Growing revenue using carbon shelterbelts

Case Study 6, Kepa

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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 to avoid tariffs 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 6 - Background

Case Study 6 is a 500 ha sheep and lucerne business located between Murray Bridge and Tailem Bend 90 km south east of Adelaide. Average annual rainfall is approx. 290 mm, soils are mostly sandy dunes and swales and the land was almost completely cleared in the early 20th century. Soils are non-wetting sands. The original farm area has been progressively subdivided over the past 10 years to allow the establishment of separate chicken farms on the property. However, this case study focuses on the 500 ha of surrounding land that continues to be run as a sheep and lucerne business.

The sheep enterprise is based on a self-replacing flock of 800 White Dorpers, though the flock is being expanded to 1,200. Pastures are based on annuals and cereals sown for sheep feed or hay. Ewes are joined 3 times over 2 years. The enterprise has found synergies with neighbouring chicken and pig farms, providing an outlet for chicken litter and pig effluent and waste water. There are four centre pivots (60 ha) on the farm growing lucerne, which is cut for hay several times each year to support sheep during summer and autumn and to sell into the fodder market. Dryland paddocks are rotationally grazed with mobs of 350 ewes. Each mob of 350 rotates across eight 20 ha paddocks with sheep moved every 7 days. Each paddock is also being set up to contain 0.6 ha of irrigated pasture.

The owners of the Kepa farm are interested in shelterbelt plantings for the following reasons:

- return more vegetation to an over-cleared landscape
- provide habitat for woodland birds and native bees
- provide extra shade and shelter for sheep
- reduce windspeeds on the farm
- connect adjacent heritage scrub to the Murray Ramsar corridor.

In addition, the owners are mindful of the fact there may in future be an opportunity to earn extra income from carbon sequestration in trees, or by aligning production to market demand for low-carbon products.

3. Shelterbelt design

A theoretical shelterbelt design for the Kepa property is shown in Figure 1. Factors considered when designing the layout were:

- protection for lambing ewes from cold winds (usually from the south west to south east)
- planting along existing fences preferred to improve biosecurity, reduce fencing costs and improve paddock biodiversity
- provide a wildlife corridor focussed on native birds and bees between areas of heritage scrub and the Murray River Ramsar corridor.

The species chosen were ‘mixed species environmental plantings’, since the owners are interested in maximising both carbon sequestration and conservation outcomes. Shelterbelts were designed to be 24 m wide, allowing 5 rows of trees to be planted 4 m apart, and keeping the outer row 2 m from fences. This design is consistent with the Reforestation by Environmental or Mallee Plantings Method (wide linear belt plantings method). The total area allocated to shelterbelts was 49 ha, representing 9.8 % of the farm area.

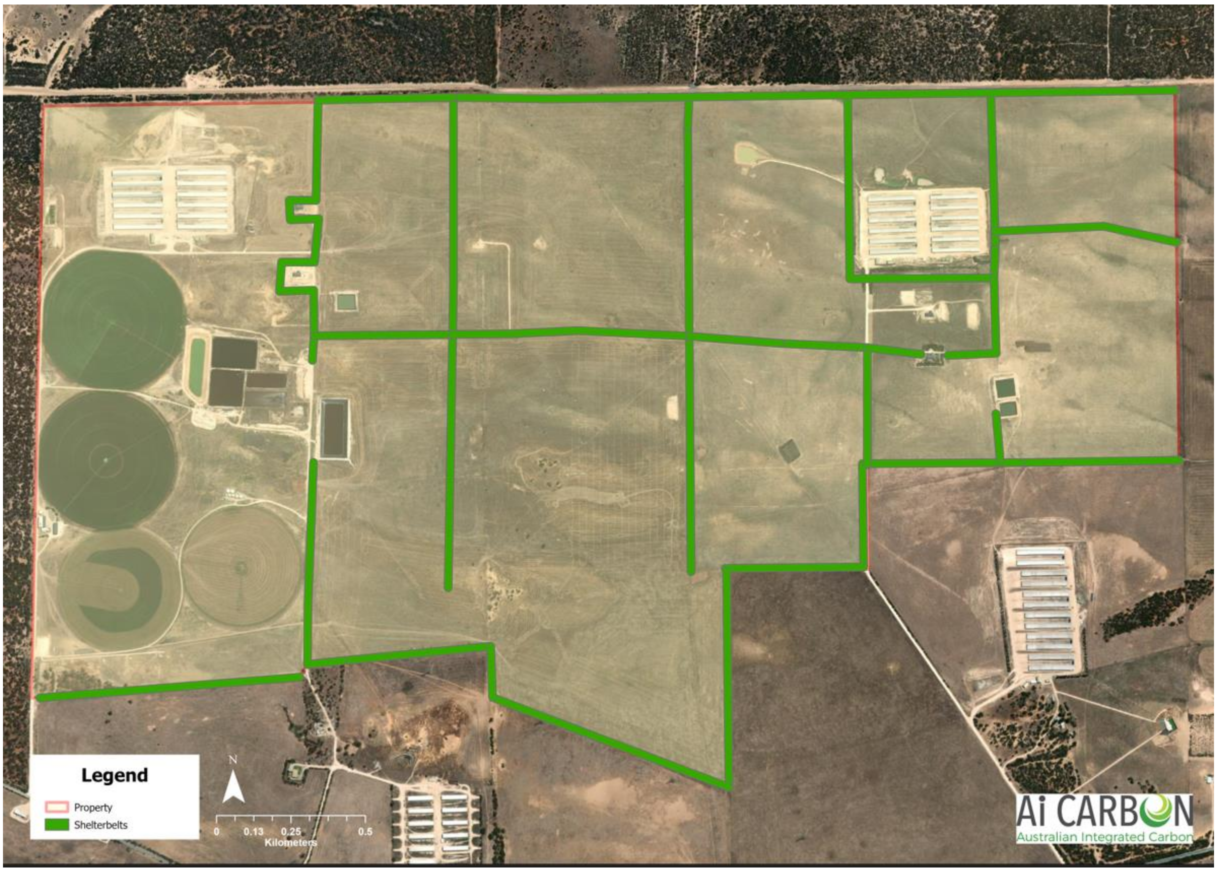

Fig. 1. Shelterbelt design on the 500 ha property at Kepa. Chicken farms have also been set up on sites within the sheep enterprise.

4. Cost of establishing shelterbelts

Cost estimates for establishing shelterbelts are shown in Table 1. Fencing costs for the design were based on a contract rate of $5000/km for 18 km of Cyclone and dropper fencing ($90,000), and a cost of $1000/ha was allowed for site preparation and direct seeding 49 ha ($49,000). At these rates, the total cost of fencing and tree planting would be $139,000. A figure of $8,000 was also 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 49 ha
18 km fencing	$5000/km	$90,000
49 ha seeding	$1000/ha	$49,000
Post-seeding weed control, fence repairs		$8,000
Total		**$147,000**

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 2022c). 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 $147,000.
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 belt design of the property (see Figure 2 for example FullCAM curve). Tree species was set at ‘Mixed species environmental planting temperate’, and planting geometry as ‘Geometry wide, stocking <1500, Prop tree<0.75’. The four FullCAM yield curves were then converted to yield in tCO_2e. These four curves were highly similar (Fig. 3), with yields highest in years 3 to 10 when trees grow fastest (approx. 10-18 tCO_2e/ha/yr), dropping to 4-11 tCO_2e/ha/yr in later years.

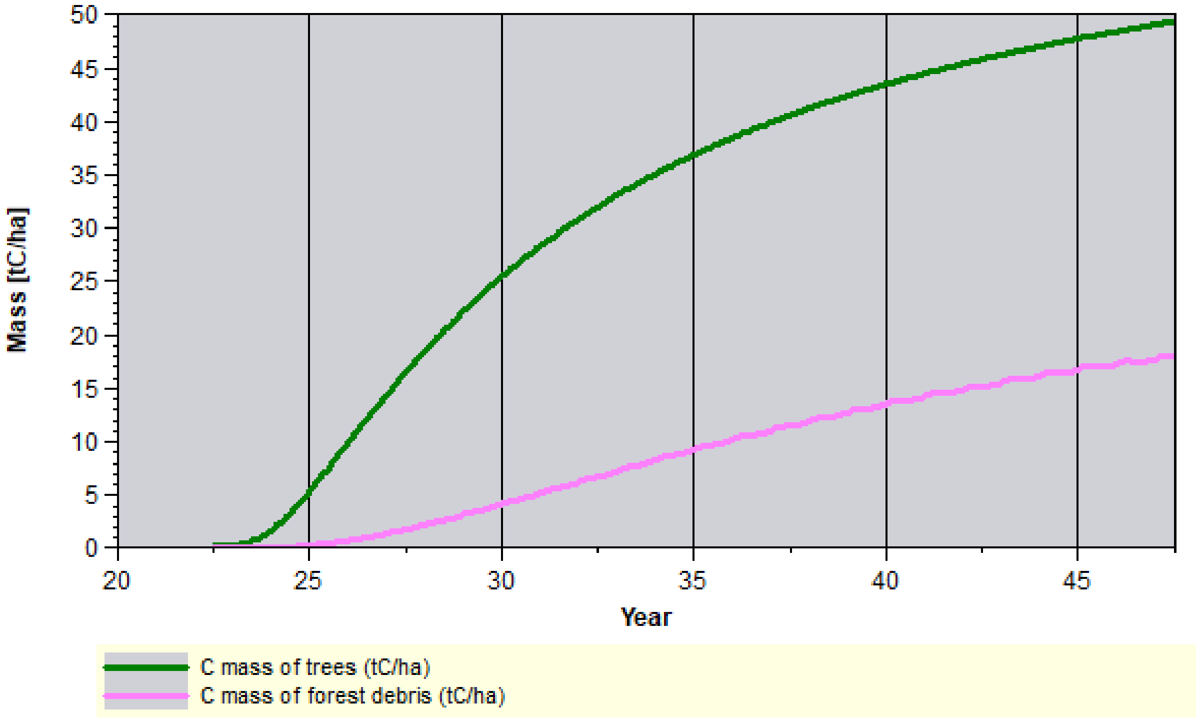

Fig. 2. FullCAM output from one site at Kepa showing cumulative carbon yield (tC/ha) over 25 years with mixed species environmental plantings in a belt configuration.

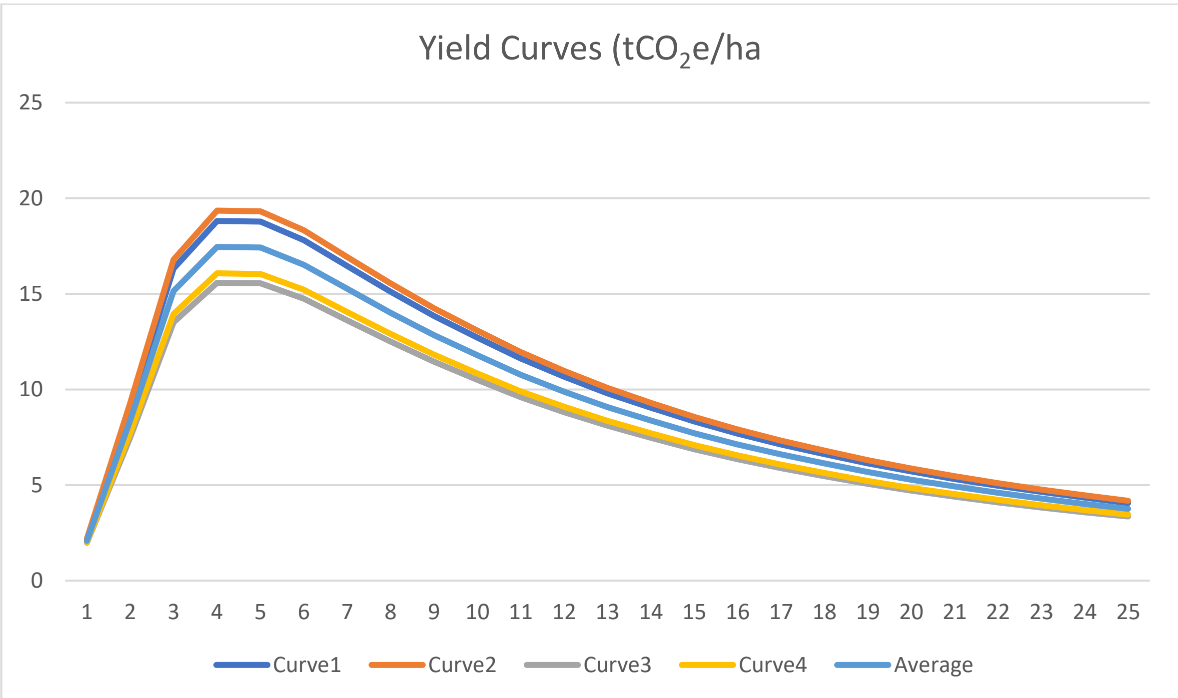

Fig. 3. Yield curves (tCO_2e/ha) at 4 different locations at Kepa over the 25 years of the project.

An average of the four curves was used to calculate project yield across 49 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 2022d, 2022e). Cumulative project yield was estimated to be 8,422 (Fig. 4), equating to 337 tCO_2e/yr (Fig. 5), or 6.9 $tCO_2e/ha/yr$.

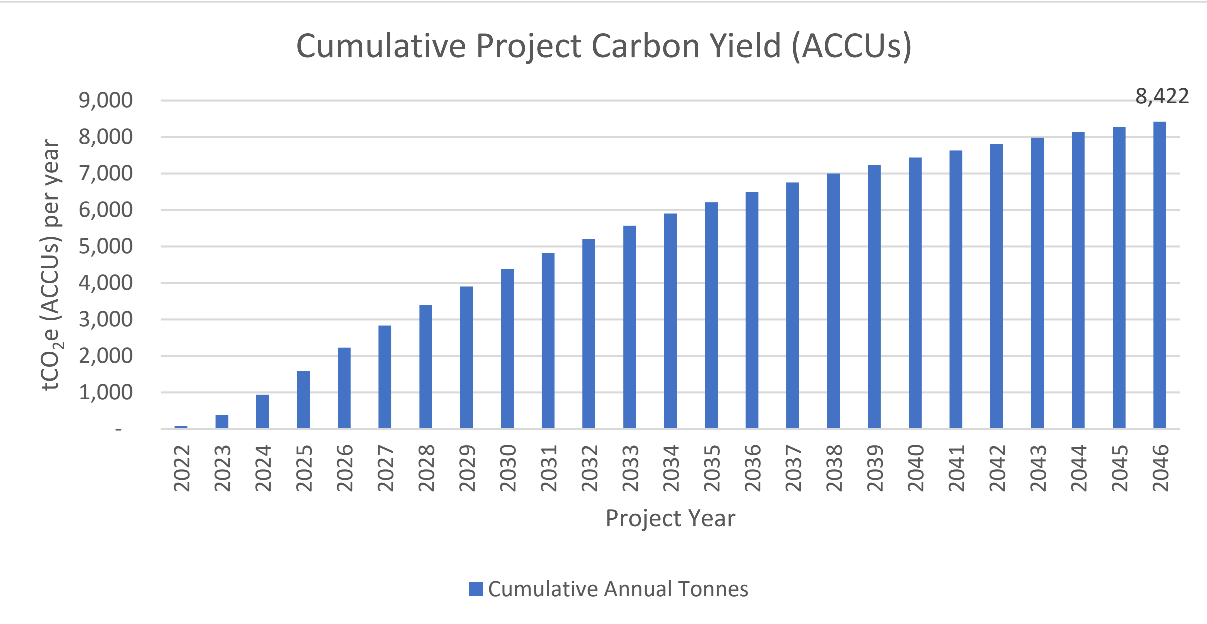

Fig. 4. Cumulative carbon yield from the 49 ha carbon estimation area at Kepa over 25 years.

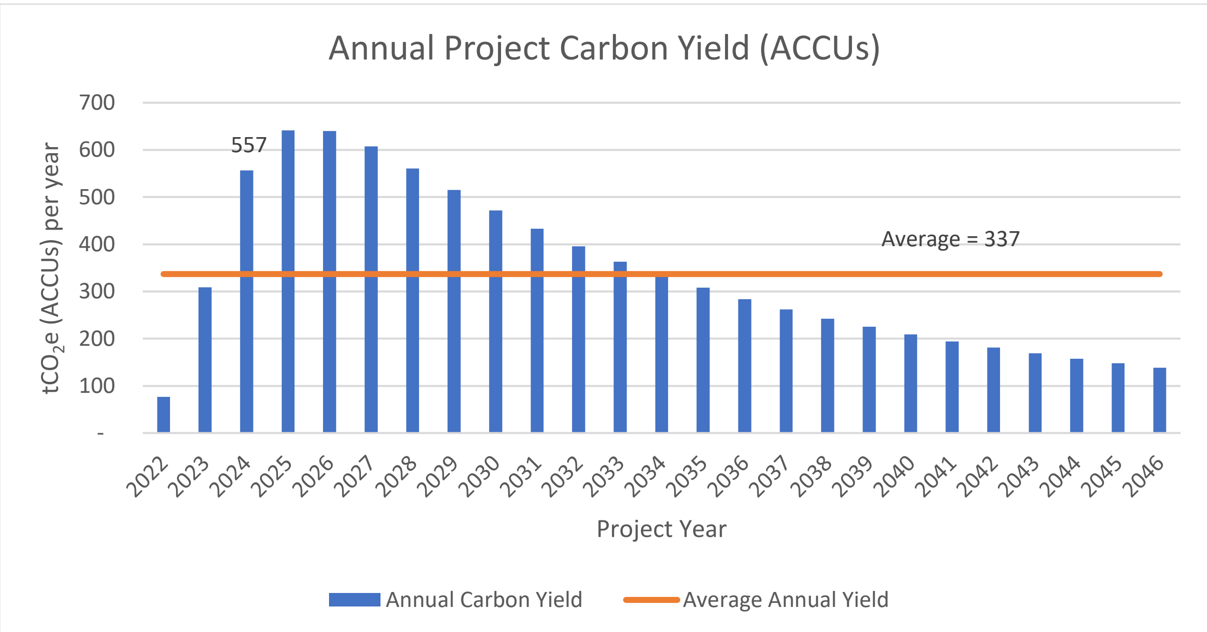

Fig. 5. Annual carbon yields (tCO_2e/yr) calculated from 4 different locations on the Kepa property over 25 years, and average annual yield across all years.

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 $46.78/t; the medium price was $35/t increasing to $71/t averaging $64/t; and the high scenario was $42 increasing to $105 averaging $93.71/t.

Revenues under the flat, low, base and high pricing scenarios totalled $146,000, $394,000, $539,000 and $789,000, respectively, and annual incomes of $5,800, $15,800, $21,600 and $31,600. Because annual carbon yields were at their highest in years 3 to 10, revenue was also greatest in those years ($10,000-$52,000/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 $46.78)	$35 to $71 (avg $64.00	$42 to $105 (avg $93.71)
1	2022	77	$1,328	$2,450	$2,679	$3,215
2	2023	309	$5,361	$11,124	$12,978	$17,304
3	2024	557	$9,657	$21,708	$27,831	$39,521
4	2025	641	$11,129	$26,300	$34,639	$48,750
5	2026	640	$11,108	$26,890	$35,853	$52,499
6	2027	607	$10,536	$26,719	$37,042	$51,616
7	2028	561	$9,732	$25,241	$34,776	$52,164
8	2029	515	$8,938	$24,212	$34,515	$51,514
9	2030	472	$8,186	$23,118	$31,610	$48,123
10	2031	433	$7,511	$22,077	$30,735	$45,454
11	2032	396	$6,866	$20,182	$28,097	$41,552
12	2033	363	$6,301	$18,521	$25,785	$38,132
13	2034	334	$5,792	$17,025	$23,702	$35,052
14	2035	308	$5,343	$15,705	$21,864	$32,335
15	2036	283	$4,919	$14,458	$20,128	$29,767
16	2037	262	$4,545	$13,361	$18,600	$27,507
17	2038	242	$4,207	$12,367	$17,217	$25,462
18	2039	225	$3,906	$11,482	$15,985	$23,640
19	2040	209	$3,622	$10,648	$14,823	$21,921
20	2041	194	$3,369	$9,905	$13,789	$20,392
21	2042	181	$3,139	$9,228	$12,846	$18,998
22	2043	169	$2,931	$8,616	$11,994	$17,738
23	2044	158	$2,736	$8,043	$11,197	$16,559
24	2045	148	$2,560	$7,526	$10,478	$15,495
25	2046	138	$2,399	$7,052	$9,818	$14,519
Total		**8,422**	**$146,122**	**$393,957**	**$538,981**	**$789,229**
Average			**$5,845**	**$15,758**	**$21,559**	**$31,569**

6. Costs and benefits

- Project costs and benefits are summarised in Table 3. Project feasibility is assessed using the base scenario, which assumes that ACCUs are sold, resulting in $539,000 total carbon revenue.
- For the purposes of this case study, establishment costs were estimated at $147,000, noting that costs could be greater in some landscapes or if consultants were used.
- Carbon income was estimated to be $392,000 greater than cost of establishing and maintaining the shelterbelts. The ratio of revenue to establishment costs was 3.8:1. Based on the revenue flows shown in Table 2, and assuming carbon was sold at the base rate, establishment costs would be recovered after 6 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 Kepa 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 $5,000 per year, or $125,000 over 25 years, if stocking rates were maintained at current levels (800 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	$147,000
Carbon revenue, base case	$539,000
Potential profit	$392,000
Ratio of revenue to establishment costs	3.8:1
Time until costs recovered	6 years
Possible value of extra lambs if lambing survival lifts 4 %	$125,000

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 20 % 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 800 ewes producing 1000 lambs, the enterprise probably produces approx. 350 t CO_2e/yr.

- With the project detailed here offering a chance to offset approx. 337 tCO_2e/yr for 25 years, the proposed plantings would offset nearly all this sheep business's emissions, potentially giving access to carbon neutral markets in future.
- Carbon neutral products may achieve a premium price in future, which could lead to substantial extra income (e.g., if lamb brought $9/kg instead of $7/kg, this would generate an extra $35,000/yr from 800 sales lambs with 22 kg carcase weight).

8. Perspective of the landholder

- The owners found it encouraging that the proposed shelterbelt design offers a way of offsetting practically all sheep business emissions without major negative impacts on production, potentially providing access to markets for carbon neutral product.
- The owners are also interested in the fact that carbon shelterbelts may enhance farm economic performance if ACCUs are sold, as well as offer co-benefits such as improved animal welfare, paddock health, landscape function and amenity.
- It is a major financial outlay to establish 49 ha of shelterbelts in one year, and a logistical challenge in dry years. Current labour availability is low and the owners would prefer to plant over multiple years.
- Access to grants from State or Federal Government that support tree planting or fencing, or 'green finance', would increase the chances of the project being established.
- The 60 ha of irrigated lucerne production may lead to net soil carbon sequestration which could impact further on the carbon account.
- Through small patch paddock irrigation, rotational grazing and integration with neighbouring chicken and pig farms, this case study farm is improving productivity and economic outcomes in the Kepa region; the modelled shelterbelts would also lead to improved biodiversity outcomes for the region.
- The property is also considering a soil carbon project – baselining soil carbon, building soil carbon through rotational grazing and application of chicken litter, then measuring soil carbon in future to measure sequestration and generate ACCUs.

9. Impact of planting type

This case study differed from others in this series in that plantings were set as environmental belt plantings rather than mallee belt plantings. To gain preliminary information on how this impacts carbon yield, test runs were conducted with FullCAM modelling mallee belt plantings on the property. Results suggested carbon yields would be approx. 25 % higher with mallee plantings (see Appendix 1 vs Fig. 2, see also Case Study 10 in this Series). This is presumably due to the higher tree density in mallee plantings compared to mixed species environmental plantings. The environmental plantings of this study were, however, preferred by the landholder due to their higher biodiversity value.

10. Conclusions

- Using the base case pricing forecast, carbon revenue from shelterbelts was estimated to be 3.8 times higher than the cost of establishment, with establishment costs recovered after 6 years.
- Once co-benefits such as improved lamb survival and animal production are considered, the proposed carbon shelterbelts project is even more 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 finding that carbon yields from mixed environmental plantings are around 25 % lower than from mallee plantings is of interest and deserves further study across more sites; despite lower carbon yields, environmental plantings may still be preferred by many farmers due to the greater biodiversity.
- 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 (tC/ha) at Kepa, near Murray Bridge, with mallee eucalyptus species.