Growing revenue using carbon shelterbelts

Case Study 3, Sherlock

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- *This report provides pricing scenarios to help understand potential revenue returns. We use four pricing scenarios:*
    - *Auction price of \$17.35/tCO_2e - the average price in the last ERF auction in April 2022*
    - *Low price \$32.00 - \$51.00/tCO_2e*
    - *Base price \$35.00 - \$71.00/tCO_2e, Compound Annual Growth (CAG) of 2.8 % over 25 years*
    - *High price \$42.00 - \$105.00/tCO_2e, or Compound Annual Growth (CAG) of 3.3 % over 25 years.*

- *The Low, Base and High scenarios are based on pricing information obtained from Reputex, which provides a subscription service to market participants and governments on carbon market dynamics, trends and outcomes. The pricing was current on 22 July 2022. More information about Reputex can be found at https://Reputex.com.*

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- *This report uses carbon yields calculated using the Clean Energy Regulator's carbon assessment tool (FullCAM), the outputs of which may vary depending on a range of input variables. Carbon yields cannot be finalised until any Australian Carbon Credit Units (ACCU) volumes have been approved by the Clean Energy Regulator (CER) and/or project auditor. As such, carbon yields per hectare should be considered as estimates at this stage.*

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1. Introduction

The Murraylands and Riverland region of South Australia is a dryland agricultural area with an average rainfall of 300-400mm, but is prone to reduced rainfall during El Nino events. Farms in the area have recently suffered a run of dry seasons. This project was funded by the Department of Agriculture, Water and Environment and the Future Drought Fund to investigate whether carbon shelterbelts could provide a useful income source during dry times.

The simplest approach to engaging in the carbon market is to use methods that conform to Australian Government carbon methods. The approach that relates best to shelterbelts is the Reforestation by Environmental or Mallee Plantings Method (Clean Energy Regulator 2022a) which uses a computer model (Full Carbon Accounting Model, FullCAM) to estimate carbon yield based on location (Department of Climate Change, Energy, the Environment and Water 2022). For projects registered with the Australian Clean Energy Regulator, carbon yields can then be converted to yield in tonnes of carbon dioxide equivalent (tCO_2e), with 1 tCO_2e of greenhouse gas storage or abatement generating one Australian Carbon Credit Unit (ACCU, Clean Energy Regulator 2022b).

The aim of this project was to identify 10 case study sites across the Murraylands and Riverland region, then develop a planting layout, use FullCAM to model carbon sequestration, and estimate costs and revenue associated with the planting. The project targeted all six council areas in the Murraylands and Riverland where typical ‘mixed farming’ occurs, namely, The Coorong, Karoonda East Murray, Mid Murray, Murray Bridge, Southern Mallee and Loxton Waikerie council areas.

There was significant farmer interest in how carbon shelterbelts would affect the farm carbon account if carbon credits are not sold, but are instead used to offset farm emissions. This interest was driven both by a desire to contribute to the effort to reduce global warming, and because farmers may in future be required to offset emissions avoid tariffs on in some markets (e.g., the EU, see Martin 2021). In response, case studies were expanded to include a simple farm carbon account, and consideration of how sequestration in shelterbelts may impact net farm emissions.

2. Case Study 3 – Background

Case Study 3 is a 417 ha mixed farm near Sherlock and in the SA Mallee 120 km south-east of Adelaide. Average annual rainfall is approx. 450 mm and soils are mostly sands and sandy loams.

The enterprise is based on 250 ha of wheat and barley, and a flock of 500 Merino ewes joined to either Merino or White Suffolk rams grazing annual a mix of annual pastures, veldt grass and stubbles.

In previous decades, the owner completed a whole farm property planning course and identified 46 ha of the farm (mostly sand dunes) that was unsuitable for cropping or annual pasture. This area was planted to widely spaced river redgums, with veldt grass later established in between the trees. These agroforestry zones have since been grazed intermittently, mostly by lambing and lactating ewes. The owner found the tree planting program to have the following benefits:

- stabilisation of light soils on top of dunes
- shelter for ewes and lambs
- improved water balance in the landscape
- improved aesthetic appeal of the landscape
- potential to harvest firewood from trees and eventually sawlogs

Because the agroforestry zones were established around 20 years ago, it is not expected that these past plantings would be eligible for carbon revenue – the plantings fail the 'additionality' requirement (i.e., that a newly registered project should sequester new carbon beyond what would happening without the project, see Clean Energy Regulator 2022c).

However, the owner has already shown a willingness to commit 11 % of his farm to agroforestry plantings. The question arises, if the owner or others in the Sherlock district were to plant a project of this type to mallee plantings that conformed to an Australian Government method, what carbon revenue would be generated?

3. *Shelterbelt design*

An aerial view of the Sherlock property is shown in Figure 1. Shaded areas indicate sandy rises not suitable for cropping or annual pastures that most suit agroforestry. The design in Figure 1 is for 58 ha of plantings, slightly higher than the original planted area and includes some extra sandy soils.

Because the agroforestry area is designed on soil type, the design is of the 'block plantings' type. The species chosen for FullCAM modelling was 'mallee eucalypt species', since local mallee trees are drought and fire resistant, maximise carbon yield, and are easier to establish than many shrubs (Noble and Bradstock 1989).

The design conforms with the Reforestation by Environmental or Mallee Plantings Method provided the block plantings setting is applied in FullCAM.

Fig. 1. Shelterbelt design on the 417 ha property at Sherlock.

4. Cost of establishing shelterbelts

Cost estimates for establishing shelterbelts are shown in Table 1. Fencing costs for the design shown in Figure 1 were based on a contract rate of $5000/km for 16 km of Cyclone and steel post fencing ($80,000), and a cost of $1000/ha was allowed for site preparation and direct seeding 58 ha ($58,000). At these rates, the total cost of fencing and seeding would be $138,000. A figure of $6,000 was allowed for post-seeding weed control (spot spraying), and for fence repairs over time.

Table 1. Cost estimates for shelterbelt establishment.

Item	Unit cost	Cost on 58 ha
16 km fencing	$5000/km	$80,000
58 ha seeding	$1000/ha	$58,000
Post-seeding weed control, fence repairs		$6,000
Total		**$144,000**

Costs associated with developing, registering and auditing the project have not been included. The Clean Energy Regulator is developing a pilot program to assist landholders to enter the carbon market, but at present, this is still in a trial phase (see environmental plantings pilot, Clean Energy Regulator 2022d). It is likely some landholders may require the services of a carbon developer to assist with mapping, carbon modelling, registration, and audits. However, at this stage these costs are difficult to define and have not been included.

The total cost of establishing the project was thus estimated at $144,000 over 25 years. These cost estimates are a guide and will change depending on soil, slopes, condition of pastures and weeds.

5. Estimating carbon yield and revenue

The FullCAM model was used to calculate project carbon yield in tC/ha over a 25 year period at four locations within the block planting design (see Figure 2 for example FullCAM curve). The four FullCAM yield curves were then converted to yield in CO_2e. These four curves were highly similar (Fig. 3), with yields highest in years 3 to 14 when trees grow fastest (approx. 5-12 tCO_2e/ha/yr), dropping to 4-6 tCO_2e/ha/yr in later years.

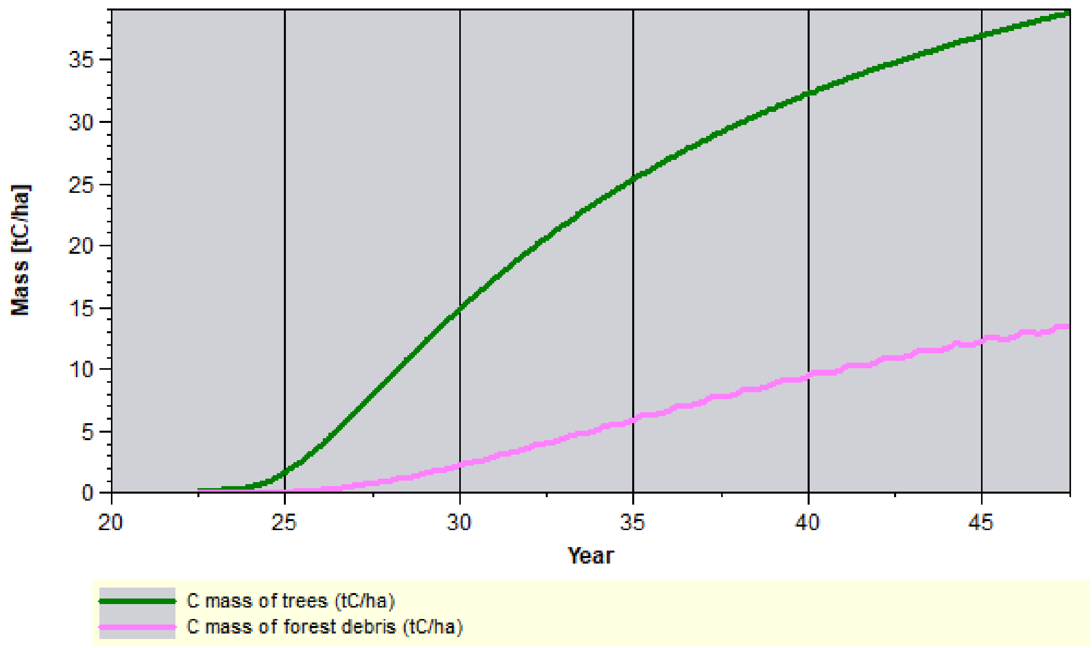

Fig. 2. FullCAM output from one site at Sherlock showing cumulative carbon yield (tC/ha) over 25 years with block planted mallee eucalyptus species.

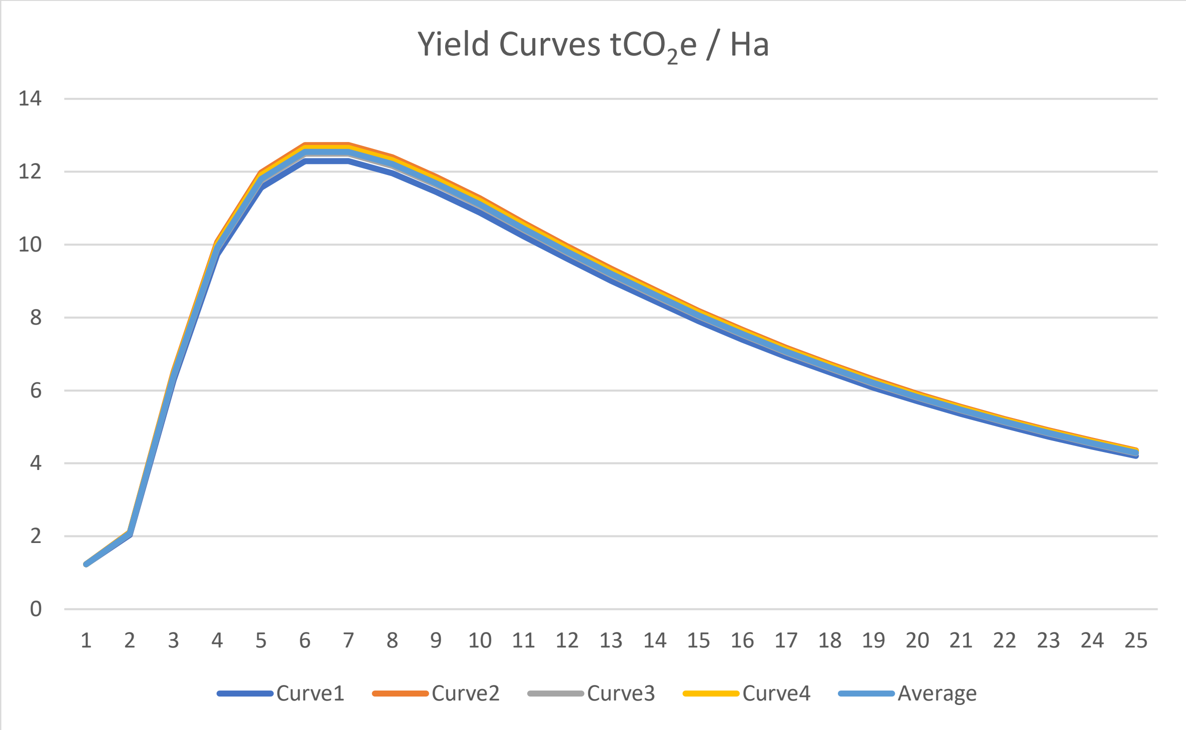

Fig. 3. Yield curves (tCO_2e/ha) for block planted mallees at 4 different locations at Sherlock over 25 years.

An average of the four curves was used to calculate project yields across 58 ha. These calculations included the 25 % yield reductions applied to 25 year vegetation projects (5 % risk reversal buffer and 20 % permanence buffer, Clean Energy Regulator 2022e, 2022f). Cumulative project yield was estimated to be 8,494 tCO_2e (Fig. 4), equating to 340 tCO_2e/yr (Fig. 5), or 5.9 tCO_2e/ha/yr.

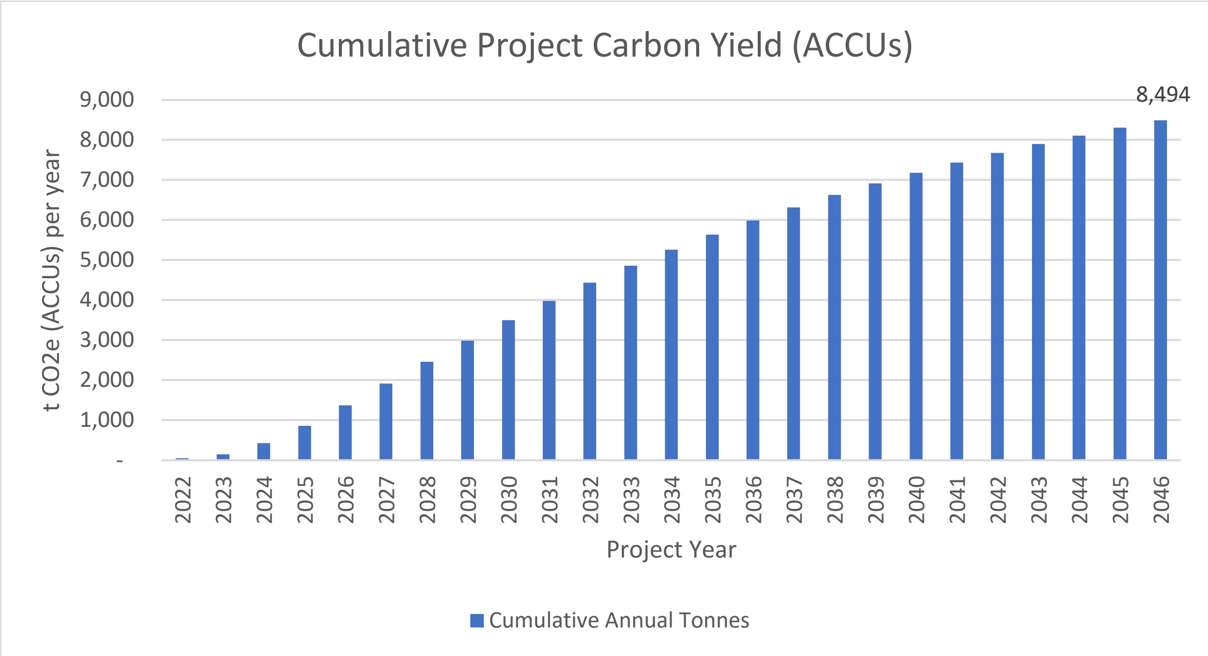

Fig. 4. Cumulative carbon yield for block planted mallees from the 58 ha carbon estimation area at Sherlock.

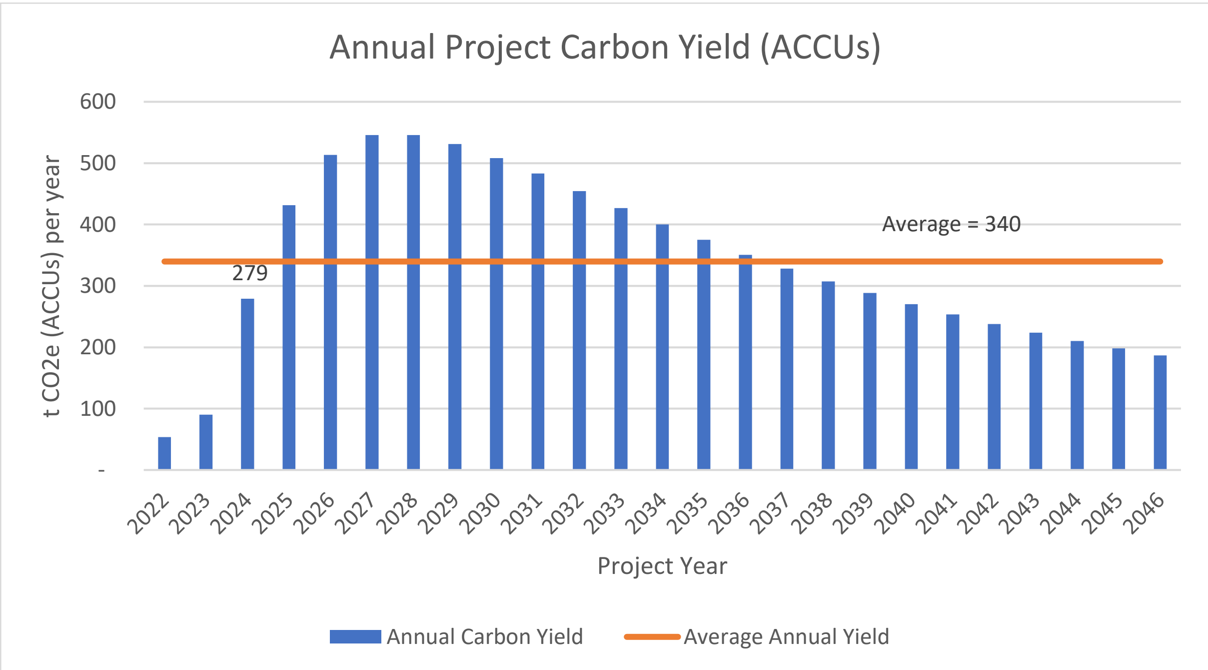

Fig. 5. Annual carbon yield (tCO_2e/yr) for block planted mallees across 4 different locations at Sherlock over 25 years, and average annual yield across all years (orange line).

Project revenue calculations were based on average carbon yield and flat, low, base and high carbon prices projected over 25 years (Table 2). Carbon prices were based on information from Reputex (https://Reputex.com) on 22/7/2022. The flat price was $17.35/t, the average carbon price in the last ERF auction (April 2022); the low price was $32/t (current spot price) increasing to $51/t and averaging $48.07/t; the medium price was $35/t increasing to $71/t averaging $66.29/t; and the high scenario was $42 increasing to $105 averaging $97.55/t.

Revenues under the flat, low, base and high pricing scenarios totalled $147,000, $408,000, $563,000 and $829,000, respectively, and annual incomes of $5,900, $16,300, $22,500 and $33,100. Because annual carbon yields were at their highest in years 3 to 14, revenue was also greatest in those years ($5,000-$53,000/yr).

Table 2. Project revenue for the base carbon yield at different pricing scenarios.

Yr	Calendar	Annual Tonnes	Auction Scenario	Low Scenario	Base Scenario	High Scenario
			Flat $17.35	$32 to $51 (avg $48.07)	$35 to $71 (avg $66.29)	$42 to $105 (avg $97.55)
1	2022	54	$930	$1,715	$1,876	$2,251
2	2023	90	$1,569	$3,256	$3,798	$5,064
3	2024	279	$4,844	$10,888	$13,959	$19,821
4	2025	432	$7,490	$17,699	$23,311	$32,808
5	2026	513	$8,906	$21,559	$28,745	$42,091
6	2027	546	$9,467	$24,008	$33,284	$46,380
7	2028	546	$9,467	$24,554	$33,830	$50,745
8	2029	531	$9,214	$24,961	$35,583	$53,109
9	2030	508	$8,821	$24,913	$34,065	$51,860
10	2031	483	$8,381	$24,635	$34,296	$50,720
11	2032	454	$7,882	$23,170	$32,256	$47,703
12	2033	427	$7,405	$21,767	$30,303	$44,814
13	2034	400	$6,943	$20,408	$28,411	$42,017
14	2035	375	$6,513	$19,143	$26,651	$39,413
15	2036	351	$6,086	$17,889	$24,904	$36,830
16	2037	328	$5,697	$16,747	$23,314	$34,479
17	2038	307	$5,335	$15,682	$21,832	$32,287
18	2039	288	$5,003	$14,707	$20,474	$30,278
19	2040	270	$4,685	$13,772	$19,172	$28,353
20	2041	253	$4,396	$12,921	$17,989	$26,603
21	2042	238	$4,128	$12,134	$16,893	$24,982
22	2043	224	$3,881	$11,408	$15,881	$23,486
23	2044	210	$3,650	$10,728	$14,936	$22,088
24	2045	198	$3,437	$10,104	$14,066	$20,802
25	2046	187	$3,241	$9,525	$13,261	$19,611
Total		**8,494**	**$147,370**	**$408,295**	**$563,092**	**$828,598**
Average			**$5,895**	**$16,332**	**$22,524**	**$33,144**

6. Costs and benefits

- Costs and benefits are summarised in Table 3. Project feasibility is assessed using the base scenario, which assumes that ACCUs are sold, resulting in $563,000 carbon revenue.
- For the purposes of this case study, establishment costs were estimated at $144,000, noting that costs could be greater in some landscapes or if consultants were used.
- Carbon income was estimated to be $419,000 greater than cost of establishing and maintaining the shelterbelts. The ratio of revenue to establishment costs was 3.9:1. Based on the revenue flows shown in Table 1, and assuming carbon was sold at the base rate, establishment costs would be recovered after 8 years.
- Though shelterbelts do take land out of production, and compete with adjacent pastures and crops, this impact can be offset by increased pasture and crop production due to reduced windspeeds across the farm (Bulman and Dalton 2000).
- A co-benefit from extra shelter on the Sherlock property may be improved lamb survival (Gregory 1995, Summers et al. 2019). A 4 % improvement in lamb survival per year could increase returns from lamb production by $3,400 per year, or $85,000 over 25 years, if stocking rates were maintained at current levels (500 ewes).
- Other co-benefits would include reduced dryland salinity risk, and improved animal welfare and production (Bulman and Dalton 2000), but are harder to quantify.

Table 3. Summary of costs and benefits if ACCUs are sold.

Item	**Costs or Benefit**
Establishment costs	$144,000
Carbon revenue, base case	$563,000
Potential profit	$419,000
Ratio of revenue to establishment costs	3.9:1
Time until costs recovered	8 years
Possible value of extra lambs if lambing survival lifts 4 %	$85,000

7. Offsetting farm emissions

- Many farmers are more interested in offsetting their own emissions than selling ACCUs. Under this scenario, ACCUs would be generated by the business but then 'retired' (e.g., see Weidemann and Longworth 2021).
- Calculating a full emissions profile for the case study farm was beyond the scope of this study, but for most livestock properties, approx. 80 % of emissions come from enteric methane, with the remaining 15 % generated from fertiliser use, diesel fuel

and electricity supply (Weidemann and Dunn 2021). Using the ESB-GAF accounting tool (Primary Industries Climate Challenges Centre 2022), and assuming the case study farm runs 500 ewes, sheep likely produce approx. 300 tCO_2e/yr. Most cropping operations emit approx. 0.3 tCO_2e per tonne of cereal grain, 0.7 tCO_2e/t oilseed, 0.25 tCO_2e/t pulses (Western Australian Department of Agriculture and Food 2022). On the Sherlock farm, cropping 250 ha with 2 tCO_2e/ha cereal yields may emit another 150 tCO_2e, taking total emissions to around 450 tCO_2e for the cropping and sheep businesses.

- With the project detailed here offering a chance to offset approx. 340 tCO_2e/yr for 25 years, the proposed plantings could offset 75 % of the farm's crop and livestock emissions.
- If premium markets became available in future for low carbon products, this could lead to substantial extra income (e.g., if lamb brought $9/kg instead of $7/kg, this would generate an extra $13,000/yr from 300 sales lambs with 22 kg carcase weight).
- To achieve carbon neutrality in crop and livestock enterprises, the case study farm would only need to increase the scale of plantings to around 77 ha, or pursue other abatement strategies – for example, through anti-methanogenic supplements or solar electricity generation. Alternatively, carbon credits could be purchased from carbon projects registered with the Clean Energy Regulator.

8. Perspective of the landholder

- The owners are interested in the fact that the mallee block plantings of the type modelled here have the potential to enhance the economic performance of farms in the Sherlock area – potentially offering extra income as well as co-benefits such as improved animal welfare, landscape function and amenity.
- It is encouraging that the planting design presented here would offset around 75 % of farm emissions – if the owners 'had their time again', they would consider the proposed design.
- That said, the owners are still happy with the performance of the widely spaced redgum plantings they established during the 1990s – the plantings have served to stabilise unproductive sand dunes, provide shelter for stock, and still allow veldt grass to grow underneath. The trees would also have offset some of the emissions from the property is a welcome bonus.
- It is a major undertaking to establish 58 ha of trees in one year, and takes time to learn what approaches give best results in a particular environment – the owners were happy with their approach, which was to spread establishment out over several years.
- While not expecting carbon credits for their previously planted redgum plantation, the owners of the Sherlock farm do hope that one day a framework can be developed that audits and recognises previous sequestration.

9. Impact of planting layout

This case study differed from others in this series in that plantings were in a block configuration rather than belts. Preliminary work was conducted to model carbon yields on this Sherlock property in a belt configuration, and suggested yields would be 30-40 % higher in a belt layout (for example, see Appendix 1 vs Fig. 2). The higher yields in a belt layout are probably due to the extra competition block planted trees experience compared to belt plantings, where trees have access to more light and water at the edges of the belt. Despite the lower yield, the financial performance of the block plantings was only slightly lower than typical belt planting projects (see Project Summary across all Case Studies in this series), and the design may be preferred by some farmers due to reduced fencing needs and greater flexibility in where block plantings can be located.

10. Conclusions

- The owners of the Sherlock property are happy with the approach they took, planting widely spaced river redgums on sandhills to stabilise soils, improve landscape function, and allow strategic grazing. Economic benefits may have accrued through better water balance and stock survival but are difficult to quantify.
- If the owners were designing their project today, and opted to register a block mallee planting on the same area and sold carbon credits at the base price, carbon revenue over 25 years would be around 3.9 times cost of establishment. Establishment costs would be recovered after 8 years. Alternately, the carbon credits could be kept and used to offset around 75 % of farm emissions.
- Once co-benefits such as improved lamb survival and animal production are considered, the proposed plantings would be highly likely to be profitable.
- Other co-benefits such as improved biodiversity, reduced dryland salinity, reduced erosion and improved aesthetics are more difficult to quantify but would also be beneficial.
- The preliminary result that carbon yields from block mallee plantings are 30-40 % lower than from belt mallee plantings is of interest and deserves further study across more sites: despite lower carbon yields, the design may be preferred due to reduced fencing costs and the ability to locate plantings on poorer soil types.
- Results of this study suggest that carbon shelterbelts provide a viable way of creating extra farm revenue or offsetting a significant proportion of farm emissions.
- Further work and pilot studies are required to better define costs farmers may incur with project registration, auditing, reporting and brokerage, or develop resources to allow farmers to manage projects themselves.

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Appendix 1. FullCAM output, cumulative carbon yield per hectare at Sherlock, with belt planted mixed mallee eucalyptus species.