The Economic Potential for Plantation Expansion in Australia

Report to the Australian Forest Products Association

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Foreword

The economics of plantation forestry in Australia are increasinglychallenged. High upfront costs coupled with long lead times to return and increasing regulatory burden mean that several factors must align to allow plantation projects to generate a profit.

Key amongst these factors is land price. For forestry operations to be economic, they generally must utilise existing plantation land, or land acquired for a competitive price. This means that plantation forestry is unable to compete for prime agricultural land, which sells at a premium.

Plantation economics are also affected by the distance products must be transported to be processed or exported. Across multiple forestry regions in Australia, it appears that investment in new plantations that requires land purchase is typically uneconomic beyond distances of approximately 100km to the nearest processing facility.

A few key factors could influence the economic viability of new plantation development. Carbon is one of these factors. Carbon sequestration has the potential to make a difference to the economics of plantation forestry. The degree to which carbon revenue positively affects plantation returns will be highly sensitive to the methodology adopted. Generous assumptions around revenues accruing from carbon sequestration improve plantation economics beyond a carbon price of around $25/t$CO_2$e. However, this is not sufficiently to allow plantation forestry to compete with prime agricultural land uses.

Plantation forestry does have potential for land-based sequestration and is of assistance in helping to achieve Australia's emissions reductions goals. Given the size of the carbon price that would be required for a qualifying plantation investment to break-even on prime agricultural land and even more marginal agricultural areas, this suggests that large-scale land use change of this sort would not be triggered by successful bids by plantation managers for carbon payments. Yet opportunities could exist for new plantation investment, particularly for smaller-scale farm forestry plantings where land costs may be less limiting.

However, investors are likely to observe regulatory change as contributing to an environment already perceived as high in sovereign risk, and further exacerbate the decline in both plantation investment and associated infrastructure such as processing facilities. This will occur as investors factor greater risk levels into the discount rate used in financial analysis.

Lower investment will have several negative consequences including a reduction in the public good characteristics of forestry projects. Moreover, it will reduce industry diversity and place pressure on the balance of trade through greater imports as timber shortages are exacerbated.

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1 Introduction and context

BAEconomics has been asked by the Australian Forest Products Association to prepare a report examining the economic potential for new plantation development in Australia.

The context for this study relates to the national forest industry's desire to increase the plantation resource for future industry growth and competitiveness. This study is at a time when there is emerging evidence that the area under existing plantations is falling and predictions that the capacity of the national plantation estate to support future domestic demand for forest products will weaken.

Previous national policy objectives for the growth of the plantation estate had been successful until 2008-09. The economic drivers that had fuelled rapid growth in new plantations in the preceding ten years then failed, and a replacement model has yet to emerge.

This report considers the underlying economic factors affecting private investment in new plantations and seeks to identify where and when it might become more attractive.

At a national level, the federal government is also delivering carbon sequestration payments for relevant land sector activities via the Carbon Farming Initiative under the Emissions Reduction Fund (ERF). It is therefore of interest to determine what is the potential for new plantations to 'bid' in the ERF under various carbon price scenarios and its impact on plantation investment hurdle rates. This report seeks to explain the current barriers to plantation development in Australia and estimate the difference that ERF carbon payments would make should methodologies be developed and interested parties enter the ERF bidding process.

The report finds that at the current carbon price of \$13/tCO_2-e, no new plantations would be developed where land costs are included in establishment costs of plantation forests. Beyond \$25/ tCO_2-e, and assuming land is purchased at or below the average price in the region, some new plantations would be developed but only within an 85- 100 kilometre radius of major timber processing operations.

1.1 Terms of reference

The terms of reference for this study are to:

- perform a literature review of economic studies into the potential for the expansion of plantation forestry in Australia;
- spatially map suitable plantation land in the forestry regions;
- determine the costs associated with, and income derived from plantations in various forestry regions around Australia, including involvement in the Carbon Farming Initiative; and

- identify impediments to the expansion of the plantation resource.

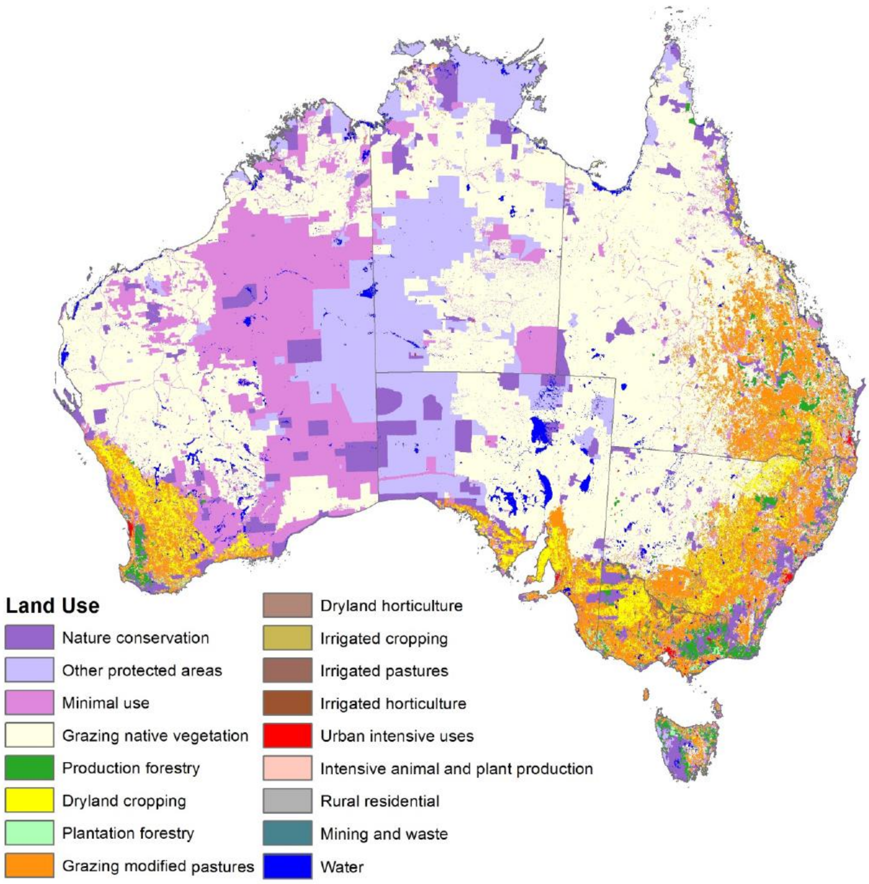
A full description of the terms of reference can be found in Appendix 1.

2 Potential for expansion of plantation forestry in Australia

Overview

In 2013-14, Australia's total plantation estate was 1.99 million hectares, comprising softwood plantations of 1.02 million hectares and hardwood plantations of 963 000 hectares. This compares with 406 million hectares of farmland. The softwood plantations are dominated by long rotation (25-30 years) radiata and southern pines (around 90 per cent), while the hardwood plantations are primarily short rotation (10-12 years) southern blue gum and shining gum (around 75 per cent). Plantation forestry occupies half of one per cent (0.005) of the total agricultural land area in Australia (406 Mha) (Figure 2.1, Table 2.1).

Figure 2-1: Australian Land Use map



Source: ABARES national scale land use map 2010 (ABARE-BRS 2010)

Table 2-1: Agricultural land use in Australia by State 2013-14

Agricultural land use in 2013-14

'000 ha	NSW	Vic	Qld	SA	WA	Tas	Australia
Area of farmland	58 303	12 290	139 933	52 823	89 313	1 701	406 269
Area of plantation	390	433	233	189	391	310	1 999
Plantations as a %	0.67	3.5	0.17	0.36	0.44	18.22	0.49

Source: Australian Bureau of Statistics, 7121.0 – Agricultural Commodities, May 2015.

The Department of Agriculture website states that increasing the plantation timber resource to expand Australia's forest industries and offset reduced access to native forest resource is a key forest policy objective of the National Forest Policy Statement, Regional Forest Agreements and the Plantations for Australia: The 2020 Vision. The overarching principle of the 2020 Vision is to enhance regional wealth creation and international competitiveness through a sustainable increase in Australia's plantation resources. This set a notional target of commercial tree crops of 3 million hectares by 2020.

However, there are questions as to whether this target is now achievable. Gavran et al. (2012) reported that a National Plantations Inventory (NPI) survey of plantation owners and managers in 2007 found that plantations could reach only 2.3–2.4 million hectares by 2019–20. Since the 2007 report some of the main survey respondents have exited the industry or are in receivership, and hence this expansion estimate is unlikely to be realised in this timeframe. The most recent national statistics show that after peaking in 2007-08, the plantation area remained static, followed by a net decline in total area of 12,800 hectares in 2013-14 (Gavran 2015). This reduction occurred primarily in the hardwood (eucalypt) pulpwood plantation estate, where areas were not replanted due to being deemed commercially unviable or were at the end of their lease agreement. Rhodes and Stephens (2014) report that over 30 per cent of the eucalypt plantation estate is expected to be converted back to agriculture by forestry companies, as part of the rationalisation of former Managed Investment Scheme (MIS) plantations.

Plantations play a vital role in providing wood and fibre for Australia's timber and paper industry, and need to be of sufficient scale to maintain and improve international competitiveness. Presently, the plantation estate accounts for more than 84 per cent of national log production (ABARES 2015a). Estimates by Burns et al (2015) of the future plantation resource indicate that the supply capacity is weakening against demand under a business as usual scenario. Table 2-2 illustrates the projected domestic sawlog and veneer log availability against demand, which is expected to deteriorate over the forecast period.

Table 2 – 2 Log equivalent consumption and log availability under a business as usual scenario

	2011-12	2030	2050
Sawnwood and veneer			
Apparent consumption	12,073	15,006	15,993
Sawlog and veneer log availability	12,707	14,899	14,308
Surplus (deficit)	634	(107)	(1,685)
Pulp, paper and panels			
Apparent consumption	6,670	9,176	11,146
Pulplog availability	18,465	21,666	18,690

Source: Burns et al (2015). Notes: consumption ('000 m^3 green round wood equivalents); log availability ('000 m^3).

In the absence of an investment model for domestic plantation expansion, there is a high risk of growing local consumption being increasingly met by imports.

By value, Australia is currently a net importer of forest products (primarily paper and paperboard from China and sawn timber from New Zealand) to the order of $2 billion per annum. Australia has also exported around A$850 million worth of hardwood woodchip per annum over the past decade (Rhodes and Stephens 2014). The demand outlook for Australian forest products is strong, and heavily influenced by economic growth assumptions in Asia. Demand for industrial round wood is forecast by the Asia Pacific Forestry Commission (2010) to increase from 317 million m3 in 2005 to 550 million m3 in 2020, while global wood pellet demand is expected to grow to around 40-50Mt per year by 2020. Local demand is also forecast to increase moderately across most forest products (ABARES 2013).

The Australian Forest Products Association (AFPA) believes that future expansion will occur within existing plantation forest areas and areas close to timber processing mills and/or export ports, due to economies of scale and transport costs. New plantations will only compete at the margin with high value agricultural land (e.g. close to a timber processing mill) due to the high up-front costs of establishment and long lead times to harvest returns.

Given the opportunities of predicted growth in demand, the question remains as to what is inhibiting the Australian plantation sector from investing in new plantations.

This paper explores the economic drivers for plantation forestry and models the returns from its existing wood products and new prospective markets. The main prospective market that may improve the economic fundamentals of new plantation investment is the advent of a reliable carbon market.

2.1 Carbon markets

Over 56 per cent of the contracts to achieve 47 Mt CO_2-e of abatement that were awarded under the April 2015 Emissions Reduction Fund (ERF) auction applied under the sequestration methods category (Clean Energy Regulator 2015). A large proportion of these sequestration projects were for avoided deforestation (e.g. avoided clearing of native vegetation) which will be limited in future due to the requirements to have retrospective clearing permits. To date, commercial scale wood plantations have not been eligible under the CFI due to a lack of recognised methodologies under the scheme. Nevertheless, carbon forestry has been ranked as the simplest and most cost-effective of all land based sequestration options to implement (feasibility and verifiability) per unit of CO_2-e, both in Australia and in selected other countries (i.e. New Zealand, Canada and the United States) (Paul et al 2013b). Carbon markets have been identified as the most likely potential source of ecosystem service payments available to plantation investors over the medium term (Stephens and Grist 2014).

The rules of additionality state that sequestration or abatement must be additional, or beyond what would have occurred in the absence of a carbon market. Assuming the development and recognition of suitable methodologies under the CFI, wood plantations could qualify for sequestration credits if i) new plantations are established on cleared land where financial viability depends on the presence of a carbon payment, or ii) active silvicultural management of existing plantations results in storing additional carbon. Since the proposed CFI legislative changes relate to the rules for carbon payment qualification for plantation expansion, the key studies to report on here are those that examine the extent of land use change from agriculture to forestry in the presence of a carbon price.

In 2011 the Commonwealth Treasury commissioned ABARES to estimate the abatement potential from reforestation under the Carbon Farming Initiative. Burns et al. (2011) found that the total area of agricultural land that is economically viable for reforestation between 2012-13 and 2049-50 is limited at 0.35 million hectares (representing 0.1 per cent of agricultural land area) under a carbon price scenario commencing at \$23/t CO_2-e and increasing at 5 per cent per year. Under much higher carbon price scenarios starting at \$47/t CO_2-e, the economic viability of CFI reforestation activities is enhanced. However, the area of agricultural land viable for carbon plantings is still less than 1 per cent of Australia's agricultural land area.

Burns et al. (2011) add a further caveat, namely, that their results represent the entire land area that is economically viable for reforestation activities, and do not reflect other factors that may affect the uptake of CFI compliant reforestation projects, such as socio-cultural factors in favour of agricultural land use, or the margin by which reforestation returns must exceed agricultural returns to induce land use change. This suggests that the land areas reported may overstate the potential for reforestation of agricultural land. However, given that a significant proportion of the economically viable land area for reforestation generates significantly higher returns than the corresponding agricultural land value, the authors believe the results to be relatively robust. For instance, under the $23/t scenario, 40 per cent of the economically viable reforestation area was found to yield returns more than 25 per cent higher than the agricultural land value; in the $47/t scenario, around 85 per cent of the expected reforestation area yielded a return more than 25 per cent above the agricultural land value.

Burns et al. (2011) showed that the proportionate increase in the land area that is economically viable for reforestation exceeds the proportionate increase in the carbon prices between the two scenarios modelled, replicating a conclusion by Lawson et al. (2008). This occurs because each land area is subject to a threshold carbon price, beyond which reforestation is economically attractive relative to other land uses. The ABARES report concludes that reforestation does respond to carbon prices and the threshold return lies between the $23/t and $47/t scenarios modelled. It is worth noting however that even at very high carbon prices, the land area subject to land use change is relatively small as a proportion of total agricultural land.

The CSIRO (Polglase et al. 2011) also modelled the potential impacts of the carbon offsets scheme with respect to how agricultural land might be affected by tree planting. Net present values for environmental carbon plantings were calculated spatially over the entire cleared land area in Australia over a 40 year period, under a range of assumptions on discount rates, carbon prices, establishment costs, carbon sequestration rates and water interception licensing costs. The authors caution that the results should be viewed as areas of opportunity for reforestation under any given scenario, and not predictions of the extent of land use change, which is affected by a multitude of market and social factors. Polglase et al. (2011) found that under plausible market-relevant scenarios involving establishment costs of $3000/ha (ongoing maintenance costs were excluded to keep the model simple), and a commercial discount rate of 10 per cent, no land areas were economically viable for reforestation until a carbon price of $40/t CO_2-e was achieved, and even then only a modest area of 1 Mha was profitable. No land areas were ever profitable if growth rates were assumed to be 30 per cent below the locally determined baseline rates of carbon sequestration.

Figure 2.2 indicates how the area of opportunity for reforestation ranges from zero hectares (for a low carbon price or combination of high carbon price and feasible establishment cost and discount rate) to a greater area being potentially profitable if low establishment costs, low discount rates and high carbon prices are assumed (Polglase et al. 2011).

Importantly, the calculated area of profitability for each scenario includes any NPV positive area, and many areas fall into the least profitable (orange coloured) category of $1-$500/ha. As such, it is unlikely that this degree of profitability would be sufficient to motivate land use change once all relevant costs including transaction costs are taken into account.

Polglase et al. (2011) note that social factors will be very important in moderating land use change, and that decisions by landholders to change land use are not purely a matter of comparing economic returns. For example, NPV modelling does not capture the loss of management flexibility inherent in reforestation, which is expensive and difficult to reverse. Nor does the model capture capital availability which may be limited by factors such as regulatory uncertainty and sovereign risk associated with the long term nature of carbon offset projects.

Figure 2-2: Forest establishment under selected carbon prices, discount rates and establishment costs

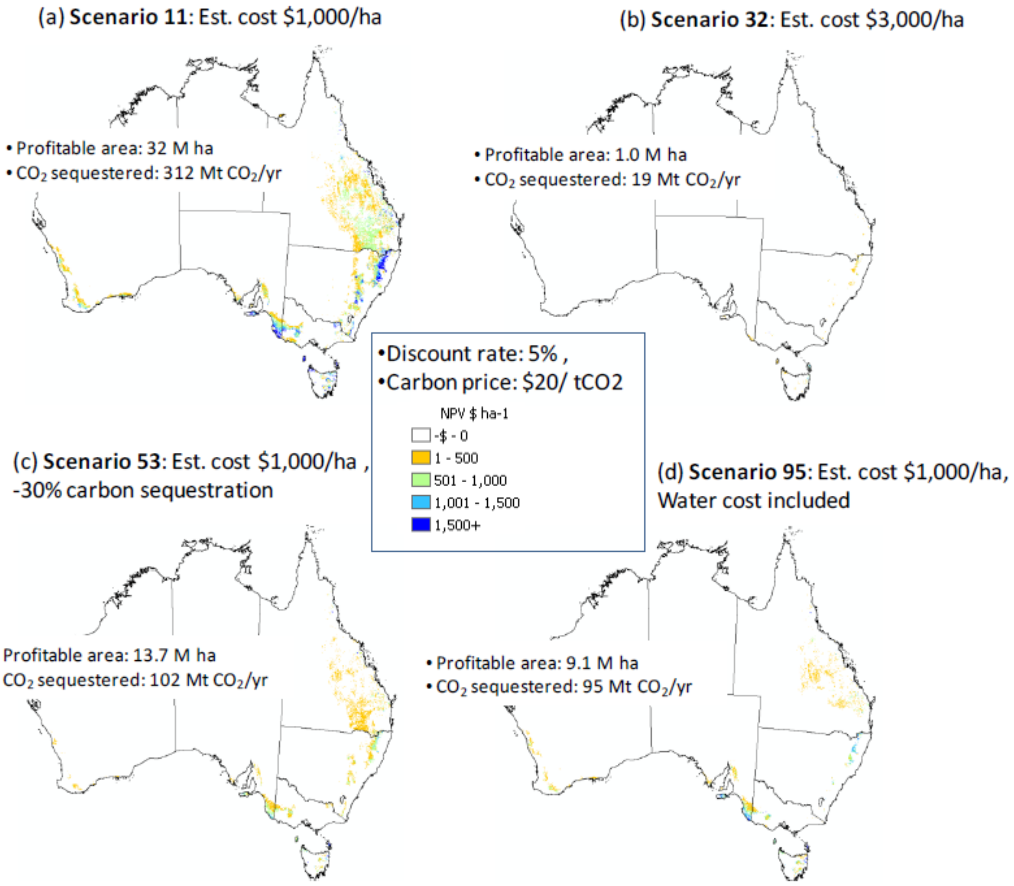


Figure 6. Example results from four scenarios that each use a discount rate of 5% and carbon price of $20 t CO_2^{-1} and: (a) establishment cost of $1,000 ha^{-1}, baseline rate of carbon sequestration, (b) establishment cost of 3,000 ha^{-1}, baseline rate of carbon sequestration, (c) establishment cost of $1,000 ha^{-1}, -30% rate of carbon sequestration, (d) establishment cost of $1,000 ha^{-1}, baseline rate of carbon sequestration, water cost included. The purpose here is to illustrate areas of relative profitability for select scenarios.

ABARE (2009) examined the area of agricultural land that could potentially be used for forestry under the Carbon Pollution Reduction Scheme (CPRS). This study found that returns from carbon sequestration could provide a competitive advantage for afforestation over existing uses on more marginal agricultural land. The ABARE projections suggested that two thirds of afforestation would occur in high rainfall zones, however due to prohibitive land costs, forestry would only be economically viable in the least productive areas of high rainfall zones with land values less than $1380/ha. In the wheat-sheep zone, afforestation would again be restricted to marginal areas with land values roughly half the regional averages. Furthermore the analysis showed that very high carbon prices would be required to allow forestry to compete with agricultural farms earning median returns. In all land use scenarios examined, this threshold carbon price was greater than \$150/t CO_2-e, and in the case of dairy more than \$360/t CO_2-e (see Box 1).

Paul et al. (2013a) caution that studies of national potential for carbon mitigation using average sequestration rates carry significant uncertainty because estimated rates of sequestration are highly variable - by up to 37 per cent - depending on local variations in site quality and management. They present a detailed study of the viability of industrial plantations considering biological, economic and institutional settings, using a series of case studies in Australia. Sequestration potential and economic returns for establishment of new plantations are modelled in four case studies under a range of carbon prices. They find it is generally not viable to establish new plantations unless the carbon price is at least \$20-50/t CO_2-e (and in some cases \$120/t CO_2-e), largely because of the high cost of land in regions where such plantations are most productive and within reasonable distance of processing plants and ports.

Paul et al. (2013b) state that it has been shown that even on marginal agricultural land (i.e. relatively low cost land) agroforestry has a relatively high potential for carbon sequestration, and with a price on carbon, agroforestry systems may potentially be more profitable than industrial plantations. Due to economies of scale the fixed costs need to be spread over a reasonable scale and 100 hectares appears to be the minimum requirement for commercial offset project viability in Australia (Polglase et al. 2011).

de Fegely, Stephens and Hansard (2011) also modelled a typical softwood and hardwood sawlog plantation using assumptions representative of average Australian conditions. They found low IRRs for both soft and hardwood plantations and the need for a carbon price to achieve an investment hurdle rate of around 7 per cent pre-tax. A carbon price of \$20/tCO_2-e still only provided a marginal IRR of 6 per cent for softwood and 4.7 per cent for hardwood (Table 2.2). These discount rates, given risk in the sector, are generally well below those needed for a viable investment, although there would be exceptions such as in the case of farm forestry, where a landowner may be in a position to trade-off other benefits such as shade and shelter for a lower IRR from wood production.

Box 1 – Emission Reduction Fund (ERF) carbon price in focus

The first Emission Reduction Fund (ERF) auction held in April 2015 resulted in the Clean Energy Regulator awarding contracts with an average price of $13.90/t CO_2-e of abatement.

ABARE (2009) analysis showed that very high carbon prices would be required to allow forestry to compete with agricultural farms earning median returns. In all land use scenarios, this threshold carbon price was greater than $150/t CO_2-e, and in the case of dairy more than $360/t CO_2-e (Box table 2.2).

As such, the abatement prices being paid, and likely to be paid into the foreseeable future, are well below the carbon prices that would incentivise large-scale land use change from agriculture to forestry.

Box table 2.1: Threshold carbon prices for carbon sink forests on median agricultural land

Land use scenario	Rainfall zone	Agricultural land value $/ha	Estimated net saleable CO2-e credits by year 30 t/ha	Threshold carbon price $/tCO2-e
Grazing	Low-medium	1,441-2,921	61-108	189 - 362
Broadacre cropping		1,235-2,464	56-96	193 - 367
Grazing	High	3,500	170	158
Dairy		12,238-13,686	148-175	369 - 399
Sugar		11,000	260	210
Vegetables		14,644	231	295

Source: ABARE (2009)

Note: the threshold carbon price is the price of carbon at which the present value of net returns from carbon sink forests becomes equal to the corresponding net returns from a representative agricultural farm.

Table 2-2: Softwood and hardwood plantation modelling

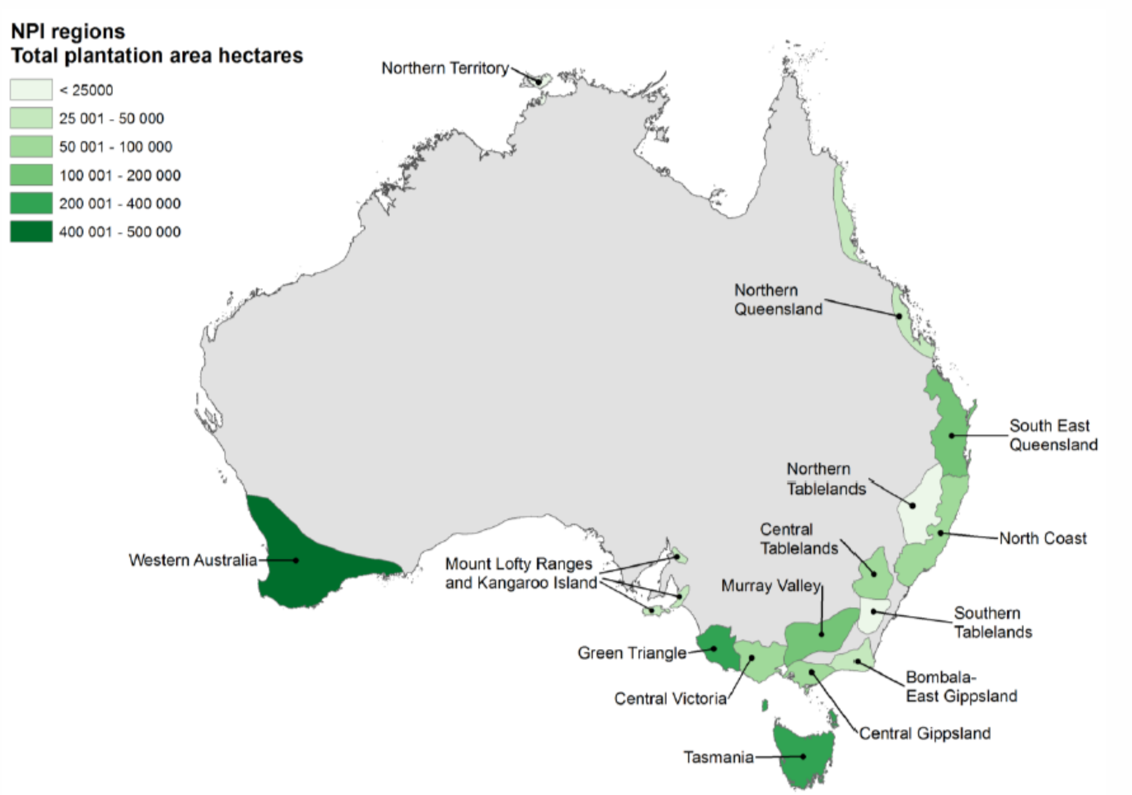
Sawlog Plantations	Units	Softwood	Hardwood
Land Price	$/ha	5,000	5,000
Establishment & Periodic costs	$/ha	2,800	3,000
Annual Maintenance	$/ha	120	150
MAI	m3/ha/yr	21	15
Rotation length	Years	33	35
Average log price	$/m^3	46	50
	IRR	**4.6%**	**3.3%**
Addition of Carbon at $20/tCO2e	**IRR**	6.0%	4.7%

Source: de Fegely, Stephens and Hansard (2011).

3 Key forestry regions and case studies

There are 15 major plantation forest regions in Australia that are mapped by the Commonwealth National Plantation Inventory (NPI) (Figure 3.1).

Figure 3-1: National Plantation Inventory regions



Source: Gavran (2015).

Within the NPI regions, plantations occupy only a few per cent of each region with the exception of the Green Triangle, which traverses the south east of South Australia and the south-west corner of Victoria (Table 3.1).

Table 3-1: Major NPI regions in Australia

Major NPI regions

NPI region	Plantation area ('000 ha)	% plantation by region
Bombala – East Gippsland	51	2%
Central Gippsland	95	4%
Central Tablelands	82	2%
Central Victoria	68.8	2%
Green Triangle	348	10%
Murray Valley	195	3%
North Coast	101	1%
Northern Queensland	38	1%
Northern Tablelands	24	<1%
South East Queensland	194	3%
Southern Tablelands	22	1%
Tasmania	310	5%
Western Australia	402	2%

Source: ABARES

The wood and fibre produced from the NPI regions generates significant employment and economic benefits in rural and regional Australia. In many regional towns, the forest industry provides significant direct employment, which helps sustain these rural communities (Table 3.2).

Table 3-2: Australian regional centres dependent on the forest industry

Regional centres highly dependent on forest industry employment

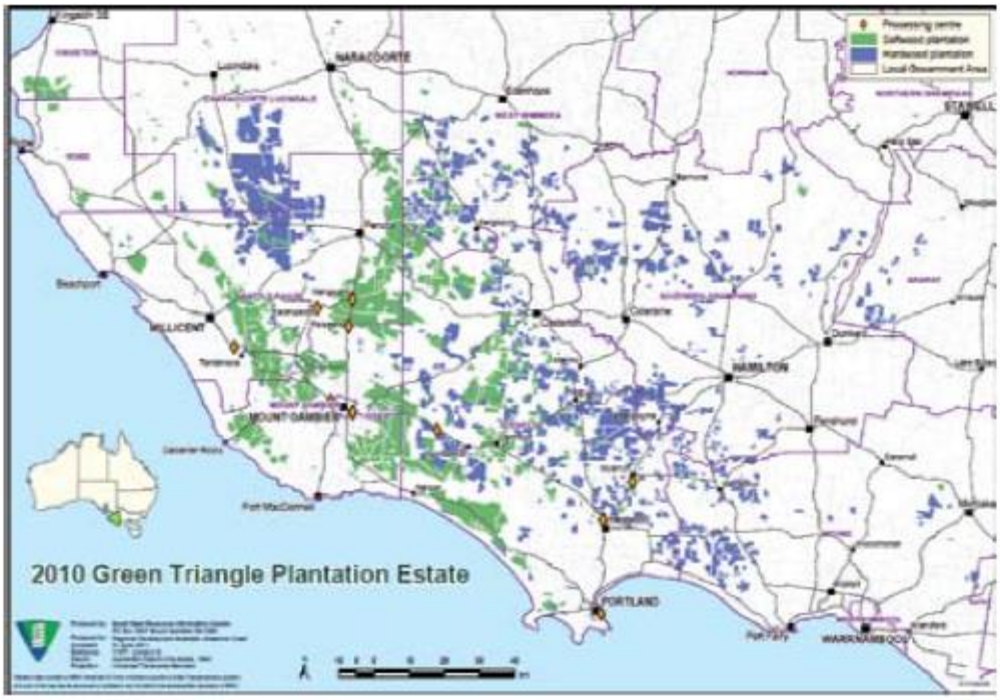
Region/town	Direct forest industry jobs (persons)	Direct as a % of regional employment	Total direct and indirect jobs from forest industry
Oberon NSW	257	24.9%	642
Tumbarumba NSW	110	19.5%	275
Tumut NSW	462	17.8%	1155
Morwell VIC	890*	16.2%	2225
Millicent SA	278	14.6%	695
Myrtleford VIC	134	12.5%	335
Mount Gambier SA	1224	10.7%	3060
Derwent Valley TAS	310	10.6%	775
Eden NSW	108	9.2%	270
Smithton TAS	123	8.7%	308
Manjimup WA	140	7.6%	350
New Norfolk TAS	119	5.9%	298
Traralgon VIC	590	5.2%	1475
Colac VIC	253	5.0 %	632
Grafton NSW	274	4.6%	685
Gympie QLD	278	4.3%	695
Benalla VIC	148	3.9%	370
Morwell VIC	182	3.9%	455
Maryborough QLD	269	3.6%	673
Albury NSW	283	1.2%	708

Source: ABS Census 2011. * Direct employment from Maryvale paper mill only and does not include jobs from forestry and other wood processing.

3.1 The Green Triangle (South Australia / Victoria)

The Green Triangle is Australia's largest collective plantation and wood processing zone and covers an area of 6 million hectares in South Australia's south east and crosses the border into south west Victoria (Fig.3.2). The forest industry in the Green Triangle is a major component of the regional economy, is strongly supported by State and local governments, and occupies 10 per cent of the region. In 2012, more than 355,000 hectares of land was occupied by softwood (50 per cent) and hardwood (50 per cent) plantations, equating to approximately 17 per cent of Australia's plantation estate. Approximately 7000 people are employed by the plantation and wood processing industry in this region, comprising over 23 per cent of employment (Regional Development Australia 2012).

Figure 3-2: Green Triangle forest area map



Source: Regional Development Australia (2012)

Some of the key forest industry companies linked with the region include: Timberlink, Carter Holt Harvey, Kimberly-Clark Australia, Van Shaiks BioGro, South West Fibre, New Forests, AKD Softwoods, Green Triangle Forest Products, HVP Plantations, OneFortyOne Plantations, Macquarie Bank, Forestry SA, Oji Paper, Nippon Paper, Mitsui and Midway.

The region has an extensive and competitive infrastructure base suited to development of forest industries. There is an extensive network of Commonwealth, State and local roads that service the forest and agricultural industries. The region is also well serviced by existing power and gas networks capable of supplying wood processing operations. However, energy prices have been increasing in recent years that has put pressure on the competitiveness of domestic manufacturers. Green Triangle plantations have access to large processing plants, including:

- Carter Holt Harvey's timber mill and particleboard mill in Mount Gambier;
- Timberlink timber mill in Tarpeena;
- Mitsui and Midway's woodchip mill at Myamyn.

The main port used by plantations in this region is the privately owned port of Portland in Victoria. This deep water port has the capacity to export more than 4 million green metric tonnes per year of forest product and is serviced by both rail and road infrastructure (Regional Development Australia 2012).

Regional Development Australia (2012) identified opportunities to develop new plantations in the Green Triangle, with over 100,000 hectares of cleared land suitable for new commercial softwood or hardwood plantations within economic haulage distances from processors or the port of Portland. RDA also identified opportunities to grow drought tolerant plantation species for firewood or niche sawlog markets in the lower rainfall areas of the region. There are currently 3,500ha of softwood or hardwood in farm forestry areas with less than 550mm rainfall.

3.1.1 Costs and Revenues

Data on Green Triangle forestry economics are difficult to obtain, however personal communications from industry sources suggest that average land values in the region are around $5,500/ha, with a lower bound of $4000/ha. Plantations in the region do best on land receiving over 650mm rainfall per annum and hence land purchase has been described as a major barrier to new plantation establishment.

Establishment and silviculture costs are over $2000/ha. Other significant costs include harvesting costs, which vary according to time stage of the rotation, overheads and transport costs. Industry participants advised that areas more than 120km from port or processing facility generate insufficient returns.

Revenues depend heavily on the products produced, which for this region are primarily softwood wood chips, domestic sawlogs, domestic pulp logs, and export sawlogs and pulp logs.

3.1.2 Impediments

While there is an abundance of suitable land for plantation purposes within the Green Triangle, land purchase cost is the primary impediment to forestry expansion.

In the higher rainfall zones, forestry competes with dairy and irrigation farming (such as potatoes), however the cost of purchasing such land is prohibitive at around $10,000/ha. In the lower rainfall zones the primary land use competitors are sheep and beef farming, however again land purchase costs render forestry expansion uneconomic in areas with sufficient rainfall.

3.1.3 Modelling

Two case studies were modelled for the Green Triangle: Industrial scale radiata pine on a 32 year rotation, and a farm forestry example on a 30 year rotation. Land costs were sourced from the ABARES Farm Surveys database (ABARES, unpublished data, 2015) with a median of $5500/ha and a range of $4000-$8000/ha. A land cost of $5500/ha was assumed for the industrial scale plantation case study, while a zero land cost was used for the farm forestry example. There is no land acquisition cost in the farm forestry case study because it is assumed that farm forestry will be carried out on small parcels of land that are largely unsuitable for other farm activities or that provide other benefits such as livestock shelter. The industry data used to model Green Triangle forestry, and the other regional case studies, is in Appendix 2.

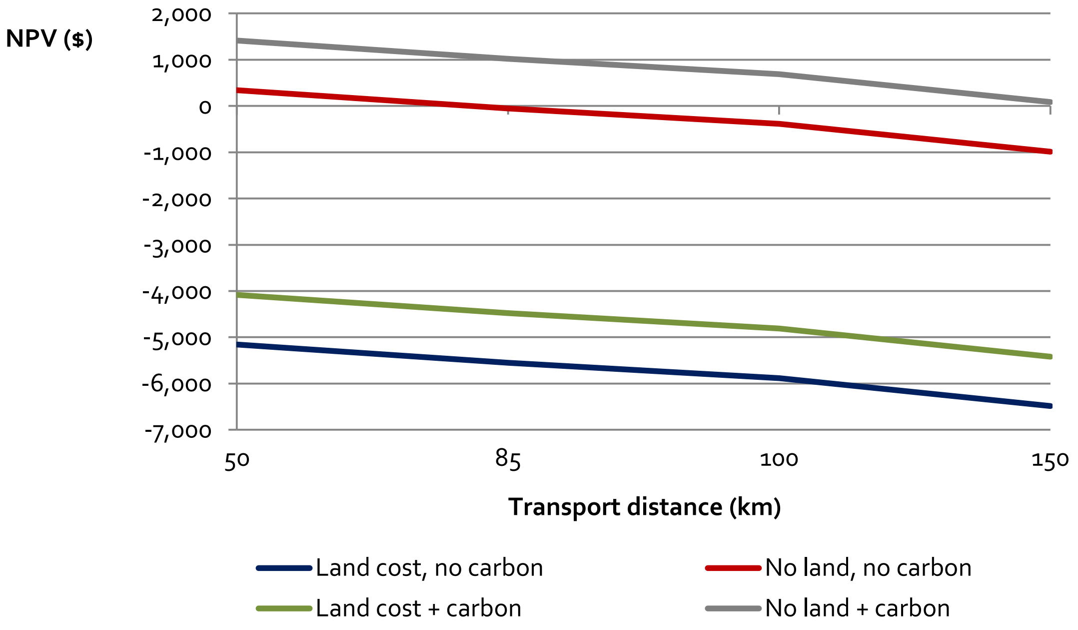
For all of the carbon modelling scenarios in this report, carbon sequestration rates were provided by industry sources using FullCam or direct estimates. As there is currently no final methodology agreed for carbon sequestration credits for plantation forestry under the ERF, a simplified approach based on average annual site carbon stock was adopted. This approach annualised the total above ground site carbon over a single rotation and assumed all of this carbon would be sold as eligible credits.

Relative to the conservative plantation carbon methodology likely to be developed by the Australian Government under the ERF, the approach used to estimate carbon revenue in these case studies is likely to overestimate the positive impact of carbon. In particular, this is because carbon revenues assumed in the case studies accrue over the life of a single rotation and do not take into account liabilities at the end of rotation or other design factors, such as an ERF buffer to manage risk or shorter contract periods. As such, for methodologies likely to be adopted under the ERF, higher carbon prices would be needed to generate a similar positive impact on the plantation economics demonstrated here.

3.1.3.1 Industrial scale Radiata pine

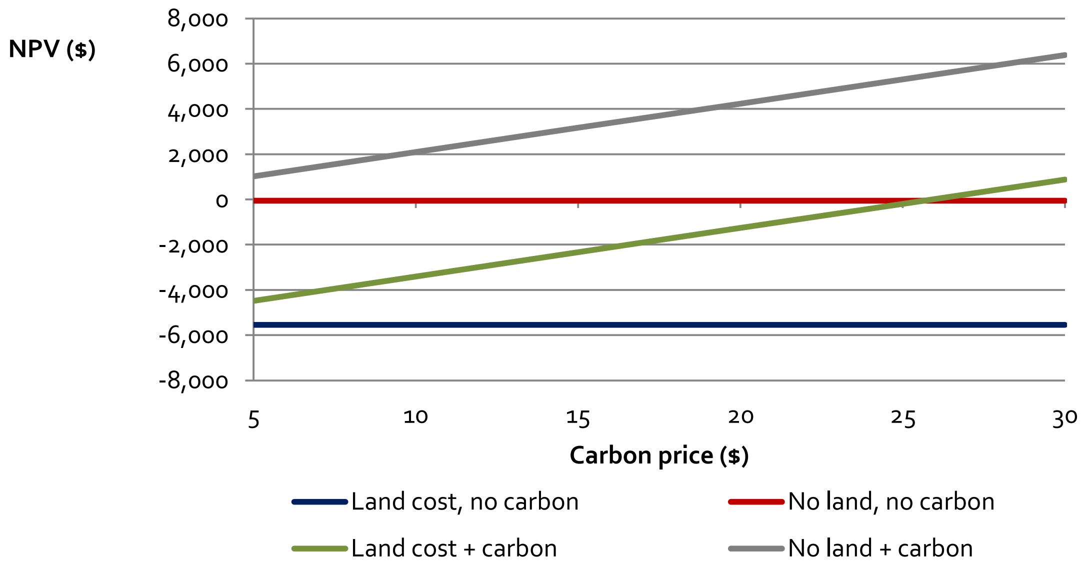
Modelling based on available cost and revenue data for the region from industry and literature sources suggest that for industrial scale plantation forestry operations in the Green Triangle, it would be difficult to generate a positive return where land must first be acquired (Figures 3.3 to 3.5). The only scenario where a positive return accrues to operations purchasing land at an average cost of $5500/ha is where carbon prices exceed $25/tCO_2e$, and it is further assumed that the plantation is within an 85km distance of a wood processing facility (Fig 3.4).

Figure 3-3: Net present value against transport distance to processing facility – Green Triangle Industrial



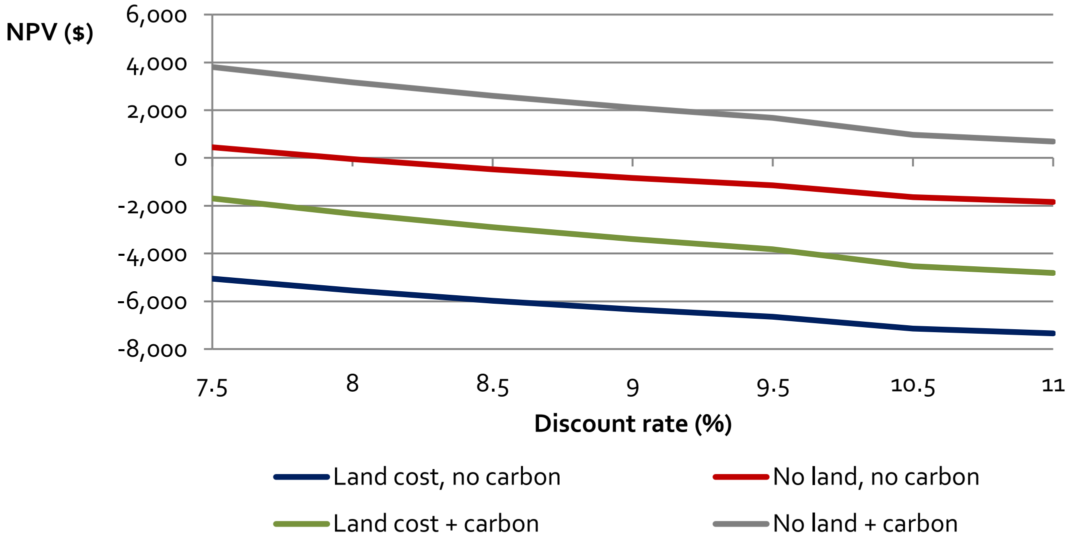
Note: modelling assumes $5500/ha land cost, 8% discount rate, $15/tCO2e carbon price as approximate to current ERF carbon price.

Figure 3-4: Net present value against carbon price – Green Triangle Industrial



Note: modelling assumes $5500/ha land cost, 85km transport distance, 8% discount rate.

Figure 3-5: Net present value against discount rate – Green Triangle Industrial



Note: modelling assumes $5500/ha land cost, 85km transport distance, $15/tCO2e carbon price as approximate to current ERF carbon price.

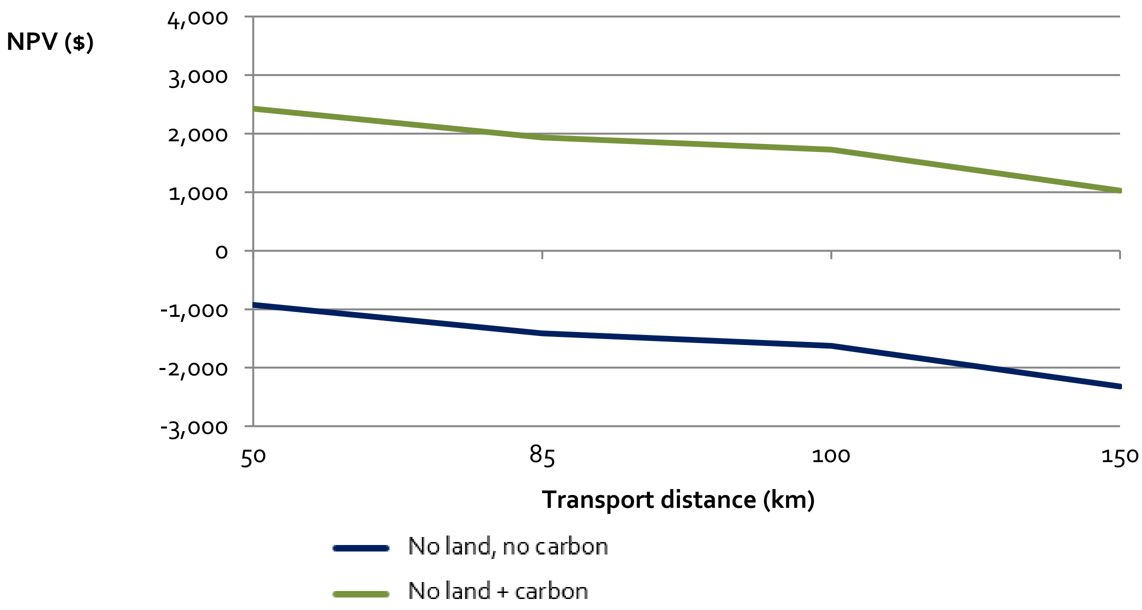
3.1.3.2 Farm forestry Radiata pine

In the Green Triangle farm forestry scenario, the economics appear better than for the industrial example, which is largely a result of the assumed zero land cost and lower establishment cost, which offset lower overall volumes. For many farm foresters, plantations may form part of a larger existing agricultural enterprise and hence the treatment of land costs may be different than for industrial owners who need to acquire new land for expansion of their estate. Farm forestry operators may impute a zero or very low opportunity cost for their existing land, given some of the other benefits from farm forestry such as shade and shelter for livestock or greater farm diversification.

Where land cost is excluded, farm forestry operations are not economic at a discount rate of 8% (Fig 3.6), but have the potential for positive returns when carbon trading is included. Within a 100 kilometre transport distance, farm forestry operators would be able to impute a land cost of just under $2000 per ha and still generate a viable return at an 8 per cent discount rate.

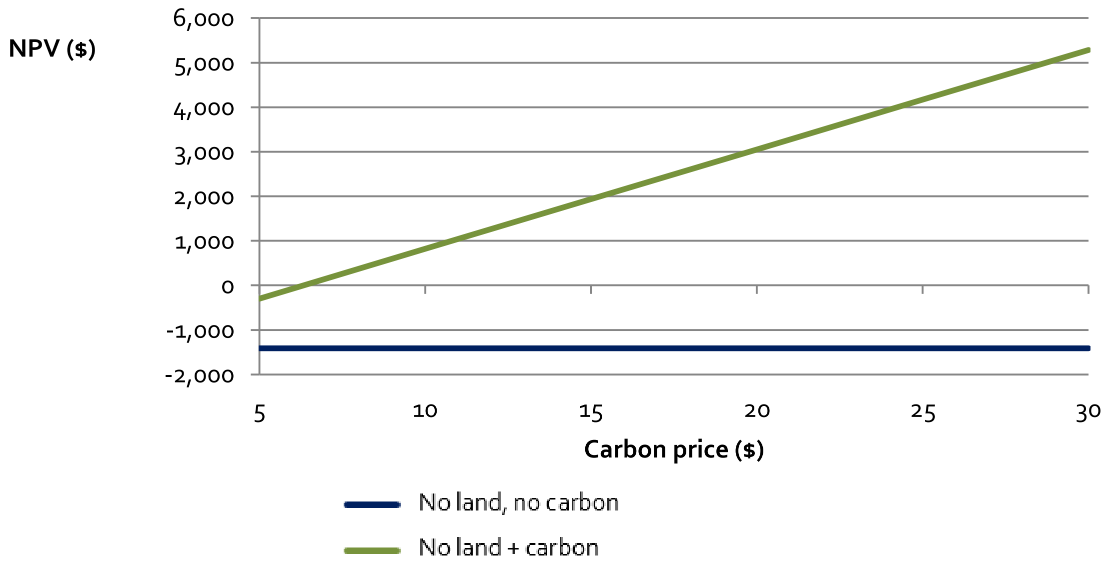
However, if land is assumed to cost $5500/ha as in the industrial example, then farm forestry operations are uneconomic. If land must first be purchased then a carbon price in excess of $30/ tCO_2e is still required to generate a positive return at a commercial discount rate of 8 per cent (Fig 3.7). Yet there are opportunities for farm forestry plantings where land costs are assumed to be less than for industrial scenarios, particularly where a lower discount rate is applied. Further sensitivity analysis showed that using a discount rate of 7.5 per cent, for example, generated a positive return up to a land cost of $2300/ha with carbon trading (Fig 3.8)

Figure 3-6: Net present value against transport distance– Green Triangle Farm forestry



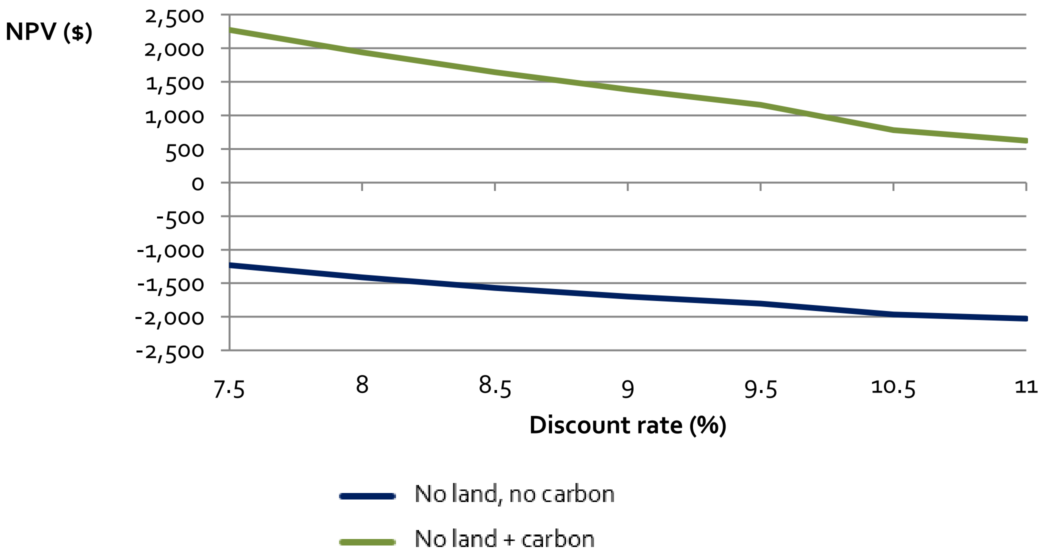
Note: modelling assumes no land cost, 8% discount rate, $15/tCO2e carbon price as approximate to current ERF carbon price.

Figure 3-7: Net present value against carbon price– Green Triangle Farm forestry



Note: modelling assumes no land cost, 85km transport distance, 8% discount rate.

Figure 3-8 Net present value against discount rate– Green Triangle Farm forestry

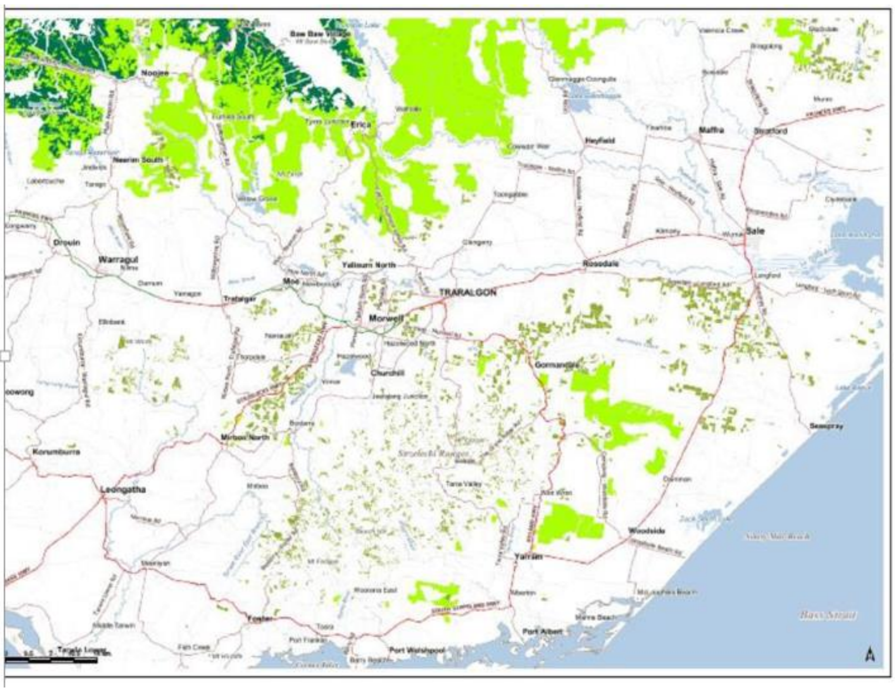


Note: modelling assumes no land cost, 85km transport distance, $15/ tCO_2e carbon price as approximate to current ERF carbon price.

3.2 Latrobe Valley, Victoria

The Latrobe Valley is an important forestry region comprised of Latrobe City, Baw Baw and Wellington Shire Councils and is located in the Gippsland region of Victoria. In 2012, 89 per cent of the Gippsland region's forest plantations were in the Latrobe Valley, representing around 90,000 hectares of plantations. The Gippsland region also has around 1 million hectares of harvestable native forests. The plantation resources in the region are managed as large scale industrial plantations. Wellington Shire contains most of Gippsland's plantations (52 per cent), followed by Latrobe City (30 per cent) and Baw Baw (7 per cent) (Regional Development Victoria 2012). The region's hardwood plantations occupy 33,000 hectares of land, (Gavran and Parsons, 2011). The Latrobe Valley region's softwood plantations occupy 62,000 hectares and are comprised almost entirely of radiata pine (Gavran and Parsons, 2011).

Figure 3-9: Latrobe Valley forest area map



Source: Fairbrother et al. (2012)

Most of the harvestable area in the Latrobe Valley is public native forest, however wood supply is sourced almost equally from native forest and plantations (Cameron et al., 2005). Around 75 per cent of wood harvested in the Latrobe Valley region is processed locally, with some plantation softwood supplied to mills elsewhere in Victoria and about a third of harvested public native forest hardwood exported overseas in the form of woodchips. The primary export facilities are located at Corio Bay Geelong, Melbourne and Eden, NSW.

The forestry, wood products and paper industry contributes around $1.1 billion to the Latrobe Valley region and employs around 2,500 people (Fairbrother et al. 2012).

The main industry players in the region include: VicForests, HVP Plantations, South East Fibre Exports, Macquarie Funds Management, Midway, New Forests, Global Forest Partners, and farm forestry.

Latrobe Valley plantations have potential access to processing plants that utilise a mix of resource inputs (i.e. plantations, native forest), including:

- Australian Sustainable Hardwoods' hardwood saw mill in Heyfield;
- Australian Paper's paper mill in Maryvale; and
- Carter Holt Harvey's timber mill at Morwell and sawmill at Yarram.

Stewart et al. (2012) undertook a substantial study of the Gippsland region timber industry on behalf of the Department of Planning and Community Development Victoria. They found that there was limited potential for expansion of plantation resources, citing that plantation investments generally do not generate returns expected by mainstream investors under current economic conditions, even though the land base exists for significant expansion. In particular, one of the main factors limiting the profitability of new plantation investments in the region is that the price of land is generally high.

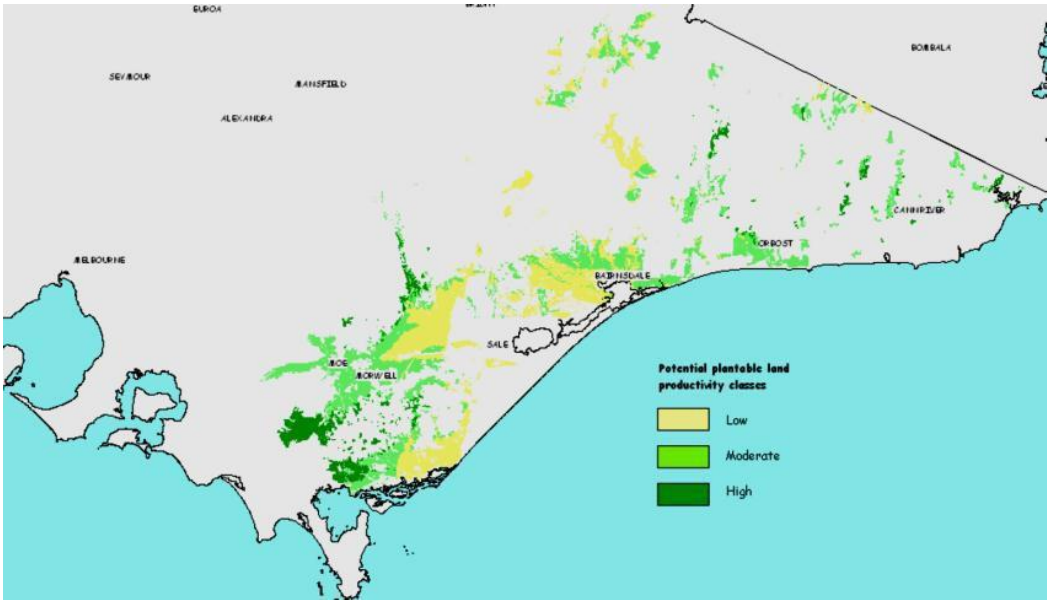
The Victorian Government has identified land in the region that may be suitable for conversion to plantation (Fairbrother et al., 2012) (Fig 3.10).

3.2.1 Impediments

In relation to this study, the Victorian Government found that while there is suitable land for increased plantation growth, the sector in the Latrobe Valley faces significant challenges, including water usage and stress, land availability, and plantation quality and transport. The sector is described as having evolved from one that was initially processor constrained, to one that is now resource constrained.

Fairbrother et al (2012) note that the Latrobe Valley region's forest and plantation resources are limited and declining. The Victorian bushfires of 2009 damaged more than 16,000 hectares of HVP's softwood and hardwood plantations across the state, and over half of this loss occurred in the Latrobe Valley region. This HVP resource is being replanted at a cost of around $25 million. Fairbrother et al. (2005) also report reductions in the working forest areas (both plantation and native) for environmental reasons, which have occurred despite the Gippsland Regional Forest Agreement (2000) between the State and Federal governments.

Figure 3-10: Potential plantation area by productivity class, Gippsland



Source: Fairbrother et al. (2012).

Other impediments to plantation expansion in the region that have been variously reported include:

- narrow ownership base affecting the flow of investment;
- higher fuel costs resulting in increased haulage costs thereby reducing the economic supply catchment area;
- high exchange rate rendering product uncompetitive for export (less relevant today); and
- resources locked in the production chain by time specific contracts, thus limiting the broadening of the industry base, for example to biofacility operators.

Poyry (2011) report there has been limited plantation expansion in Gippsland over the past decade, even when significant capital was available via forestry Managed Investment Schemes. This was considered a result of:

- poor economic return on investment;
- high land costs of over $4000/ net planted ha for freehold land and more than $250/ha per year on a leased basis;
- low productivity projections due to drought and expected adverse long term climate change effects;
- community opposition to plantation expansion;
- low scale economies due to small properties; and
- lack of market diversity due to the Midway export terminal at Geelong being more than 200km away and Australian Paper the only major buyer.

3.3 New South Wales

3.3.1 Tumut and Tumbarumba

Tumut is an important softwood plantation area in Australia, with 130,000 hectares of pine plantation. The majority of these plantations are comprised of radiata pine.

In 2010, over 1700 people in the Tumut shire were employed in the forestry and timber manufacturing sector. Tumut is also an important area for forestry education for New South Wales as the TAFE campus provides timber industry training for the whole state (Tumut Council 2010).

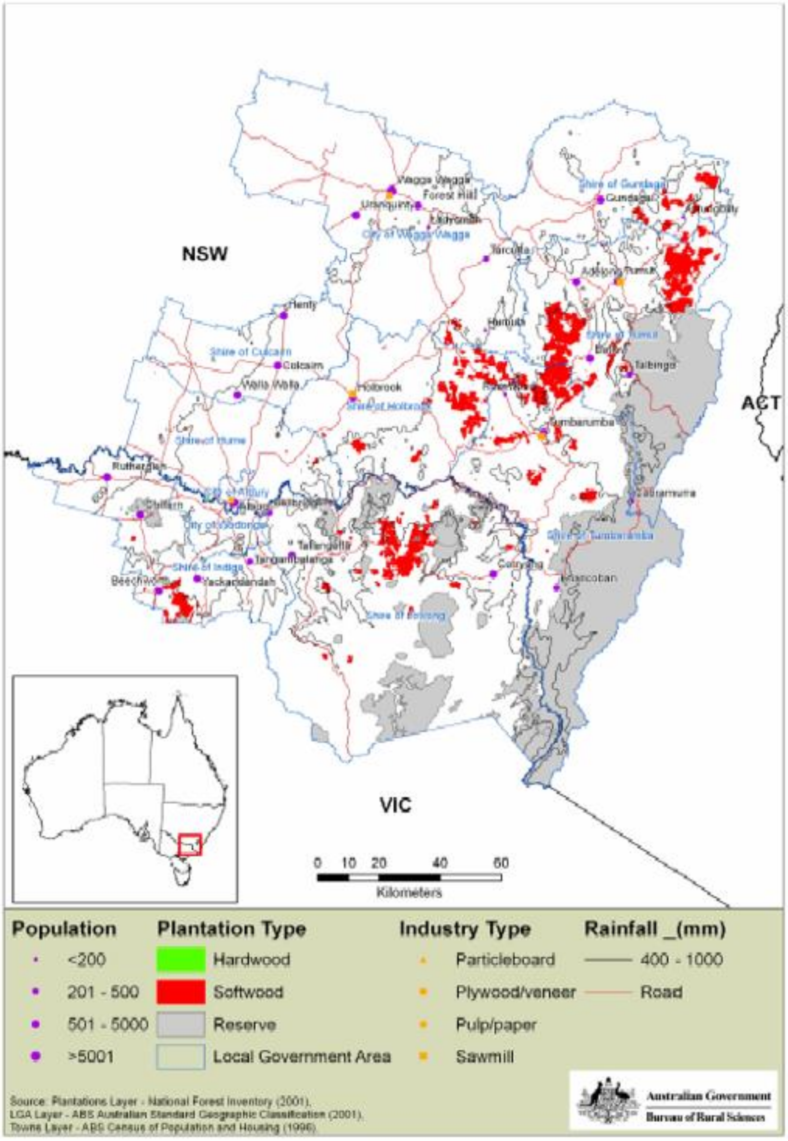
Tumut and Tumbarumba plantations have access to processing plants including:

- Visy's paper mill in Tumut (one of Australia's largest exporters of containerised manufactured product (McCormack 2015);
- Carter Holt Harvey's timber mill and particleboard mill in Tumut;

- Norske Skog’s newsprint mill in Albury; and
- Hyne’s timber mill in Tumbarumba.

A study into Tumut economic development stated that, in 2010, a deficit in timber supply for manufacturing in the region resulted in more than 500,000 tonnes of timber products being brought into the South-West Slopes region. The South-West slopes region stretches across 17 local government areas, including Tumut and Tumbarumba, located on the inland slopes of the Great Dividing Range. The additional wood comes mainly from the Macquarie and Bombala regions and the higher transport costs have affected the international competitiveness of local production. Consequently, Tumut’s economic development strategy recommends that an additional 30,000-40,000 hectares of plantation are required in this area to meet manufacturing demands (Tumut Council 2010).

Figure 3-11: South West slopes plantation map



3.3.2 North Coast New South Wales

The Northern Rivers region is roughly equivalent to the NPI region of North Coast NSW, and in 2009 had just over 103,000 hectares of softwood and hardwood plantations. It covers the Tweed, Byron, Ballina, Clarence Valley, Richmond Valley, Lismore and Kyogle Council areas. This is an important region in Australia for hardwood and the only forestry region within New South Wales where hardwood plantations are dominant. Hardwood makes up approximately 83 per cent of the total plantation resources. In other forestry areas hardwood makes up 11 per cent or less of plantations (Montoya 2010).

This region has had the greatest recent expansion of any forestry area in Australia with roughly 75,000 hectares of new plantations established between 2001 and 2010. In particular, the Kyogle and Clarence Valley LGAs have seen the greatest number of plantations established during this time frame (Montoya 2010; BILTechnologies 2007).

North Coast NSW plantations have access to around eighty sawmills in the area including many small fixed and mobile mills that operate on a part time basis. Clarence Valley alone is home to 26 sawmills. Sawmills refer here to all primary and secondary processing operations, including green and value added sawn production, pole, pile and girder production and plywood or veneer manufacture. Figure 3.12 shows mill location in relation to the native forest and plantation resources of the area.

Figure 3-12: North coast plantation resource and sawmills

Source: Northern NSW Forestry Services (2008).

3.3.3 Costs and Revenues

Information on costs and revenues for New South Wales plantation forestry is scarce. Northern NSW Forestry Services (2008) provide indicative average landed costs for plantation products as shown in Table 3.3. No information is available on revenues.

Table 3-3: Indicative landed costs of forest products, NSW

Radius around processing location (km)	**Indicative average landed cost - plantation ($/tonne ex GST)**	
	Small logs	Other residues
0-50	55	49
51-100	60	54
101-150	66	60
151-200	70	64

Establishment costs in the nearby New England region have been reported by North-West Forestry Investment Group (2002) to be in the range $1000-4000/ha at a stocking rate of more than 1000 trees/ha. Silvicultural costs for eucalypt plantations are also reported for 2 to 3 stage thinning / pruning on a 30-40 year rotation in the range of $150-500/ha depending on stage, density and growth rate. Roading costs for haulage are as high as $240/ha. Falling, snigging and log loading costs are $15-25/cubic metre, and haulage costs depend on distance to sawmill and range from $5-20/cubic metre. Other costs include professional advice (silvicultural, management, harvesting planning), insurance, and land opportunity cost.

Based on data from State Forests NSW, typical hardwood stumpage prices for North coast NSW are:

- Pulp logs $8-15/m^3
- Small sawlogs $15-25/ m
- Large sawlogs $30-60/ m^3

However, these prices assume access to pulp markets and this access is limited for North coast and New England plantations.

North coast indicative yields for hardwood plantations are reported as approximately $1800/ha for year 14 thinning producing small sawlogs, $1200/ha at year 20 thinning producing small sawlogs and $20,000/ha for year 34 clearfell producing mostly sawlog/veneer log and some small sawlog and pulp (North West Forestry Investment Group 2002).

3.3.4 Expansion potential in NSW

Montoya (2010) reported studies of plantation capability, plantation suitability and economic viability. The economic competitiveness of plantations were compared with estimated farm business profits and estimated agricultural land values. The reference case indicated the potential for around 160,000 hectares of additional plantations, comprised of two-thirds softwood in the northern tablelands and far south coast. The analysis also included three carbon price scenarios, which assumed plantation owners could sell carbon sequestration credits annually. The inclusion of carbon credits in the model increased the competitiveness of plantations in NSW. The potentially economically viable plantation area increased by around 250,000 hectares of plantation under a $15/t CO_2-e carbon price. Whilst this result appears to indicate a significant potential addition to plantation area, the study appears to compare gross margins across agricultural and forest products, and therefore does not appear to have taken land purchase cost into account. It is also worth noting that relative prices of agricultural products to forest products have improved since the study quoted was completed in 2001.

Montoya (2010) also referenced studies on the potential for farm forestry in NSW. In 2005-06, 8.4 per cent of all NSW plantations were located on farms. It was reported that environmental values from farm forestry are concentrated in the northern rivers region of NSW. Moreover, it was noted that profitable farm forestry typically occurs close by an established forestry industry growing the same species, and hence markets are available and existing industry knowledge can mitigate risk.

3.3.5 Impediments to NSW plantation forestry expansion

A host of issues facing plantation forestry in NSW have been identified by industry participants as reported by Montoya (2010). These include:

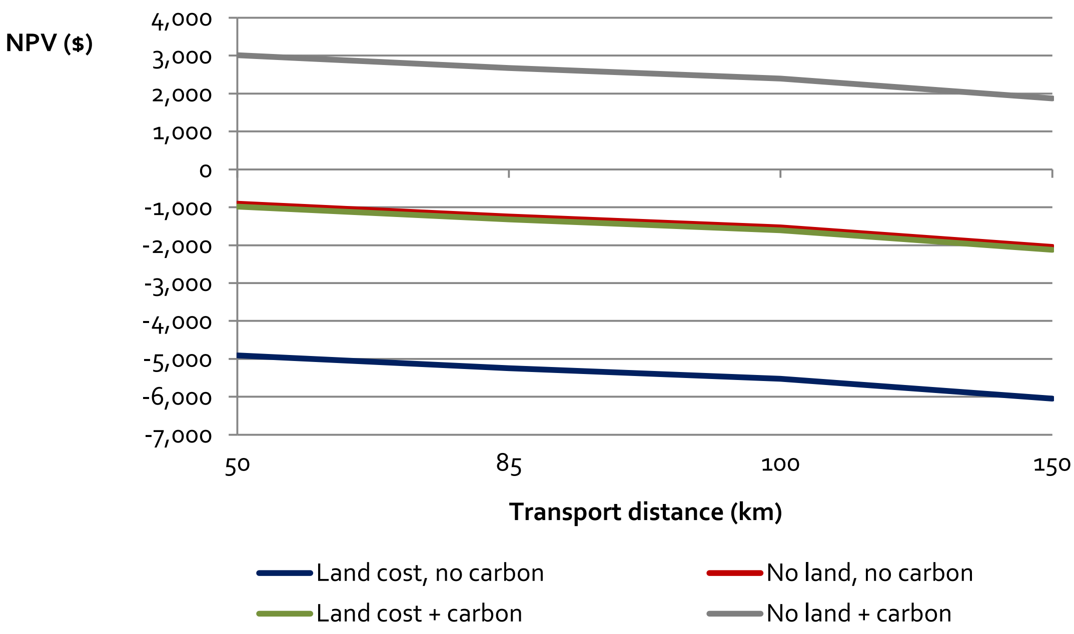
- impacts from Managed Investment Schemes (MIS) such as initially driving up local land prices, followed by declining confidence with the collapse of several large MIS companies;
- the potential for increased costs due to plantation water consumption charges;
- lack of investment in value adding industries;
- lack of transport infrastructure funding and lack of advanced planning for transport, electricity and port infrastructure;
- skill and labour shortages;
- lack of investment in long rotation hardwood for sawlogs, with a looming shortage in sawn timber supply; and
- sovereign risk due to policy changes.

3.3.6 Modelling case study: Hume NSW

A single case study was modelled for the Hume region in New South Wales on a long run rotation of 32 years. This region includes the south-west slopes of New South Wales and the towns of Tumut and Tumbarumba, which have paper and wood processing centres respectively. Land costs were sourced from the ABARES Farm Surveys database (ABARES, unpublished data, 2015) with a median of $4000/ha and a range of $2600-$6200/ha. Carbon sequestration rates were provided by industry sources modified from FullCam based on rotation characteristics.

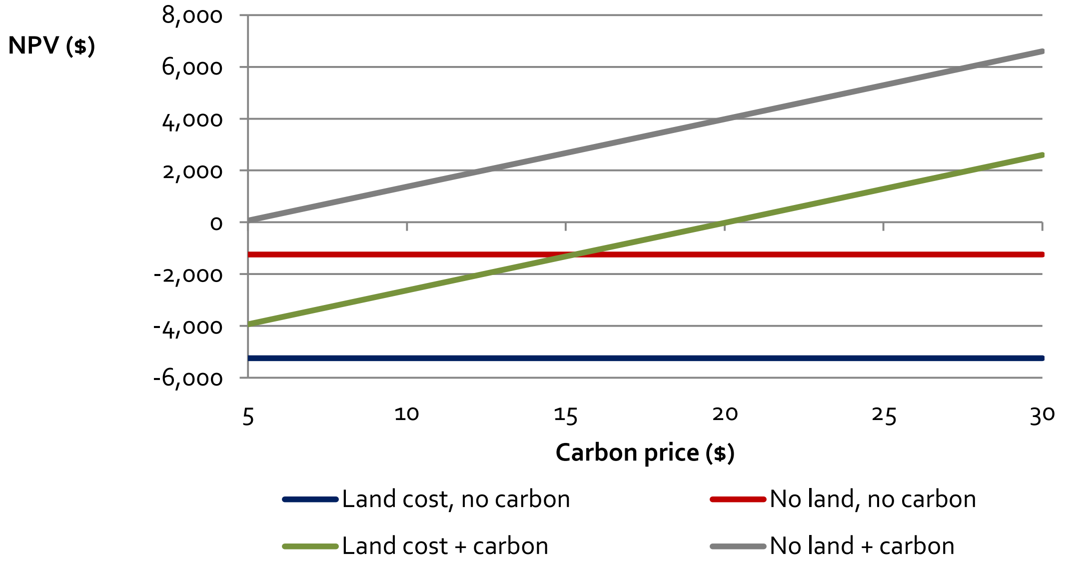
Cost and revenue data for the region were provided by industry sources, and the modelling indicates that new plantations are uneconomic to establish where land must first be acquired. The economics become marginal for land acquisition scenarios where a carbon price of $15/ tCO_2e is reached alongside a transport distance less than 85km (Figures 3.13 to 3.15). These results are highly sensitive to the methodology used to account for carbon revenue. As previously indicated, the methodology adopted to account for carbon in these case studies is likely to overestimate the positive financial impact relative to the conservative methods likely to be adopted by the Australian Government under the ERF.

Figure 3-13: Net present value against transport distance: Hume NSW



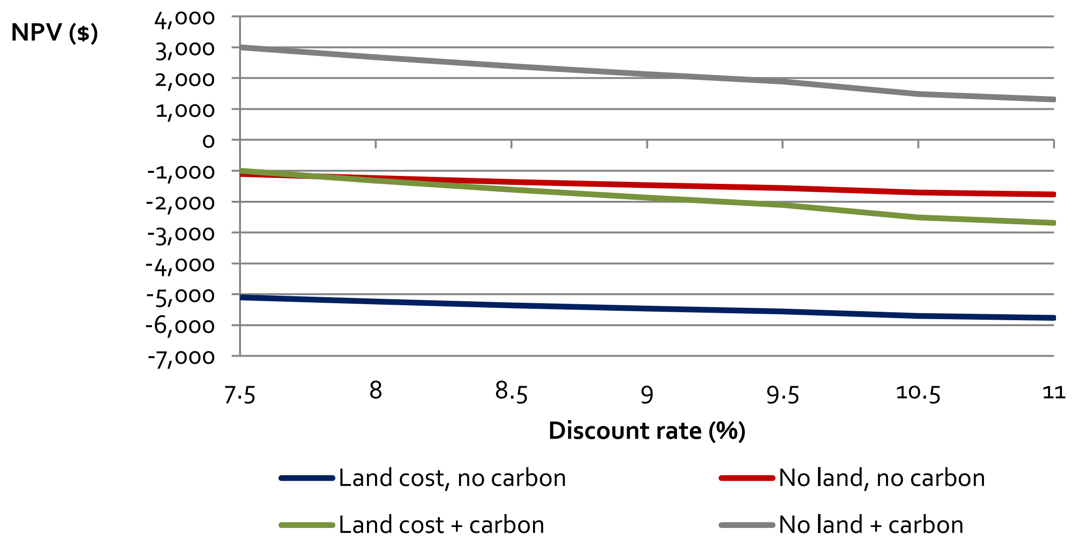
Note: modelling assumes $4000/ha land cost, 8% discount rate, $15/tCO2e carbon price as approximate to current ERF carbon price.

Figure 3-14: Net present value against carbon price: Hume NSW



Note: modelling assumes $4000/ha land cost, 8% discount rate, 85km transport distance.

Figure 3-15: Net present value against discount rate: Hume NSW



Note: modelling assumes $4000/ha land cost, 85km transport distance, $15/tCO2e carbon price as approximate to current ERF carbon price.

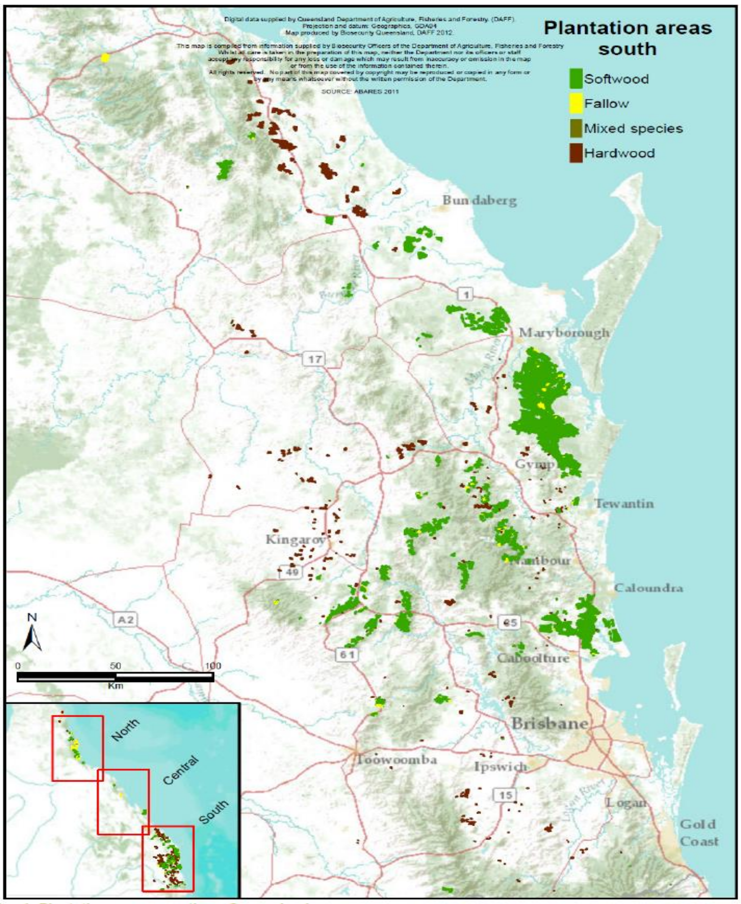
3.4 Queensland

In 2006-07, the forest and timber industry contributed around $3.8 billion in economic activity in Queensland. The sector employed around 19,000 people across the full industry chain in 2011-12. Indirectly, for every dollar of value-adding generated in the industry, an additional $1.80 of value-adding is generated in the Queensland economy. For every additional full-time equivalent (FTE) job in the industry, an estimated 1.3 FTEs are created in the Queensland economy (State of Queensland 2012).

3.4.1 South East Queensland

South East Queensland is the state's most important forestry region. In 2012, 203,500 hectares of plantation forest existed in subtropical Queensland, and the majority of this was located in the coastal, higher rainfall areas in the southeast (Figure 3.16). Approximately 85 per cent of subtropical Queensland plantation consists of softwood species (State of Queensland 2012) and is largely owned and managed by HQPlantations.

Figure 3-16: Southeast Queensland plantation area map



Source: State of Queensland 2012

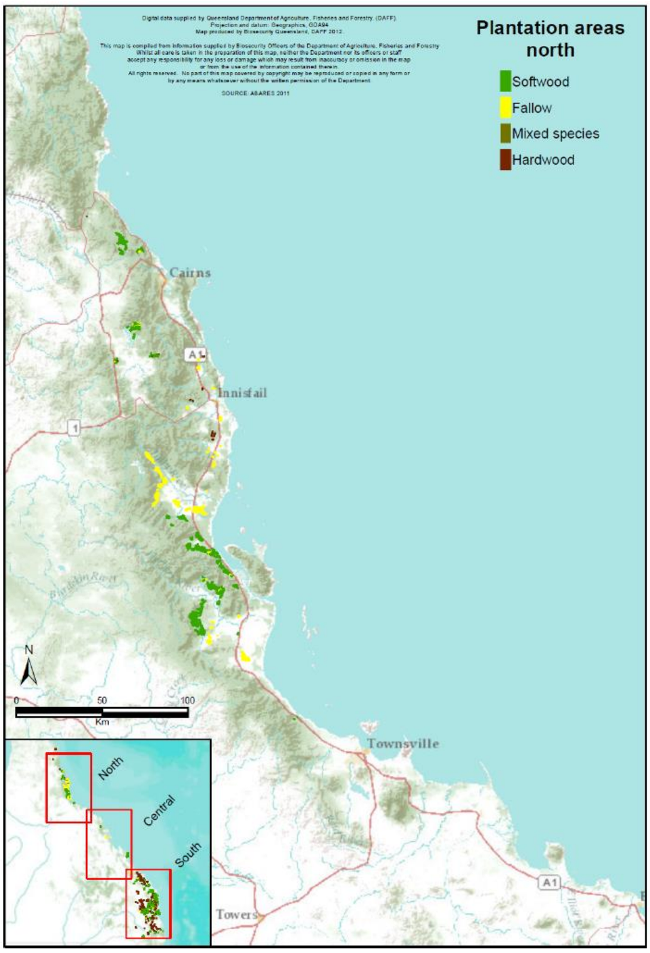
Queensland's hardwood plantation estate is relatively immature and still to produce a final crop. Over half (56 per cent) of the hardwood plantation estate is being managed by HQPlantations for sawlog production.

In 2004, the Queensland Government committed to the establishment of a total of 20,000 hectares of new native hardwood plantations as part of its South East Queensland Forests Agreement and Western Hardwoods/Statewide Forests Process initiatives. This estate will be delivered by HQPlantations as part of the 2010 sale arrangements with the Queensland Government. These arrangements require the new plantation estate to be finalised by 2025, meaning that annual planting rates under this program are around 400 hectares per year (State of Queensland 2012).

3.4.2 North Queensland

North Queensland is one of Australia's smaller forestry regions (Figure 3.17). In 2012, tropical Queensland contained 38,500 hectares of hardwood and softwood plantations. However, softwood was the dominant choice, making up 75 per cent (State of Queensland 2012).

Figure 3-17: North Queensland plantation areas



Source: State of Queensland 2012

South East Queensland plantations have access to a number of processing plants including:

- Carter Holt Harvey's sawmill in Caboolture and particleboard mill at Gympie; and
- Hyne's timber mill in Maryborough.

The number of primary processing plants in Queensland is reported to have fallen significantly over the past decade. ABARES reports that there were 16 sawmills processing plantation softwood in Queensland in 2013-14 (ABARES 2014). Combined, these sawmills utilised 1.1 million m^3 of log input, mostly by the three large sawmills with a log intake in excess of 100,000 m^3 per year.

There were 43 sawmills processing 247,000 m^3 of hardwood log timber in Queensland in 2013–14 (ABARES 2014). However, only eight sawmills had an annual log timber intake of more than 15,000 m^3 per year. There are a further 15 cypress pine sawmills in Queensland processing timber primarily from state-owned native forests.

3.4.3 Expansion potential in Queensland

The Queensland Forest and Timber Industry Plan (2012) identifies many of the financial viability challenges facing any future expansion of the Queensland plantation estate.

It has been estimated that at least 100,000 hectares of new local sawlog plantations would be needed to meet Queensland's future timber demand (Timber Queensland 2015). This includes both hardwood and softwood plantations, on long rotation to produce solid wood and engineered wood products.

New plantations should be located close to existing forest industry clusters to take advantage of existing industry infrastructure and ensure the highest stumpage prices. Queensland currently has some 'stranded' sub-scale plantation resources developed when competitive scale for processors was much lower or where there was an intention to expand the estates to sufficient scale to establish a processing industry.

Over the past decade, agribusiness MIS companies were the major source of funding for new plantations in Queensland. Most of the schemes involved short rotation hardwood plantation or other potentially high value agricultural investments. However, most of these MIS companies have now failed or the trees have been harvested, and are unlikely to be replanted (State of Queensland 2012). Other significant investors include Hancock Natural Resources, an international timber investment company, which purchased the former Queensland government plantation estate in 2010 via HQPlantations.

Queensland does not have a high competitive advantage in plantation investment relative to other Australian states because of its relatively lower growth rates. de Fegely, Stephens and Hansard (2011) reported that when land costs are included the returns from investment in typical long rotation plantations in Australia are low, with IRRs of 4.6 per cent for Australian softwood plantations and just 3.3 per cent for hardwood plantations. They assumed an Australian average mean annual increment (MAI) of around 15 m^3/ha/year yield for an average Australian softwood plantation. This compares with average MAIs in Queensland of between 12-18 m^3/ha/year for southern pines and 11-15 m^3/ha/year for Araucaria plantations (Gavran et al 2012; industry data). Long rotation hardwood plantations have reported MAIs of around 8 m^3/ha/yr. As a slow growing species, Araucaria plantations also have a typical rotation length of around 45 to 50 years which has a direct impact on discounted net returns.

de Fegely, Stephens and Hansard (2011) also investigated a range of options to support plantation investment, and highlight the need for policies to address the financial viability of plantation investments by mitigating the high up-front costs and long return lead times. One of the key areas identified to help improve the overall profitability of long rotation investments was additional sources of revenue such as from carbon sequestration. de Fegely et al. (2011) noted the need to enhance support from local communities given previous expansion of the plantation estate, particularly in north Queensland, which caused some frictions with the traditional cane industry. This latter concern now holds little relevance given the failure of most agribusiness MIS companies and recent cyclones in tropical north Queensland have caused new plantation establishment to effectively cease, with little prospect of any large-scale expansion on this land.

The only known significant plantation expansion program in Queensland involves the agreement between the Queensland Government and HQPlantations which requires a further 7000 hectares (of a total 20 000 hectare estate) of hardwood plantations be established by HQPlantations by 2025 (de Fegely, Stephens and Hansard 2011).

3.4.4 Costs and Revenues

The financial viability of expanding the plantation estate is highly sensitive to the discount rate, as expected for long term investments. Herbohn (2006) found that investment in Araucaria plantations in the Atherton Tablelands would only be economically viable for discount rates of 5.5 per cent or less, which is typically lower than current commercial hurdle rates. This financial assessment of Araucaria plantations in Northern Queensland estimated total establishment costs (excluding land costs) of $2600 and maintenance costs as shown in Table 3.4. Estimated land costs in South-East Queensland for forestry compatible uses are in the range $5000-7000 per hectare (Queensland Department of Agriculture and Fisheries 2014).

Table 3-4: Maintenance costs of Araucaria plantation

Activity	Estimated cost ($/ha)	Timing (year)
Post plant spray (supply and apply)	450	1
Prune - contract (3 m lift)	650	4
Post plant spray (supply & apply)	300	1
Post plant spray (supply & apply)	150	2
Pre-commercial thin (400 stems/ha)	500	3
Prune - contract (5.4 m lift)	850	6
Resource assessment (timber inventory plots) – 1	80	5
Resource assessment (timber inventory plots) – 2	80	10
Resource assessment (timber inventory plots) – 3	80	25
Annual expenses (yrs 1-20)	40	1-20
Opportunity cost of land	a	1-45
Rates	a	1-45

[a] No cost allocation made.

Source: Harrison and Herbohn (2006).

Araucaria currently has no market for thinnings and hence the only income occurs at final harvest. Assuming a 45 year rotation and an MAI of around 19 m^3/ha/yr, the stumpage royalty for high quality timber is around $70/ m^3 in south-east Queensland (Harrison and Herbohn 2006). Based on these assumptions and a 5 per cent discount rate, the authors calculate a marginally positive NPV, suggesting the project would proceed. They also estimate a land cost of $823 per hectare, representing the maximum price that could be paid per hectare of land for the investment to remain viable.

3.4.5 Impediments to plantation establishment in Queensland

The challenges to further industrial plantation expansion in Queensland have been drawn out by several authors. The State of Queensland (2012) reported that the key issues include:

- low profitability and return on investment across the industry constraining new investment, particularly in the plantation and processing sectors;
- a lack of understanding or certainty about the size and nature of future timber markets in Queensland;
- exchange rate exposure negatively impacting the competitiveness of Queensland-produced forest and timber products, resulting in some business failures;
- a low level of public awareness and understanding of the industry, particularly the environmental benefits of wood products, has resulted in relatively poor community support for the industry; and
- difficulty in attracting and retaining professional and skilled labour.

Other impediments to commercial plantation expansion include perceived high sovereign risk associated with long term investments in forestry, long distances to timber markets, lack of support for forestry expansion by the State forest agency, low stumpage prices charged by the state forest agency as a price leader, poor integration between the softwood and hardwood sectors, damage from cyclones, and the large number of species resulting in a lack of threshold volume (Harrison 2006).

Impediments to small-scale timber plantation expansion and export were reported by Cox (2006) as:

- supply uncertainty owing to small and scattered woodlots;
- lack of a recognised brand system for mixed species;
- high compliance costs for solitary small scale exporters coupled with lack of export experience;
- high transport costs due to distance to processors and ports, and under-developed road systems; and
- obtaining appropriate land for accessible plantings.

3.4.6 Modelling case studies: South East Queensland

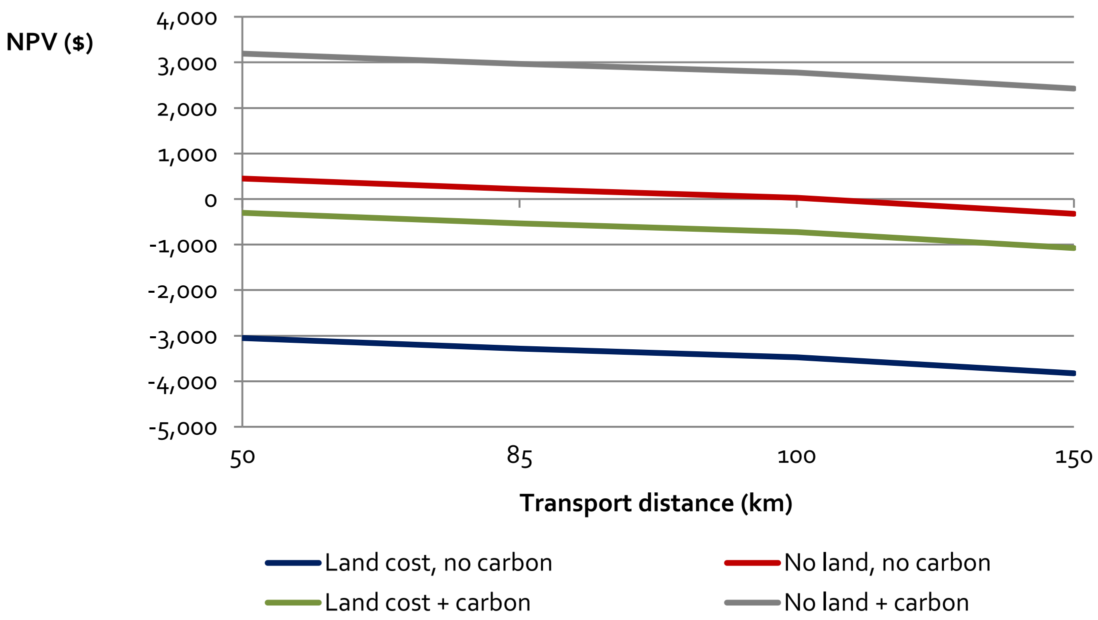
Two case studies were modelled for SE Queensland based on Pine and Araucaria plantations under single long run rotation lengths of 28 years and 45 years respectively. Average land costs obtained from the ABARES Farm Survey data were $3500/ha with a range of $2000 to $7500/ha. Carbon sequestration rates were provided by industry sources from FullCam based on site carbon stock.

Cost and revenue data for the region and different species were provided by industry sources. The modelling indicates that where land costs are included, plantations of pine are not economic at discount rates greater than 7.5 per cent (Figure 3.20). Even when land cost is excluded from the analysis, the economics of pine are marginal (Figures 3.18-3.20).

Pine plantations inclusive of land cost are economic at a carbon price beyond around $20/ t$CO_2$e assuming a transport distance of 85km and discount rate of 8 per cent (Fig 3.19). For Araucaria plantations, the corresponding break-even carbon price is around $35/ t$CO_2$e (Figure 3.22).

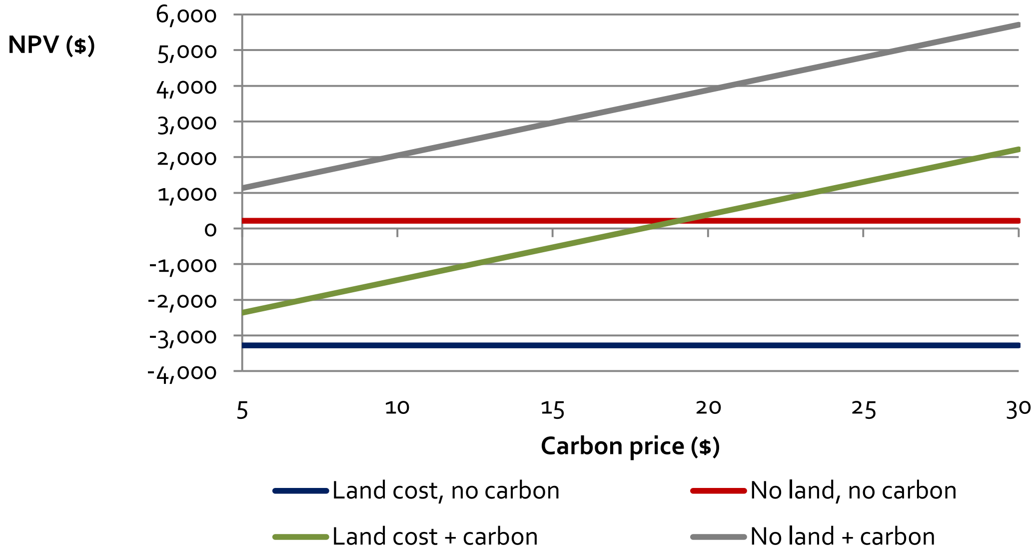
As previously indicated, the methodology adopted to account for carbon in these case studies is likely to overestimate the positive financial impact relative to the conservative methods likely to be adopted by the Australian Government.

Figure 3-18: Net present value against transport distance – SE Qld Pine



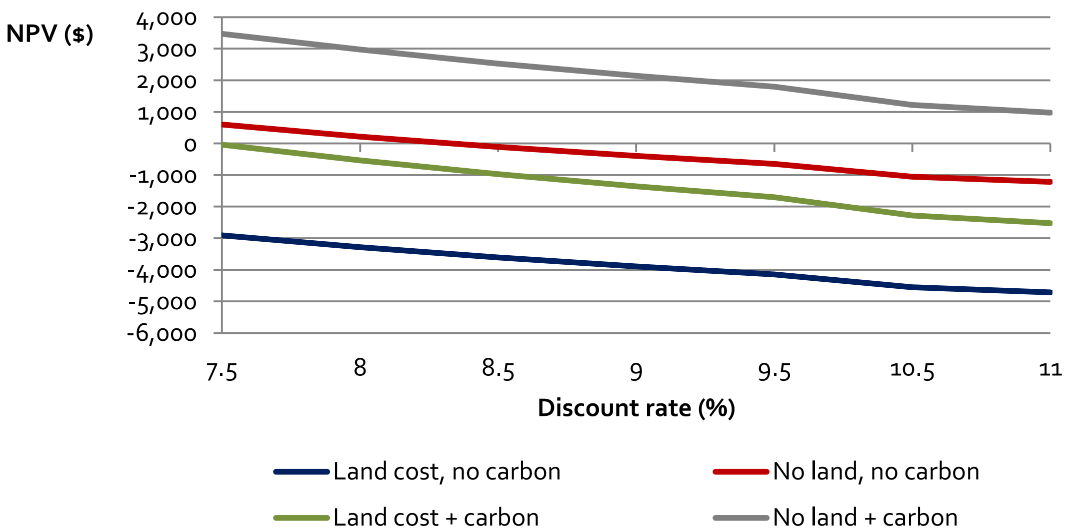
Note: modelling assumes $3500/ha land cost, 8% discount rate, $15/tCO2e carbon price as approximate to current ERF carbon price.

Figure 3-19: Net present value against carbon price - SE Qld Pine



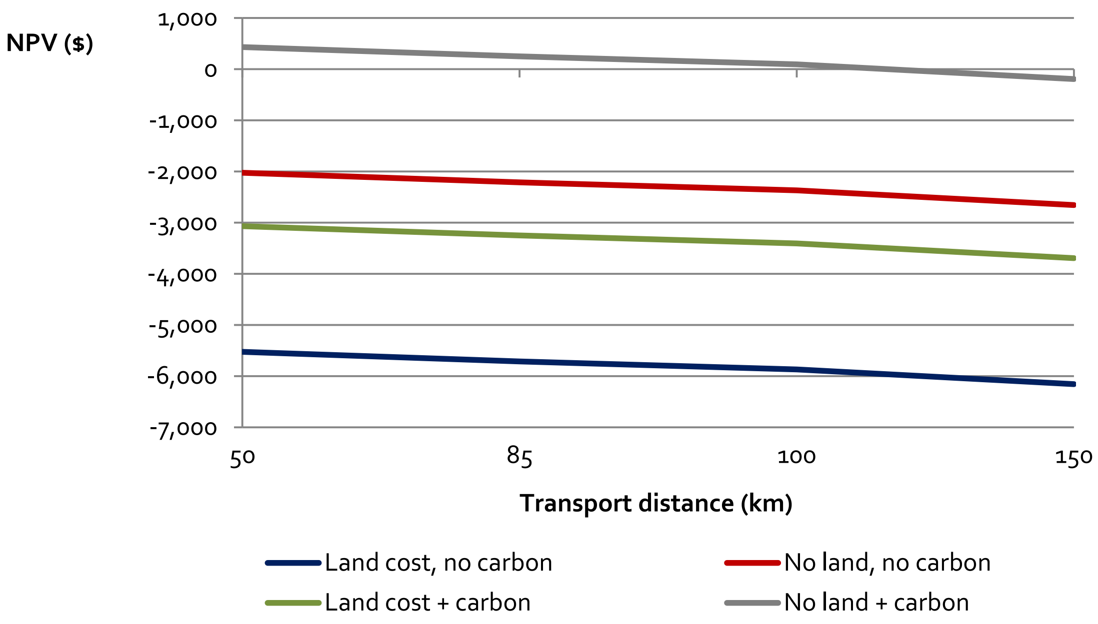
Note: modelling assumes $3500/ha land cost, 85km transport distance, 8% discount rate.

Figure 3-20: Net present value against discount rate - SE Qld Pine



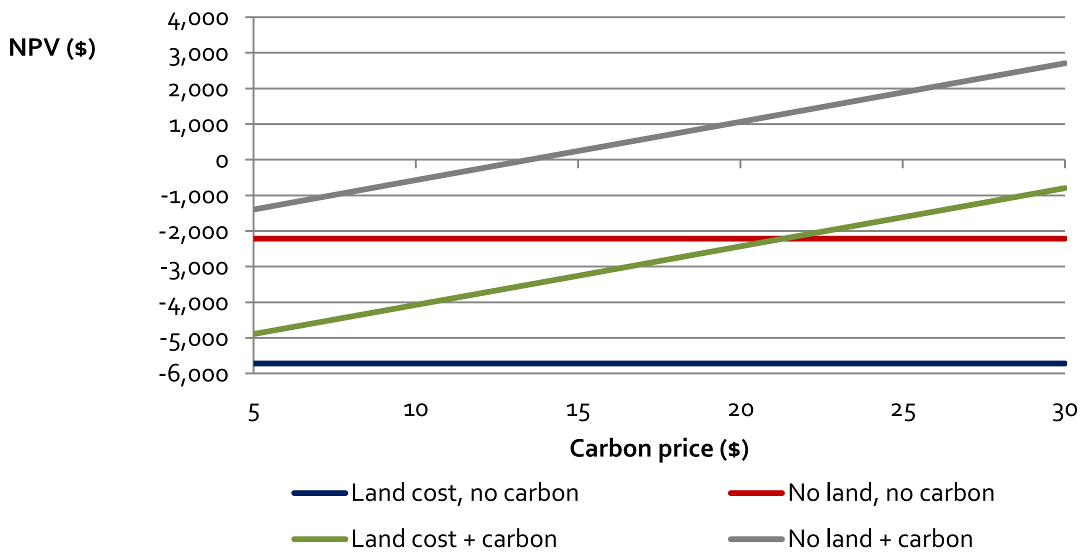
Note: modelling assumes $3500/ha land cost, 85km transport distance, $15/tCO2e carbon price as approximate to current ERF carbon price.

Figure 3-21: Net present value against transport distance - SE Qld Araucaria



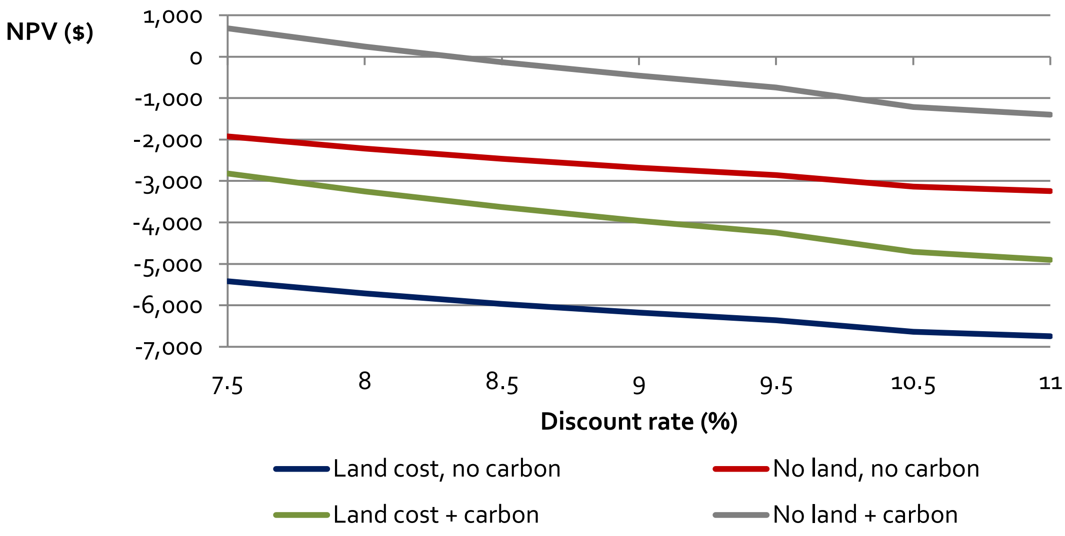
Note: modelling assumes $3500/ha land cost, 8% discount rate, $15/tCO2e carbon price as approximate to current ERF carbon price.

Figure 3-22: Net present value against carbon price - SE Qld Araucaria



Note: modelling assumes $3500/ha land cost, 85km transport distance, 8% discount rate.

Figure 3-23: Net present value against discount rate - SE Qld Araucaria



Note: modelling assumes $3500/ha land cost, 85km transport distance, $15/tCO2e carbon price as approximate to current ERF carbon price.

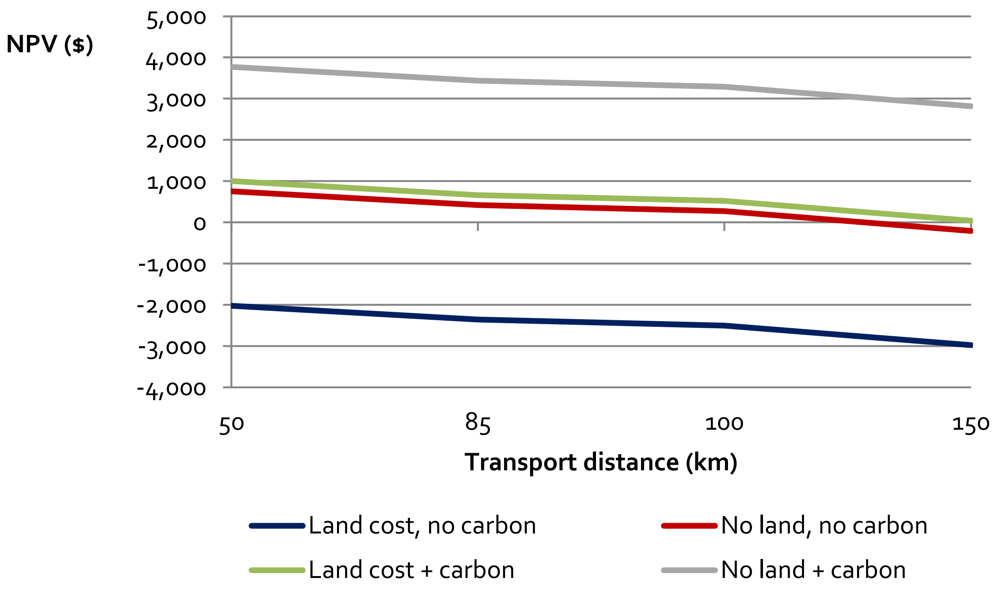
3.5 Additional modelling case study – Western Australia Eucalyptus globulus

A single case study was modelled for SE Western Australia based on a short run bluegum plantation under a rotation length of 12 years. Land costs for the region were unavailable from the ABARES Farm Survey data and were sourced from industry, with an assumed average cost of $3600/ha, and a range of $2200 to $12000/ha. Carbon sequestration rates were provided by industry sources.

Cost and revenue data for the region were also provided by industry sources. As for the other case studies, the modelling indicates that where land costs of $3600/ha are included and no carbon revenue is available, bluegum plantations are not economic at any transport distance (Fig 3.24). A break-even carbon price of around $15/tCO_2e$ is required to generate a positive return where land must first be purchased. This is somewhat lower than for most other regions due to the relatively modest land cost and relatively high carbon sequestration credits available to WA bluegum.

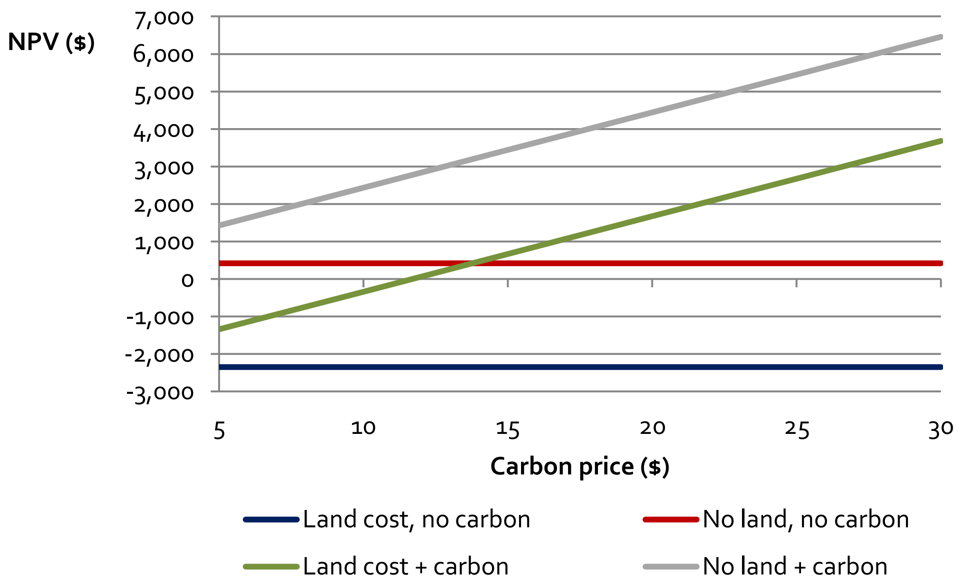
When land cost and carbon are excluded from the analysis, the economics begin to improve at a discount rate of less than 9.5 per cent (Figure 3.26) or at a transport distance less than 120km to a processing facility (Figure 3.24).

Figure 3-24: Net present value against transport distance - WA Eucalyptus globulus



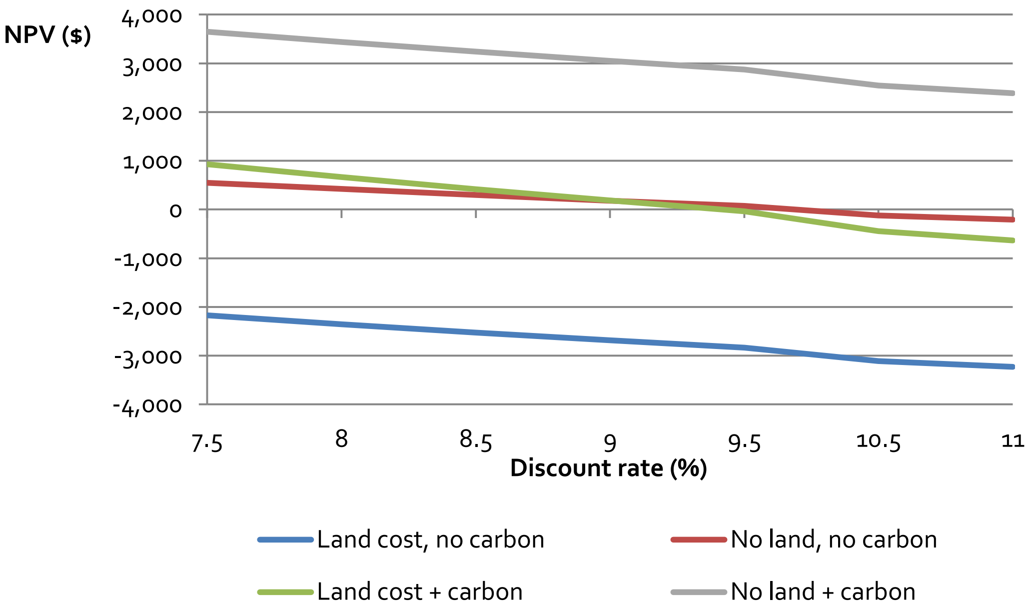
Note: modelling assumes $3600/ha land cost, 8% discount rate, $15/tCO2e carbon price as approximate to current ERF carbon price.

Figure 3-25: Net present value against carbon price - WA Eucalyptus globulus



Note: modelling assumes $3600/ha land cost, 85km transport distance, 8% discount rate.

Figure 3-26: Net present value against discount rate - WA Eucalyptus globulus



Note: modelling assumes $3600/ha land cost, 85km transport distance, $15/tCO2e carbon price as approximate to current ERF carbon price.

3.6 Additional sensitivity analysis

Further sensitivity analysis was not undertaken in this report, however it is clear from the sensitivity analyses already undertaken that land cost is a significant factor in determining the commerciality of new plantation forest. Carbon price, transport distance and discount rate also generate significant variability in NPV, and were considered the other key parameters in economic viability.

de Fegely, Stephens and Hansard (2001) undertook sensitivity analysis for other variables including land cost, establishment cost, maintenance costs, MAI, and average log price for a representative softwood sawlog plantation (Table 3-5). When each of these variables were varied by a 50 per cent positive change, they found that higher growth rates (i.e. MAI) and log prices were the most sensitive with a 30 per cent impact on IRR, followed by land costs at 22 per cent. Establishment and annual maintenance costs varied by 11 per cent and 9 per cent respectively. They found similar order of magnitude results for hardwood sawlog plantation.

Table 3-5: IRR sensitivity to a 50% positive shift in variable

Sofwood Sawlog Plantations	Original	New	IRR	Impact
Land Price	5000	2,500	5.6%	22%
Establishment & Periodic costs	2800	1,400	5.1%	11%
Annual Maintenance	120	60	5.0%	9%
MAI	21	32	6.0%	30%
Average log price	46	53	6.0%	30%
IRR		**4.6%**		

4 Spatial mapping

4.1 Australia's forest products industry – geographic extent

The terms of reference call for a spatial map of areas suitable for future plantation expansion and distances to port and processing infrastructure.

Figure 4.1 provides a map of the existing Australian forest products industry, including the location of major wood processing facilities, hardwood and softwood plantations, native forest tenure, and roads and ports utilised by the forest industry (ABARES 2015b). The map also includes information on sawmills, employment, historical and projected national sawlog availability, the areas under forest or plantation, and new plantation area by planting year.

By their very nature, the National Plantation Inventory (NPI) regions denote the areas where plantations are likely to be generally more suitable given the large areas of existing plantation and processing facilities (refer Figure 3-1). ABARES has also spatially mapped the area of cleared agricultural land in Australia that is potentially available for reforestation in a carbon trading context (Burns et al. 2011). Figure 4.1.1 reproduces this map.

However, there are several important issues to note. First, as is clear from the case studies in this report, there is limited information available regarding suitable plantation expansion areas by region. There are very few studies where these areas have been mapped in detail taking into account biophysical (i.e. site productivity) and economic factors such as land cost and available infrastructure. Second, high cost land such as prime agricultural land (PAL), does not have a common definition (or no definition) between States. Third, for those States that do define a concept such as PAL, there is in most cases limited accessible information on the areas so defined.

Queensland has undertaken comprehensive spatial mapping of strategic cropping land and prime agricultural areas, and NSW has mapped strategic agricultural land, and these maps are shown in Figures 4.2 to 4.4.

Tasmania has undertaken detailed land capability modelling however the information is only available at a localised level and not state-wide. Victoria's land capability assessments appear to be incomplete based on information available online, and those assessments that are available are highly localised.

The authors have been unable to obtain information on land capability assessments in Western Australia and South Australia.

Figure 4-1: **Australia's forestry industry**

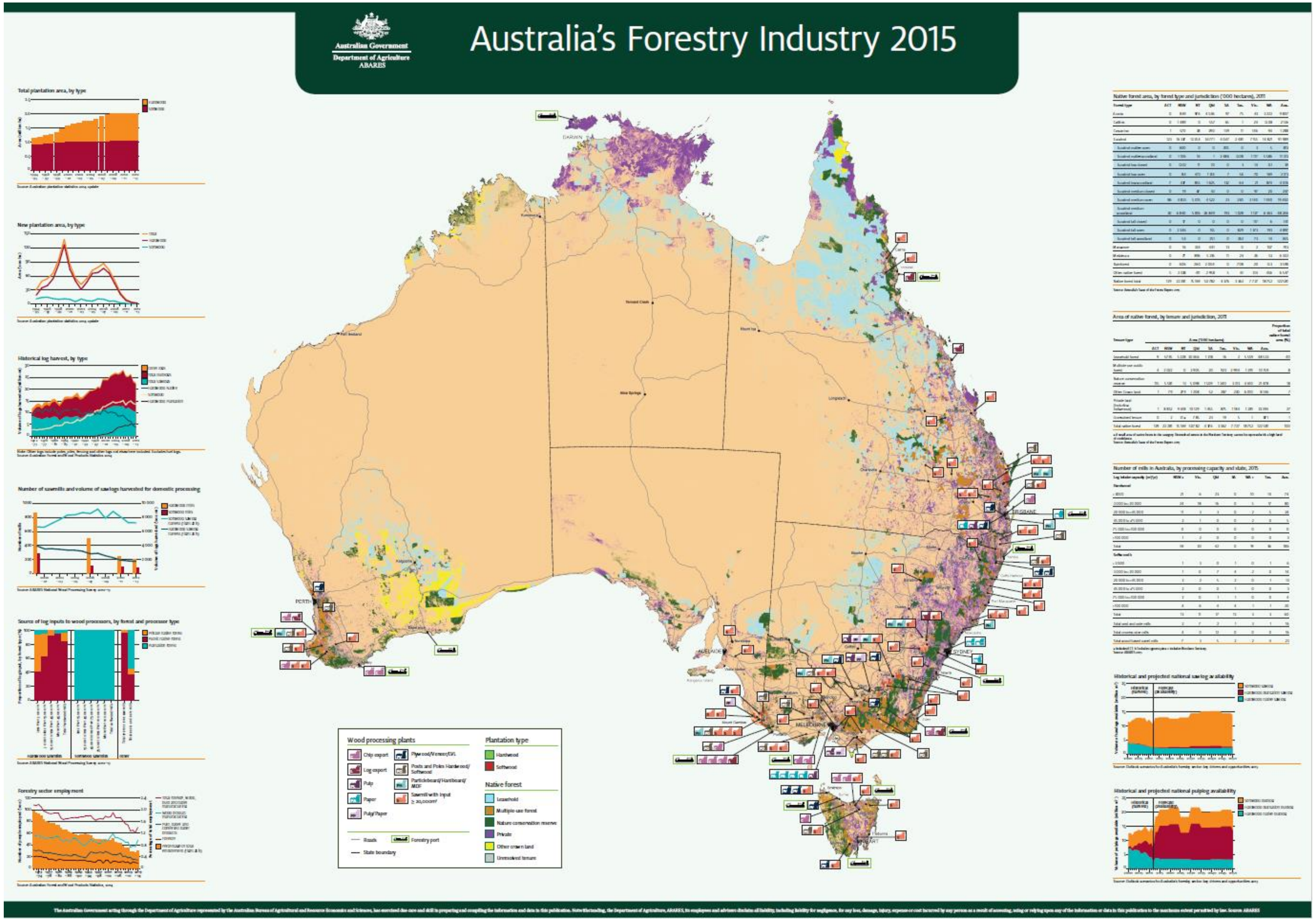
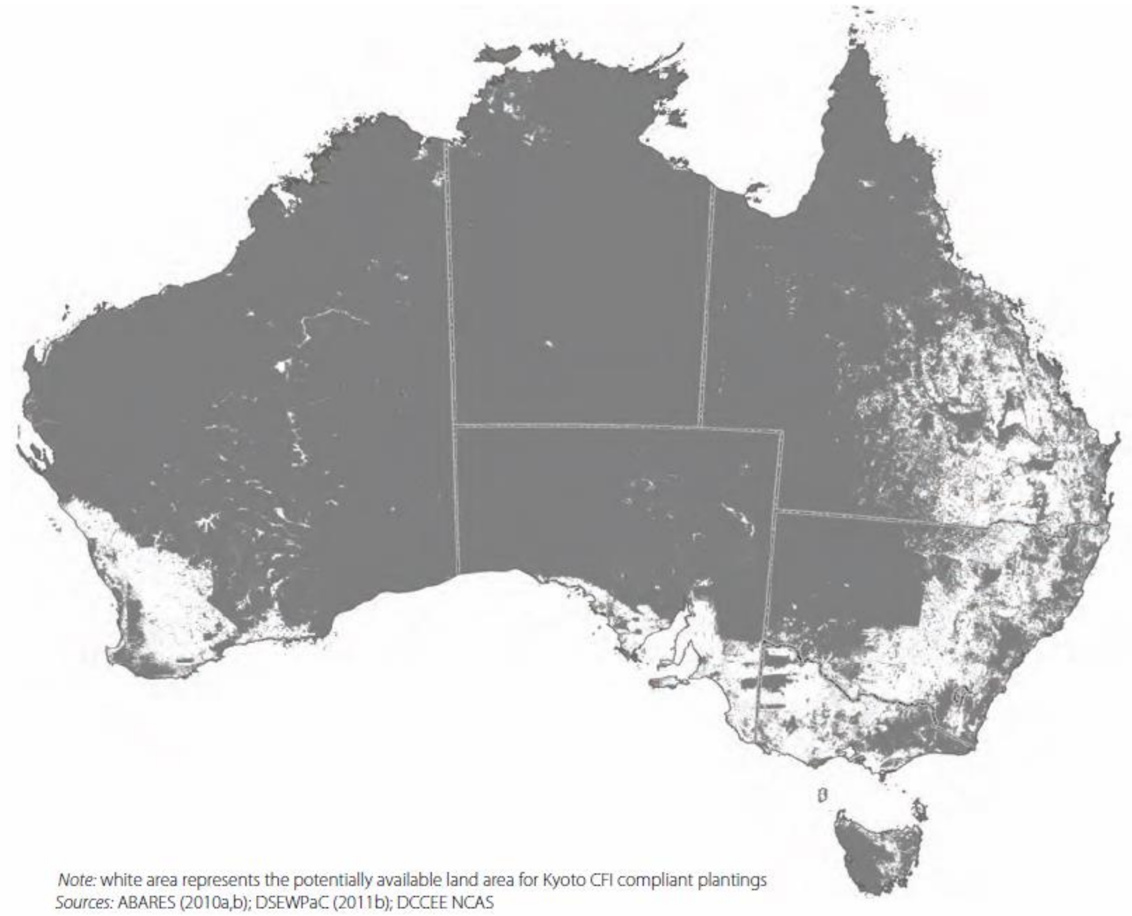

Australian Government
Department of Agriculture
ABARES
Australia's Forestry Industry 2015
DARWIN
PERTH
ADELAIDE
MELBOURNE
SYDNEY
BRISBANE
HOBART
Wood processing plants
Chip export
Log export
Pulp
Paper
Pulp/Paper
Plywood/Veneer/LVL
Posts and Poles Hardwood/Softwood
Particleboard/Hardboard/MDF
Sawmill with input ≥ 30,000m³
Plantation type
Hardwood
Softwood
Native forest
Leasehold
Multiple-use forest
Nature conservation reserve
Private
Other crown land
Unresolved tenure
Roads
State boundary
Forestry port

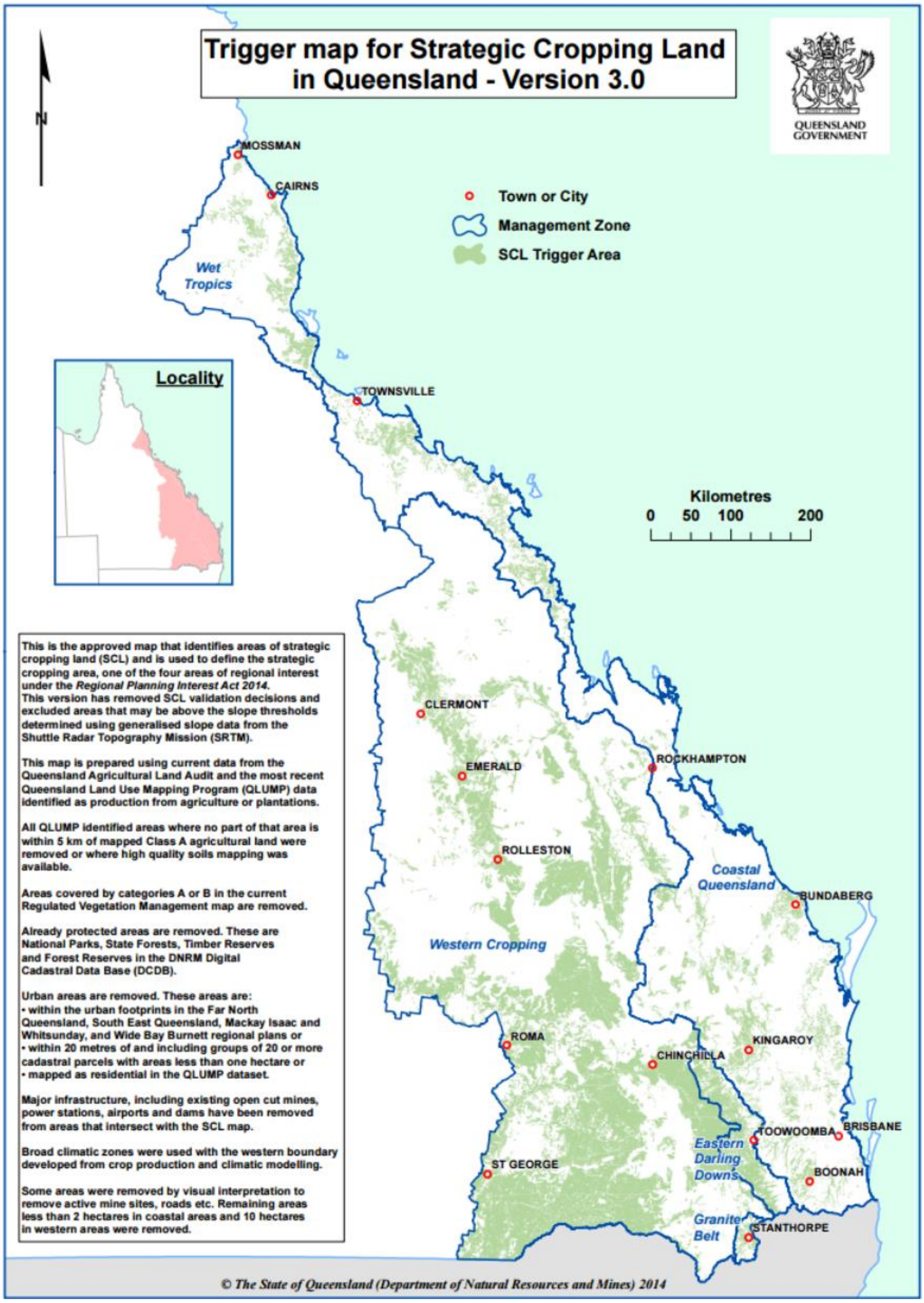
Figure 4-2: Potentially available cleared agricultural land



Note: white area represents the potentially available land area for Kyoto CFI compliant plantings
Sources: ABARES (2010a,b); DSEWPaC (2011b); DCCEE NCAS

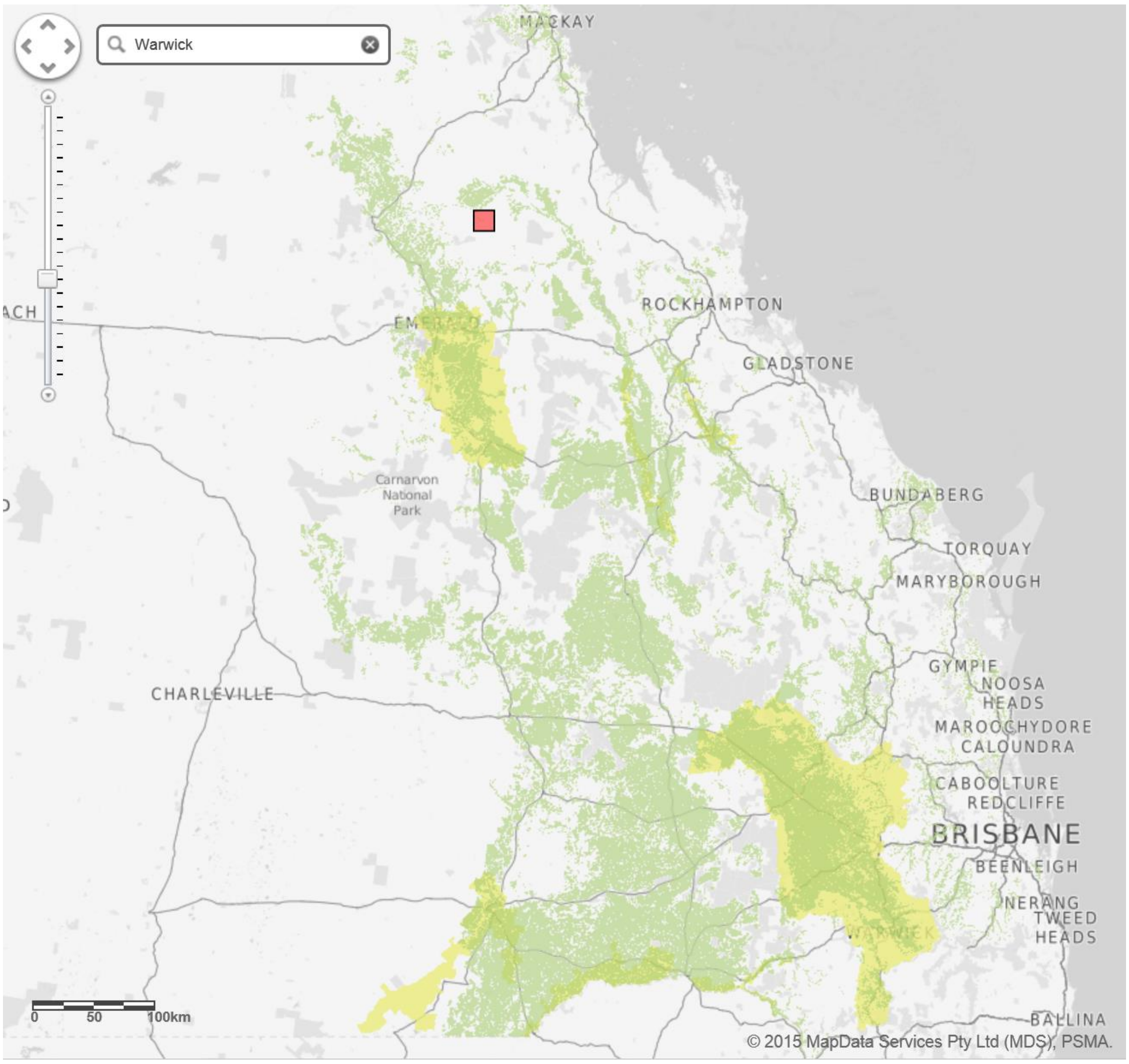
Source: Burns et al. (2011).

Figure 4-3: Queensland map strategic cropping land



Source: https://www.dnrm.qld.gov.au/land/accessing-using-land/strategic-cropping-land

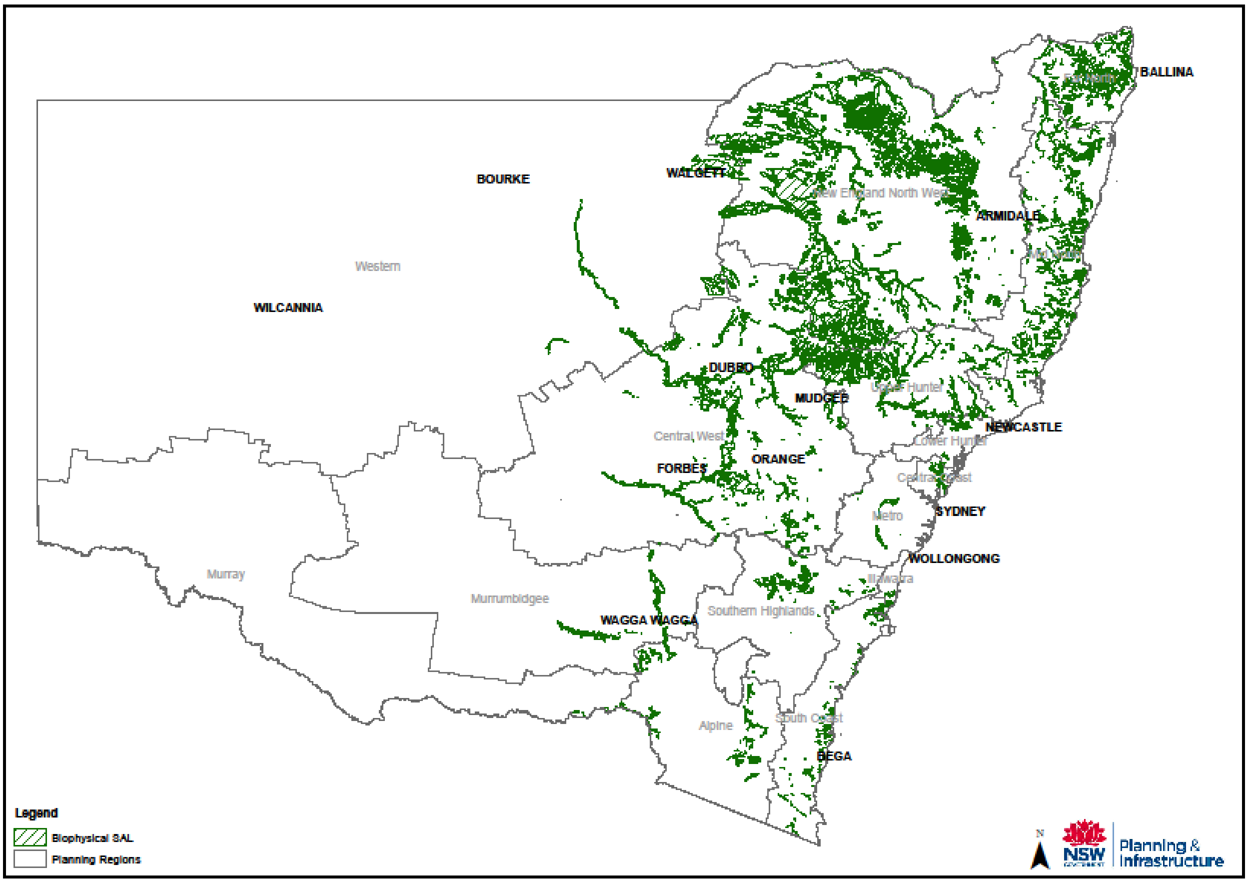
Figure 4-4: Regional Queensland – Strategic Cropping Land and Prime Agricultural Areas



Source: http://dams.dsdip.esriaustraliaonline.com.au/damappingsystem/

Note: yellow=PAA; green=SCL

Figure 4-5: NSW map of strategic agricultural land



Source: http://www.planning.nsw.gov.au/~/media/Files/DPE/Maps/map-biophysical-sal-across-the-state.ashx

Conclusions

In summary, the main conclusions from this analysis include:

- plantation development has currently stalled in Australia;
- in the absence of any new investment mechanisms for new plantations, based on current trends, Australia will be increasingly reliant on imports of timber products to meet the growing demand for domestic consumption;
- it is difficult for investment in new plantations to achieve commercial rates of return at current land costs, and therefore they do not compete for high value agricultural land;
- receiving payment for the carbon sequestered provides one means of improving the commercial viability of plantation investment, but this is dependent on future carbon prices;
- new investment in plantations should be located close to processing regions or export facilities, such as within 100 kilometres, to minimise transport costs and maximise viability; and
- there is scope for farm forestry activities to play a greater role in new wood plantation investment, given their multiple benefits including the enhancement of agricultural productivity.

The proportion of plantation forest to agricultural land is very small at half of one per cent of total agricultural land in Australia. While there are around fifteen key forestry regions around the country, the economics of expansion outside of these zones, or even beyond an approximate 100 km radius from processing and port facilities is not good. To this end, Australia may experience a looming shortage in domestic plantation timber and wood fibre supply.

The economics of plantation expansion are challenging. The IRRs for long rotation hardwood and softwood sawlog plantations established on agricultural land have been shown in the literature to be less than 5 per cent. This poor profitability is attributed to the high upfront cost of acquiring suitable land, with growth rates and product returns insufficient to cover these costs. Allowing additional revenue through carbon credits perhaps raises the investment to an acceptable rate of return but only at relatively high carbon prices, high wood yields and low land acquisition costs. This is particularly the case for farm forestry, where there is scope to generate a positive return with carbon trading, assuming a lower land cost given other agricultural productivity benefits.

Case studies modelled in this report confirm the challenged economics of plantation forestry across multiple key forestry regions in Australia. Each case study has confirmed that new industrial plantations are uneconomic where land must be acquired at the average regional cost per hectare. This suggests that the only land viable for plantation forestry will be the least productive and hence least expensive land in the region, or land that is attainable at no capital cost. From this perspective it is clear that industrial scale forestry expansions into prime agricultural land zones will be unlikely. The modelling also showed that if carbon sequestration revenue is available, plantation forestry economics improve. In most cases, to achieve an 8% rate of return, the break-even carbon price for industrial plantations purchasing land at the local average land price is around $20-25/ tCO_2e$. At these carbon prices, the projects are economically viable, however it is important to note that the methodology used to calculate carbon revenues likely overstates that which would be available under any negotiated future scheme. For example, the methodology likely to be adopted by the Australian Government would generate much lower carbon revenues than the average carbon site stock approach adopted in the modelling of the case studies.

Multiple studies by ABARES, CSIRO and others have also shown that plantation forestry cannot compete for high value agricultural land, even when sequestration credits are included at significant carbon prices. While there has been some land competition from MIS companies in the past, the collapse of many MIS companies and the rationalisation of these resources by the new owners could result in at least 30 per cent of former MIS plantations not being replanted.

Plantation forestry does have potential for land-based sequestration and is of assistance in helping to achieve Australia's emissions reductions goals. While over half of the recent Emissions Reduction Fund auction projects were sequestration based, these were not plantation related and were based on avoided deforestation (i.e. avoided native vegetation clearing) projects. Furthermore, the price paid for these credits was $13.90/ tCO_2e$. While this carbon price is clearly sufficient to have made some sequestration projects viable (as required by the qualifying rules of additionality), according to the studies reviewed in this report and our own modelling, this is below the price that would be required to allow plantation forestry investments to compete with agriculture. Given the size of the carbon price that would be required for a qualifying plantation investment to break-even on prime agricultural land and even more marginal agricultural areas, this suggests that large scale land use change of this sort would not be triggered by successful bids by plantation managers for carbon farming initiative funding.

The difficulty of achieving a commercial return for investment that includes the cost of land suggests that alternative plantation expansion strategies may be attractive as part of an overall plantation mix. Farm forestry approaches where trees are established as a part of an existing farming enterprise have not been extensively adopted in Australia. These avoid the high initial capital cost of acquiring land, and can provide long-term benefits to farming enterprises through on-farm benefits and the diversification of farm income. Government policy to foster the development of integration of trees with agriculture may help overcome some of the previous barriers to commercial tree investment by farmers.

However, if CFI legislation limited, for example, plantation eligibility on prime agricultural (i.e. high value) land it would also generate significant additional regulatory burden.

Indeed, investors are likely to observe such regulatory change as contributing to an environment already perceived as high in sovereign risk, and further exacerbate the decline in both plantation investment and associated infrastructure such as processing facilities. This will occur as investors factor greater risk levels into the discount rate used in financial analysis.

Lower investment will have several negative consequences including a reduction in the public good characteristics of forestry projects, including carbon sequestration, ecosystems services, landscape rehabilitation, soil and water conservation and enhanced biodiversity. Moreover, it will reduce industry diversity and place pressure on the balance of trade through greater imports as timber shortages are exacerbated.

Placing further limits on project qualification generates additional complexity, expense and uncertainty. Some options being considered by policy makers include limiting eligibility on:

- state designated prime agricultural land or other land use surrogates; and
- in the absence of any such designations, any land that has been used for agricultural purposes for at least 3 of the 5 years preceding plantation investment.

For such examples, both commercial and farm forestry investors would need to confirm that their investment does not encroach on prime agricultural land. This is a significant additional challenge for investors particularly in light of inconsistent definitions of prime land across States and Territories, and an apparent lack of information in some regions. In these areas, any legislative changes would also generate a significant time and monetary cost to local authorities who will be required to complete mapping of the 'relevant land designations'.

Moreover, the '600mm rainfall rule' in the CFI legislation is a significant regulatory burden as most wood plantations will require 600mm of rainfall as a minimum to be commercially viable. The 600mm rule in the CFI to require water interception approval from the Commonwealth for any new wood plantations duplicates existing water regulation via the National Water Initiative and state implementation and is unnecessary.

In a non-interventionist 'small government' environment, there is a strong argument that the free market should decide land use allocation based on its highest value use. The regulatory burden, sovereign risk, cost and uncertainty associated with such legislative change does not appear to be warranted given that the market is taking care of the issue. Numerous submissions to the 2011 Inquiry into the Future of the Australian Forest Industry made this point, and the House of Representatives Standing Committee on Agriculture, Resources, Fisheries and Forestry is on record stating that 'plantations can make a local impact on land competition, but at a regional or national level, their impact has been overestimated. It supports the principle that the market be used to allocate land to the highest-value use' (Commonwealth of Australia 2011).

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Appendix 1: Terms of Reference

Terms of Reference

1. A short literature review of economic studies into the potential for the expansion of plantation forestry in Australia, considering plantation establishment at both industrial and farm forestry scales and identifying significant forestry hubs in each state with existing processing, export and transport infrastructure.
2. Case studies (hubs), including Green Triangle, Latrobe Valley, Tumut/Tumbarumba, North Coast NSW, North and Southeast Queensland, to provide examples of the logistics and infrastructure required to underpin the economics of plantation development at both industrial and farm forestry scale including:

- the cost of plantation establishment (hardwood, softwood, sawlog, and pulpwood - reflecting the intended silviculture and rotation length) and management (recognising different scales) including costs associated with and sensitivity to :
  - land costs taking into account productivity for various land use categories/types (e.g. soil and rainfall zones),
  - establishment costs
  - silviculture costs
  - harvesting costs
  - transport costs
  - interest rates and taxation; and
  - other relevant costs
- the income derived from:
  - prices (delivered prices to a mill gate for various product classes)
  - participation in the CFI, the impact of a carbon price for plantations:
  - how much carbon per hectare per year could be sequestered
  - the potential of carbon revenue to improve plantation profitability and support the diversification of rural/agricultural industries:
    - based on a range of carbon prices (e.g. from \$5 - \$30 – noting the initial ERF auction price of \$13.95 price); and
    - how much would this amount to over 25 years?

3. Spatially map suitable land in the study areas and identify economic transport distances to processing facilities / ports.
4. For the proposed study areas, identify any impediments to plantation establishment, such as:

- availability of suitable land
- competing land uses
- water licenses
- planning constraints (e.g. regulation around land use)
- the next best alternative land use; and
- any other relevant issues.

5. Narrative on any limitations to the expansion of the plantation resource, including scale requirements for economic efficiencies.

Appendix 2: Summary data input for case studies

Note: log prices and revenues are excluded from the individual data input tables for commercial-in-confidence reasons. Carbon revenues per hectare assume $15/t CO_2e carbon price. For the range of pine plantation scenarios assessed, the average mill door price varied from around $40 to $90 per green metric tonne depending on the species and product mix (i.e. extent of pulplog and sawlog).

Hume NSW – Radiata Pine

Period	Activity	Direct costs	Land cost	Maintain costs	Annual costs	Total costs	Carbon Revenue	Volume
		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
0	Establishment	1900	4000		0	5900	315.47	
1					0	0	315.47	
2				400	0	400	315.47	
3					0	0	315.47	
4					0	0	315.47	
5					0	0	315.47	
6					0	0	315.47	
7					0	0	315.47	
8					0	0	315.47	
9					0	0	315.47	
10					0	0	315.47	
11					0	0	315.47	
12				461	0	461	315.47	
13	1st thinning	135.3		126.5	0	261.8	315.47	95

Period	Activity	Direct costs	Land cost	Maintain costs	Annual costs	Total costs	Carbon Revenue	Volume
		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
14					0	0	315.47	
15					0	0	315.47	
16					0	0	315.47	
17					0	0	315.47	
18					0	0	315.47	
19		403.4			0	403.4	315.47	
20					0	0	315.47	
21				253.8	0	253.8	315.47	
22	2nd thinning			135.3	0	135.3	315.47	90
23					0	0	315.47	
24					0	0	315.47	
25		354.09			0	354.09	315.47	
26					0	0	315.47	
27					0	0	315.47	
28					0	0	315.47	
29					0	0	315.47	
30					0	0	315.47	
31				403.4	0	403.4	315.47	
32	Clear fell			354.09	0	354.09	315.47	510

Note – For this scenario, harvest costs are not included as log revenues (i.e. prices) were reported at stump.

MAI	Above ground CO2e
(m3/ha)	t
22	673

South East Queensland – Southern Pine

Period	Activity	Establishment costs	Land cost	Maintenance costs	Production costs	Annual costs	Total costs	Carbon Revenue	Volume
(years)		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
0	Establishment	1500	3500			90	5090	228.21	
1				200		90	290	228.21	
2				125		90	215	228.21	
3				125		90	215	228.21	
4				100		90	190	228.21	
5						90	90	228.21	
6						90	90	228.21	
7						90	90	228.21	
8						90	90	228.21	
9						90	90	228.21	
10						90	90	228.21	
11						90	90	228.21	
12						90	90	228.21	
13						90	90	228.21	
14						90	90	228.21	
15						90	90	228.21	

Period	Activity	Establishment costs	Land cost	Maintenance costs	Production costs	Annual costs	Total costs	Carbon Revenue	Volume
(years)		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
16	Thinning				3000	90	3090	228.21	80
17						90	90	228.21	
18						90	90	228.21	
19						90	90	228.21	
20						90	90	228.21	
21						90	90	228.21	
22						90	90	228.21	
23						90	90	228.21	
24						90	90	228.21	
25						90	90	228.21	
26						90	90	228.21	
27						90	90	228.21	
28	Clear fell				10726.25	90	10816.25	228.21	405

MAI	Above ground CO2e
(m3/ha)	t
17	426

South East Queensland – Araucaria

Period	Activity	Establishment cost	Land cost	Maintenance costs	Production costs	Annual costs	Total costs	Carbon Revenue	Volume
(years)		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
0	Establishment	2350	3500			90	5940	175.67	
1				400		90	490	175.67	
2				100		90	190	175.67	
3				0		90	90	175.67	
4				100		90	190	175.67	
5				150		90	240	175.67	
6						90	90	175.67	
7						90	90	175.67	
8						90	90	175.67	
9				1850		90	1940	175.67	
10						90	90	175.67	
11						90	90	175.67	
12						90	90	175.67	
13						90	90	175.67	
14						90	90	175.67	
15						90	90	175.67	
16						90	90	175.67	
17						90	90	175.67	
18						90	90	175.67	
19						90	90	175.67	
20						90	90	175.67	
21						90	90	175.67	
22						90	90	175.67	
23						90	90	175.67	
24						90	90	175.67	
25						90	90	175.67	

Period	Activity	Establishment cost	Land cost	Maintenance costs	Production costs	Annual costs	Total costs	Carbon Revenue	Volume
(years)		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
26						90	90	175.67	
27						90	90	175.67	
28						90	90	175.67	
29						90	90	175.67	
30						90	90	175.67	
31						90	90	175.67	
32						90	90	175.67	
33						90	90	175.67	
34						90	90	175.67	
35						90	90	175.67	
36						90	90	175.67	
37						90	90	175.67	
38						90	90	175.67	
39						90	90	175.67	
40						90	90	175.67	
41						90	90	175.67	
42						90	90	175.67	
43						90	90	175.67	
44						90	90	175.67	
45	Clear fell				18948.75	90	19038.75	175.67	495

MAI	Above ground CO2e
(m3/ha)	t
11	527

Green Triangle Industrial – Radiata Pine

Period	Activity	Establishment and direct costs	Land cost	Maintenance costs	Annual costs	Total costs	Carbon Revenue	Volume
		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
0	Establishment	1770	5500	7.5	147.5	7425	258.75	
1		280		7.5	147.5	435	258.75	
2		85		7.5	147.5	240	258.75	
3		295		7.5	147.5	450	258.75	
4				7.5	147.5	155	258.75	
5				7.5	147.5	155	258.75	
6				7.5	147.5	155	258.75	
7				7.5	147.5	155	258.75	
8				7.5	147.5	155	258.75	
9				7.5	147.5	155	258.75	
10		30		7.5	147.5	185	258.75	
11				7.5	147.5	155	258.75	
12	1st thinning	2300		7.5	147.5	2455	258.75	95
13		330		7.5	147.5	485	258.75	
14				7.5	147.5	155	258.75	
15				7.5	147.5	155	258.75	
16				7.5	147.5	155	258.75	
17				7.5	147.5	155	258.75	
18	2nd thinning	1510		7.5	147.5	1665	258.75	90
19		330		7.5	147.5	485	258.75	
20				7.5	147.5	155	258.75	
21				7.5	147.5	155	258.75	
22				7.5	147.5	155	258.75	
23				7.5	147.5	155	258.75	
24	3rd thinning	1370		7.5	147.5	1525	258.75	110
25		300		7.5	147.5	455	258.75	
26				7.5	147.5	155	258.75	

Period	Activity	Establishment and direct costs	Land cost	Maintenance costs	Annual costs	Total costs	Carbon Revenue	Volume
		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
27				7.5	147.5	155	258.75	
28				7.5	147.5	155	258.75	
29				7.5	147.5	155	258.75	
30	Inventory	35		7.5	147.5	190	258.75	
31				7.5	147.5	155	258.75	
32	Clear fell	4590		7.5	147.5	4745	258.75	510

MAI	Above ground CO_2e
(m3/ha)	t
25	552

Green Triangle Farm Forestry – Radiata Pine

Period	Activity	Establishment cost	Land cost	Maintenance costs	Annual costs (including insurance)	Total costs	Carbon Revenue	Volume
		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
0	Establishment	1300			110	1410	273.5	
1				190	110	300	273.5	
2					110	110	273.5	
3					110	110	273.5	
4					110	110	273.5	
5					110	110	273.5	
6					110	110	273.5	
7					110	110	273.5	
8					110	110	273.5	
9					110	110	273.5	
10					110	110	273.5	
11					110	110	273.5	
12	1st thinning			715	110	825	273.5	60
13					110	110	273.5	
14					110	110	273.5	
15					110	110	273.5	
16					110	110	273.5	
17					110	110	273.5	
18	2nd thinning			80	110	190	273.5	70
19					110	110	273.5	
20					110	110	273.5	
21					110	110	273.5	
22					110	110	273.5	
23					110	110	273.5	
24	3rd thinning			70	110	180	273.5	95
25					110	110	273.5	

Period	Activity	Establishment cost	Land cost	Maintenance costs	Annual costs (including insurance)	Total costs	Carbon Revenue	Volume
		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(m3/ha)
26					110	110	273.5	
27					110	110	273.5	
28					110	110	273.5	
29					110	110	273.5	
30	Clear fell				110	110	273.5	400

Note – For this scenario, harvest costs are not included as log revenues (i.e. prices) were reported at stump.

MAI	Above ground CO2e
(m3/ha)	t
21	547

Western Australia – Eucalyptus (short rotation)

Period	Activity	Establishment, tending & silviculture	Direct costs	Land cost	Maintenance costs	Annual costs	Total costs	Carbon Revenue	Volume
(years)		($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/ha)	(GMT/ha)
0	Establishment	1200		3600	12	64	4876		
1		310			12	64	386	401	
2					12	64	76	401	
3					12	64	76	401	
4					12	64	76	401	
5					12	64	76	401	
6		8			12	64	84	401	
7					12	64	76	401	
8					12	64	76	401	
9					12	64	76	401	
10		8			12	64	84	401	
11					12	64	76	401	
12	Clear fell		9612		12	64	9688	401	215

MAI	Above ground CO2e
(m3/ha)	t
17.9	320.5