Evaluation of an integrated plantation forestry and beef production system

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Summary

The profitability of timber plantations and combined timber and grazing enterprises were compared to conventional grazing. Scenarios were considered at two sites (one near Kingaroy and one near Nambour) where hardwood plantation forests have been established. At each site a number of contrasting variables were considered. These were: (1) plantation rotation lengths (20, 25 and 30 years); (2) plantation establishment costs (high and low); and (3) prices paid for the timber at harvest (high and low stumpage price). A spreadsheet-based investment analysis tool was used to compare these scenarios. The marginal NPV (net present value) and marginal IRR (internal rate of return) were calculated to indicate the difference in return between the traditional land use of grazing and the introduction of plantation hardwood trees into the traditional just grazing system.

Marginal internal rate of return, which is a measure of the marginal return to the extra funds invested, ranged from 0.46% under the most pessimistic option without cattle, to 10.7% under the most optimistic option with cattle, at the Kingaroy site, and from 2.8% to 13.3% under contrasting options at the Nambour site. The more profitable scenarios occurred when planted forests were coupled with cattle grazing systems. The internal rate of return and net present value were particularly sensitive to the price received for the final product when the trees are harvested. Engineered wood products may provide a future high-value option for the hardwood plantation resource and revenues from commercial thinning may be brought forward if an existing technology (i.e. spindle-less lathe technology) is taken up by industry. Expansion of hardwood plantation forests could help meet the increasing demand for hardwood products in Australia if investments in plantation forests are made. The scenarios considered here demonstrate that there is potential for profitable agroforestry systems in the two regions where plantation forests have been successfully established.

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Background

With the proposed end date for logging in crown native forests in south-east Queensland drawing closer (i.e. 2025) there will potentially be a significantly reduced supply of hardwood timber to supply regional sawmills, which should lead to increased demand from non-crown sources. Further, increasing demand for timber for residential and commercial medium-high rise construction will stretch available timber resources in Queensland. Hardwood plantation forests could help meet the increased demand, if a suitable area of plantation can be successfully established and maintained. While it was originally proposed that hardwood plantations would supply future timber to the industry after 2024, many plantations were established with inappropriate species for the site, and hence in many cases, plantations failed to successfully establish or had much slower growth rates than expected (Matysek & Fisher 2016). Subsequently there has been limited investment in establishing new plantations (Matysek & Fisher 2016). Nevertheless, opportunities exist for investment, particularly from private landholders, if it can be shown that planted forests are a viable alternative enterprise.

One way to enhance the viability of plantation forests is to integrate with other production systems, in particular, combining wood production with cattle grazing. This project aimed to explore the potential of such integrated production systems. Cattle grazing within plantation forests provides an ongoing, regular and relatively consistent income from beef sales to help offset the costs associated with establishment of planted forests. Cattle can usually be introduced into a plantation two to three years after tree establishment and may also provide additional benefits such as mitigating the cost of weed management. Although trees compete with pasture and there is a loss of pasture production as the plantation ages, appropriate plantation management can ensure grazing can continue over the life of the plantation. The potential benefits of such mixed production systems needs to be assessed to determine economic returns when cattle production and timber production are integrated. The few studies that have considered the economic opportunities associated with combining timber plantings with livestock grazing in Queensland suggest that there is potential to increase the profitability above either system on its own (e.g. Donaghy et al. 2009; Maraseni and Cockfield 2011). However, these studies have focused on conventional forest rotation lengths and wood products.

Advances in timber processing methods and engineered wood products is likely to increase the profitability of hardwood plantations. New spindle-less lathe technology has been shown to be able to efficiently convert smaller diameter and lower quality logs, providing an opportunity for commercial thinning operations, and potentially shorter rotation lengths between plantings (McGavin et al. 2014a). These opportunities weren't available until recently. The rotary veneer that results from even young plantation hardwoods grown in Queensland has the properties and qualities suitable for the manufacture of engineered wood products (McGavin et al. 2014b, 2015a and b). Plantations established for engineered wood products, or for a combination of engineered wood products and conventional products (e.g. sawlog and power poles) are likely to require different management approaches from those that currently exist in south-east Queensland. This could positively influence the factors considered in an analysis of agroforestry investments. In addition to accessing markets for smaller diameter logs, and increasing opportunities for livestock grazing, there are three key factors that might influence profitability of plantation forestry: (a) tree growth rates (and survival) and the subsequent rotation length of the plantation; (b) costs associated with plantation establishment; and (c) the likely value of the tree (i.e. stumpage price) when it is harvested. This study has considered these factors though investigation of likely rates of return for a number of scenarios. The scenarios investigated consider two regions in south-east Queensland (the South Burnett and the Sunshine

Coast) in which hardwood plantations have been previously established and are showing reasonable promise in terms of tree growth.

Project objectives

This project investigated different economic scenarios associated with commercial hardwood plantations. In particular, it aimed to explore the following:

- The additional benefits associated with combining cattle grazing with timber production.
- The sensitivities around tree growth rates (rotation length), plantation costs and the price paid for harvested material.

This study is needed to justify further investigations into determining profitable scenarios in which hardwood plantations can be established managed in Queensland. Such studies should help individual landholders and industry leaders when considering investment options for agroforestry with existing grazing systems.

Methodology

Meetings and a workshop with project participants were held to discuss possible scenarios. Two existing hardwood plantation sites were selected as case studies; one in the South Burnett region and one in the Sunshine Coast region (Figure 1). The South Burnett site—referred to as the Kingaroy site—was located near Benair, approximately 20 km south-west of Kingaroy (26.620°S; 151.707°E). The Sunshine Coast site—referred to as the Nambour site—was located approximately 10 km south-west of Mapleton (26.669°S; 152.814°E).

In all the scenarios, it was assumed that the landholder already owned the land (i.e. land purchase was not factored into the analysis). Scenarios were run for a 20, 25 or 30-year period using a paddock size of 40 ha.

Pasture growth and livestock carrying capacity were determined using the GRASP model (Littleboy and McKeon 1997) based on simulations run over 100 years (1918–2017). Stocking rate (hectares per adult equivalent, AE) was calculated based on ‘A condition’ pasture (fully watered) and an intake of 3285 kg/AE/year, assuming median pasture growth over the 100 years. For the Kingaroy site, the ‘bastard scrub’ land type was used and for the Nambour site, the ‘tall open forest on steep hills and mountains’ land type was used. Stocking rate was calculated for varying levels of tree basal area (a measure of forest occupancy on the site). Due to the competitive interactions between trees and grasses, stocking rate varied over time in each scenario. In all scenarios it was assumed livestock were removed from the site for three years after tree planting.

For the tree plantations, the assumptions were:

(1) Costs of plantation establishment and management, up to age five, were determined using information provided by HQPlantations. The high cost scenario ($4236/ha) was based on HQPlantations current (2016) predicted costs. This included site preparation, tree planting, fertiliser, post-planting tending, pruning and non-commercial thinning. The lost cost scenario ($2188/ha) assumed lower costs associated with site preparation (i.e. an existing grass paddock), planting of fewer trees per hectare, and reduced costs associated with weed control, thinning and pruning.

(2) A final tree density of 250 stems/ha for the Kingaroy site and 350 stems/ha for the Nambour site, reflecting higher site productivity in the higher rainfall zone closer to the coast.

(3) That each tree yields 1.06 m^3 of merchantable log, which is equivalent to an average log diameter of 30 cm and log length of 15 m. The relatively small log diameter (i.e. <30 cm small end diameter) reflects the new opportunity for peeler logs. Logs with a small end diameter of <30 cm are rarely accepted by sawmills, due to the low efficiency of traditional sawmilling approaches resulting in low and unprofitable product recoveries.

(4) Tree harvesting occurs at age 20, 25 or 30 years, depending on the growth rate of trees. For the Kingaroy site, this is equivalent to a mean annual increment (MAI, total standing volume/year) of 8.8 m^3/year (slow growth), 10.6 m^3/year (moderate growth) and 13.3 m^3/year (high growth). For the Nambour site, this is equivalent to a mean annual increment of 12.4 m^3/year (slow growth), 14.8 m^3/year (moderate growth) and 18.6 m^3/year (high growth). Existing data on the DAF–Forestry Science database was investigated to confirm the applied tree growth rates were realistic for the two case study sites.

(5) Stumpage price (the negotiated price paid for the merchantable log) was either \$40/m^3 (low stumpage price) or \$80/m^3 (high stumpage price). The high stumpage price assumes a high proportion of high grade logs suitable for higher value products (e.g. higher value poles, or veneer products) is harvested. The lower stumpage price assumes most of the harvested material is lower grade logs.

A total of 24 scenarios were evaluated at each site; 12 with cattle grazing included and 12 without. These scenarios included the various combinations of growth rate, cost of establishment and stumpage price. For each scenario, paddock-level productivity and profitability were assessed over the final investment period which was dependent on the assumed time of harvest. Change was implemented by: (a) developing a plantation forestry investment for the same paddock over the same investment period without livestock; and (b) where a combined livestock and plantation forestry enterprise was being considered, altering the herd performance and inputs of the baseline scenario to construct the new combined scenario. The analysis focused on comparing alternative scenarios, one of which reflected the implementation and results of the proposed change from a common starting point. Discounted cash flow (DCF) techniques examined the marginal returns associated with any additional capital or resources invested. The DCF analysis was compiled in real (constant value) terms, with all variables expressed in terms of the price level of the current year, 2018. It was assumed that future inflation would affect all costs and benefits even-handedly. Spreadsheet-based investment analysis tools (as described by Gittinger (1982), Makeham and Malcolm (1993) and Campbell and Brown (2003)) were used to develop bio-economic models and discounted cash flow budgets for each alternative scenario. The spreadsheets contained livestock and plantation forestry schedules linked to cash flow and investment budgets, for the baseline scenarios and each alternative scenario, with plantations grown for either 20, 25 or 30 years.

The economic criteria were net present value (NPV) at the required rate of return (5%; taken as the real opportunity cost of funds to the producer) and the internal rate of return (IRR). NPV was calculated as the net returns (income minus costs) over the life of the investment, expressed in present day terms. IRR was calculated as the discount rate at which the present value of income from a project equals the present value of total expenditure (capital and annual costs) on the project (i.e. the break-even discount rate). Profit was calculated at the paddock level and did not include an allowance for any variation in the labour and management of the owner associated with the alternative investments. The marginal NPV and marginal IRR were calculated to indicate the difference between the baseline case-study paddock and the paddock after the investment strategy was implemented.

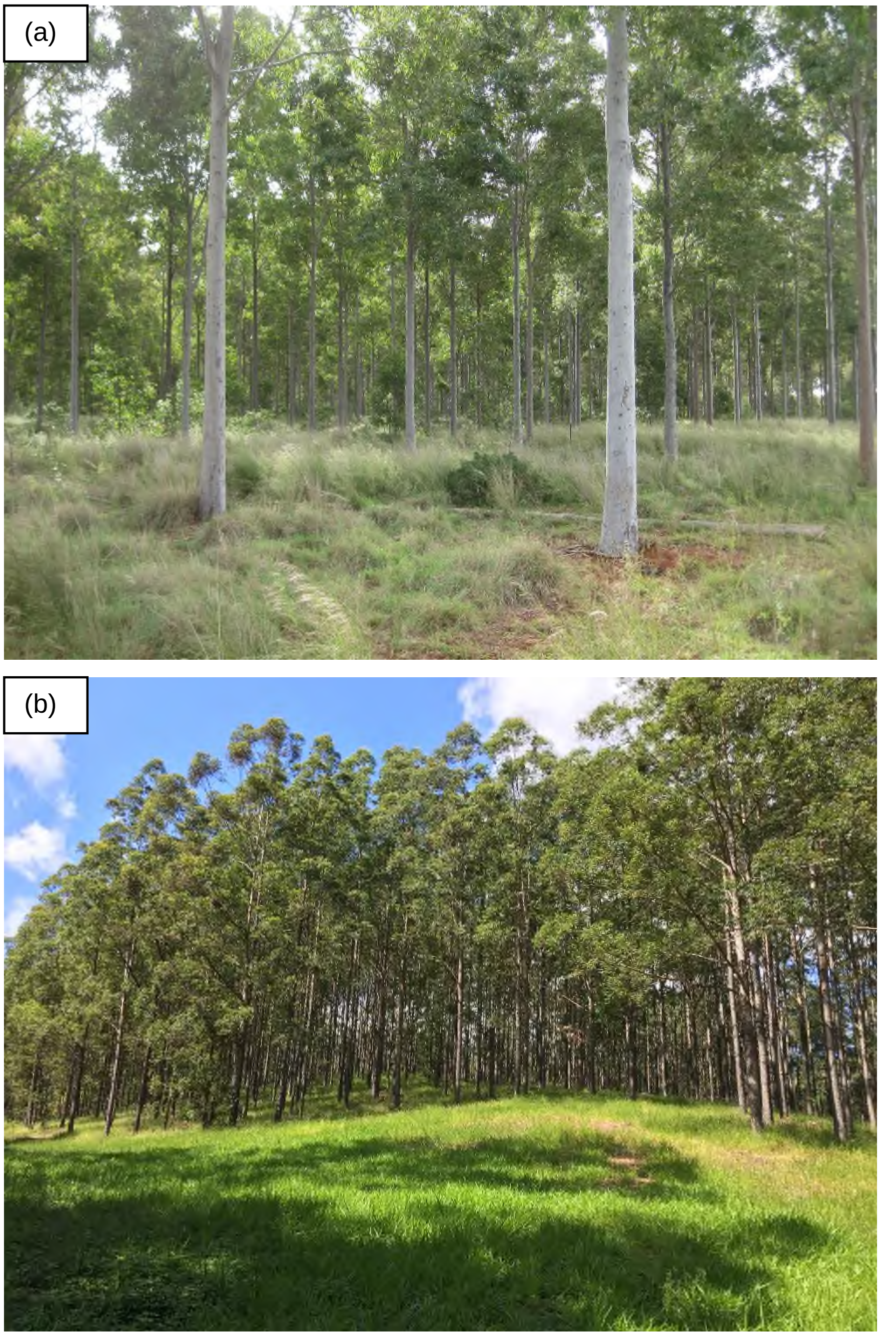

Figure 1. (a) Spotted gum (*Corymbia citriodora* subsp *citriodora)* plantation near Kingaroy, approximately 12 years after planting; and (b) Gympie messmate (*Eucalyptus cloeziana*) plantation near Nambour, approximately 18 years after planting.

Results

Combining grazing and timber production at the Kingaroy site resulted in NPV (5% discount rate) ranging from: –$163 812 under the most pessimistic option (poor growth rate, high establishment cost and low stumpage price option) with timber production only; to $184 469 under the most optimistic option (high growth rate, low establishment cost and high stumpage price option) with combined timber and grazing (Figure 2a). Only three scenarios, all with a high stumpage price, resulted in a positive NPV with timber only (Figure 2a). Including grazing with timber production increased NPV and IRR substantially. When grazing and timber production were combined, seven of the 12 scenarios resulted in a positive NPV for the Kingaroy site (Figure 2a). A high stumpage price was the key determinant of positive NPV. Negative NPV was observed at the Kingaroy site where establishment costs were high and stumpage values were low, irrespective of tree growth rate (Figure 2a). Internal rate of return for the Kingaroy site varied from just 0.46% under the most pessimistic option without cattle, to 10.7% under the most optimistic option with cattle (Figure 3a).

At the Nambour site, NPV ranged from –$88 481 under the most pessimistic option with timber production only to $327 199 under the most optimistic option with combined timber and grazing (Figure 2b). The internal rate of return ranged from 2.8% (the most pessimistic option) to 13.3% (the most optimistic option, Figure 3b). When timber and grazing were combined, only two scenarios (moderate and poor tree growth rates with high establishment cost and low stumpage price) resulted in a negative NPV and IRR of less than 5% (Figures 2b, 3b).

Across all 12 scenarios considered at the Kingaroy site, the average IRR was 3.9% (average NPV of –$31 578) with timber only and 5.8% (average NPV of $30 332) when timber and grazing were combined. At the Nambour site, across all scenarios, the average IRR was 6.7% (average NPV of $77 856) with timber only and 7.7% (average NPV of $113 972) when timber and grazing were combined. Thus combining grazing with timber production was more beneficial at the Kingaroy site than it was at the Nambour site. This was because cattle grazing was more profitable (i.e. a greater number of steers could be managed) at the Kingaroy site.

Maraseni et al. (2009) also reported the financial benefits of including cattle grazing with timber plantings for a spotted gum plantation near Kingaroy, but did not consider shorter rotation lengths associated with peeler logs. A NPV of $2 865 per hectare for a combined timber and livestock enterprise at age 30 and a NPV of $2 091 per hectare for timber alone was reported by Maraseni and Cockfield (2011). The findings of the current study suggests such values may be possible under certain scenarios (i.e. high or moderate growth rates, and high stumpage prices) but this study highlights the importance of sensitivities around rotation length (i.e. tree growth rates), plantation establishment costs and stumpage prices.

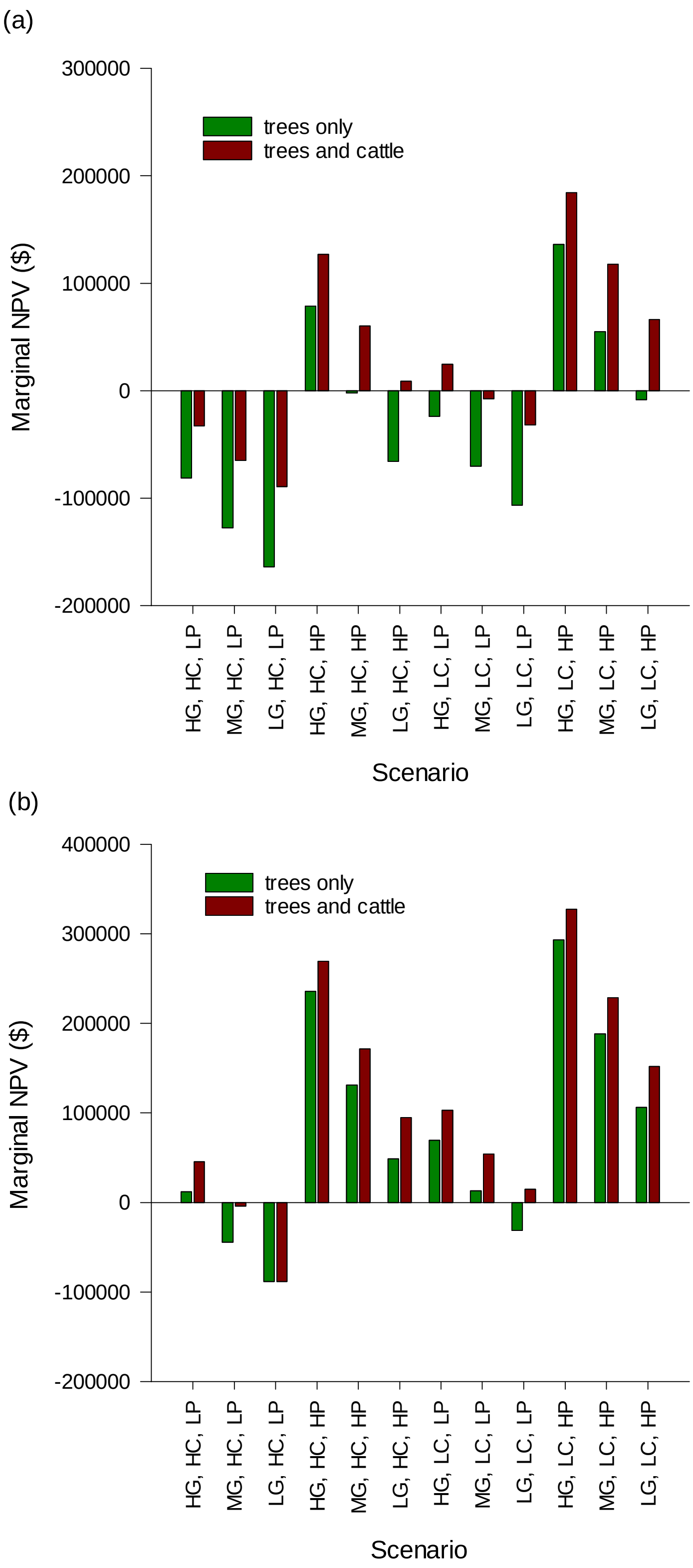

Figure 2. Net present value (NPV, marginal above cattle alone) under different scenarios of trees growth rate (HG, MG, LG: high, moderate and low growth, respectively), cost of plantation establishment (HC, LC: high and low cost, respectively) and value of timber (LP, HP: low and high price of timber, respectively) for a 40 ha plantation near Kingaroy (a) and Nambour (b).

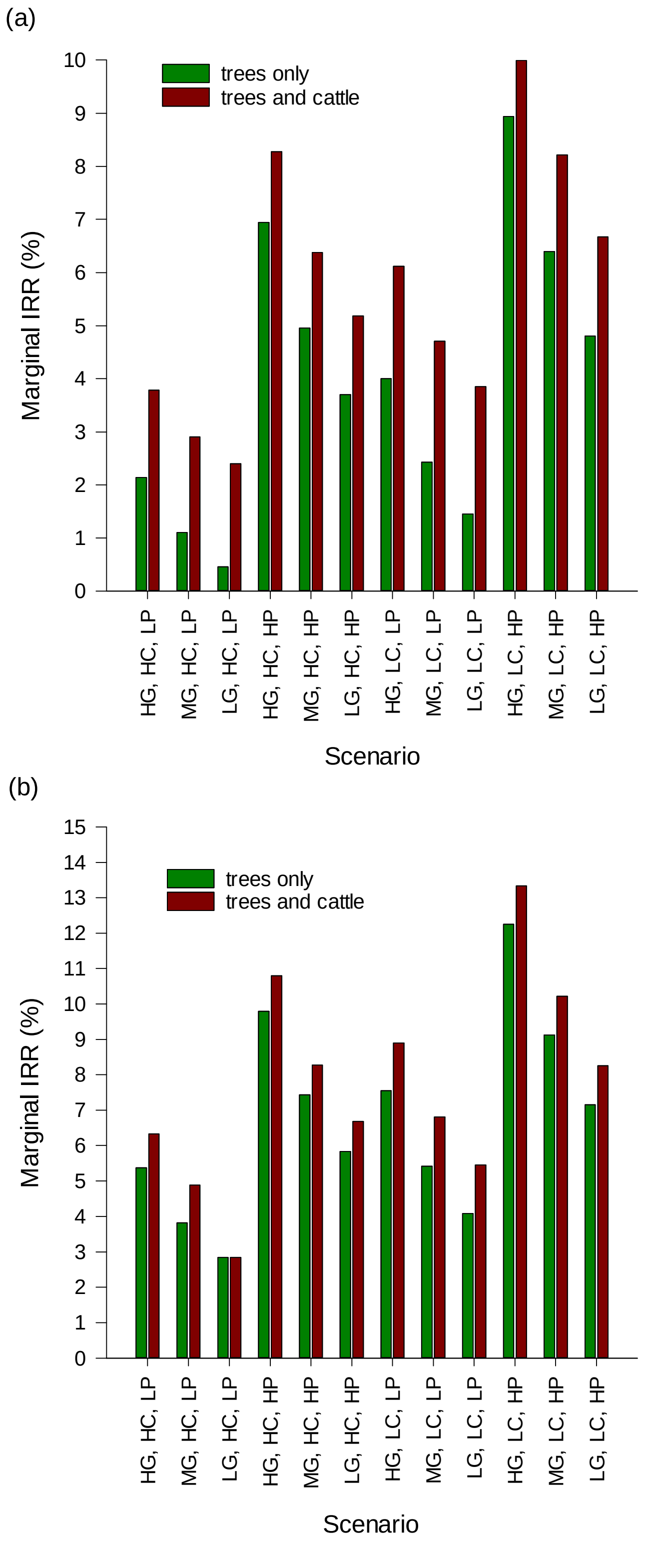

Figure 3. Internal rate of return (IRR, marginal above cattle alone) under different scenarios of trees growth rate (HG, MG, LG: high, moderate and low growth, respectively), cost of plantation establishment (HC, LC: high and low cost, respectively) and value of timber (LP, HP: low and high price of timber, respectively) for a plantation near Kingaroy (a) and Nambour (b).

Conclusions/significance/recommendations

Key factors that influence the profitability of plantation forestry include establishment and management costs, tree survival, growth rates and rotation length, access to markets for commercial thinning with utilisation of smaller logs and acceptable prices for the product at the end of the rotation. The current study demonstrated that variation in some of these factors (where plantation species are assumed appropriate for the site, with good survival and health of planted trees) can result in a wide range in marginal IRR and NPV. Stumpage price had a particularly strong influence on profitability. This highlights the importance of growing products that are likely to be of greater value at the time of harvest. In Queensland, hardwood stumpage prices are currently driven by native forest product prices. As such, products from plantations would need to be of a similar quality to that from native forest or at least be suitable for efficient processing.

For private landholders, cash flow and the perceived riskiness of the venture are likely to be critical to the success of a plantation forestry enterprise. The income from livestock grazing within the plantation provides a steady cash flow and this is likely to be a contributing reason why silvopastoral system have been successful in many other countries. Unless thinning prior to harvest produces profitable products, cash flow patterns with plantation forests will be negative until harvest. Certain scenarios in the current study assume that the grower has to only wait 20 years for the final harvest, which may be considered optimistic and assumes that there is a market for smaller diameter logs grown in plantation or thinning material of smaller diameter. Indeed, opportunities could be explored that reduce the rotation length below 20 years, which would be expected to further improve the profitability of the plantation and also reduce some of the investor concerns associated with long-term investments.

Use of the spindle-less lathe technology would enable smaller diameter logs (down to ~15 cm) to be processed, specifically for the engineered wood products market. The set-up costs for this relatively new technology are a fraction of those required for conventional processing systems (McGavin 2016). The first industry adopter of this technology is confirming the many benefits of the spindle-less veneering approach and several Queensland based processors are currently evaluating the investment. This study did not consider separate scenarios for commercial thinning of small diameter (i.e. <25 cm) peeler logs processed using the spindle-less lathe technology, however, the peeler technology could provide a major incentive for shorter-rotation stands and/or thinnings to produce returns prior to harvest. Early thinning sales, through peeler logs, could provide a means of offsetting thinning costs, further helping the cash flow situation. Assuming a future market for smaller logs (i.e. for engineered wood products using veneers), revenue could be brought forward to help to offset establishment and silvicultural costs. This could have an important effect on the rate of return on investment. In the absence of a peeler market, some thinning material could be sold as piles (with a minimum top-end diameter of 15 cm) or fence posts, although at a lower stumpage value by comparison. Stumpage price of piles (smaller logs, ≤10 m in length) are generally \$25 to \$37/m^3 (equivalent, as these are sold per linear metre). Further work is needed to consider modelling additional options for utilising stems from commercial thinning.

Competing land-use options, such as cropping or horticulture, and the impact of having to purchase land to undertake silvopastoral activities have not been considered in this study. Previous analysis by Venn (2005) incorporated land values and recognised the important trade-off between land-value and tree growth rates. Generally, sites with better tree growth rates (e.g. better soils and rainfall) are located on land that is of higher value. Nevertheless hardwood plantations were still profitable in some regions (e.g. Sunshine Coast) where rural land values are less than $2300/ha. On certain soil types in the Kingaroy district, cultivation cropping has proved to be a more profitable option than pasture or timber plantation, when a carbon value was not included (Maraseni and Cockfield 2011). Agroforestry opportunities are more likely to take place on properties that are no longer viable for cropping, or on soils where cropping is not suitable. The two case study sites considered in the current study feature soils that are less likely to be utilised through cropping systems.

Key messages

- Analysis suggests that returns are very sensitive to factors such as price of product (stumpage), plantation establishment costs and the length of the rotation (i.e. tree growth rates).
- Rates of return were greater for the Nambour site, due to assumed greater volumes of timber available (a function of higher rainfall), despite higher grazing productivity at the Kingaroy site.
- Investors in hardwood plantations should aspire to grow products that are of high value (e.g. including future engineered wood products), whilst minimising the costs of plantation establishment and management.
- The inclusion of spindle-less rotary veneer processing has great potential to positively influence the profitability of hardwood plantations in Queensland.
- Many profitable scenarios arise when plantation forestry systems are coupled with complementary cattle grazing systems. Marginal rates of return are more favourable where livestock grazing occurs under the plantation.
- In absolute terms, the marginal rates of return shown even for the more optimistic scenarios are unlikely to encourage large scale investment in silvopastoral activities in either of these environments.

Where to next

This work has provided the basis for the development of a future multi-agency project to further investigate the potential benefits of the mixed production systems. External funding will be sought to:

- Establish research trials to demonstrate the benefits of advanced mixed production systems and act as demonstration sites for potential investors. Such trials could determine whether certain tree species facilitate greater pasture growth, allowing a greater window of high grazing production prior to canopy closure, and appropriate species for pasture improvement in agroforestry. They could also consider alternative plantation management options, where trees are grown specifically for engineered wood products.
- Consider additional scenarios and sensitivity analysis. In particular, further scenarios should be evaluated, including options that consider commercial thinning of small logs, scenarios where a lower stocking of trees is maintained (encouraging more grazing production) and shorter rotation lengths. Hardwood plantations are usually established at densities of 800 to 1000 stems/ha, before thinning to a final crop, often to only a quarter of the original planting density. Assuming a market is available for peeler logs, perhaps plantations could be

established at a much lower density, and some of the costs associated with thinning and pruning could be avoided. There is also great variation in stumpage prices paid (e.g. from \$10/m³ for salvage material to \$300/m³ for girders). In this study only a moderately 'high' and 'low' option was considered. However, further scenarios could consider a wide range of different, but realistic options.

- Include potential returns from carbon farming in future analyses.
- Consider the economics associated with different processing strategies, product specifications and recovery rates associated with the spindle-less lathe processing technology.
- Develop of a more concise version of the economic spreadsheet used and a web application to allow widespread access to the investment analysis process and aid in the investment decision making process.

Budget summary

Expenditure was less than expected in this project. Labour costs were less than expected as budgeted labour for Business groups outside of Horticulture and Forestry Science was not spent (e.g. collaborators in Animal Science). Hence the labour costs (Table 1) don't realistically reflect the actual labour spent on the project. Travel costs were kept low, as field trips to the study sites were carried out under other projects. Some expected costs associated with travelling to meetings was not required. Budgeted operating costs, such as charges associated with IT and phone expenses for staff and vehicle use, were not costed to this project.

Table 1. Summary of project expenditure relative to amounts budgeted for the project.

Project costs	Budgeted	Spent
DAF labour	\$4536	\$2963
Travel	\$5400	\$442
Operating	\$4600	\$162
Total	\$14536	\$3566

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Key terms and definitions

Discounted cash flow (DCF): Is a valuation method used to estimate the attractiveness of an investment opportunity. DCF analyses use future free cash flow projections and discounts them, using a required annual rate, to arrive at present value estimates.

Net present value (NPV):- Is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used to analyse the profitability of a projected investment or project.

Internal rate of return (IRR): Is used to evaluate the attractiveness of a project or investment (as measure of the return to the funds invested). The higher the IRR the better the investment. It is the rate of return that sets the net present value of all cash flows (both positive and negative) from the investment equal to zero.

Stumpage price: The price per cubic metre a private firm (e.g. sawmill) pays for the right to harvest timber from a given property or site. It is the agreed price paid to the current owner of the land.