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Estimated Threshold Carbon Prices for Investment in Carbon Sink Forests
–ABARE estimates under alternative cost and productivity assumptions for selected representative farms

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Contents

Tables

Figures

Summary

This report presents estimates of the threshold carbon prices required to equate the net present value (NPV) of returns from carbon sink forests with a range of representative agricultural land values. These threshold carbon prices are estimated by analysing six representative farms with different agricultural land uses spanning across two different rainfall zones. The analysis explicitly considers the tax treatment of carbon sink forests by including tax deductibility for some costs and tax payments for carbon revenues.

The results indicate that the estimated threshold carbon prices that equate agricultural land values to the NPV of returns from carbon sink forests range from \$158 to \$399 per tonne of carbon dioxide equivalent (CO_2-e), assuming non-zero fencing costs. In comparison, assuming zero fencing costs associated with carbon sink forests reduces the range of threshold carbon prices to between \$141 and \$379 per tonne of CO_2-e.

It should be noted that the results presented in this report are based on specific cost, productivity and agricultural land value assumptions, and will differ greatly at the individual farm level.

1. Introduction

The Australian Government recently introduced legislation to amend the *Income Tax Assessment Act 1997* to allow carbon sink forest growers to depreciate the costs of establishing a qualifying carbon sink forest in line with the horticultural plant provisions, with effect from 1 July 2007. The legislation is structured in two steps. The first step allows deductibility in the year of expense for eligible establishment costs and applies from 1 July 2007 to 30 June 2012. The second step, commencing from 1 July 2012, applies a rate of deductibility of 7 per cent per annum over 14 years to eligible establishment costs.

In the legislation, carbon sink forests are described as forests established for the primary and principal purpose of sequestering carbon from the atmosphere. These carbon sink forests cannot be used for harvest or for commercial horticulture. Under the legislation, taxpayers that meet the conditions for a carbon sink forest may only deduct eligible establishment costs. These include the costs of acquiring and planting the trees but not the costs of acquiring the land or fencing.

Carbon sink forests have the potential to sequester carbon and contribute to Australia's greenhouse gas emission reduction targets, while also contributing to national policy objectives for sustainable natural resource management. However, the introduction of tax deductions for carbon sink forests has raised concerns regarding the potential reforestation of agricultural land, for example, that it may contribute to the competition for scarce water resources in some regions or lead to the displacement of some agricultural activities.

This report examines the potential range of carbon prices that may induce carbon sink forest establishment. The analysis employs specific assumptions relating to carbon sink forest costs and productivity, and the opportunity costs of several agricultural land types in a number of regions across Australia.

2. Modelling framework

This analysis uses a discounted cash flow approach to examine the indicative threshold carbon prices required to equate the Net Present Value (NPV) of returns from carbon sink forests to the returns from six representative farms; which span across six different agricultural land uses and two rainfall zones. The assumptions used in the modelling framework have been developed in consultation with the Department of Climate Change (DCC). Two alternate scenarios which incorporate high and low productivity and carbon sink forest cost assumptions were also analysed using the modelling framework. The results from the analysis of the two alternate scenarios are presented in Appendix A.

Representative agricultural farms

The estimated threshold carbon price for each agricultural land use is based on selected representative farms as agreed by the DCC. The regions were selected because they provide a good representation of the Australian agricultural industry; or where there is existing carbon sink forest activity. The representative farms selected for this analysis are presented in Table 1. A more detailed discussion of each representative farm is presented in Appendix B.

Table 1: Selected representative farms

Low - Medium rainfall zone (350mm-700mm per annum)	**High rainfall zone (> 700mm per annum)**
Grazing	Grazing
Broadacre cropping	Sugar
	Vegetables
	Dairy

In this analysis, it is assumed that agricultural land value represents the opportunity cost of establishing a carbon sink forest. The land values for each scenario used in this analysis are presented in Table 2. Estimates of agricultural land values are derived from surveys undertaken by ABARE for the 2006–07 financial year. In some cases the estimates of the land values for each representative farm has been compiled using data from several survey regions (this is represented by the range of land values for some scenarios in Table 2). These agricultural land values represent the median value of the distribution of agricultural returns for each representative farm. Hence, they are representative of farms with typical land values. For simplicity, it is also assumed that there is no real growth in these agricultural land values over time.

Table 2: Estimated agricultural land values for each representative farm ($/ha)

Land use type of each representative farm	Rainfall zone	Agricultural land value
Grazing	Low- Medium rainfall	1 441 – 2 921
Broadacre cropping		1 235 – 2 464
Grazing	High rainfall	3 500
Dairy		12 238 – 13 686
Sugar		11 000
Vegetables		14 644

Cost assumptions relating to carbon sink forests

The cost assumptions relating to investment in carbon sink forests are divided into three main categories – fencing costs, other establishment costs and annual management expenses (Table 3). In this analysis, the fencing, establishment and maintenance costs of carbon sink forests are discounted at an annual real rate of 7 per cent for 100 years. The discount rate used in this analysis represents a rate of return consistent with long term risk free market rates of return, and is also consistent with the return on 10-year government bonds. Further, non-fencing establishment costs and all the annual management expenses associated with carbon sink forests are assumed to be tax deductible at the company tax rate of 30 per cent.

Table 3: Carbon sink forest cost assumptions

	Reference case ($/ha)	Zero fencing cost scenario ($/ha)
Fencing costs– *(non tax deductible)*	800	0
Other establishment costs– *(tax deductible)*	2 250	2 250
Annual management expenses first 30 years of forest establishment – *(tax deductible)*	150	150
Annual management expenses after the first 30 years of forest establishment – *(tax deductible)*	50	50

Source: Assumptions have been developed in consultation with the Department of Climate Change.

Fencing costs relate to the establishment of boundaries as a method of bordering and restricting access to the carbon sink forest. In the reference case, the fencing cost is assumed to be incurred in the same year as other establishment costs. Other establishment costs associated with carbon sink forests include land preparation, cultivation and surveying.

An alternate scenario, modelling the impact of zero fencing costs associated with carbon sink forests, has also been considered in this analysis to represent cases where fencing may not be required, for example, on some cropping land or in paddocks or farms with existing fences.

Annual management expenses associated with carbon sink forests are assumed to include fire and pest management, and the costs of quantification and verification of the sequestered carbon. These annual management expenses are assumed to be incurred at a constant rate each year by the landholder. After 30 years, the annual management expenses associated with carbon sink forests are assumed to decline to $50/ha. The decline in management expenses is assumed to reflect the more intensive management required during the early years of when the carbon sink forest is initially established. It is also assumed landholders continue to incur ongoing management costs for a further 70 years after the last carbon revenues are generated at age 30. This reflects the typical maintenance obligations of current emissions reduction schemes.

Calculating the net present value of carbon sink forests

The NPV of carbon sink forests is determined by calculating the returns under a carbon pricing scheme at an annual real discount rate of 7 per cent over a 100 year time horizon. Further, the returns from carbon sink forests are assumed to be generated only from the sale of sequestered carbon and not from other forest products such as timber or from horticultural activities.

For each representative farm, revenue from the sale of carbon is assumed to be obtained for a maximum period of 30 years after the carbon sink forest is established. This assumes that carbon sequestration after age 30 is very limited.

Carbon returns are assumed to be received annually based on the volume of CO_2-e sequestered in that year. The volume of carbon sequestration is estimated using mean forest productivity assumptions for each rainfall region and agricultural land use. This data is derived from DCC datasets, and is explained further in Appendix C. The volume of carbon returns that may be claimed by a carbon sink forest owner is assumed to be 90 per cent of the total carbon sequestered in the roots, trunks and branches of the forest over the first 30 years of forest growth. This assumption reflects the uncertainties and risks associated with carbon sink forest investment including potential losses from fire or pests. A summary of the net saleable carbon generated by these carbon sink forests over the 30 year period is presented in Table 4.

Table 4: Estimated net saleable CO_2-e by year 30 (t/ha)

Land use type of each representative farm	Rainfall zone	Estimated net saleable CO_2-e by year 30 (t/ha)
Grazing	Low – Medium rainfall	61 – 108
Broadacre cropping	Low – Medium rainfall	56 – 96
Grazing	High rainfall	170
Dairy	High rainfall	148 – 175
Sugar	High rainfall	260
Vegetables	High rainfall	231

3. Results

The threshold carbon prices at which the NPV of returns to carbon sink forests are estimated to compete with existing agricultural land uses are presented in Table 5. When interpreting the results, it is important to recognise that the estimated threshold carbon prices should not be generalised to all agricultural industries as they are calculated using representative farms which have median land values.

In general, the results indicate that the threshold carbon prices required for competitive carbon sink forest investments are higher in high rainfall areas than in the low-medium rainfall regions. In particular, dairy and horticultural (vegetables) land is estimated to require carbon prices of at least $295 per tonne of CO_2-e. While these areas are highly productive in terms of forest growth rates, they also represent areas highly productive for agriculture, and hence have the highest opportunity costs of all the examined representative farms. The exception to this generalisation is grazing land in the high rainfall region, which is estimated to have the lowest threshold carbon price across all the examined representative farms. This reflects the relatively high forest productivity levels, and the relatively low agricultural land values compared to other high rainfall activities in the region. In comparison, there is a broad range of threshold carbon prices in the low-medium rainfall region, reflecting the spread of estimated forest productivity and agricultural opportunity costs.

However, the use of the agricultural land value as an opportunity cost of carbon sink forest investment implies that established carbon sink forests entirely replace existing agricultural land uses. In many cases this may overstate the actual opportunity cost of carbon sink forests, which may occur on less intensively used agricultural land or which may be established in a way that is complementary to existing land uses.

Table 5: Estimated threshold carbon price for each representative farm ($/t CO_2-e)

Land use type of each representative farm	Rainfall zone	Threshold carbon price ($/t CO_2-e)		
		Reference case ($/ha)	**Zero fencing cost scenario ($/ha)**	**Percentage difference relative to the reference case (%)**
Grazing	Low – Medium rainfall	189-362	162-314	13.3-14.3
Broadacre cropping	Low – Medium rainfall	193-367	162-314	14.4-16.1
Grazing	High rainfall	158	141	10.8
Dairy	High rainfall	369-399	352-379	4.6-5.0
Sugar	High rainfall	210	199	5.2
Vegetables	High rainfall	295	283	4.1

The zero fencing cost scenario suggests that fencing costs may have a significant impact on the estimated threshold carbon price. However, the influence of a zero fencing cost on the threshold carbon price is relatively lower for higher value agricultural land such as dairy, sugar and vegetables. Excluding the fencing costs from the analysis is estimated to reduce the per hectare establishment costs by approximately 26 per cent. The resulting decrease in the threshold carbon price is estimated to be between 4.1 and 16.1 per cent depending on the assumed value attached to the agricultural land.

Additional estimates of the threshold carbon price were also analysed using different assumptions relating to carbon sink forest costs, agricultural land values and forest productivity. These results are presented in Appendix A. Results from this sensitivity analysis suggest that the threshold carbon price will increase substantially with increases in costs. However, the analysis does not allow us to assess the relative importance of the different cost components.

4. Conclusion

The estimated threshold carbon prices which equate the NPV of agriculture to carbon sink forest activities for each selected representative farm are presented in this report. The results from the analysis presented in this report suggest that there may be competition between agriculture and the carbon sink forests sector for productive land only at relatively high carbon prices. In the reference case, which assumes a non-zero fencing cost, the carbon threshold prices are estimated to range from \$158 to \$399 per tonne of carbon of dioxide equivalent (CO_2-e), depending on the particular set of assumptions used in the analysis.

The degree to which land use change may occur between agricultural land and carbon sink forestry activities depends on a number of factors. These factors include the cost of establishing, managing and fencing carbon sink forests as well as land productivity. Further, the results also suggest that the threshold carbon price can be reduced by establishing these carbon sink forests in a way that utilises existing infrastructure, and hence avoids additional costs, such as fencing.

The analysis also suggests that agricultural regions which receive high annual rainfall (and hence have relatively high forest productivity) and/or have relatively low land values, will require, *ceteris paribus*, lower threshold carbon prices.

However, the presented threshold carbon prices should not be generalised to all agricultural industries because the analysis is based in on selected representative farms from across Australia. Further, the threshold carbon prices are estimated using the median value of the expected distribution of agricultural returns. Hence, the presented threshold carbon prices in this report are only representative of farms with typical land values.

Appendix A: High and low cost and productivity scenarios – results

In addition to the main analysis, the threshold carbon price was also estimated using two alternate assumptions regarding the productivity of agricultural land. These scenarios – low and high scenario – correspond to the first and third quartile of the distributions of agricultural returns respectively. In Table 6, the agricultural opportunity costs assumed in each scenario are presented. The estimated threshold carbon prices presented in the main body of the report is presented in this appendix as the reference case.

Table 6: Estimated agricultural land values for each representative farm ($/ha)– 2006/07

Land use type of each representative farm	Rainfall zone	Low scenario ($/ha)	Reference case ($/ha)	High scenario ($/ha)
Grazing	Low - Medium rainfall	769 – 1 551	1 441 – 2 921	3 301 – 5 176
Broadacre cropping	Low - Medium rainfall	933 –1 847	1 235 – 2 464	2 034 – 3 890
Grazing	High rainfall	2 223	3 500	6 403
Dairy	High rainfall	9 818 – 11 583	12 238 – 13 686	14 815 – 17 500
Sugar	High rainfall	9 456	11 000	16 949
Vegetables	High rainfall	11 301	14 644	17 361

The low and high scenarios are also differentiated in their assumptions regarding the cost and productivity associated with carbon sink forest investments (Table 7). In general, the low scenario has lower cost and productivity assumptions of carbon sink forests relative to the reference case. In comparison, the high scenario has higher cost and productivity assumptions regarding carbon sink forests relative to the reference case and the low scenario.

Table 7: Carbon sink forest cost assumptions

	Low scenario ($/ha)	Reference case ($/ha)	High scenario ($/ha)
Fencing costs– *(non tax deductible)*	400	800	1 200
Other Establishment costs– *(tax deductible)*	1 700	2 250	2 800
Annual management expenses first 30 years of forest establishment – *(tax deductible)*	100	150	250
Annual management expenses after the first 30 years of forest establishment – *(tax deductible)*	50	50	50

Source: Assumptions have been developed in consultation with the Department of Climate Change

Results

The modelling results using the assumptions for the alternate carbon sink forest scenarios suggest that changes in the assumed agricultural land value and to both the establishment and management costs associated with carbon sink forest investments has an influence on the threshold carbon price (Table 8). In general, increases in the costs associated with carbon sink forests can potentially increase the threshold carbon price, despite the higher productivity assumptions of carbon sink forest land.

Table 8: Estimated threshold carbon price for each representative farm ($/t CO_2-e)

Land use type of each representative farm	Rainfall zone	Low scenario ($/t CO_2-e)	Reference case ($/t CO_2-e)	High scenario ($/t CO_2-e)
Grazing	Low- Medium rainfall	168-293	189-362	242-442
Broadacre cropping	Low- Medium rainfall	167-319	193-367	240-441
Grazing	High rainfall	133	158	211
Dairy	High rainfall	369-393	369-399	408-416
Sugar	High rainfall	232	210	252
Vegetables	High rainfall	278	295	304

Appendix B: Selected representative farms

Six representative farms were selected for the land use analysis presented in this report. Selection of each representative farm was determined based upon expert advice provided by ABARE commodity analysts and consultation with the Department of Climate Change. To simplify the analysis, only cleared, non-irrigated agricultural land on each representative farm was considered.

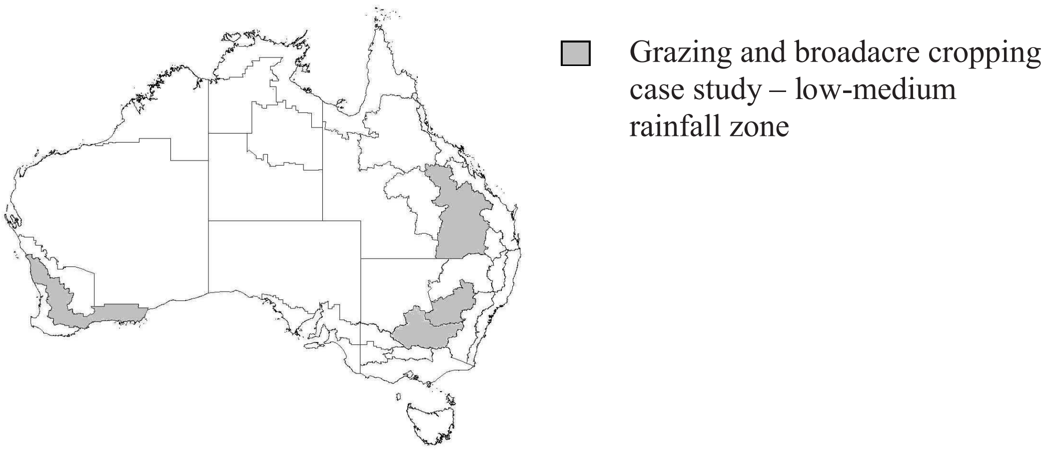
Land use information about each representative grazing and broadacre cropping farm was collected from the 2006/2007 Australian Agriculture Grazing Industries Survey (AAGIS); which is conducted by ABARE each year. Information about the representative dairy farm was collected from the 2006/2007 ABARE Australian Dairy Industry Survey (ADIS). For sugar and vegetables, the representative farms were selected from 2006/2007 farm surveys on the states of Queensland and Tasmania respectively.

The land values of agricultural land use in the alternate scenarios correspond to the first and third quartile of the distributions of agricultural returns for each representative farm. In comparison, the reference case, which is the scenario analysed in the main body of the report, correspond to the median value of the distribution of agricultural returns.

Low - Medium rainfall zone

The low to medium rainfall zone of Australia is defined as any region which receives between 350mm and 700mm of rainfall each year. The two representative farms that are analysed from the low-medium rainfall zone in this report include grazing and broadacre cropping (Figure 1). Both of these representative farms were selected from the same AAGIS regions. These regions include the Central West areas of New South Wales, the Riverina region, the Central Highlands of Queensland, and the Central and South regions of the Western Australian Wheat Belt.

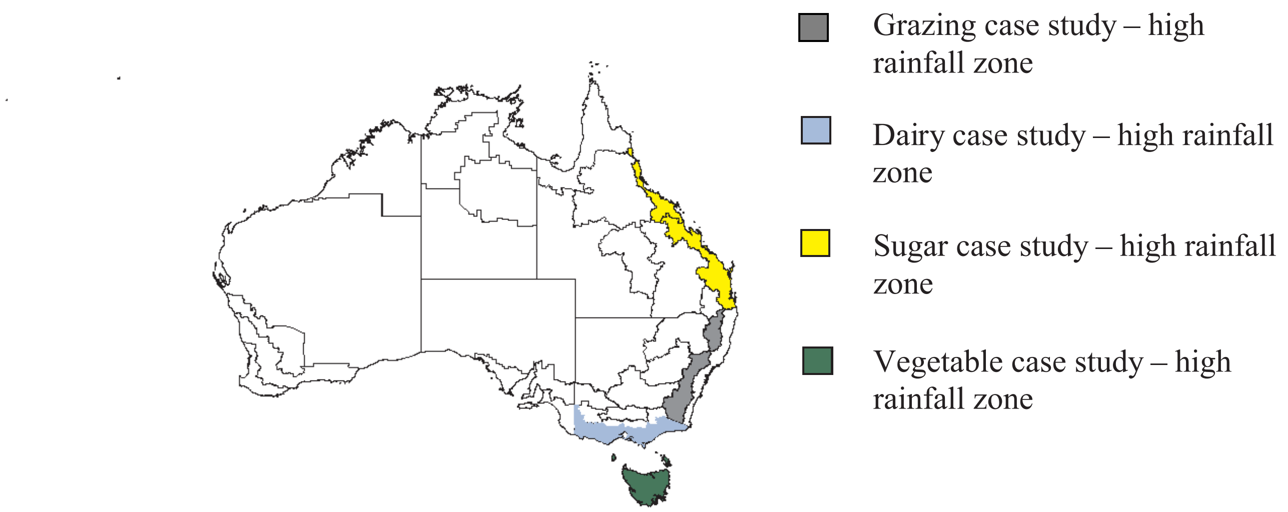
Figure 1: Selected representative farms from the low-medium rainfall zone of Australia



High rainfall zone

The high rainfall zone of Australia is defined as any region which receives more than 700mm of rainfall each year. The four representative farms that are analysed from the high rainfall zone in this report include grazing, dairy, sugar and vegetables (Figure 2). For grazing, the selected AAGIS region includes the New South Wales Tablelands. For dairy, the selected ADIS regions include south western Victoria and Gippsland. For sugar, the selected regions include non-irrigated sugar farms located throughout Queensland coast. For vegetable land, the selected survey region includes all of Tasmania.

Figure 2: Selected representative farms from the high rainfall zone of Australia



Appendix C: Estimating carbon sequestration in carbon sink forests

The carbon sequestration potential of the carbon sink forest for each representative farm is determined by equation 1.

$$SC = M \times (1+RSR) \times BC \times {}^{44}/_{12} \qquad (1)$$

Where *SC* is the estimated sequestered tree carbon (t CO_2-e/ha); *M* is the maximum obtainable aboveground biomass (t/ha); *RSR* is the carbon sequestered by the planting's root in comparison to its shoot (assumed to be 0.25); and *BC* is the conversion rate of biomass into carbon (assumed to be 50 per cent). The maximum aboveground biomass (*M*) is assumed to be a function of the National Carbon Accounting System Forest Productivity Index (*FPI*).

$$M = (6.019 \times (FPI)^{½} -5.2912)^2 \qquad (2)$$

The rate at which biomass is accumulated within each grid cell is assumed to grow logarithmically up to year 30. In this analysis, the cumulative growth in biomass at age *a* is calculated using equation 3.

$$M_a = M \times e^{(-2G+1.25)/a} \qquad (3)$$

Where M_a is the cumulative growth in biomass at age *a*; *a* is the age of the forest in years; and *G* is the age of the forest in which the maximum biomass increment is reached (assumed to be 10 years in this analysis). The marginal growth in biomass each year is calculated by subtracting $M_{(a-1)}$ from M_a. Similarly, the carbon sequestered in each year is derived by substituting the annual growth in biomass of the environmental planting into equation 1. The productivity values used in the analysis are estimates from the median quartile of the potential biomass within the relevant area. The relevant area is determined by intersecting the survey region boundaries with the 2001/02 (version 3) national land use map of Australia compiled by the Bureau of Rural Sciences.