AN ASSESSMENT OF SILVIPASTURE POTENTIAL IN SOUTHEAST QUEENSLAND, AUSTRALIA

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ABSTRACT: The Queensland State Government provides incentives for landholders to establish hardwood plantations on former pasture and cropping areas; however the long-term viability of the timber plantation program in medium to low rainfall areas remains questionable. In order to make hardwood plantations viable, some value adding is necessary. Thus, several trials including silvipastoral systems have been undertaken. This paper assesses both the successes of the trials and the additional benefits resulting from grazing in spotted gum (Corymbia citriodora subspecies variegata) plantations at Taabinga, southeast Queensland. The results show that at the optimal harvesting age of 31 years, the cumulative net present value from pasture alone would be A$779/ha. Therefore, there is considerable opportunity for increasing financial returns through the inclusion of pasture within plantations without reducing the rotation age of plantations. This silvipasture system will also offer other benefits such as improvements in soil conservation, soil and biomass carbon sequestration and biodiversity.

1. INTRODUCTION

In Australia, forests have been extensively cleared since European settlement, for a variety of uses but significantly for cropping and grazing as the basis for economic development and nation-building agendas. However, the rate of clearing has decreased significantly from 546,000 ha/yr in 1988 to 187,000 ha/yr between 2000-2003, which is still higher than the annual average plantation rate of 74,000 ha between 2000-2003 (AGO, 2000; BRS, 2005). About 80 percent of land clearing in Australia has occurred in Queensland (AGO, 2000), largely motivated by the availability of low-priced land, quick profits through crop production, and long-term profit via increased value-added land (AGO, 2000). Land clearing in Queensland accelerated in the second half of the 20th century under a government-sponsored development scheme, where low-cost land and low-interest loans were offered under the condition that landholders improve the land through clearing (Fensham and Fairfax, 2003). Tax concessions via the deduction of full clearing costs and low-cost finances provided some additional incentives (AGO, 2000).

The cleared land was predominantly used for grazing. However, in areas with favourable climatic and topographic conditions, much of the cleared land was used for crop production. By the 1980s, increasing costs of crop production, high interest rates and decreasing commodity prices, especially of major cereals, created financial pressure on farmers (Zammit et al., 2001) resulting in land use changes from more intensive cultivation practices to grazed pasture especially in marginal country (Zammit et al., 2001, Maraseni et al., 2006). More recently, with increased environmental concerns on land degradation and dryland salinity, the Queensland Government has encouraged farmers to establish hardwood plantations as a viable alternative on some degraded ex-cultivation and pasture areas (DPIF and DNR, 1999; DPIF, 2000; Brown, 2002).

In southeast Queensland (SEQ) the main hardwood species promoted by government agencies is spotted gum (*Corymbia citriodora* subspecies variegata) which is also the most favoured species for plantation (Huth *et al*., 2004) accounting for >60 percent of native hardwood volume harvested in Queensland (DPIF, 2004a). There are a number of reasons for the popularity of spotted gum as a plantation species: 1) Over time, large areas of SEQ were World Heritage listed, became National Parks or had tenure restricted. This reduced the supply of native timber including spotted gum but demand is still increasing by two to three percent every year (DPIF and DNR, 1999); 2) Although full rotation plantation data are not available, the early-age performance of spotted gum is encouraging (Huth et al., 2004); 3) Preliminary results of the genetic improvement program of spotted gum are promising with seedlings having vegetative propagative capacity, frost tolerance and *Ramularia* shoot blight resistance (Lee, 2005); 4) The timber is preferred for its durability, hardness and pale colour (Huth et al., 2004); and 5) Of the 3.42 M ha of cleared land evaluated for plantation in the South East Queensland Regional Forest Agreement (SEQRFA) region, 2.72 M ha met the slope (<20 percent) and size (>10 ha) constraint, and 73 percent of that was suitable for spotted gum (Queensland CRA/FRA Steering Committee, 1998).

The national policy statement 'Plantation for Australia: The 2020 Vision' has targeted a trebling of the national plantation estate to more than 3 M ha by 2020 (Kirschbaum, 2003). To support this target, the Queensland Government has committed to increase the plantation estates by 320,000 ha between 1996 to 2020 (DPIF, 2000). The 20-year Federal-State SEQRFA, was implemented in 1996 for native forest conservation and timber resource management in SEQ (Brown, 2002). As part of this program, the Queensland Government has approved A$30 M to increase the area of hardwood plantations, especially spotted gum (DPIF, 2004b).

Despite considerable effort by the Queensland Government, the long-term viability of the timbr plantation program, in medium to low rainfall areas, remains questionable (Venn, 2005; Maraseni, 2007). The key driving force for commercial-scale plantations is economic return. To this end several trials, including grazing value in plantations (silvipastoral processes), have been undertaken in Kingaroy as part of the SEQRFA program. How much value adding is possible due to the incorporation of a silvipastoral system, is the main subject of interest in this paper.

1.1 Species description

Spotted gum is a trade name of the group of four species: *Corymbia maculata, Corymbia citriodora subspecies variegata, Corymbia citriodora subspecies citriodora*, and *Corymbia henry. P*rior to 1995 they were placed in the genus *Eucalyptus.* Hill and Johnson, while making taxonomic revisions in 1995, placed them in a new genus Corymbia, series Maculatae and section Politaria under the Family Myrtaceae. Politaria is derived from the Latin word *politus,* which means made smooth or polished, as all species under politaria have smooth decorticating bark throughout (Asnate et al., 2001). *Corymbia citriodia* subspecies variegata, the species of concern in this study, has more frost resistant capacity than others and is most popularly known as spotted gum (Larmour et al., 2000).

Spotted gum is widely distributed in SEQ especially between 25°S to 38°S latitude extending up to 400 km inland and to an altitude of 950 m above sea level (Boland et al., 1984). These trees attain heights of 35-45 m with diameter at breast height (DBH) of 1-1.3 m (Boland et al., 1984); larger dimensions are reached at the southern limits of the species' range in northern New South Wales (Huth et al., 2004). This species has high site adaptability, and copes well with soils that have highly variable fertility, annual rainfall >600 mm, moderate frequency of non-severe frost, low to medium salinity and low to moderately high pH (DPIF, 2004c).

The main grass species under the plantations of the study sites were varieties of native grasses, Rhodes grass *(Chloris gayana)* and the dominant legume species of burr medic (*Medicago polymorpha)* and Siratro *(Macroptilium atropurpureum*). Rhodes grass is a tufted perennial grass whose runners cover the ground surface and produce plantlets. It can tolerate salt and moderate frost and complements many legumes. Burr medic is a smooth-leafed small annual medic. It has naturalised over some 2 M ha of SEQ and provides excellent feed for cattle in 'medic years' when good autumn and winter rainfall follow a dry summer. Siratro is a perennial twining legume established from seed and plant nodules. Despite its high phosphorus demand (Brown, 1983), Siratro is still popular in the study area as it fixes large amounts of nitrogen that are quickly passed on to companion grasses.

Cattle producers in the study area have adopted a crossbreed of *Bos indicus* and *Bos taurus*. The tropical breed *Bos indicus* was chosen for its heat and tick resistance whilst the British breed *Bos taurus* was chosen for its good marbling content, which has significant appeal for the Japanese beef market (C. Marshall, 2005, pers.com., 7 April).

1.2 Site description

This study has been conducted on a property at Taabinga, near Kingaroy (26° 35'S, 151° 50'E) in the southern Inland Burnett region of SEQ (Figure 1). Taabinga is situated approximately 215 km northwest of Brisbane and some 130 km inland from the coast. This property has historically had a wide range of land uses with scrub vegetation until 1950, then peanuts and maize cultivation until 1983 before returning to grazed pasture. In 2001, spotted gum plantations were established in this pasture as part of the SEQRFA program. The plantations are joint ventures between the property owner and the Department of Primary Industries and Fisheries (DPIF).

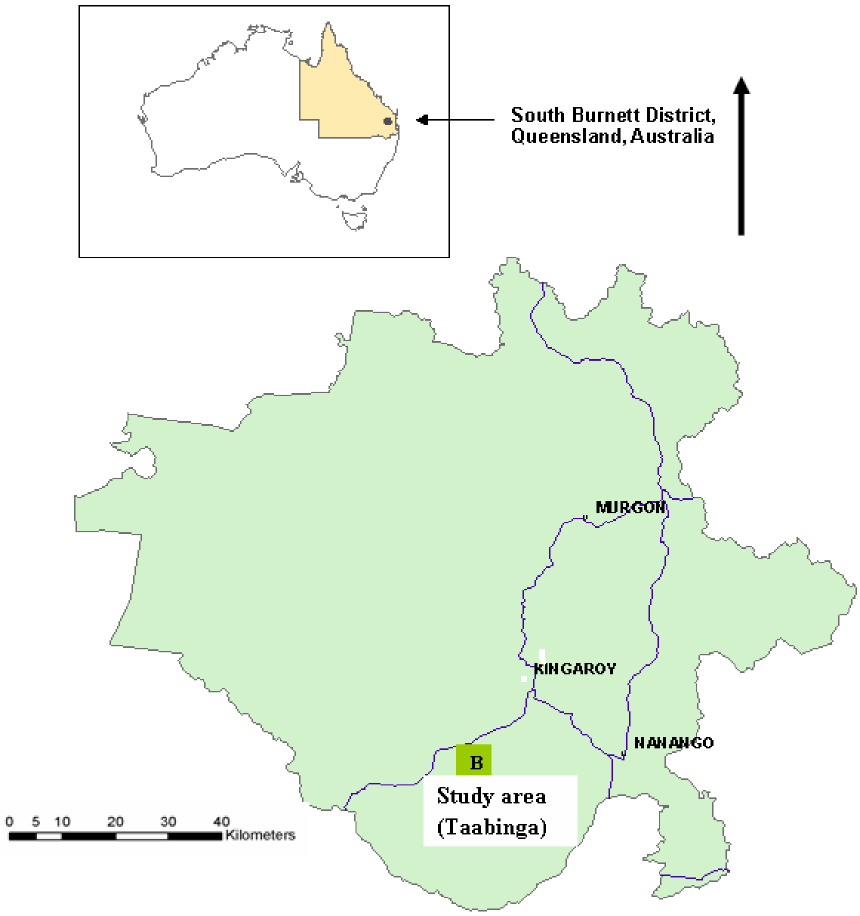

Figure 1. Location of study area (Taabinga) in the South Burnett district, SEQ, Australia

The soil on Taabinga is classified as a Red Ferrosol (Isbell, 2002). The area has a subtropical climate, with long summers and mild winters. Annual rainfall varies from 339 to 1430 mm, with an average of 781 mm. It has a summer-dominant rainfall pattern with ~70 percent falling between October and March. Frosts occur most years with low-lying areas having the highest number of severe frosts. The annual average maximum temperature is 24.7°C, while the annual average minimum is 11.4°C.

The spotted gum plantations, with a total area of 36.48 ha (24.3 ha of four year plantations and 12.15 ha one year plantations), were developed as an improved silvipastoral system in which grazing was permitted three years after establishment. Additional exotic pasture seeds (medics and Rhodes) were established between the tree rows in the first year of the plantation. The tree stem density was initially 1,000/ha reduced at first thinning (fourth year), to 400/ha, with an expected final density of 250 trees/ha after the second thinning, at age 11, as this is represents the optimal final density (Maraseni et al., 2007). The grass biomass and thus the stocking rate is assumed to decrease at various rates as the plantation ages, given the increasing demands on soil moisture by the trees and the compounding effects of canopy closure. Stocking rates in the plantation were implemented as follows: (a) in the fourth year, the actual number and days of cattle grazed was based on the cattle grazing calendar, provided by the landowner, (b) between the 5^{th} and 10^{th} year, a stock decrease of 2.5 percent/year, (c) at year 12, rates as per the fourth year (due to the effects of thinning) and (d) after year 12, a stock decrease of 5 percent/year up to the 26^{th} year (canopy closure) and then constant carrying capacity until harvesting (C. Marshall and N. Halpin, 2005, pers.com., 7 April).

1.3 Costs and benefits

The average gross live weight gain of weaners at 12 months is around 250 kg at a price ranging between A$1.80/kg and A$2.20/kg live weight (N. Halpin, 2005, pers.com., 7 April). Therefore, the average price of A$2/kg and annual gross weight gain of 250 kg was used in this study. Additional costs due to the inclusion of the pasture in the plantation were provided by the landholder and independently verified, especially for determining official selling costs. As cattle in the plantations only grazed for a limited time each year, the total costs and benefits were divided proportionally to obtain the real costs and benefits from this silvipastoral practice.

In order to bring all future costs and benefits to present values, a discounting process was necessary. Two types of discount rates are common in practice; (a) risk free discount rate and (b) real rate (net of inflation). In Australia, the risk free discount rate is calculated by subtracting the consumer price index from the annual yield of Australian Treasury Bonds for that year. Taking the mean value of the past few years, Alaouze (2001) found this value to be 5 percent. The other commonly adopted discount rate is real rate (net inflation rate), which is around 7% (Spencer et al., 1999 in Venn, 2005; DPI, 2000). In this study, a private, pre-tax, constant price and nominal discount rate of 6 percent was applied. It was also assumed that all costs and prices change at the same rate over time, which is also an estimate of the long-term real rate of return achieved from alternate uses of primary industry firm capital (Cockfield, 2005).

After estimating the costs and benefits data for individual years, each year's net cost or benefit (not discounted) was discounted to present value using Equation 1.

$$V_0 = V_n/(1+i)^n \qquad (1)$$

where Vo and Vn are the value (cost or benefit) at present and future (after 'n' years), respectively, and 'i' is the discount rate (0.06 is used here).

After determining the NPV (net present value = net present benefit – net present cost) for consecutive years, the cumulative NPV for different ages of the plantation was calculated to show the actual contribution from pasture for any possible plantation harvesting age. The NPV of spotted gum plantations of different ages was taken from Maraseni (2007), where the author applied the same discount rate.

The NPV from stock production is sensitive to various factors, which can be highlighted using a sensitivity index (Equation 2). The concept of a sensitivity index is similar to the concept of price elasticity of demand or supply; i.e., a percentage change in quantity (demand/supply) due to a percentage change in price (refer to Layton et al., 2005). Here, the elasticity of NPV was determined by dividing the percentage change in NPV by the percentage change in various key parameters including gross weight gain and cattle price (A$/kg live weight). The percentage change in NPV was estimated by the mid point method using the NPV of a base case scenario (NPV_1) and predicted NPV (NPV_2) due to change in any key parameter. Similarly, percentage change of a given parameter was estimated by the mid point method using the value of a given key parameter in a base case scenario (P_1, related to NPV_1) and new scenario (P_2, related to NPV_2).

Sensitivity index of NPV (elasticity of NPV)

$$= [(NPV_1-NPV_2)/(NPV_1+NPV_2)]/[(P_1-P_2)/(P_1+P_2) \qquad (2)$$

2. RESULTS

The initial stocking rate for the plantation (in year 4) was 27 cattle in two rotations for a total period of 94 days or 0.29 head/ha[1]. From years 4-11 the stocking rate decreased constantly by 2.5 percent/year to as low as 0.24 head/ha. At year 12, after the second thinning at the 11th year, the stocking rate returned to 0.29/ha. Stocking rates would then decrease constantly to 0.14 head/ha at age 26 and continue at that level until harvest (Table 1).

First year costs of A$72/ha (or per 0.286 head) was spent on seeds, planting operations and the establishment of a watering system (Table 2). There are no other beef production costs attributed until the start of grazing. In the fourth year, at a rate of A$2/kg live weight and 250 kg/head/yr gross live weight gain, the gross benefits was approximately A$143/ha. After deducting costs such as selling costs of A$3.86 (A$13.49/head), annual health costs A$1.68

[1] The long-term average stocking rate in the nearby pasture on the same property was twice that at 0.56/ha.

(A$5.87/head), annual ear tag costs of A$0.57 (A$2/head), annual electricity cost of A$0.85 (A$1.66/0.56 head) and annual maintenance of A$30/ha, the total annual benefit for the fourth year was approximately A$100/ha. There would be no establishment costs after year four, so the cumulative NPV of stocking would continue to increase despite the decreasing rates of stock. However, the rate of increase of cumulative NPV would decline after 15 years because of the decrease in the stocking rate and the lower discounted value of the later income (Figure 2).

Table 1. Estimation of net present value from beef cattle in plantations-pasture (silvipasture) at Taabinga, southeast Queensland.

Age of plantations	Stock (rate/ha)	Net benefit from stock (A$/ha)	Cumulative NPV (A$/ha)	NPV from timber (A$/ha)*	Total NPV from timber and stock (A$/ha)
1	0.00	-72.07	-67.99	-1565.70	-1633.69
2	0.00	0.00	-67.99	-1613.70	-1681.69
3	0.00	0.00	-67.99	-1918.70	-1986.69
4	0.29	100.32	11.47	-1918.70	-1907.23
5	0.28	97.59	84.40	-1918.70	-1834.3
6	0.27	93.03	149.98	-1918.70	-1768.72
7	0.26	88.48	208.82	-2099.60	-1890.78
8	0.26	88.00	264.04	-2099.60	-1835.56
9	0.25	83.92	313.71	-2099.60	-1785.89
10	0.24	79.36	358.02	-2099.60	-1741.58
11	0.24	77.00	398.59	-2099.60	-1701.01
12	0.29	100.32	448.44	-2294.30	-1845.86
13	0.27	93.03	492.06	-2294.30	-1802.24
14	0.26	88.48	531.19	-1309.50	-778.31
15	0.25	83.92	566.21	-867.70	-301.49
16	0.23	74.81	595.66	-460.90	134.76
17	0.22	70.25	621.75	-88.60	533.15
18	0.21	65.69	644.76	249.90	894.66
19	0.20	61.14	664.97	555.60	1220.57
20	0.19	56.68	682.64	829.70	1512.34
21	0.18	52.00	697.94	1073.40	1771.34
22	0.17	47.46	711.11	1288.20	1999.31
23	0.16	42.91	722.34	1475.50	2197.84
24	0.15	38.35	731.81	1636.90	2368.71
25	0.15	37.00	740.43	1773.90	2514.33
26	0.14	33.79	747.86	1887.90	2635.76
27	0.14	33.79	754.87	1967.50	2722.37
28	0.14	33.79	761.48	2026.80	2788.28
29	0.14	33.79	767.71	2067.60	2835.31

30	0.14	33.79	773.60	2091.40	2865.00
31	0.14	33.79	779.15	2099.60	2878.75
32	0.14	33.79	784.38	2093.80	2878.18
33	0.14	33.79	789.32	2075.10	2864.42
34	0.14	33.79	793.98	2045.00	2838.98
35	0.14	33.79	798.38	2004.60	2802.98
36	0.14	33.79	802.53	1955.00	2757.53
37	0.14	33.79	806.44	1897.30	2703.74
38	0.14	33.79	810.13	1832.40	2642.53
39	0.14	33.79	813.61	1761.30	2574.91
40	0.14	33.79	816.90	1684.70	2501.60

Table 2. Costs and benefits data due to addition of pasture in plantation (silvipasture) in Taabinga, southeast Queensland

Description	Example for year 4	Costs/Benefits (A$/ha)
Stocking rates (varies in different years)	Fourth year = 0.286/ha	
Gross weight gain (250 kg/head) in 12 months	250*0.286=71.5 kg	
Gross gain in price (A$2/kg)	A$2.00*71.5 kg	143.00
Selling cost (A$13.49/head): It includes yard dues (A$3.28/head), MLA Levy (A$5/head), average freight costs to sale yard (A$5/head), tail tags A$0.11/each, NLIS tag @ 2.9 for all sold cattle (27 Cattle)	A$13.49/head*0.286 head	3.86
Commissions (4%)		5.72
Annual income (net of selling price) (ie: A$143-A$3.86-A$5.72)		133.42
Annual health cost (A$5.87/head)		1.68
Annual ear tag cost (A$2/head)		0.57
Annual electricity (A$1.66/0.56 head)		0.85
Annual maintenance (A$30/ha)		30.00
Annual benefit for year 4 (ie: A$133.42– A$33.10)		100.32
1st yr establishment costs:		
Seed costs (legumes & others)		25.00
Planting/seeding (1 time x A$10/ha)		10.00
Water boring (A$1500) pumps and pipes (2000) for 27 cattle for 50 years (A$129.62/head)		37.07
Total of first year cost		72.07

Note: On the basis of stocking rate of given year total annual benefit for that year is estimated

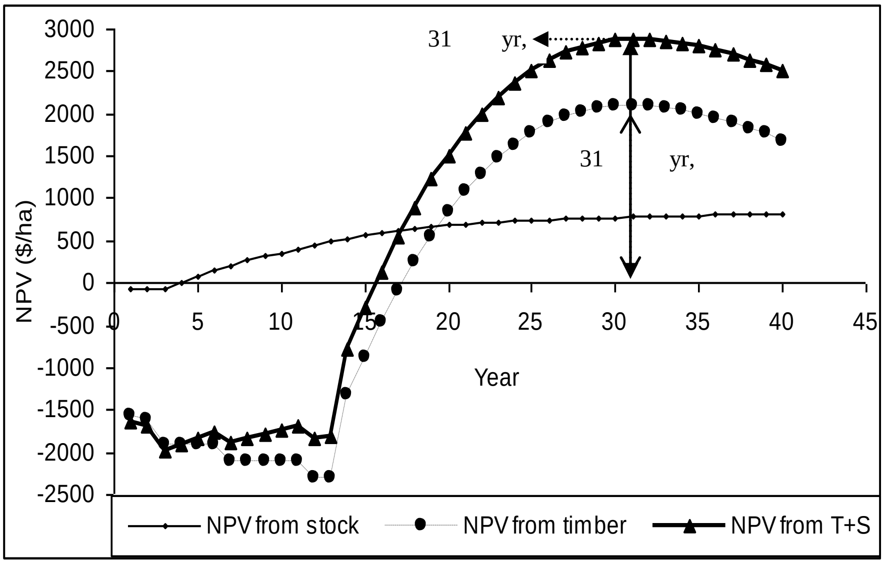

Figure 2. Optimal rotation of timber-alone spotted gum plantations and timber plus stock (silvipastoral) plantations in Taabinga, southeast Queensland

Maraseni (2007) found that the NPV from timber would be negative up to a plantation age of 17 years (Figure 2, Table 1), with year 18 being the break-even age when NPV of costs and NPV of benefits would be equal. After that the NPV from timber would start rising and approach the maximum (around A$2100/ha) at year 31. Therefore, this is the age at which trees need to be harvested to maximise the benefits from the timber. After this age, the NPV from timber would start to decline (Figure 2).

Adding the cumulative stock NPV with the timber NPV provides a series of combined NPVs for different years. From Table 1 and Figure 2, it is clear that the combined NPV would approach a maximum (A$2878.80/ha) at year 31. At this stage (the optimal harvesting age for timber-alone plantations), the cumulative NPV from pasture would be A$779/ha while the cumulative NPV gain from stock at year 31 is lower than at year 32 (A$784/ha). In fact, the combined NPV from timber and stock was further reduced due to a reduction in the NPV rate in plantations. Given the combined NPV was maximised at age 31, this is the harvesting age of the plantation, even if we consider both timber and stock values (Figure 2). Thus, there is considerable opportunity for increasing NPV by employing silvipastoral practices without reducing the rotation age of plantations.

Moreover, inclusion of pasture in plantations, will not only increase the direct benefits, it will also offer some intangible benefits such as soil erosion conservation, soil and biomass carbon sequestration and biodiversity promotion.

From the sensitivity analysis, the gross gain in beef weight was found to be the most sensitive parameter for stock. NPV would drop by 3 percent with a 1 percent decrease in gross gain in beef live weight. The beef price and stocking rate is almost unitary elastic. A 1 percent change in price or stocking rate would also change the stock NPV by the same percentage.

3. DISCUSSION OF THE RESULTS

Australia's plantation history began with softwood (pines) plantations in the 1870s designed to meet the growing domestic softwood demand for small-scale industries and mining (Turner et al., 1999; DAFF, 2009). Only in the 1980s, due to environmental concerns and commercialisation of forest services, has pressure mounted on government authorities to reduce the area of exotic pines, especially *Pinus radiata* (Turner et al., 1999). Two major changes that have characterised Australia's plantation history are: change from softwood to hardwood, and shifting from public to private plantations. Of the total Australian plantation area of 1.97 M ha in 2008, 48 percent is hardwood and 52 percent is softwood species (DAFF, 2009), whereas in 2003, 74 percent was hardwood and 26 percent was softwood. Similarly, the proportion of private plantations was 30 percent in 1990, and this has increased to approximately 64 percent in 2008 (DAFF, 2009). Although plantation areas in Queensland are small at 12 percent (or 240,305 ha) of the national plantation area, the general pattern of plantations is similar (DAFF, 2009). The current trends in plantations both at state and national levels show some positive connection with government policy, but the annual plantation rate of 72,000 ha (DAFF, 2009) falls well short, as at least 86,000 ha are needed to meet the plantation target set by '*Vision 2020'.* Currently, commercial plantations have been established mainly in areas with >700 mm of annual rainfall. In order to meet the Vision 2020 goal, inland medium-low rainfall (450mm-650mm) areas and farm forestry will need to be targeted, as timber-alone plantations in these areas are not viable (Venn, 2005).

This empirical research shows that silvipasture practices would be very helpful for enhancing the profitability to the local farming community, and also help meet national targets. This study only considers the timber and beef value of silvipasture system. Further value adding from silvipastural practices are possible for various reasons: (1) increasing recognition of forestry environmental services through different MBIs; (2) inclusion of forest plantation in the Australian Carbon Pollution Reduction Scheme (CPRS); (3) potential of receiving multiple environmental and financial benefits of producing biochar from forest wastes and putting these back into the farm soils; and (4) the medicinal possibility of spotted gums.

In Australia, there are several MBIs for both at the national (Round One and Round Two of the National MBIs Pilot Project established under the National Action Plan) and states levels (for example, Environmental Service Scheme in NSW; 'BushTender' in Victoria; and State Investment Program in Queensland) (Grieve and Uebel, 2003; Stoneham et al., 2003; DSE, 2006). Major objectives of these market-based schemes are to promote forestry systems by recognising previously unrecognised benefits of forests such as biodiversity conservation, salinity control, soil conservation, water quality improvement and acid sulphate soil mitigation (Whitten and Young, 2003; Whitten, et al., 2003; Bryan et al., 2005; Coggan et al., 2005; Coggan and Whitten, 2005). Promoting silvipasture in salinity-prone areas could be even more beneficial, as the present benefit of salinity amelioration on a single rotation plantation in Queensland is A$400-A$1300 (Venn, 2005).

Further value adding is possible through the proposed CPRS, scheduled for implementation from mid-2011, as it covers forest plantations (DCC, 2008). Given that silvipasture systems with spotted gum plantations can meet the Kyoto (or CPRS) definition of a forest (trees with >2m height and >20 percent crown cover), there is a strong chance of receiving carbon credits both from biomass and soil carbon sequestrations, as afforestation of hardwood species is likely to increase soil carbon in ex-pastureland (Paul et al., 2002; Paul et al., 2003; Saffigna et al., 2004; Maraseni et al., 2006).

The production of biochar from forestry wastes and incorporating it into farm soils is yet another emerging value adding activity for plantations. Biochar can dramatically increase agricultural production by up to three times and carbon can be retained in soils for >1,000 years (Cheng et al. 2008), which has enormous carbon sequestration advantages. Currently in SEQ, due to higher processing costs, logs up to a 25 cm small end diameter are acceptable at the sawmill. The recovery rate of accepted logs is approximately 43 percent (Maraseni et al., 2008). Therefore, vast amounts of forest residues from first and second thinnings, harvesting and sawmilling are available. However, managing and tiding-up these residues incur additional costs as they contain residues of degradable cellulose, decompose much faster (within 3-4 years) and emit a key greenhouse gas methane into the atmosphere. If these wastes are converted into biochar and injected directly into the soil, they have multiple environmental and financial benefits, especially given that 75 percent of Australia's agricultural lands contain <1 percent organic matter (Russell, 2008). Besides the carbon and productivity benefits, biochar has many other co-benefits for soils such as:

- reduces leaching of soil nutrients;
- enhances nutrient availability for plants;
- increases water quality of runoff;
- reduces dependency on artificial fertilizers;
- reduces toxicity of aluminum to plant roots and microbiota;
- increases soil structure and pH, thus reducing the need for lime;
- reduces bioavailability of heavy metals, thus works as bioremediation; and
- decreases N_2O and CH_4 emissions from soils, thus further reducing GHG emissions (Lehmann et al., 2006; Yanai et al., 2007; Mathews 2008).

Therefore, silvipasture has enormous potential for increasing productivity, profitability and sustainability in farming systems through the production and use of biochar.

Finally, there is the possibility of using spotted gum for medicinal purposes, as Aborigines have traditionally used the leaves of the spotted gum species. Thus it has potential uses as a food additive and perfume, curing food poisoning, acne and athlete's foot caused by microbial activities (Takahashi et al., 2004), controlling leaf cutting ants (Marsaro et al., 2004) and the provision of leaf oil (Asante et al., 2000).

4. CONCLUSION

This study assessed the financial benefits of including pasture components in spotted gum plantations in Taabinga, SEQ. The analysis shows that the inclusion of pasture with plantations (silvipasture) has considerable financial benefits. These findings have implications for attempts to increase the Australian plantation estate to 3 M hectares by 2020. However, the estimated financial benefits should be used cautiously as it applies only to silvipasture system including improved pasture and spotted gum plantation in the Red Ferrosol soils in the SEQ environment.

ACKNOWLEDGEMENTS

We would like to thank Neil Halpin (DPIF) for his helpful advice and discussion about this research. Our thanks also go to the Australian Centre for Sustainable Catchments (ACSC), University of Southern Queensland and Condamine Alliance for their logistical and other support. Most importantly, we would like to thank Colin Marshall, for his invaluable advice and hospitality during the fieldwork. We cordially thank two anonymous referees for their highly valuable suggestions which were gratefully acknowledged.

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