vegetation condition – Forage shrub corridors would enhance the condition of the existing native vegetation by increasing biodiversity and connecting large areas for enhanced genetic flow and self-organization. Planting a diverse range of fodder shrubs, rather than a monoculture of OMS, will further enhance this value.

Woodland birds and other fauna - Adding shrubs creates a new vegetation layer, resulting in increased biodiversity compared with simpler agricultural landscapes. Increased numbers of birds and reptiles are found in forage shrub plantations compared with annual pasture systems. The forage shrub species detailed in the *Enrich* booklet also host beneficial predatory insects offering potential advantages for pest management in nearby crops and pastures. A study (Collard et al, 2011) conducted in South Australia examined selected ecological indicators, including plant and bird communities, in saltbush plantings, finding that saltbush sites contained a diverse range of plants and birds, including a number of threatened bird species not found in adjacent pasture.

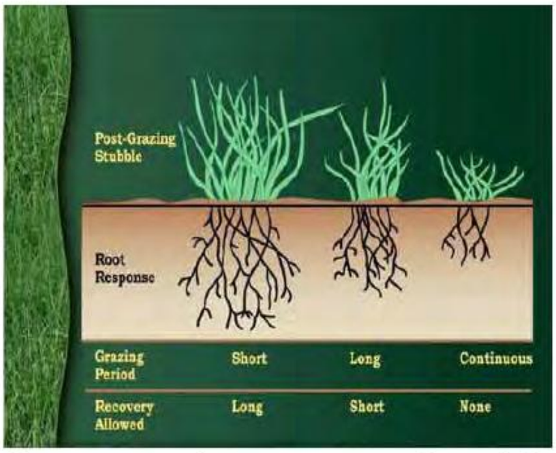
Water – On the eastern saltbush plain of Poonunda, the interaction of hydrology, soil and plants is obvious, with the health and integrity of each having feedback impacts on the others. Similar benefits could be derived in the western parts of Poonunda by planting shrub corridors in a parallel keyline design, slowing water flow, controlling erosion and conserving soil.

REST-BASED GRAZING SYSTEM

Production System Benefits

The PMP for Poonunda identifies grazing management as a general issue, in terms of matching stocking rate to feed on offer and recovery period. The development of a confined livestock facility on the property may enable the Poonunda grazing system to allow longer rest periods for pasture recovery. In addition, if tree and forage shrub plantings are developed, as above, these areas and associated fencing may lend themselves to a more strategic division of the property at the western end to facilitate a further shift along the spectrum from continuous grazing to rotational grazing. Anecdotal and (some, but not all) experimental evidence suggests that there are a number of production benefits to transitioning from a continuous grazing system to a rotational one, including:

- Healthier root system of perennial tussock grasses, conferring a better chance of surviving long dry spells (see images below)
- Increases in perennial grass cover offering more feed towards the end of the dry season, increasing overall carrying capacity
- Improved rainfall use efficiency - *Research on long term grazing trials at Old Man Plains (OMP) research station, Alice Springs, has shown that over a ten year period, by rigorous determination of appropriate annual stocking rates and with the introduction of pasture resting, rangeland condition was improved and rainfall use efficiency improved by a factor of 2.5 in terms of kg Dry Matter (DM)/ha/yr/mm rainfall. These improvements came largely from regenerating populations of native perennial grasses.*



Plant response to grazing periods of different lengths (Colorado State University 2013).

Continuously grazed grasses will have small root systems (Australian Wool Innovation and Meat and Livestock Australia 2009).

Given projected declines in annual rainfall and increasing evapotranspiration, improved rainfall use efficiency of the pasture resource would be a critical benefit for the sustainability of the Poonunda grazing operation. Also, the return of historically overgrazed and now sparse summer-active perennial grasses would help to adapt the production system to projected relative increases in summer rainfall events.

Other reported benefits of rotational grazing include even grazing pressure; reduced herbivore selectivity and selection of most palatable species; enhanced flowering, growth and survival of plant species; improved pasture utilization; maintenance of pasture cover; increased herbage production; reduced soil erosion and improved animal production.

The length of the rest time relative to the graze time can also be influential. McDonald et al (2019) found that increasing the length of rest relative to graze time under strategic-rest grazing was associated with an increase in plant biomass, ground cover, animal weight gain and animal production per hectare when compared to continuous grazing.

Natural Capital Benefits

Continuous livestock grazing can have negative effects on biodiversity and landscape function in arid and semi-arid rangelands. Alternative grazing management practices, such as rotational grazing, may be a viable option for broad-scale biodiversity conservation and sustainable pastoral management (McDonald et al, 2019). The adoption of a more rotational grazing system at Poonunda may offer natural capital benefits as follows:

Vegetation biomass carbon – Some studies have found that rotational grazing can improve the biomass of pastures. For example, Lawrence at al (2019) found that pastures under rotational grazing management were characterised by increased cover and depth of plant litter and greater retention of pasture biomass, while McDonald (2019) found that biomass only became greater under rotational grazing when a rest:graze time greater than 6:1 was applied. Badgery (2017) found that intensive rotational grazing with a 20-paddock flexible system was able to increase pasture growth of a native pasture by 21%. Therefore, although this report does not estimate uplift of biomass carbon via rotational grazing, we can reasonably expect gains in the Poonunda pastures with this practice change, which is likely to support improved landscape function (e.g stabilize soil, provide a buffer from extreme temperatures, reduce soil erosion, improve infiltration and contribute to nutrient cycling through the decomposition and mineralization of plant material).

Soil carbon – McDonald et al (2023) conducted a review of research into the impacts of grazing management on SOC in Australia, finding that most studies reported no significant difference in SOC between grazing management treatments. This is despite key drivers of soil carbon sequestration being favoured by rotational gazing, including above and below-ground biomass, plant growth rate, groundcover, soil structure and soil nitrogen. Similarly, in the vicinity of the Mid North Agricultural District, a study by Sanderman et al (2015) found a significant positive trend of increasing NDVI (plant growth) under rotational grazing relative to continuous grazing but no significant difference in SOC stocks. Therefore, while this report makes no attempt to estimate a change in soil carbon for Poonunda under rotational grazing, the practice change will help to create the conditions that make soil carbon sequestration more likely.

Vegetation condition – Rotational grazing can improve the condition of pasture species by reducing selective grazing and allowing recovery of preferred plants after grazing. A study by McDonald et al (2019) found few differences in plant biodiversity and ground cover between a rotationally grazed property and a nearby ungrazed nature reserve (despite differences in overall plant species composition), suggesting that rotational grazing may have potential to sustain some elements of biodiversity and ground cover on pastoral properties. It is expected that incorporating more rest into a multi-paddock grazing system, which includes fodder shrub corridors, will help recover some favoured pasture species reduced by past grazing practices, especially summer-active native perennial grasses (e.g. Ampt and Doornbos (2010)). However, it should be noted that semi-arid pastoral resources can be slow to recover from past degradation.

Birds and other fauna – By moving towards a grazing system that incorporates longer periods of rest, ground cover vegetation at Poonunda will become more functionally diverse in composition and structure, with some areas recently grazed short with low cover and others with greater cover and biomass/height after a period of prolonged rest. This increased structural and floristic diversity in the ground-layer could potentially add to that provided by shrub and tree plantings to greatly increase habitat heterogeneity in all vegetation strata across Poonunda. Vegetation heterogeneity has been identified as a key element in promoting bird and other biodiversity on farms, with rotational grazing being highlighted by Toombs et al (2010) as a key way to achieve this. Generally speaking, the increased standing biomass and ground litter provided under rotational grazing management will also offer superior habitat for small animals including invertebrates, birds, reptiles and small mammals.

Water – Rotational grazing offers the benefit of improved water infiltration and rainfall use efficiency. For example, a report by Ampt and Doornbos (2011) found that properties under rotational grazing management in NSW achieved results for a water infiltration indicator that was 40% higher than the continuous grazing comparison sites. Achieving a similar outcome at Poonunda will enhance pasture growth and help control erosion, particularly if implemented in concert with keyline contour plantings.

4. POTENTIAL PROJECT & BUSINESS CASE

DISCLAIMER: The information provided in this section of the report does not constitute a business offer, nor does any other part of this report. The environmental & carbon related findings and recommendations given in this section are specific to "Poonunda", however the financial information that has been used to demonstrate indicative revenue and costs is of a general nature only. RegenCo recommends that independent legal and financial advice is sought prior to entering into any commitment.

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ENVIRONMENTAL PLANTING PROJECT

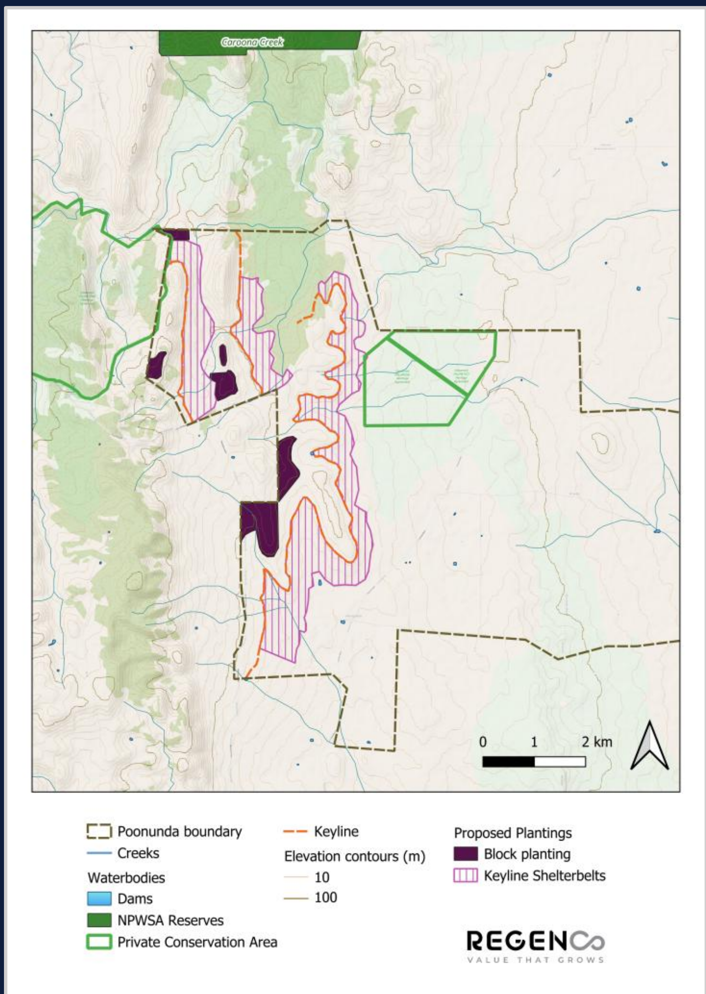
Design

The map below presents a proposed configuration for an Environmental Planting project, that could potentially be registered under the Australian Carbon Credit Unit (ACCU) Scheme for the generation of ACCUs. Key features of the proposed 392 ha project are:

Keyline shelterbelts - The project would establish keyline shelterbelts – belts of mallee trees planted parallel to the upslope keyline – across the hatched area displayed in the map below. It is envisaged that these belt plantings would cover about a third of the hatched area, which would bring the planted area to about 254 ha, with belt width of 30-40 m to maximise ecological value and effectiveness in providing shelter and shade to stock. These plantings are located to provide strong ecological benefit in the form of north-south connecting habitat through the property, and also east-west connecting habitat in the north-west corner of the property. This corner presents as a local ecological "hotspot", connecting up Heritage Agreement blocks, Newikie Creek riparian vegetation, and through to Caroona Creek Conservation Park. High quality woodland bird communities are known to occur in this area. Most importantly, these belts and their orientation parallel to keylines will both enable the plantings to take advantage of any rainfall, minimising the chances of drought failure, but also facilitate spreading and slowing of water flow when rains do come, mitigating soil erosion and facilitating infiltration. This will help to rehydrate the landscape which, in concert with the shade and wind shelter offered by the trees, will improve growing conditions for pasture between the shelterbelts. With moister soils, better groundcover and less erosion, it is highly likely that soil carbon levels will increase between the shelterbelts, which will further increase the water-holding capacity of the soils and enhance rehydration. There is also potential for the keyline works to facilitate replenishment of diminishing groundwater in this area. The general north-south orientation, along with twists and turns that follow the keyline, will offer excellent protection from prevailing strong, south-westerly winds that pose the greatest wind chill risk to lambs and pregnant ewes in late winter-early spring, and also are well orientated to weaken the drying effects of hot north-westerlies.

Block planting - It is also suggested that 138 ha of block plantings could be established on the flatter tops of some of the rises on the western boundary of the property. Once again, these plantings would slow the movement of water that falls on their elevated position, mitigating soil erosion and facilitating infiltration. It is suggested that they could also be used to bring back to the landscape some palatable tree and shrub species that have largely been lost from the area due to overgrazing and mechanical clearance. A mixed open grassy woodland may be the target condition. It is highly recommended that a local botanical expert is consulted regarding species mix. These blocks are mostly located where some fencing already exists, and could potentially be fully fenced off for maximum control of grazing pressure. Once plantings have matured, this would be a valuable and reliable asset for strict time-managed grazing of stock, while helping to return some of the rarer elements and biological resources to the local ecosystem.

It is envisaged, at this stage, that most of the planting will be done by direct seeding, supplemented with some strategic planting of tubestock. Protection of the plantings may be achieved through additional fencing or temporary exclusion of stock from the western end of the property.



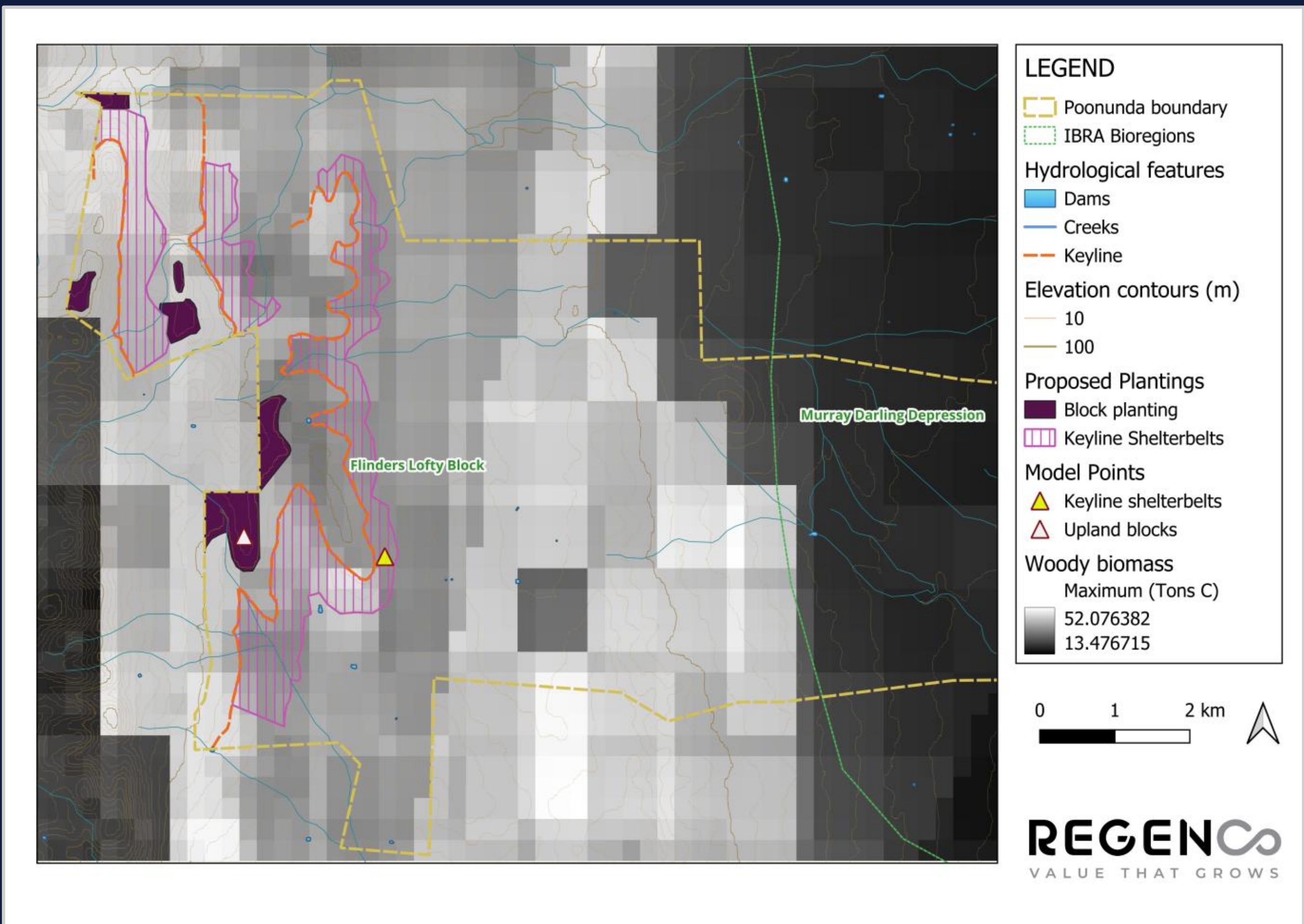
Proposed planting for Poonunda Station and indicative keylines

ENVIRONMENTAL PLANTING PROJECT

Business Case

There are three key components to a business case for a carbon project – carbon yield & revenue, start-up & ongoing costs, and co-benefits for production, resilience, biodiversity & marketing.

Carbon yield - The FullCAM model incorporates a spatial layer (Mbio) that represents the theoretical maximum biomass for any given location across Australia. This can be regarded as an index for carbon yield. The Mbio layer over Poonunda is presented in the map below, showing a modelled area of relatively high carbon yield west of the IBRA bioregion boundary, in the Flinders Lofty Block bioregion. Within this higher yield zone, there is generally only minor variation in the Mbio score. The model point chosen for the keyline shelterbelts shows a maximum biomass score of 36 tons/ha, while the model point for the block plantings is 43 tons/ha.



Modelled carbon yield for west Poonunda Station

The FullCAM model was run to estimate carbon yields for the various parts of the proposed Poonunda planting. The parameters entered into the model assumed less than 1500 stems per hectare. The model outputs suggest that the keyline shelterbelts in will sequester carbon at a rate of about 4.1 tCO_2e^-/ha/yr. The block plantings at the top of the western rises will yield carbon at a rate of about 3.8 tCO_2e^-/ha/yr. On an area-weighted basis, the overall project would yield 3.9 tCO_2e^-/ha/yr. This equates to an annual average of **1,540 tCO_2e-/yr** for the entire project area and **38,494 tCO_2e-** for the entire 25-year crediting period.

ENVIRONMENTAL PLANTING PROJECT

The following business case example is based purely on estimations and indicative ACCU pricing. It is for demonstration purposes only and RegenCo recommends the landholders seek independent financial advice that is specific to their business at Poonunda before deciding on any environmental initiative.

Business Case

Potential revenue - The estimated carbon yield can be converted to a gross revenue estimation, noting that the carbon market is still evolving and future value of ACCUs is unknown and hard to predict. At the time of writing, the ACCU spot price is $35.45. Environmental Planting projects may draw a premium due to their perceived higher integrity, though this not certain. Recent ACCU spot price history can be viewed here.

Therefore, to cover an indicative range of potential future ACCU values, we provide here a revenue estimation at $40/ACCU (approx. current value with an Environmental Planting premium), $50/ACCU (assuming future value gains), and $30/ACCU (assuming future value losses). The figures incorporate a mandatory 5% deduction of ACCUs issued by the regulator to cover the project's "risk of reversal buffer".

Est. Gross Revenue	$30/ACCU	$40/ACCU	$50/ACCU
Annual avg.	$43,890	$58,520	$73,150
Total (25 yr)	$1,097,000	$1,463,000	$1,828,750

Carbon project implementation costs - Costs for carbon project implementation can be categorised into:

1) initial (start-up) or ongoing costs, and
2) operational (on-farm) or ACCU Scheme participation costs.

The table to the right presents a breakdown of estimated costs by generalised item, and potential estimated revenue projections assuming a $40/ACCU carbon credit value.

Note: These figures include costs for 9 km of fencing, on the assumption that the hilltop block plantings would be fenced but the keyline belt plantings would not be.

TOTAL COSTS and REVENUE over project lifetime	
ON-GROUND WORKS COSTS	**$464,180.00**
Fencing	$54,000.00
Tubestock planting	$141,450.00
Direct seeding	$151,130.00
Site maintenance	$117,600.00
ERF PARTICIPATION COSTS	**$165,000.00**
Feasibility assessment	$2,500.00
Registration	$2,500.00
Annual monitoring and reporting	$100,000.00
Auditing	$60,000.00
CARBON REVENUE	
Carbon revenue per ha per yr	**$149.34**
Carbon revenue per yr	**$58,541.28**
Total aggregated carbon revenue over 25 year crediting period	**$1,463,532.00**

And this table presents some summary statistics describing the project's basic business case, (minus production system benefits) including a breakdown of potential costs over the first 5 years vs the last 20 years of the project.

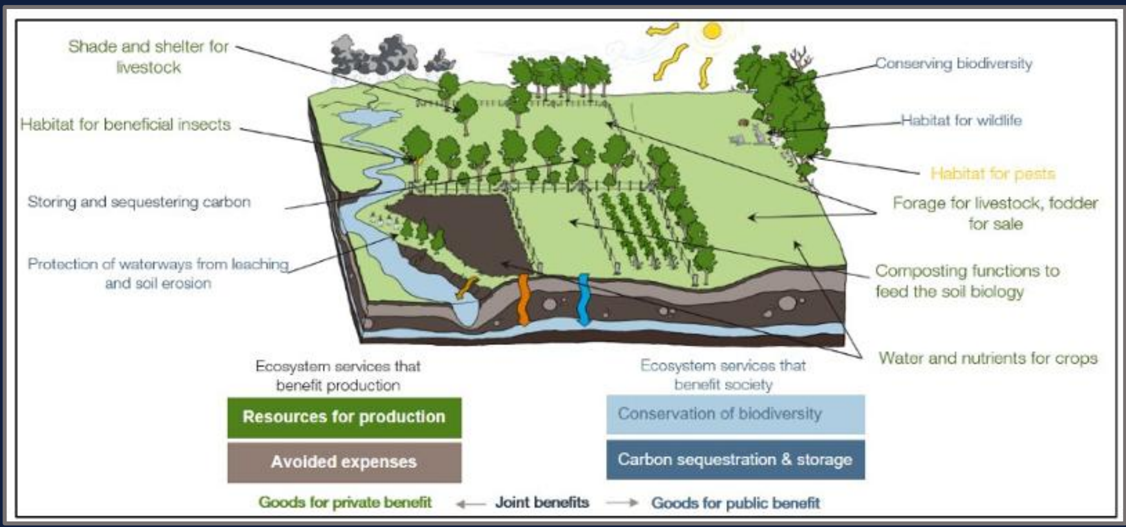
BUSINESS CASE SUMMARY STATISTICS	
Total cost	**$629,180.00**
Cost per ha	$1,605.05
Cost of production (per ton CO2e)	$16.34
Total cost in first 5 years	$529,140.000
Total cost in last 20 years	$99,980.00
Total profit (after all costs)	**$834,352.00**
Profit per ha	$2,128.45
Profit on production (per ton CO2e)	$21.66
Annualised profit over 25 years (after all costs)	$33,374.08
Annualised per ha profit over 25 years	$85.14
Cost-benefit comparison to standard reveg project costs (per ha)	**$3,312.58**

ENVIRONMENTAL PLANTING PROJECT

Business Case

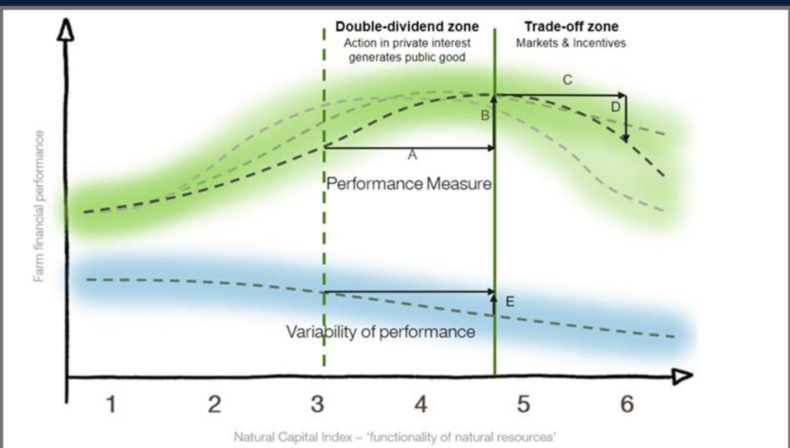
Production & Resilience - The system production and resilience co-benefits of the proposed Environmental Planting project are described in some detail in "*Section 3: Key Opportunities*" of this document. The information provided includes some financial estimates against practice change that the landholders could use to estimate potential financial benefit for their operation.

Farming for the Future is a program focusing on private production benefits associated with on-farm natural capital, including remnant native vegetation, productive pasture and croplands, riparian areas, agroforestry, environmental plantings and animals.



The pilot program report (focusing on 113 farms, mainly sheep/wool, in the Central & Tablelands region, South-eastern Australia and South-western Australia) confirmed that potential benefits like increased productivity, profitability and resilience are the most compelling motivation for producers to invest in natural capital, and that natural capital is positively correlated with production efficiency, gross margin and earnings before interest and tax (EBIT).

- Our landholder surveys show that the potential for private financial benefits is the most compelling reason for producers to invest in natural capital improvements.
- Our analysis of 113 livestock farms indicated that natural capital is positively correlated with production efficiency across a number of our natural capital indices, providing evidence of a 'double dividend zone'.
- We found different benefit pathways through which natural capital can support farm businesses, including via improving productivity, and/or by reducing input costs. These are relevant to different extents in our different study regions.
- High natural capital farms also had lower input costs across certain of the cost types examined (energy, fodder, health and labour). We suggest that natural capital may support production efficiency by replacing / substituting for some of these inputs.
- Natural capital was positively correlated with financial performance (gross margin and EBIT). Optimised natural capital levels delivered higher EBIT with median $75 - $175 /ha/yr higher in the Central and Tablelands region, $20 - $135 /ha/yr higher in the South-eastern region, and ~$70 /ha/yr higher in the Western region, depending on the farm type. Differences in gross margin were of a similar magnitude.
- High natural capital was also associated with higher levels of resilience to both climate and market shocks. This may occur for two reasons. Natural capital may help build climate resilience by enabling higher levels of water retention in farm soils. It may help to build financial resilience and improve financial performance because natural capital inputs tend to be low-cost relative to manufactured inputs, and their 'price' is not subject to volatility of international market shocks or input supply chain disruptions.



Explanation for Figure 5: The Natural Capital Index (x axis) indicates increasing levels of natural capital functionality as the scale increases from left to right. The Y axis indicates farm financial performance, and may be measured as gross margin, EBIT, productivity or any other of a range of potential measures of financial performance (or other benefits like producer wellbeing). The two curves indicate potential associations between different 'levels' of natural capital and measures of performance (green shaded curve), and performance variability (blue shaded curve).

Importantly, the research also demonstrated that natural capital can confer livestock businesses with increased levels of resilience in the face of both climate and market shocks – delivering increased stability on EBIT for livestock operations from 2017 to 2022.

ENVIRONMENTAL PLANTING PROJECT

Business Case

Finance - The main natural resource management issues identified by the Poonunda PMP are to do with interference of natural hydrological processes and consequent erosion, land dehydration and degradation of the grazing resource. The proposed planting project and associated keyline works will directly contribute to the remediation of several of the hydrological and erosion priorities identified in the PMP. The PMP notes that *"some near contour ripping near the homestead in Horse Paddock recently have been quite successful and indicate that this approach could be enhanced and expanded"*. There is also the possibility that keyline ploughing will help to recharge local groundwater systems and solve another significant problem identified in the PMP – the deterioration of watering points in the western part of Poonunda.

The PMP adds that *"Whenever focusing on a priority site or small group of sites it is always useful to consider the wider drainage ecosystem (context) within which these initiatives will take place. This contextual approach can increase the chances of success and avoid any unforeseen, off-site consequences"*. The proposed planting project would very much feed into this land management philosophy, broadly encompassing the upper reaches of Poonunda's western drainage systems.

The carbon revenue from the project potentially offers a pathway to pay for the cost of these management actions, already planned under the PMP, either up-front or by servicing a bank loan, depending on the selected business model. If taking out a loan to pay for on-ground works, discounted interest rates (e.g. green loans) are available from some lenders. For example, Rabobank is currently offering discounts of up to 1.15% on loans for Environmental Planting carbon projects.

Nature Repair & Biodiversity Markets – Biodiversity markets operate by putting a price on nature commodities or ecosystem services, such as woodland bird communities, with the intention of facilitating investment in conservation and restoration. At this stage biodiversity markets are in their early days and it has not yet been well established what the scale of the market for these products might be, although financial advisory, PwC, estimates that a biodiversity market could be worth $137 billion by 2050.

Mechanisms are now emerging to enable land managers to earn high-integrity products representing scientifically robust verification of positive biodiversity outcomes. Accounting for Nature, for example, are developing two products, one that is linked to nature-positive carbon projects (CarbonPlus™), and one that generates tradeable certificates independent of any carbon value (NaturePlus™).

The baseline assessment performed on the woodland bird community has placed Poonunda in a strong position to take advantage of these products and add further value to the carbon revenue earned through the planting project. The soil parameters that have been tested at Poonunda could also enable a baseline to be established under one of AfN's soil methods - *S-02: Level 3 Soil Assessment for Productive Land (Landcare)*. It should be noted that there would also be additional costs if participating in a scheme such as these (e.g. monitoring, reporting and auditing costs).

Another potential pathway is through the Australian Government's proposed Nature Repair Market. Under the scheme, which will work in alignment with the Australian Government's carbon farming scheme, nature repair projects such as the proposed Environmental Planting project can generate a tradable certificate. Biodiversity certificates will describe the biodiversity benefits from each project in a consistent way. This information will help the market users to compare and value projects. The 2024 Environmental Planting Method acknowledges the development of the nature repair market, which means registering the carbon planting for nature repair credits can be considered, once this new market comes online.

In preparation for this new market, the Australian Government ran a Carbon + Biodiversity Pilot in 2022-23 across six Natural Resource Management regions, including Northern and Yorke. The project aimed to deliver income to landholders through carbon credits while testing aspects of buying and selling biodiversity services. Under this scheme, proposed projects were graded with a modelled biodiversity benefit score. Based on the score, a biodiversity payment was calculated to cover a portion of establishment costs. Business models such as these may be worth exploring with third parties, such as NRMs and environmental not-for-profit organisations.

ENVIRONMENTAL PLANTING PROJECT

Business Case

Market access – It is widely acknowledged that there has been a shift by large wholesalers of farm products, including lamb and sheep meat, towards requiring suppliers to show their credentials in being good stewards of the environment, reducing the carbon footprint of their production systems, and being attentive to animal husbandry and humane treatment.

For example, Thomas Foods International require their suppliers to be accredited under their Thomas Family Guarantee program. This includes environmental guidelines requiring suppliers to consider actions such as planting trees and other native vegetation to encourage biodiversity, fencing creeks to deter erosion, and reducing chemical application across crops and pastures. The proposed Environmental Planting project, amongst other actions under the PMP, would enable the landholders at Poonunda to keep meeting requirements such as these to maintain market access and "stay ahead of the curve" of increasing demands on suppliers.

There are also programs in place and emerging from some large buyers of farm product that deliberately, as a marketing angle towards higher value product, look to raise the bar on "Nature Positive Farming". For example, Woolmark used the *Farming for the Future* pilot to help identify 12 core metrics for monitoring and reporting by suppliers, and awareness raising and capacity building by Woolmark to drive improvement of environmental performance.

Similarly, in order to maintain access to international markets, Sheep Producers Australia (SPA) and Wool Producers Australia (WPA) lead the Sheep Sustainability Framework. The Sheep Sustainability Framework monitors and measures industry performance against priorities aligned with four themes: animal care, the environment, economic resilience, and people and community. It is likely that reporting of performance against these themes will have the effect of raising industry expectations on suppliers over time.

Some farmers who are undertaking strong environmental stewardship actions on their farms and/or adopting more regenerative practices are leveraging the sustainable agriculture marketing angle to attract a premium price in "paddock-to-plate" business models. There is a growing product market for these kind of offerings, including in the lamb/sheep meat industry, in Australia. An example of a Mid North farm that has adopted this approach is Gilberdale farm, north of Gawler.

The above considerations around market access don't only relate to the proposed planting project but also to other matters identified in the PMP and discussed in this document, such as rehabilitating the scald areas in the far east of the property, undertaking actions to conserve the permanent spring on Newikie Creek, and returning a diverse group of fodder shrubs to the grazing system.

A Landscape Function Toolkit (LiFT) being developed by the Mulloon Institute may soon offer a cost-effective and accessible framework for assessing, monitoring and reporting on landscape condition and resilience improvements made through management actions such as those proposed here and in the PMP.

Acknowledgement

This project has been funded by the South Australian Government under the Growing Carbon Farming Demonstration Pilot and delivered in partnership with Upper North Farming Systems, RegenCo, FarmLab and the Northern and Yorke Landscape Board on Ngadjuri Land.

Acknowledgement and thanks goes to independent vegetation and sustainable agriculture consultant, Anne Brown, for conducting the vegetation condition assessment, and to AgEx Alliance Climate Smart Facilitator, Emma McInerney, for assisting with initial scoping.

This project was delivered on the property, and with the positive engagement, of the Poonunda landholders, Ryan and Ellie Oates. Our thanks to them for their participation.

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