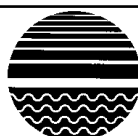




RURAL INDUSTRIES
RESEARCH & DEVELOPMENT CORPORATION

The Potential for Tropical Agroforestry in Wood and Animal Feed Production

An assessment for the
Joint Venture Agroforestry Program partners:
Rural Industries Research and Development Corporation
Land and Water Resources Research and Development Corporation
Forest and Wood Products Research and Development Corporation
by
J. Brian Lowry and Jayne Seebeck



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Researcher Contact Details

J. Brian Lowry and Jayne Seebeck
CSIRO Tropical Agriculture
120 Meiers Road,
Indooroopilly, Queensland 4068

Phone: 07 3214 2700
Fax: 07 3214 2880

RIRDC Contact Details

Rural Industries Research and Development Corporation
Level 1, AMA House
42 Macquarie Street
BARTON ACT 2600

PO Box 4776
KINGSTON ACT 2604

Phone: 02 6272 4539
Fax: 02 6272 5877
email: rirdc@netinfo.com.au
Internet: <http://www.dpie.gov.au/rirdc>

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Foreword

It is widely believed in Australia that trees compete with crops and pasture. However, the research described in this report shows that this may may not be the case, especially in the tropical north of the continent.

CSIRO's Dr Brian Lowry and Jayne Seebeck reviewed literature and conducted a survey to assess the potential for agroforestry in Australia's wet-dry tropics based on trees for both wood and animal production. They conclude there is clear evidence that some tree species can have a promotional effect on pastures.

The authors say that, through their research, it became increasingly apparent that Australia has a biological resource in the form of certain tree species that can promote animal production in a variety of ways and also yield cabinet timber similar to that which previously came from rainforests.

Their report shows why they are confident that agroforestry systems could be devised for northern Australia in which the trees not only increase total pasture production, but also prolong the period of higher pasture quality.

The results of a survey Jayne Seebeck conducted of primary producers as part of the this project, also were encouraging. The survey has helped identify areas where farmers would like more research.

This is an exciting project conducted for the Joint Venture Agroforestry Program which was established in 1993 with funding from the Rural Industries, Land and Water Resources, and Forest and Wood Products Research and Development Corporations.

The findings are being followed up in further research.

Peter Core

Managing Director

Rural Industries Research and Development Corporation

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PREFACE

In the course of a long and varied career, one of us (JBL) has had the privilege of being involved in a number of original research findings, and to be well aware of the excitement that comes from believing one has some new insight into the natural world.

In comparison the commission from Rural Industries Research and Development Corporation to conduct this review should have seemed rather more pedestrian. In fact it has brought excitement of quite a different order. As Australians we are continually reminded of the harshness and infertility of much of the continent, land degradation, declining employment in agriculture and what this does to rural communities.

In preparing this report we have had a growing conviction that it should indeed be possible to develop agroforestry systems that will offer a more, perhaps much more, profitable land-use while being environmentally benign and socially beneficial.

This belief arises from a certain amount of original research, but mainly from becoming aware of information from a variety of sources, from having seen trees on the ground. It also arises from learning of changing perceptions among producers and seeing the initiative of particular individuals.

The overall conclusion is that there really **are** trees that could have this dual role and they really **could** be established in much of northern Australia!

ACKNOWLEDGEMENTS

We wish to thank first of all the 171 landholders who took the trouble to respond to our questionnaire, not only in ticking boxes but also in supplying a considerable amount of written comment. Various individuals who helped by providing information or comment, or actually taking one to field sites, are listed in Appendix 3.

EXECUTIVE SUMMARY

A wide-ranging review of literature, as well as local findings, unequivocally show that in the tropics certain trees in pasture are capable of promoting grass production and quality below the tree canopy. Less documented, requiring further research, but almost as definite, is the ability of certain large free-standing trees to supply dry-season feed to grazing animals by the fall of deciduous leaf, flower or pod. Remarkably, there are several species that we highlight here, which appear to have both characteristics and would thus, when grown as isolated trees in pasture, be expected to substantially boost pastoral production.

The same species are known elsewhere as sources of quality timber. They thus provide the basis for an agroforestry system for northern Australia combining production of quality cabinet timber with increased pastoral production.

Managing open-grown trees in pasture to obtain clearwood would be novel for the species concerned, would require more management than for forage alone, but need not reduce forage production and would not rule out partial lopping of tree crowns for drought feeding. Returns from wood production would initially depend on on-farm processing, and marketing of small volumes of wood for high-value applications. Wood produced would be seen as similar to and replacing native rain forest timbers now largely unobtainable. By the time logs are ready, pathways for marketing similar timbers will be established through the Community Rainforest Reforestation Programs. However, for at least three of the species highlighted there is already a significant use for wood craft purposes.

The most attractive species is siris (*Albizia lebbbeck*), with strong potential also shown by forest siris (*Albizia procera*); yemane (*Gmelina arborea*); and tipuana (*Tipuana tipu*). At least 15 other species are also of interest, including rain tree (*Samanea saman*), Mackay cedar (*Paraserianthes toona*) and white cedar (*Melia azedarach*).

A survey of landholders who might be expected to have some interest in tree establishment was conducted by questionnaire and elicited 171 responses, many of them accompanied by additional written comment. The responses showed a considerable diversity of views and attitude, with evidence of increasing interest in tree planting for environmental restoration. There was already significant experience with some of the species of interest, and several producers offered to cooperate in developing their use.

For each species there are particular requirements for further agroecological or nutritional research. This could be based on existing trees on sites seen during this project. For developing the concept further we have attempted to identify some of the key organisations and individuals.

SECTION A

**J.B. Lowry: Can Trees Support
Both Wood and Animal
Production?**

1. INTRODUCTION

Most pastoral production in northern Australia takes place in sclerophyll eucalypt woodland, so that most producers have involvement with trees, if only in terms of clearing them to varying extents to minimise their effects. Agroforestry is distinguished from pastoral production carried on in a woodland environment by purposeful management to obtain a variety of environmental and production benefits from the tree component of the system.. In southern Australia and New Zealand one specific system has had much attention; this is the establishment of fast-growing pines or eucalypts in pasture to produce sawlogs that will be accepted by an existing forest industry. The trees compete with pasture and there is some loss of animal production, but the joint land use results in a greater return than from either separately. Although young trees must be protected from damage by browsing, the trees themselves have little significance as feed because pasture quality is high in relation to that of pine or eucalypt foliage.

In northern Australia such agroforestry systems are almost unknown. There has been some tree planting for environmental purposes, some planting of eucalypts in farm woodlots for timber, and more recently the planting of native rainforest trees for timber. In terms of tree forages, there has been wide interest in and localised planting of leucaena, but this is managed to keep it in shrubby rather than tree form.

Because of the sheer prevalence of eucalypts over the Australian continent it is easy for the land manager to accept their characteristics as defining those of “trees” in general. However we should note how unfavourable eucalypts are to grazing animal production - they have no fodder value, provide poor shade, usually inhibit grass production. Agroforestry with eucalypts may indeed be a profitable landuse, but one in which there would be a clear trade-off between animal and wood production.

In fact very different possibilities apply in northern Australia. There are tree species which, from natural forests or forest plantations, are known to yield quality timber. These same species are known also, often in a quite different context, to have significant fodder value, and rather than restricting pasture may actually promote it. Some of these species are indigenous to northern Australia, some are exotics that have already been introduced, perhaps used in limited trials but are otherwise hardly known.

The obvious question is thus whether such species can be used in agroforestry regimes designed to obtain a final timber crop but which for most of the growing period would also give rise to enhanced animal production. This would be a win-win situation rare in agriculture. Such a prospect might seem utopian in the present economic climate. The remarkable thing is that there is plenty of evidence that it is possible, but almost no effort has been made to try it.

This report attempts to synthesise current information on species that could have this dual role. Discussion of the animal production aspects is based on published and unpublished research, ranging from full feeding trials to anecdotal field observation. An attempt to obtain a perspective on the wood utilisation aspects was undertaken differently with different sources, as discussed in that Section 2.2.

Certain tree species stand out as promising candidates for dual purpose agroforestry, and these are discussed in separate sections. There is also a large array of species about which we know little but which might also have this role. They are noted here to arouse a preliminary awareness of them.

An attempt was made to obtain some current awareness of attitudes among landholders by mailing out a detailed questionnaire designed and analysed by Mrs Jayne Seebeck. The response

to this was outstanding with some 160 responses, many containing much written opinion. This survey forms the subject of Section B.

This project has, we believe, shown the feasibility of dual-purpose agroforestry in northern Australia. It has also revealed some obvious research and development needs and identified resources. These are discussed in Section C.

2. REVIEW

2.1 Review Of Literature Relating To Animal Production Aspects

Summary

If trees are grown in pasture at wide spacings, and pruned to produce a clear bole, most of the tree canopy will be out of reach of the animal for most of the growing period. A key idea here is that browsing of green leaf is not the only way that trees can provide feed. In the semi-arid tropics certain trees can provide feed in three different ways.

Green Leaf. This may be available from thinning and pruning operations. More importantly, the green crown can be regarded as a reserve of high quality feed for use in drought. This would involve partial removal of the tree crown, by lopping the lowest branches, without destroying log form.

Natural fall of leaf, flower or pod. The novelty here is to regard dead fallen leaf as a feed for livestock. In temperate areas this is hardly likely to be so. However many tropical trees are deciduous in the dry season and the leaf falls at a time when pasture quality is at its worst. This report shows that this fallen leaf can be a feed resource. It is of lower quality than green leaf but may be higher quality than the dry season grass. Furthermore it has rather different nutritional properties. It is usually not very digestible, but it breaks up easily so the animal can eat a lot more of it than tough fibrous grasses. There is even evidence that the two materials interact positively so that digestion of the mixture is better than either separately. Dry-season fall of flower or pods may occur in significant amounts. These are likely to be of higher protein content than fallen leaf, but less tree species show this behaviour.

Pasture promotion. Most producers see trees as having an adverse effect on pasture. This does indeed apply to eucalypts or pines under most circumstances. However there are certain trees in the tropics which can actually have a positive effect on grass growth and quality. This has been observed in Africa and India as well as northern Australia. It is very much a characteristic of the particular tree species. However conditions under which positive effects are likely to be seen include: strongly marked dry season, low to medium fertility soil, moderately dense canopy, and preferably but not exclusively, a nitrogen-fixing tree.

In principle, trees grown for final sawlog production in an agroforestry system can contribute to grazing-animal nutrition in three ways.

1. Green leaf being made available for browsing directly.
2. Natural fall of edible material from tree canopy out of reach of the animal.
3. Enhancement of pasture production and quality by the tree.

The first is the most obvious but least likely to be important, the second two have the potential to be more significant for dual-purpose agroforestry systems, are less well known, and will be considered in more detail.

(1). Trees With Edible Green Leaf

Even if the tree concerned is a recognised fodder tree, there will, if it is being grown for wood production in an agroforestry system, be little green leaf available for associated livestock. For most of the growing period trees will be at wide spacings and will be so large that most leaf will be out of reach of the animal. During establishment it will be necessary to prevent the animals from browsing. However some leaf would be available from the vigorous pruning that would be necessary to obtain good log form from open-grown trees, and from thinning of trees when final crop trees were selected.

Two aspects are worth noting

1. Green leaf may have high value in relation to its available biomass if it is fed as a supplement to dry-season pasture. It has a catalytic effect in enabling rumen microbes to ferment highly fibrous material which would otherwise be poorly digested. In North Queensland a series of experiments with sheep on basal diets of mature spear grass showed that in general supplementation with 20% legume significantly improved intake and digestibility of the basal diet (A.C. Schlink - to be publ.).
2. With well-established trees the green crowns would constitute a standing reserve of high-quality feed that could be utilised for drought feeding. This would involve removal of part of the crown by lopping lower branches, without destroying the log form. This might delay eventual log harvest but contribute strongly to animal production.

The value of green leaf as feed is indicated in numerous publications on fodder trees, the most recent and relevant being Gutteridge and Shelton (1994). A recent astringent review on tree forages Benjamin (1995) has questioned the actual production data as against the motherhood statements on the value of tree forages. However this is a "review of reviews" and there are plenty of primary publications dealing with the evaluation of particular tree species. In general the green leaf is a good source of protein, availability depending on species. Other chemical data can be misleading as we know there are important differences in the fibres of tree leaf and grass and the way they are fermented (Kennedy and Lowry 1996). Quality is also affected by secondary compounds that may have antinutritional or toxic effects. These vary greatly between taxa, and the nutritional value of green leaf will be considered for each species in the section on individual species.

(2). Natural Fall Of Edible Material: Flower, Fruit And Leaf

The point here is that aspects of tree phenology that have no bearing on wood production will have a profound effect on whether or not it contributes to animal production in an agroforestry system.

Flowers and fruit: Depending on species, annual production of flower or fruit biomass may be negligible or up to 20 kg/tree. It may have high feed value or none at all. It may be shed at a time of year for it to be of little use or at a time when it has high strategic nutritional value. Several trees with agroforestry potential do shed edible flowers or fruit, but this is such a species-specific characteristic that it will be covered in the accounts of particular trees.

Deciduous leaf fall: This aspect is worth more general consideration. Some of the tree species suitable for agroforestry systems in the wet-dry tropics are obligately deciduous in the dry season, while others are facultatively deciduous under prolonged dry conditions. In either case all the current canopy leaf becomes accessible to the animal. We suggest that it is possible for this

fallen leaf to make a useful contribution to grazing-animal nutrition. The literature in direct support of this assertion is rather sparse, but, together with other data suggests this could be an important attribute for certain species.

Elementary biology indicates that freshly fallen senescent leaf will be of much lower feed value than green leaf, due to translocation from it of cytoplasmic components, particularly protein. However there is remarkably little published comparative data relevant to animal nutrition. The detailed account of leaf senescence by Thimann (1980) does not give any indication of bulk composition differences between green and senescent leaf. However a recent review by Killingbeck (1996) gathers nitrogen and phosphorus data for some 77 tree species, none of them tropical. A key finding is that in general changes in phosphorus follow those in nitrogen, and that in nitrogen fixing trees nitrogen is less resorbed on senescence, thus leaving higher levels of protein in the fallen leaf.

In temperate regions, autumn leaf fall would occur when feed supply is not too low, and most temperate pastures would be expected to be of higher quality than the fallen leaf. There is thus little reason to expect animals to eat it. A quite different situation applies in the tropics, where the dry-season loss of feed quality in the grasses makes the comparative feed value much more of an open question. It was this consideration that prompted the author to compare rumen digestibility of fallen leaf from 27 native deciduous trees with dry-season grasses in North Queensland (Lowry 1995). These showed that they were in general more digestible than the grasses, some surprisingly so. Of course, only feeding experiments could determine their actual value.

A very large number of publications are concerned with litter fall in terms of forest biomass transactions, utilisation by invertebrates, or mineral nutrient recycling, but almost none on its utilisation by mammalian herbivores. Is this considerable annual production being consumed entirely by micro-organisms and invertebrates? Fallen leaf has rarely been considered as a mammalian feed resource in either forest, rangeland or pastoral systems. A notable exception is in a fascinating account of the trees of the Okavango Delta in Africa (Roodte 1995) which highlights the importance to wildlife of the dry-season leaf fall from the dominant mopane tree (*Colophospermum mopane*) and a number of other species. In his account of 120 species of Queensland fodder trees Everist (1986) mentions only three where fallen leaf is eaten (*Albizia lebbbeck*, *Planchonella pohlmania*, and the exotic *Celtis sinensis*). Cattle are also said to eat fallen leaf of Moreton Bay fig, *Ficus macrophylla* (Chew 1989), in which case they almost certainly utilise other fig species as well.

Direct experimental results on the feed value of fallen leaf are very few. Fallen leaf of *Griselinia littoralis* was by far the largest single component of the diet of fallow deer in certain New Zealand forests and ranged from 20 to 50% of the total diet (Nugent 1990). This paper also carries suggestions that other deer species utilise litterfall in broadleaf forests. Fallen leaf of *Gmelina arborea* apparently raised the value of dry season pasture to a level where there was little response to supplementation (Serra et al. 1995). Fallen teak leaves were progressively substituted for spear grass as the 70% roughage component in 4 diets for sheep (Reddy and Reddy 1984). The diet with the highest level of teak leaf had slightly lower digestibility but, with sheep having a considerably higher voluntary intake of it, actually provided more nutrients. This aspect was remarkably similar to the author's findings although their experiment involved a pelleted diet containing 30% concentrate. Fallen leaf of *Albizia lebbbeck* (siris) was palatable to sheep and revealed the interesting aspect that intake was high in relation to whole-tract digestibility, so that feed value was higher than the digestibility alone would indicate (Lowry 1989). Further experiments indicate that, compared to mature grasses, tree leaf fragments more readily, digests to a lesser extent but does so more rapidly, so that indigestible particles rapidly

leave the rumen (Kennedy and Lowry 1996). There is also recent evidence that there is a synergistic effect when the two substrates are fermented together (Appendix 1).

Overall, it seems likely that utilisation of fallen leaf by grazing ruminants occurs to a considerable extent in the dry tropics. Comments from certain graziers in North Queensland on the dry-season carrying capacity of “softwood scrubs” certainly suggest it. The paucity of published accounts and research is simply because it is not a conspicuous behaviour and no scientist has paid much attention to it.

These considerations suggest that it is possible through choice of suitable species to have an agroforestry system in which the trees themselves make a significant contribution to grazing-animal nutrition at the time of greatest nutritional stress.

(3). Promotion Of Pasture In The Wet-Dry Tropics Through The Use Of Selected Tree Species

A. Trees vs grass - the common paradigm

Agroforestry regimes in temperate Australia and New Zealand using *Pinus radiata* or *Eucalyptus* spp. at wide spacings, accept that the trees will have an adverse effect on pasture production, and there is by now considerable experimental data on the relation between grass production, tree density and canopy area. Animals may benefit from an improved microclimate, but there will be reduction in feed availability, and there will be some loss in animal production.

The pastoral areas of northern Australia are primarily eucalypt woodland with native grasses that lose quality drastically in the dry season. It is generally accepted that the trees, whatever their other attributes, have negligible forage value and have a negative effect on grass production, with net herbage production showing an inverse relation with tree basal area over a range of sites and communities (Burrows et al. 1988, Scanlan and Burrows 1990, and references therein).

B. Canopy effects - not so simple

The negative association between tree cover and pasture productivity is so well established in Australia as to be almost axiomatic. It is possibly understandable given the ecophysiology of eucalypts and their dominance in the landscape. It is of interest that guava, like the eucalypts a member of Myrtaceae, has been found also to have an adverse effect, with pasture production under its shade being 49-63% of that in the open (Somarriba 1988). In fact the situation is much more complex. Even the effect of eucalypts has to be qualified when looking at growing trees rather than comparing established communities. Direct monitoring of pasture when *Eucalyptus grandis* was established in an agroforestry trial in south-east Queensland showed that there was a 35% increase in grass yield under 5-year old trees (Wilson et al. 1990).

Elsewhere there is clear evidence that particular tree species in certain environments have a promotional effect on pasture. This is hardly a new observation. Jagoe (1948) showed with meticulous measurements (if in Imperial units !) that dry matter yields of *Axonopus compressus* were enhanced under the canopy of the rain tree (*Albizia saman*).

In both Africa and the Indian subcontinent it is accepted that certain trees in the semi-arid to arid areas promote grass or crop growth below the tree canopy. This appears to be so obvious to local researchers that it is rarely the subject of quantitative measurement (often the main concern is simply the preservation of such trees). A considerable number of allusions to this "canopy effect" are unsourced or in inaccessible publications. Usually the only concern is crop yield or dry-matter production; there appears to have been no documentation of the effect on pasture quality

and its seasonal change. It may be because this effect has been taken for granted that the negative effect associated with eucalypts has been something of a surprise, and has contributed to the strong backlash against their use in social forestry that has developed in India and Thailand as villagers have found diminished forage availability for cut and carry feeding.

Because the claim for a positive canopy effect is still novel in the Australian context, and still tends to be dismissed with such explanations as "increased fertility from cattle camping under the trees" or "the trees happen to be on the best sites", we first (C) list those tree species for which it has been documented, and then (D) indicate that there are explanations for it that are not only rational but relevant to agroforestry systems in Australia.

C. Trees that promote grass or crop growth

This section deals with individual tree species that have been highlighted in publication for their positive effect on grass or crop growth. Most but not all are tree legumes. We refer here to large free-standing trees, and not those hedged, coppiced on in alley cropping systems; i.e. in a system where clear logs could be obtained.

Acacia albida (Mimosaceae)

This African species is almost unique for those of semi-arid woodland in that it is deciduous in the wet season. It is highly valued for promoting grass or crop growth, and there are well-established farming systems that utilise the shaded area for maize or sorghum production. Crop yields under the canopy have been recorded as 56% higher than in areas without trees (Poschen 1986). In Senegal, yields of groundnut and millet increased from 500 to 900 kg/ha when grown under the tree canopy (Felker 1978).

Acacia caven (Mimosaceae)

Thinning natural stands in Chile to various densities showed that the tree canopy had a positive effect on the composition and productivity of the herbaceous layer. DM production at 80% cover was 3.97 t/ha (vs 2.78 t/ha at 30% cover), the length of the short growing season was extended by 25-35 days (Ovalle and Avendano 1987).

Acacia spp (Mimosaceae)

In the Sahel of West Africa, productivity of *Pennisetum pedicellatum* under the trees is about twice that in the open (Bille 1978). In Botswana the same applied to *Panicum maximum*; potential evapotranspiration was reduced by 50-70% under shade and the grass remained green 6 weeks longer at the beginning of the dry season (Le Houerou 1978).

Acacia nilotica (Mimosaceae)

Individual trees were found to promote *Panicum maximum* in Kenya (Pinney 1989). This species is of course a major woody weed in Australia, where it certainly does not enhance the native Mitchell grass. This is not surprising as it is typically found in dense shrubby thickets on cracking clay soils with no ground water available for deep rooting trees.

Acacia tortilis; *A. seiberiana* (Mimosaceae)

In the Turkana district of Kenya, Weltzin and Coughenour (1990) found marked positive effects due to tree canopy, with total herbaceous biomass 260 g/m² at the bole and 95 g/m² in the space

between trees. A major study also in Kenya by Belsky et al. (1989) directly compared various parameters under the tree canopy and in the open, including rainfall interception, light transmission, soil temperature and moisture, and herbaceous layer composition and production. Net primary production under the tree was 705 g/m², as against 361 g/m² in the open.

Adansonia digitata (Bombaceae)

Although not a legume, and of different canopy form, this species was found by Belskey et al. (1989) to promote grasses to almost the same extent as *Acacia tortilis*, the main difference being a lower nitrogen content in the herbaceous layer. The dominant sub-canopy grass was *Cynodon nlemfuensis*, with lesser amounts of *Panicum maximum*, noted elsewhere as the characteristic grass of tree legume shade.

Albizia lebbbeck (Mimosaceae)

In North Queensland, early wet season yields of grass dry matter were 82% higher under the canopy in grazed areas and 127% higher in an ungrazed area (Lowry et al. 1988). In early dry season there was also a positive effect on production and even more on quality (Liano 1990). The positive effect on grass has been noted also at Gayndah (Prinsen 1986) and Rockhampton (J. Wildin, unpubl.), but does not appear to be conspicuous in southeast Queensland. Apart from the question of relative overall dry-matter production, it was noted that grass below the canopy remained green and continued growing for up to 2 months after that in the open had died off, and that, at the end of the dry season, there was a more rapid response to rain from grass below the canopy. The author suggests the effect on quality may be more important than that of total grass dry-matter production.

Albizia saman; *syn Samanea saman* (Mimosaceae)

This species is called "rain tree" throughout much of the tropics, and its effect in promoting green grass below the canopy when that in the surroundings has dried off is said to be one of the reasons for the common name (NFTA 1987). Jagoe (1948) found difficulty in finding a suitable unshaded control but found the yield of carpet grass (*Axonopus compressus*) under the canopy (20,840 lbs/acre) as considerably greater than grass growing in the open (4180 - 9380 lbs/acre). Crude protein levels were also higher (14.3% vs 9.68%).

Combretum molle (Combretaceae)

This was found to promote growth of *Panicum maximum* in a Zimbabwe savanna, the yield under an "open canopy" being 500 g/m², as against 300 g/m² in the open. Interestingly, this paper gives results also for a "closed canopy", also close to 300 g/m², indicating that only partial shade is beneficial. A variety of other parameters were measured (Kennard and Walker 1973). Of the dominant tree species in the same savanna, *Terminalia sericea* had similar effects but *Brachystegia spiciformis* and *Julbernardia globiflora* did not.

Cordia alliodora (Tiliaceae)

When this timber tree was grown in association with *Cynodon nlemfuensis* in an agroforestry trial in Costa Rica annual grass yield was 4.087 t/ha, in comparison to 2.632 t/ha in the control plots without trees (Pezo et al. 1989).

Erythrina poeppigiana (Papilionaceae)

Yields of African star grass (*Cynodon nlemfuensis*) obtained in association with this tree were 9.311 t/ha, compared with 2.632 t/ha in control plots without trees (Pezo et al. 1989).

Prosopis cinerea (Mimosaceae)

This is the tree that is repeatedly highlighted on the Indian subcontinent for its positive effect on grass or crop production. Shankar et al. (1976) found grass production increased about 100% within a 3-m radius of the stem compared with the surrounding area. There were marked differences between tree species, with *Prosopis* having the greatest effect. Other aspects of the system are discussed by Singh and Lal (1969) and Mann and Shankarnarayan (1980).

Prosopis juliflora (Mimosaceae)

This species is used with the grass *Leptochloa fusca* to rehabilitate harsh saline sites. Apparently it is almost impossible to establish the grass without the trees being present (Singh 1995)

Quercus douglasii (Fagaceae)

The effects of blue oak on sub-canopy herbaceous vegetation appear to be adverse in northern California but positive in central California, including in drought years (Frost and McDougald 1989; this paper cites several other references for both areas). Peak standing crop was 700-1000kg/ha higher beneath the canopies than in open grassland. Removal of trees led to a reduction in herbage production.

Quercus suber; *Q. rotundifolia* (Fagaceae)

The Dehasa of southern Spain, although not tropical, is another area of woodland with hot dry summers. In this open woodland the oak trees apparently create a microenvironment favourable to perennial grasses through their effect on soil water relations (Joffre and Rambal 1988).

Terminalia sericea (Combretaceae)

This species was noted by Kennard and Walker (1973) as one of the two that particularly promoted *Panicum maximum* (see *Combretum molle*).

Species Unspecified

A study in the Nigerian savanna, reporting higher herbage yields under the tree canopy, provides considerable detail on the relative amounts of 5 grass species but does not state what tree species are involved (Muoghalu and Ischei 1995).

D. Mechanisms for canopy effect

While the author was becoming interested in the grass-enhancing characteristics of siris (Lowry et al. 1988), a series of studies by J.R. Wilson and associates on the ecophysiology of pasture plants in Southeast Queensland, that had earlier been concerned with the factors affecting the differences between tropical and temperate forages, was increasingly highlighting the positive effect of shading (Samarakoon et al. 1990a, 1990b; Wild et al. 1993; Wilson 1990, 1993; Wilson et al. 1986, Wilson et al. 1990). These illuminate the relationships between plant species and shade tolerance, response to nitrogen, soil temperature and nitrogen, and degree of natural or artificial shade. They reveal some apparent contradictions, but do show that, even in the sub-tropical environment of southeast Queensland, it is possible to get increased grass growth under tree canopies, particularly with *Panicum maximum* cv Green Panic which increased production by 37% under 50% shade (Wilson 1996).

In the more extreme conditions of the semi-arid tropics light is even less, and water more, limiting for plant growth. Simple competition for water would seem to ensure that trees are inevitably a constraint on pasture production. However the real question concerns the overall utilisation of water by the tree - grass system. The grass microenvironment may be modified by the tree to reduce insolation, and wind velocity, and increase humidity, all of which reduce evapotranspiration. There will be reduced soil temperature and increased soil nitrogen and organic matter, and interception of rain from storm events that has already passed through the grass root zone. Clearly the extent of each effect will depend on the particular tree species. It is reasonable to suppose that in some cases for the grass microenvironment, the water-conserving effects of the canopy outweigh the water uptake by the tree and there is a net positive effect on water regime experienced by the grass. This was the conclusion arrived from our empirical observations on siris in North Queensland (Lowry et al. 1988).

Very similar conclusions appear to have been reached in Sahelian (and francophone) Africa, possibly not making an initial impact because not much was published in english. Bille (1978) also emphasised that light is not limiting. For low-rainfall regions he cited a net productivity of 80 g/m² outside the tree canopy, as compared with 160 g/m² below it, and 170 g/m² from the tree itself. Photosynthetic efficiency was 1.45% below the tree compared with 0.3% outside it. The benefits of tree cover are regarded as unequivocal (" . . . une strate ligneuse moderee est plutot benefique pour le development herbage.").

More recently, a remarkable physiological mechanism ("hydraulic lift") has been found by which some trees actually supply, rather than deny, water to surface herbage. One advantage of forage trees or shrubs is their ability to exploit water at depths unavailable to grasses. This has seemed to be a competitive advantage against grasses. However it is now apparent that this may sometimes be directly beneficial to grasses associated with the tree canopy. Caldwell and Richards (1988) have shown that the desert shrub *Artemisia tridentata* brings water to its canopy from its deepest roots in two stages, with an intermediate stage in which the water is stored in the surface roots or secreted into the surface soil. The grass *Agropyron desertorum* growing below the canopy was able to "parasitise" this water. A proportion of the deuterated water supplied to the deepest roots of the tree was found to appear in the grass within hours.

The discussion so far has been largely about pasture biomass production. In fact the effect on quality may be of greater animal production importance, as at optimum stocking rates, it is the low quality rather than supply of dry-season feed that limits animal liveweight gain. There have been many observations of *Panicum maximum* cv green panic becoming spontaneously dominant under the siris canopy. This is of much higher quality than the spear grass likely to predominate in the surrounding pasture. In addition it has been found that grass associated with the canopy in North Queensland had digestibility 5-10 units higher than that in the open, and maintained quality for 6-8 weeks longer at the onset of the dry season (Liano 1990). Several of the observations on canopy effect in India or Africa also refer to grass remaining green for longer into the dry season.

The rationale for a positive canopy effect seems strongest where there is strong seasonality. The initial efforts in agroforestry in north Queensland are with "high value rain forest timbers" on degraded pasture lands on the wetter tropical coast, and it might be questionable whether a positive canopy effect would be obtained there too. It is thus interesting to note that one of the earliest accounts of a canopy effect, in Peninsular Malaysia (Jagoe 1948), is unequivocally from a wet tropical environment.

There is still some tendency to regard canopy effects as anecdotal. However these ideas now rest on a much firmer basis. Following her major study in Tsavo National Park in Kenya, Belsky has

addressed the question of canopy effects on forage quality Belsky (1992) and on the whole ecophysiology of the canopy effect (Belsky et al. 1994). There is no question that in a seasonal tropical environment, large isolated trees with the right canopy characteristics can have a strong promotional effect on subcanopy herbage. The canopy effect is respectable!

Overall, from these results one can be confident that it is possible to devise agroforestry regimes for northern Australia in which the trees will not only increase total pasture production but also prolong the period of higher pasture quality. It is also possible to indicate the conditions under which positive effects can be obtained: strongly seasonal climate, medium dense tree canopy (40-60% transmission), medium to low fertility soils, and preferably but not necessarily a nitrogen-fixing tree species.

2.2 Review Of Wood Utilisation Aspects

Summary

Some of the species highlighted in this report are recognised as Queensland rainforest timbers (forest siris Albizia procera and red siris or Mackay cedar, Paraseriathes toona). Most of the other species highlighted are allied to rainforest species and could be so considered in terms of wood value and marketing. The cessation of rainforest logging in World Heritage listed areas has caused some unrealistic projections of future value of rainforest cabinet wood. However the likely formation of cooperatives marketing timber from existing forest on private land, and the growth of Community Rainforest Reforestation Programs, makes it seem probable that a high-value market will exist. Projections of \$2000/ m³ for sawn timber appear reasonable and actual values could be much higher.

Despite the association with rain forest habitat, all species mentioned here are capable of growing in the open, in seasonally dry areas, well away from rain forest. The tending of open-grown trees of these species to obtain clear logs is something of an unknown, but appears to be practicable. Relevant experience is currently being obtained under the Community Rainforest Reforestation Programs operating in North Queensland.

Some species such as siris (Albizia lebbek) are hardly known in Australia but well known as cabinet wood overseas. However their availability as wayside trees has already given rise to small-volume high-value use.

The increasing availability and quality of mobile milling services means that it will be possible to sell wood directly as sawn timber. This is conducive to the development of low-volume high-value marketing. It is also likely to give rise to specialist operators dealing in small volumes of high value timbers.

In agroforestry in southern Australia and New Zealand, most of the emphasis is on trees (such as radiata pine or certain eucalypts) already used on a large scale in plantation forestry. The objective is to produce sawlogs that can be sold into an existing large-scale market. The returns can be estimated with some confidence.

For the species under consideration for northern Australia in this project, no such marketing system exists. Furthermore, there is little published data on wood properties for Australian-grown material. Although the Queensland Forest Service has recently carried out intensive evaluation of lesser-known plantation-grown species under the "Plantation Hardwoods Initiative" (Gough 1995), this work did not cover any of the species highlighted in this project. At first it might seem that both the potential market and expected returns would be so uncertain as to

discourage investment. We have approached the question of projected returns from wood in accordance with the type of information available.

Nature of timber from species considered in this report

Currently there are two main groups of Australian-grown timbers. There are the softwoods, plantation grown pine and native hoop pine. There are the “hardwoods” consisting mainly of eucalypts from temperate old-growth forests. The rainforests, particularly those in Queensland, have supplied a great diversity of other, non-eucalypt, hardwoods, some highly valued. The diversity of eucalypt species means that they provide a range of wood properties greater than would be expected within a single genus of timber trees. However, the rainforest species provide a more diverse array of timbers some of exceptional value or unusual properties. Despite an array of english names, many are closely allied to such famous tropical timbers as teak and mahogany. At one time these enabled a truly amazing number of particular applications to be covered by the range of available timber species (Swain 1928). Most of these applications are no longer relevant but many rainforest timbers are still highly valued for interior work, cabinet or other high value applications. The distinctive qualities of some such as silky oak, black bean, or red cedar are, for many people, a significant part of Australian material culture.

In terms of botanical affinity and timber quality, the tree species being considered in this project can be considered in the general category of “rainforest timbers”. Some are actually found as rain forest trees or are closely allied to them. Recent accounts of the timber properties of many of the species mentioned in this report can be found in Bootle (1983) and Keating and Bolza (1982). Detailed accounts of the albizia species can be found in Gamble (1902).

Shortage of rainforest timbers

The total area of rainforests in Australia was quite small at the time of European settlement, much was subsequently cleared for agriculture, and the yield from those managed for timber production was already in decline before strong pressures for rainforest protection reduced it further. Timber production from the wet tropics virtually ceased when 98% of the tropical rainforest hitherto managed for timber production was closed by World Heritage listing (Anon 1989). There had been earlier attempts by the Queensland Forest Service to establish plantations of such species as red cedar or black bean. These encountered technical problems and were probably under-resourced. World Heritage listing lead to a reappraisal of the possibilities (Russell et al. 1993). The prospect of shortage spectacularly pushing up prices has not been realised, at least not to the satisfaction of those who stockpiled supplies. Apparently larger-scale users simply changed to imported rainforest woods. However there has been a recent detailed analysis of the future market for North Queensland rain forest cabinet timbers by Herbohn et al. (1986). They pointed out that there was likely to be a continuing small production from private land, and that future prices would probably be high, but would require the formation of cooperatives.

Apart from the simple matter of scarcity value we consider there are other indications that there would indeed be a high-value market (c. \$2000 / m³) for these timbers.

CRRP planting

The Community Rainforest Reforestation Program was initiated first as a response to World Heritage listing of the wet tropics; with the loss of employment in timber processing, funds were made available to employ people in tree establishment. Although there was state technical and federal financial support this program has operated essentially at the local level through local government. Although this had land rehabilitation aspects there has usually been a definite intention to create a new resource of high-quality cabinet wood. It is highly relevant to this project

in at least two ways. Firstly, the trees have usually been planted at relatively wide spacings into existing pasture rather than forming a woodlot. Secondly there has already been some pruning of open-grown trees to obtain good stem form - a useful precedent in that it had not been done before on some of these species. An important difference, as well as climatic one, is that CRRP planting has taken place on freehold land. Most pastoral land is leasehold and the question of the status of native trees planted by the lessee is of concern to producers (see Section B).

It would be fair to say that selection of species was approached from a forestry perspective (Gough et al. 1993; Russell et al. 1993). There was no available evidence to suggest which trees might have a particular benefit on animal or pasture production. However, at least some of the species that have been incorporated in CRRP plantings can be considered to have a dual purpose role (see *Paraserianthes toona*). Existence of the CRRP means that there will be some momentum for the utilisation of plantation-grown rainforest hardwoods. It can be expected that by the time any of the species highlighted here are ready for marketing, there will already have been sales of some farm-grown rainforest timbers.

Pruning for clearwood

Most open-grown trees and particularly siris adopt a spreading habit and it might be asked if it was possible to obtain useful wood from them at all. Attempting to obtain clearwood from fodder trees is almost the reverse of the aim in managing browse trees which is to maximise leaf and minimise wood production. However there seems no reason why pruning should not be applied to the species considered in this study any less than those for which it is already recommended (Cremer 1990, QDPI 1995). A useful precedent is that pruning of rain forest hardwoods is already being carried out in some CRRP plantings. Although an “unknown” in this study it is not likely to be too daunting for two reasons. In any scenario many more trees would be planted than would be required for the final crop. Thus there can be selection of elite trees that already have good form. Secondly, if producing high quality cabinet wood, it would not be necessary to obtain the usual log length of at least 4.8 m. Pruning to obtain a clear bole to 3 m should be relatively easy and would give a useable log.

The case of camphor laurel

In S.E. Queensland and northern N.S.W. the exotic camphor laurel (*Cinnamomum camphora*), a highly prized tree in its Taiwan habitat, has become a major weed tree, reaching considerable sizes in some thickets. Utilisation of it might be driven partly for ethical motives (reducing demand on threatened native species), but more probably because camphorwood is unequivocally of high value in its own right. There has developed a thriving small scale local industry with certain furniture makers advertising themselves as specialists in camphor laurel. The implication of this is that where a new high-value resource is created, even in a non-conventional forest system, utilisation will follow.

Mobile milling

Utilisation of agroforestry plantings through a conventional sawmill would require harvesting and transport with specialised and heavy equipment. This would be difficult to arrange on the initial small scale that would be expected, and could present major problems of access. Furthermore it appears that sawmills tend to offer low prices for small lots or “unusual” species. Under these conditions it would be difficult to see returns from initial small scale plantings being economically attractive. However there is no reason why logs need be processed through conventional mills. There have been rapid developments in the area of mobile sawmilling with a number of rigs being produced in Australia. At least three companies were demonstrating equipment at the Brisbane “Timber and Working with Wood Show” and two at the Queensland Department of Natural Resources’ “Managing and Growing Trees Training Conference” at Bundaberg 8-10 October 1996. The simplest options involve a long-bar chain saw mounted on a rail. However those that have a small direct-driven circular saw that is driven along a preset track determined by jigs and rails appear to be able to cut very precise dimensions, with boards down to 15 mm thickness cut directly from fallen logs in situ. The options for small scale harvesting are now receiving serious attention (Kerruish and Reid 1996).

A surprising number of mobile mills are operating in Queensland, particularly in the southeast (Appendix 2).

In general these operators will mill logs in situ at a cost of about \$100-\$200 / m³. It was claimed by one informant that a load of timber cut for him at a cost of \$100 / m³ could be sold in town for \$1000 / m³.

A further advantage of on-farm milling is that felling and processing can be done at different times. The trees can be felled when the forage value of the canopy is at a maximum. Allowing the log to dry out in situ may give more dimensionally stable timber. Some wood workers prefer to use wood that has been allowed to cure in the field.

Mobile milling need not be limited to the production of roughly sawn slabs and billets. The author has seen a property where spontaneous regeneration of *Acacia melanoxylon* (Tasmanian blackwood, growing as an outlier population in tropical Queensland) was milled on farm and then used for interior walls.

Demand from the woodcraft industry

Most appraisal of timber markets assumes the demand is largely in the building industry. However one of the surprises in the course of this project was the realisation that wood working, from amateur to professional, was a significant economic activity in Australia. This is not only in the value of the goods produced, but in the supply of wood working equipment, of timbers for craft use, and in terms of the number of individuals involved. Thus the “Timber and Working with Wood Show” which rotated among capital cities and was in Brisbane 24-26 May 1996, had approximately 180 exhibitors, most of them selling equipment or materials, and was reputedly attended by about 15,000 people. It can be inferred also from magazines such as “Australian Wood Review” and the glossiness of the advertising therein. A subjective impression is that there is also developing a high level of skill and talent which will ensure the future of this industry.

Wood working for craft purposes obviously uses smaller timber sizes than those used in framing or construction, and also uses less common species. Some are imported, for particular qualities or reputation. Despite the small sizes there is some use of the highly dense timbers (classically mulga, but see also *Albizia basaltica*) from the arid zone. However the greatest interest is

attached to Australian rain forest timbers, due to both the tradition of high-value use and current scarcity. A number of substantial companies (2 in Brisbane) advertise themselves as dealing in rare timbers, and there appear to be a large number of small dealers, down to the individual selling a slab of rainforest timber off the back of a utility at a country market (see *Paraserianthes toona*).

Thus, for the agroforestry system we are considering, there is already a trade that would absorb both the species being considered and the likely initial quantities.

Some indicative prices

The major dealer in rare timbers in Brisbane indicated that the current price for rainforest species, as sawn timber, properly dried, was in the range \$1000-1500 per cubic metre.

Although in the forest industry wood prices are usually quoted in terms of cubic metres, this may not be helpful in terms of agroforestry with high value species. In assessing possible returns it seems more meaningful to look at the way rain forest hardwoods are being sold at present. Rare or high value species may be sold in almost any size. However there seems to be a tendency to deal in flat billets in the size range 1.5-2m × 0.5m × 0.1 m. This is probably determined by the upper limit for a single piece likely to be of use to furniture makers (e.g. for a dining table top), and also a convenient limit for physical handling of single pieces. Such slabs are being sold for \$200 - \$400, depending on species.

On this basis if a tree pruned to give a clear bole of 3.5 m was grown to 60 cm dbh, it would yield four such slabs and a similar amount of material in smaller pieces. This suggests a cif value in town of \$1000-\$1500. Allowing for mobile milling and transporting it suggests a return of \$500-1000 per tree is possible.

2.3 Notes On Outstanding Candidate Species

Summary

The siris tree - Albizia lebbbeck

From its widespread occurrence as a shade tree, this species is clearly capable of growing well over much of northern Australia, where it also occurs as a native tree in monsoon forest. The green leaf is of recognised value for forage overseas but it has never been grown for this purpose in Australia. Isolated large trees shed large amounts of leaf, flower and pod in the dry season and also promote the pasture below the canopy. The combined contribution to animal production has never been assessed, but would appear high. The timber is valued overseas as cabinet wood. It has not been evaluated in Australia, but small amounts are being used for craft purpose, and further development could be done with existing wayside trees. Growing it for both wood and animal production in a single system seems feasible, and this species would be the most attractive for this purpose. In principle this could have a radical effect on the existing pastoral system, making it more productive and sustainable.

Forest Siris - Albizia procera

This is the name given by the Queensland Forest Service to a tree already recognised, but rarely seen, as a native rainforest timber. It can be found naturally in open habitats well away from rain forest and can almost certainly be established over a wide area of northern Australia, although not as widely as siris. It has more erect stem form than siris implying less pruning to obtain good log form. The green leaf would be of high feed value but there would be less dry-season fall of edible material. It also appears to promote pasture growth.

Tipuana - *Tipuana tipu*

Tipuana, introduced as an ornamental, could be an outstanding tree for dual-purpose agroforestry because it appears easy to establish, highly productive, and provides an easily worked attractive timber. Its value as forage, particularly in utilisation of fallen leaf and pod, would be higher when pasture quality is poor. It appears to promote pasture below the canopy. All aspects need more investigation. It may grow better in the subtropics but be of more forage value in the dry tropics. Although an exotic, and unlike the other species highlighted, there is little relevant overseas information

Yemane - *Gmelina arborea*

Although a well-known tree of tropical plantation forestry, and closely related to the native white beech, there is little experience with it in Australia. Its use in a wood/grazing agroforestry system would be quite novel, and is suggested here because all the leaf falls in the dry season and appears to be of remarkably high feed value. Other attractions are the fine timber and rapid growth rate. Much further work needs to be done.

White cedar - *Melia azedarach*

Although not having the near-icon status of the related red cedar, clear wood from white cedar is of very high value. The tree is found over a very wide range of habitats in Australia, including semi-arid areas. The leaf has an exceptionally high digestibility and has been said to be fed to dairy cows. White cedar is conspicuously deciduous, but leaf drop occurs rather early in the dry season which may detract from feed value of the fallen leaf.

Mackay Cedar, Red Siris - *Paraserianthes toona* (*Albizia toona*)

The rich red heartwood of Mackay cedar is responsible for its trade name. It is a well-known rain forest timber which is still sought by furniture makers and craftsmen. Mackay cedar is of interest to this project because, like many rainforest trees, it can be found occurring naturally well away from closed forests. The fodder value is unknown but it is presumably nitrogen fixing, and could be expected to have a promotional effect on pasture. It is one of the species included in some CRRP plantings, so there would be some opportunity to test the tree-grass interaction in the future.

Rain tree, monkey pod - *Samanea saman* (*Albizia saman*)

The wood is well known from abundant imported wooden handicrafts. It is an excellent shade tree in much of the tropics, including North Queensland. It seems that any large stems are actively sought after by woodworkers in North Queensland who have thus become quite familiar with the timber. The rain tree prefers a wetter climate than siris, but is by no means confined to the wet tropics. It has already been documented as a fodder tree in relation to the pods which fall in the dry season. However the species is also deciduous and in pen trials the fallen leaf was eaten in surprisingly high amounts. The rain tree is also one of the species that can unequivocally promote grass growth.

Dead finish - *Albizia basaltica*

This is a small tree that is widespread over inland regions. It is regarded as a good browse shrub and the log, although of small size, is apparently highly prized by wood turners. The wood is extremely hard and dense, deep red with yellow outerwood, and takes a high polish

Albizia retusa*, *Albizia canescens

Little-known native species, similar to siris.

Flame tree, kurrajong. *Brachychiton* spp.

Good fodder trees, with very soft low density wood, apparently similar to imported balsa.

Dalbergia - Dalbergia sissoo

Has performed well in initial trials for browse in Australia, and yields the valuable rosewood of Brazil.

White Beech - Gmelina leichardtii, G. dalrympleana

A well-known but now rare rain forest timber. In agroforestry plantings, the role of fallen leaf for animal nutrition could be of particular interest.

Leucaena - Leucaena leucocephala

Well known as a fodder shrub. Some of the new lines are more tree like than shrubby, opening the possibility of use in a dual purpose regime.

Velvet leaf, yellow boxwood - Planchonella pohlmaniana

A common native tree of North Queensland, said to be good browse, and timber is said to be very even-grained and easy to work.

Sandalwood - Santalum acuminatum, S. lanceolatum

Valued as browse by graziers in the north Australia savanna regions. The wood is of high value because of its fragrance.

Red Ash - Alphitonia excelsa

Minor recognition for both browse and timber, but of interest for its vigorous regeneration as a pioneer species.

African Mahogany - Khaya senegalensis

This species has fine timber, can grow under dry conditions, the large leaves are palatable to cattle and it is deciduous.

Melia volkensii

This African tree is closely related to white cedar, and appears to perform well in a semi-arid environment in Australia. It has browse value, yields good timber and is deciduous.

A tentative ranking of the suitability of the main species for different zones is given in Table 1.

A The siris tree, *Albizia lebbek*

The quality of life in many a town, homestead or stockyard in northern Australia is improved by the shade of this tree. Overseas it is famed both for forage and timber. It can be seen thriving in many places in northern Australia. Yet until recently no one seems to have planted it for any purpose but shade. Surprisingly few residents can apply a meaningful name to it.

Names include the trivial ("mother-in-law's tongue, rattle-pod"), misleading ("acacia"), or obscure ("flea tree"). The name "rain tree" is incorrect because this applies to the related but certainly different *Samanea saman*, but more acceptable when qualified as "Queensland rain tree" or "Kimberley rain tree", both of which are used. In terms of the heaviest human use the Indian name "siris" is the logical choice and has been applied in some widely distributed publications (Anon 1980). However calling it "Indian siris" seems inappropriate because the plant is genuinely native to Australia. Use of "albizia" as a common name should be avoided as it is often applied to *A. falcataria*, a species of major importance in the wet tropics, and very different from siris. *Albizia* is a genus of about 100 species, very similar to *Acacia*. The most important practical differences are that most of the albizia species are more tropical and none have the harsh sclerophyllous leaves (phyllodes) found in the Australian acacias, and are thus inherently more likely to be of good feed quality. See also *A. procera*, *A. toona*, *A. canescens* and *A. retusa*.

Siris is a medium to large tree, usually of multi-stemmed widely spreading habit; to 30m diameter, 20m high. The bark is rough, grey, with reddish inner bark, often exuding a tea-coloured gum. The leaf is doubly pinnate with the leaflets variable but about 35X25 mm, big enough for stock to see and pick up when they fall. The leaves are initially bright green and fold at night, as they mature they become more fibrous, a duller glaucous green and fixed on the rachis. The tree is fully deciduous in the dry season, the length and timing of the leafless period varying with individual trees, and with latitude. Thus it is leafless for about May-October in southern Queensland, but only 4-6 weeks in August-September in North Queensland. New leaf appears at the height of the dry season. Flowering occurs gregariously in October in North Queensland, later in the south. Mature trees carry a crop of large, fluffy, yellow-green inflorescences with distinctive pleasant fragrance, profuse enough to soon carpet the ground. The pods are flat-oblong 120-350 X 30-60mm, stiff-papery when ripe, with heavy crops the pods rattle together in the wind.

Siris can grow well under a wide range of rainfall regimes (600-2500 mm). The author has seen good specimens, if not quite the same size, at Julia Creek (400 mm) and in the Kebun Raya in Bogor, Indonesia (rainfall 4000 mm). It may be established in areas of highly variable rainfall but in its natural habitat probably requires a reliable wet season. It is found on a wide range of soil types including those that are alkaline and saline (Prinsen 1986). Frost kills seedlings and low growth.

Status as native tree

Siris is indigenous to the Indian subcontinent, to those areas of South East Asia with a marked dry season (e.g. Northeast Thailand, Eastern Islands of Indonesia) and to the monsoon areas of Northern Australia. Early botanists were unfamiliar with these areas, and as it was certainly introduced into coastal Queensland, probably from India, during early settlement, it was commonly regarded as an exotic. In fact its introduction was advocated by the Victorian Government Botanist, Baron Von Mueller (1888). However recent floras (e.g. Dunlop et al. 1995) consider it indigenous. It is also so treated in the Brisbane Botanic Gardens and Queensland Herbarium. Indigenous stands have been recorded in the Kimberleys in such formations as "semi-deciduous mesophyll vine forest" (Kabay and Burbidge 1977). Collections in the Queensland Herbarium are distinguished as either exotic or indigenous. Notes on the latter often place it at the rainforest-eucalypt woodland ecotone. These indigenous populations are probably declining as seedlings can hardly establish under continuous grazing by cattle.

Animal production value

The basic problem with pastoral production in the tropical dry season is the low feed quality of the basal diet, mature tropical grasses. Siris addresses this problem in three ways: as a feed, as a supplement, and by improving grass quality

Trees may adapt to a semi-arid environment in two divergent ways that are very relevant to animal nutrition. Leaves may be long-lived, heavily cutinised, durable and sclerophyllous, as in the phyllodinous acacias, or they may as with siris be less lignified, short-lived and deciduous. The latter are of potentially higher feed value because of the lower lignified fibre content but may be protected from browsing by secondary compounds. Leaves of siris are remarkable for the absence of toxins, tannins, and the low level of soluble phenolic compounds. This is shown in an unusual way by it being one of the very few species where the leaves are utilised by fruit bats (Lowry 1987), and also by good growth performance of rabbits when siris leaf comprised 50% of the diet (Lowry et al. 1992). Flowers contain no adverse constituents but pods contain saponins (Varshney et al. 1971) which may limit intake but appear to have no other adverse effect. Protein and fibre (NDF) contents are as follows: green leaf, 16-23 and 41-35%; fallen leaf, 10 and 49%;

fallen flower, 23 and 51%; pods, 19 and 55%. *In vitro* digestibility values for leaf have been reported in the range 45-70% and are usually around 50% for mature leaf. Results of actual feeding experiments are reviewed by Lowry et al. (1994). The overall conclusion is that the leaf is an excellent feed early in the season, or in regrowth after cutting, but of only moderate digestibility when mature although still of higher quality than mature grass. The fallen leaf is of surprising value because of the high voluntary intakes shown by sheep. All fractions fed as supplements produced an increase in digestible dry matter intake, with the effect being much more marked with the lower quality basal diet (spear grass). Fallen flower is an excellent feed. The pods are of particular interest for the poor response when fed to sheep on their own compared with their positive effect as a supplement to poor quality spear grass. Cattle find them palatable (cover). The protein is mostly in the seed, which is retained in pods when they fall (unlike leucaena). A little seed escapes digestion in cattle but not in sheep.

The value of siris as supplement in extensive grazing systems is that leaf, flower and pod drop sequentially during the dry season and can be utilised directly by grazing animals without any management effort being necessary. In mature trees leaf, flower and pod fall in comparable amounts (Lowry 1989) and can total 100kg.

Trees promoting pasture

One of the most interesting aspects of siris is that, in addition to providing feed directly, it can enhance pasture production and quality. Isolated siris trees in tropical woodland frequently have a conspicuously greener sub-canopy area in which *Heteropogon contortus* dominant in the open grassland, has been replaced by higher-quality *Panicum maximum*. At a Townsville site dry matter yields under the trees were much higher (1710 kg/ha) than between trees (753 kg/ha) during the early wet season (Lowry et al. 1988). Subsequent studies at the same site showed that grass quality was maintained under the trees for about 2 months longer into the dry season than in the surrounding area (Liano et al. unpubl.). Cattle admitted to the site confirmed the difference by preferentially grazing the subcanopy grasses. Similar observations of a "canopy effect" have been made in widely separated areas of coastal Queensland (Prinsen 1986; Wildin unpubl.). A wider discussion of the "canopy effect" is in Section 2.1.3. In northern Australia siris appears to be the tree that shows it most markedly. One could say that the tree provides a biological method for dealing with the problem of loss of feed quality in dry season grasses.

Shading and animal production

Excessive insolation affects production of grazing animals in the dry tropics and the requirement for shade is well known although there is little quantitative data. In the case on the Australian tropical woodlands, although there are usually many eucalypt trees, the shade from these is typically thin (transmission through canopy about 80%). Transmission through the canopy of mature siris trees is 40-50%. Provision of such shade would itself benefit production.

Wood value

There is apparently some international trade in siris timber, as it is known in the U.K. as "East Indian walnut" (TRADA 1979), a name which, while incorrect, seems to indicate the value set on the timber. Also according to TRADA : "*The wide sapwood is yellowish-white in colour, and the heartwood is dark brown streaked with lighter and darker bands. The grain is often deeply interlocked and wavy, giving the wood a figured appearance. The strength properties are similar to those of American black walnut . . . moderately durable . . . polishes excellently but requires careful grain filling . . (uses). furniture, panelling, carving, boats, casks and for structural purposes*". A more detailed account is that of Gamble (1902). A range of uses as cabinet timber

have been listed, including the doors of Chinese temples (Burkhill 1966). A more recent, but essentially similar, summary of timber properties is that of Keating and Bolza (1982).

No siris logs have been subject to wood quality assessment in Australia and it is not on the very comprehensive list of Queensland timbers (Cause et al. 1989).

The large-scale uses of timber are of course in construction. However there seems to be an increasing interest in fine furniture, hand-crafted articles and amateur woodworking, particularly with rare or native timbers. Given the high quality of siris heartwood as reported in overseas publications, and the availability of many large wayside trees in Central and North Queensland, it seemed probable that there would already be some limited use of it in Australia. In this project the author sought for evidence of such use. Four aspects became evident.

1. Siris was indeed being used by individual craftsmen who are well aware of its identity, but the majority were not aware of it.
2. In North Queensland there is significant utilisation of the closely related rain tree (See *Samanea saman*), which has been found to have very similar properties and the two are often not distinguished.
3. Both the wood and the finished articles can be very attractive.
4. The wood was said to be easy to cure and work, but did produce an irritant dust.
5. Where the information could be compared with the overseas sources there was complete agreement.

Overall, it seems certain that siris timber will be saleable as a premium cabinet timber in the future, but the actual value is impossible to predict.

Although some articles make use of the strong sapwood-heartwood boundary for decorative purposes, the real value for cabinet work is attached to the heartwood. Siris is very fast growing so that the log may contain a large proportion of less valuable outerwood. Conversion of outerwood to heartwood is a physiological process, largely determined by time. Thus if tree growth is arrested, wood volume increments would decrease, but conversion of outerwood to heartwood would continue at the same rate, giving an increase in the proportion of heartwood. This offers the attractive possibility that the wood in trees that had been heavily lopped for drought feeding would continue to add value even though the wood volume growth was reduced. This is a positive aspect of management for wood and animal production that would be quite novel.

Productivity

Comprehensive yield data have not been published. However it is evident that the species is productive when actively growing or regenerating and also as undisturbed mature trees. Under best conditions plants can grow to height 5 m in one year. Fuelwood plantations produce 5 m³/ha/year (Anon 1980). Leaf litter fall under plantation conditions was 5000 kg/ha/yr (Pradhan and Dayal 1981). In Puerto Rico plantings of 2500, 10000, and 40000 trees/ha had leaf dry matter yields in the first 24 months of 1710, 2560 and 3670 kg/ha (Parrota 1988).

In the Townsville area (wet-dry tropics) of North Queensland, isolated mature trees produce edible dry matter (falling leaf, flower and pod) at the rate of 100-120 kg/year (Lowry 1989). Existing wayside trees show a crown diameter expansion of 2-2.2 m/year until mature (Lowry and Lowry 1991). Individual newly planted trees have been seen to reach a height of 5 m in 2 years.

In the wet tropics (Lannercoast State Forest) the 8-year old siris planted in the Shell Trial (see under Yemane) were observed during the present project (June 1996) to have become medium-sized trees with crowns branching out at c. 2.5 m with a clear bole of dbh 15 - 33 cm. In this area siris had outperformed tipuana, which were barely surviving.

In sub-tropical Queensland at Brian Pastures, stands of mature trees with triennial pollarding yielded 1700 kg/ha/yr. According to Prinsen (unpubl.) hedgerow stands browsed by cattle twice a year yielded 2500 kg/ha/yr, in a subtropical low-rainfall area where leucaena yielded 1500 kg/ha/yr.

It is evident that in Australia there is a latitudinal range in growth rates. Although individual large trees can be seen in southern Queensland, new plantations such as the QDPI sites at Worrall View and Mutdapilly have grown much more slowly than in the tropics. However an older plantation at the Gatton campus of the University of Queensland shows massive coppice regrowth and probably now has a high annual dry matter production. The Browse net plots at Brian Pastures have grown somewhat faster (height 2.6 m in 2 years) and the tree appears to perform better than at more southerly locations.

Establishment and silviculture

There is no doubt that there have been a number of disappointments in trying to establish siris over the last 5 years, despite accounts that make it seem easy (Anon 1970). Often this has been due to worst than average seasonal conditions. Two comments are worth making. It does seem that container-grown seedlings are likely to perform badly if left too long in the container. Secondly, planting as bare-rooted stumps, almost unknown in Australia, has been quite successful (cf Lowry 1991). Establishment can be affected by attack on young plants by mice or rabbits. Reserves in the root system enable young plants to survive total defoliation from frost, fire or grazing. Thus what looks like a total failure may turn out to be a setback of one year. Growth is opportunistic when conditions are suitable but ceases for 2-3 months before leaf drop. Leaves are largely unaffected by insects, but young leaves may be subject to heavy predation by larvae of the grass yellow butterfly (*Eurema hecoba*). This appears to be a very short-lived effect. The most serious pests are bark-feeding larvae of longicorn beetles. These do not affect small stems and have little effect on large stems, but through complete girdling can cause dieback in stems in the diameter range 40-100mm. There is considerable variation in susceptibility of individual trees. Trees may be more susceptible under prolonged water stress. The real challenge in growing trees for wood and forage is to obtain a clear stem. Open-grown trees tend to branch out at about 2 m and good stem form would have to be achieved by timely pruning.

Costs and benefits

It is not possible at this stage to add much to the "scenario" presented in Section B. From observed growth rates it can be expected that well growing trees could be harvested for timber at age 20-25. Trees would contribute progressively to animal production after year 3 but should make a big difference from about age 8. Both the break-even time and the final return are critically dependent on establishment costs (and of course interest rates). Costs should not be very different from leucaena, but it would require further study to obtain a meaningful figure.

A surprising aspect is the small number of large trees that would be required to improve cattle nutrition. For a 200kg beast, significant supplementary feeding (1 kg/day for 3 months) could be obtained from just one large tree. This is in country carrying one beast to 3 ha.

If enough trees were planted to double the total feed available, this should at least triple animal production because of the overall higher feed quality and the buffering of seasonal extremes. This should still take only 6-10 trees/ha.

Implementation of such a system on a large scale would not only bring a greater return from a given land unit but would generate new rural employment. It is not hard to envisage both tree establishment and harvesting being done for the landholder by specialist contractors.

One can assume some specific environmental benefits from trees such as siris compared with eucalypts. These include better interception of storm rain by the canopy, better penetration below the canopy, increased soil organic matter, and the favouring of some wildlife.

B Forest Siris - *Albizia procera*

Forest siris is the timber trade name used by the Queensland Forest Service for an attractive tree seen from Sarina northwards. It is closely related to siris and like it is native, but not endemic, to Australia. It has a wide distribution through tropical Asia in savanna and deciduous forest habitats and has become established elsewhere in the tropics, to the extent of becoming a weed in Puerto Rico (Chinearivera 1995). The tree is clearly distinguished from siris by the smooth pale green or buff bark, larger leaves, more diffuse canopy, much smaller flowers, and smaller flatter red pods. It occurs in rainforests, at the boundary between woodland and rainforest, and not uncommonly in eucalypt woodland far from rainforest. Although regarded as a "rainforest timber" Turnbull (1986) gives a detailed account of the distribution, clearly placing it in a range of eucalypt woodland types. The author has seen extremely tall trees in riverine rain forest at Lannercost, inland from Ingham. In North Queensland, volunteer trees can be seen abundantly on roadsides in the Sarina area, on hillsides around Cairns, and - an easily defined location on the Bruce Highway - the lookout on the Cardwell Range over the Hinchinbrook Channel. These are relatively wet areas. However it can also be seen in drier areas, with scattered large trees, c. 50 cm d.b.h., at "Lansdown" station, 50 km inland from Townsville, and on the slopes of Mt Stuart. Its occurrence in drier areas is probably associated with drainage lines, dry watercourses, or run-out areas from hillsides. It should be noted that these are large trees, unlike, apparently, the Cape York populations which become shrubby under harsh conditions. This distribution highlights the ability of many Australian species regarded as rainforest trees to exist well away from the rainforest, a reflection of earlier vegetational history.

The restricted distribution in drier areas need not reduce its value. In extensive grazing areas stocked at about one beast to 3 ha, the tree would have a strong impact on production at only 1 tree/ha.

An important difference from siris is its tendency to adopt a straight single-stemmed form when growing as an isolated tree rather than a multi-stemmed spreading habit. Overseas names include "white siris"; a name applied in Queensland to the totally unrelated *Ailanthus triphysa* (Cause et al. 1989).

Forage value

From a note on a specimen in the Queensland Herbarium it appears that early settlers regarded it as a good fodder tree. This observation would be difficult to make today because it has largely gone from areas under continuous grazing, probably due to the palatability of the seedlings. Any material accessible to cattle at the CSIRO station "Lansdown" outside Townsville was actively browsed. At "Glen Dhu", north of Charters Towers, where both trees are present, cattle prefer it to siris (R. Holme pers. comm.). Overseas, it is certainly regarded as a good fodder tree for all

ruminants, the leaves being highly palatable and high in protein (Parrotta, undated). However there does not appear to be any published result from an actual feeding trial.

A bizarre but convincing indication of the palatability and lack of toxicity of the leaves is obtained by the behaviour of fruit bats, which chew the leaves to extract soluble nutrients (Richards and Prociv 1984). This and siris (Lowry 1989) are among the very few tree species utilised in this way. This can be taken as a strong bioindicator of relatively high soluble protein levels, low tannins, and absence of mammalian toxins.

Like siris, forest siris is deciduous and the fallen leaf would be expected to have similar feed value. However leaf fall occurs much later in the dry season (late November - early December). This may be an advantage if there was a prolonged dry season, less so if the rains came early. Leaf would be the main feed supplied from the canopy. The biomass of flowers is insignificant, while the pods are produced much more sparingly than siris.

Isolated trees of forest siris would be expected to have a promotional effect on pasture like that of siris and this appears to be happening with some wayside trees but has yet to be investigated. The tree is common enough for suitable sites to be located from which indications of tree-grass interaction could be obtained. In the Philippines it forms the tree component of an agroforestry system in which trees at a final density of 45 stems/ha are underplanted with food crops (Penafiel and Botengan 1985).

Wood value

This species is the only one of the 4 major species highlighted in this study listed as a Queensland timber by the Queensland Forest Service (Cause et al. 1989). However this shows only that sapwood lyctid susceptibility has not been determined and that the heartwood has a density of 735 kg/m³. It appears that very little has been sold in recent years. At the 1996 Brisbane "Timber and Working with Wood Show", only one dealer knew of it, having obtained a log from the Daintree region. He found it to have good working properties. Overseas reports are as follows:

"Several wood properties of the species make it a good all-purpose timber. The light brown to light chocolate-brown heartwood (S.G. 0.6-0.9) is moderately hard, straight grained, strong, durable and resistant to dry-wood termites. It is difficult to saw due to its broadly interlocked grain; with care it works to a smooth surface and polishes well" (Parrotta, undated).

"The sapwood is yellowish white in colour, and the heartwood is brown, with lighter and darker bands, similar to A. lebbeck in appearance, but less ornamental, lighter in weight and softer. The timber is strong, elastic, tough and hard. Compared to teak it is 10% stronger in modulus of elasticity, 25% more resistant in compression parallel to the grain, and twice as hard. The heartwood is moderately durable. Moderately hard work and saw by hand, but the wood planes to a smooth surface more readily than A. lebbeck due to the less oblique grain angle. Uses . . . furniture, and table and counter tops" (TRADA 1979).

A considerable volume of wood recovery data is condensed in volume tables of Indian-grown material (Sharma and Jain 1979).

Productivity, establishment and silviculture

A considerable number of reports, mostly from India, on the performance, establishment and silviculture of forest siris have been summarised by Parrotta (undated). Overall, it is regarded as

a fast growing tree. Although high growth rates are reported from Asia, it did not perform well in trials conducted by the QFS Forest Research Institute (P. Ryan unpubl.). According to Dr Ryan, this might have been because of an initial lack of the right rhizobia; growth later suddenly increased. There may also have been influence of provenance: seed came from Cape York, and Queensland Herbarium collections indicate many of the Cape populations have a shrubby habit. It does not feature in TREDAT (Cameron and Jermyn 1991).

It seems almost certain that it can be rapid growing in Australia no less than overseas. The author has observed young volunteer trees in the Townsville area, to have made height growth of 1-1.5m/y. The physiognomy of young trees appearing at locations such as forest margins and roadsides, and the context, certainly indicates rapid growth. Some data on germination and seedling development have been obtained in Australia (Arche 1994). Forest siris does not seem to suffer the dieback from stem-girdling longicorn larvae which is a problem with siris.

An obvious attraction of forest siris is that because of the more erect growth habit trees would require less active pruning than siris.

C Yemane - *Gmelina arborea*

Harvested from the forests of India and Burma, yemane was first known for its fine timber, secondly because it seemed a species that could be replanted readily. Tropical foresters have had an interest in it for many years. In the 1970s there was considerable optimism over the use of fast-growing tropical hardwoods to create new resources and take the pressure off tropical forests. Yemane having already shown some very high growth rates was one of the prime candidates, and was trialed widely around the tropics. It has since suffered, perhaps unfairly, from its association with the gigantic but flawed Jari project in Brazil. There is by now a considerable literature on its establishment and silviculture in plantation forestry.

In general it has been seen as a fast-growing hardwood for plantation forestry, and certainly not as a fodder tree or a tree for agroforestry. The suggestion that it could have a dual purpose agroforestry role is novel and arises for reasons that are explained below.

Animal production value

In contrast to a multitude of publications relating to forestry aspects, there are only two references to feeding it to ruminants.

Although not grown as a browse tree it appears that in India some material from plantations is available for cut-and-carry feeding and was thus used in a feeding trial (Majgaonkar et al. 1987). The leaf had a dry matter digestibility of 57%, a crude protein content of 11.5%, and the protein was 55% digestible. Animals showed a very high dry-matter intake of 2.6% body weight, indicating it was palatable as well as digestible. All these parameters indicate the leaf is an excellent feed.

A somewhat confusing paper from the Philippines (Serra et al. 1995) describes the effect of supplements on sheep grazing a dry season upland pasture which was part of an agroforestry system involving *Gmelina arborea*. There was little response to supplementation, indicating that the forage was not in fact as low in quality as would be expected. The only explanation for this appeared to be a high nutritional contribution from the fallen leaf from the *Gmelina*.

The interest of the author was aroused when, in studying *in vitro* digestibility of the fallen leaf of deciduous trees in the Townsville region (Lowry 1995), he found the species occurring as a large

wayside tree in two locations. The trees were completely deciduous in the late dry season in the Townsville area, the large membranous leaves forming a considerable carpet on the ground. This fallen leaf turned out to have an intraruminal digestibility at 24h of 80%. This was quite improbably high, but has since been confirmed by results obtained in Brisbane with material collected from the Mt Coot-Tha Botanic Gardens. This not only confirmed the overall high digestibility but showed that most of the rumen fermentation occurred very rapidly in the first 24 h. We also showed that, under conditions simulating chewing by the animal, tree leaf in general fragments more rapidly into smaller particles than fibrous grasses (Kennedy and Lowry 1996). These factors together suggest the fallen leaf should be a very effective energy source - the animal can process the material rapidly, extracting most of the available energy in a short time, with the indigestible fraction able to leave the rumen rapidly because of the rapid fragmentation to small particles.

These results, together with the sparse literature cited, suggest that if yemane was grown at wide spacings in pasture in the wet-dry tropics, there would be a substantial dry-season leaf fall with a digestibility so high that it could be regarded as an energy supplement. Animal performance would then be limited by protein, which of course is low in both the dry season grass and the fallen leaf. An interesting possibility would be co-planting with siris to take advantage of the protein from the fallen flower and pods.

The effect on pasture is quite unknown. Yemane is not nitrogen fixing, and the canopy is moderately dense, more so in the wet tropics than in Townsville or Brisbane. We have no data on light transmission by the leafy canopy of open-grown trees, nor of the period of leaflessness. From the overview by Wilson (1996) there is every possibility that the shading would be in the range to promote shade-tolerant grasses.

Wood production

Rapid tree growth is often assumed to be associated with production of low-density wood, suitable for pulping or preservative treatment, but not as high quality cabinet wood. This is certainly not the case with yemane as the timber is -

“One of the best and most reliable timbers found in southern Asia. The sapwood is not distinct by colour from the heartwood, the wood being yellowish-brown, lustrous, with a smooth oily feel”...“..is botanically related to teak, and by comparison with this timber is not quite as strong, has the advantage of being lighter in weight “ . .”works readily to a smooth finish, and takes stain and polish well” (TRADA 1979).

It is said to be durable and used inter alia for boat decking, planking, doors, panelling, furniture. A more detailed account is that of Gamble (1902).

Unlike the other species highlighted in this report there are very few trees at present in Australia for evaluation. Indications of wood quality would have to be based on overseas data. As there is no distinct sapwood zone, value would be more simply related to wood volume than in the case of siris. In Australia it may have an attraction if perceived as a substitute for the valuable but almost unobtainable rainforest timber white beech (the closely related *Gmelina leichardtii*) which appears to be very slow growing in at least one agroforestry trial (D. Lamb unpubl.).

Performance In Australia

In accordance with a much earlier interest in yemane the Queensland Forest Service established some small plots in Imbil State Forest (lat. 26 31') in 1933. As reported by Cameron and Jermyn (1991) *“original planting very variable in form and vigour. Much well formed natural regeneration”*. Although the maximum dbh was 71 cm, most trees had an unimpressive dbh, for

the age, of 30-50 cm. It thus appears that the species does not do well in the subtropics. The entire compartment was clear felled in February 1996, shortly before the author learned of its existence.

Shell Trials. In the mid-80s the Shell Oil Company in Australia, apparently considering large-scale investment in plantation forestry, provided funds to the Queensland Forest Service to carry out certain trials. Some of these were of species of no interest here, but they included multi-species trials involving a considerable number of species, planted in December 1987 as randomised replicated line plots of 6 plants each. The forestry investment did not go ahead but the trials, once established, have been left in the ground with no further attempt to gather data from them. They provide an interesting resource for study of several species of interest. The author was able to visit two sites, at Lannercost State Forest and Kennedy State Forest, both in the wet tropics.

The 8-year-old yemane at both locations can only be described as spectacular. It appeared to be the pre-eminent species among those in the trial, with many stems reaching a height (estimated) of 20-25m, of erect form, with a dense vivid green canopy. Although most trees had the grave defect of being multistemmed, the individual stems were extremely straight and lightly branched. Converting the total basal area of multi-leader trees to the single-stem equivalent gave dbh in the range 35-48 cm. This represents an impressive wood volume growth. It is of course likely to be much less than this where there is a marked dry season, but, from the appearance of the Townsville trees, one is optimistic. The multi-leader feature seen on these trees should be of little consequence as open-grown trees would need pruning in any case, and this would be the easiest to correct.

D Tipuana - The Next Big One? - *Tipuana tipu*

Leucaena leucocephala, *Calliandra calothyrsus*, *Acacia mangium*, these are among the tropical trees that had minor or localised importance in their original habitat. Then, introduced, often casually, sometimes as ornamentals, in some far-removed location, they displayed qualities that led to world-wide interest in the species. *Tipuana* may be the next such tree, with the “discovery” taking place in Southeast Queensland!

Tipuana tipu (Benth.) O.Kuntze (Papilionaceae) is known as tipa, tipa blanca, or tipu in its native range of northern Argentina and southern Bolivia, but no common name has been brought with it to Australia and, apparently, no trivial or incorrect names come into common use. It seems to be known, if anything, as tipuana. This may be just as well, as the complete botanical name sounds frivolous when spoken quickly. The species is a handsome tree legume with yellow papilionate flowers, single-seeded winged pods resembling sycamore fruits, and singly pinnate leaves of a rather dull grey-green. It is a common tree of streets and parks throughout Queensland, particularly in the southeast where it may reach more than 1 m dbh. It is the major large tree around the St Lucia campus of the University of Queensland.

Around 1987, John Wildin in Rockhampton noted its ease of establishment and performance and started suggesting it could have a role as a tree forage. The author was doubtful, as in Townsville it seemed to be very much a tree of well-watered gardens. However, probably as a result of Wildin’s advocacy it was incorporated in the “browse net” trials from 1989. It was also planted among the browse collection at the University of Queensland research farm at Mt Cotton.

For such a common substantial tree, remarkably little is on record about it. There was a brief entry in a relentlessly optimistic publication that highlighted little-known tropical legumes (NAS 1979), in which it was said to be fast growing, reached large size (40m height, 1.5m dbh), had well-regarded timber but was known mostly as an ornamental. However the research literature for the last 25 years contains very few references to it, and then often incidental ones, such as in lists of hosts for a

particular fungus, or aspects of its amenity use. The only relevant publication was a study of performance of 12 tree species in southeast Queensland where it was found to be unsuitable for saline sites (Dunn et al. 1994). Although there have been a number of volumes devoted to browse trees or tree legumes Gutteridge and Shelton (1994) it does not appear in any of these. Recent floras refer to it only as an ornamental, both in its native range (Lewis 1987), and in Africa (Lock 1989).

Animal Production Value

The only published results on forage quality are for an experiment where tipuana was one of nine tree legumes being compared for nitrogen digestibility (Ahn et al. 1989). Tipuana leaf had a high protein content (23%), a high dry matter digestibility (75% by intra-ruminal nylon bag), and a rather high phenolic content that did not seem to affect the protein digestibility which was very high (86%). These results should indicate very high feed value. However in the University of Queensland Mt Cotton experiment station, just south of Brisbane, a field trial is currently being conducted with grazing cattle in the presence of leucaena, *Albizia chinensis*, and tipuana. Weight gains were in the same order, so that performance with tipuana was less than with the other two species. However this seems to have been a function of relative forage availability rather than quality (R. Gutteridge unpubl.). Acceptance may depend on the accompanying pasture quality. It is extremely palatable to cattle in Central Queensland (J. Wildin unpubl.) and in North Queensland (R. Holme unpubl.). However in the Browsenet plots at Gayndah, when cattle were admitted to the multi-species plots, it was notably less selected for than siris and other trees.

Tipuana is a nitrogen - fixing tree with a canopy transmission comparable to siris. It is therefore likely to have positive effects on pasture, and observation by the author suggests this is so, but this needs to be checked. It is definitely deciduous but the leaf drop is not conspicuous because leaves show little colour change and the timing varies between branches and between trees. Leaf drop occurs in September in the Brisbane area but may be earlier in the dry tropics. Whether fallen leaf was utilised by ruminants would probably depend on the condition of the pasture. Leaf drop is preceded by ripening and progressive shedding of the fruit, a single-seeded, dry membranous winged pod, c. 30 × 10 mm. This is produced in considerable quantity, would certainly be accessible when it falls, and is almost certainly of high feed value although it would be important to know if cattle can crush the seed.

Wood Value

According to the National Academy of Science (NAS 1979): *“In Argentina the lumber is highly regarded for timber and cabinet work. It is finely striped, light coloured, and finishes with a high polish. It is not resistant to decay and insects, but reportedly has potential for use in light boxing as well as wall panelling, door frames, fine furniture and other interior work”*. There appears to be no wood quality data obtained in Australia. However wood workers in southern Queensland have been obtaining it, presumably from council-felled town trees, and it has been made into quite attractive articles which generally bear out the NAS description. It does not have the strong colour contrasts, flecks and grain seen in siris, but visual interest is added by a bright yellow compound, probably a 5-deoxyflavonol, which occurs in diffuse zones. It was noteworthy that it was said by wood turners to be easy to work and that - in contrast to many tropical woods - there was no problem with irritant dust. Its abundance as a town tree seems certain to ensure that a trickle of material will enter the woodworking trade, so that if farm-grown logs became available there would already be some knowledge of its utilisation.

Performance in Australia

In North Queensland tipuana can be found as a substantial town tree but is rarely seen in fully rural areas. It seemed likely that this was because it needed the extra water obtainable under urban conditions. However Mr R. Holme has established vigorously growing trees under moderately harsh conditions 100 km south of Mt Garnet. In the Shell Trials in Lannercost State Forest (see Yemane) it has performed very poorly, having barely survived at the present time (1996).

In Central Queensland it has performed comparably with siris in the Browsenet plots at Etna Creek. In subtropical Queensland, at the Browsenet plots at Brian Pastures tipuana reached a height of 2.6 m in 2 years, similar to siris but with a much thicker wider canopy (3.7 m v. 1.8 m), indicating a much greater difference in biomass. Currently, at four years, there is still a strong difference. The spreading canopy of these trees made stem measurements unfeasible and shows that active pruning would be necessary to obtain good log form.

As well as this, it appears from the survey (Section B) that a number of producers around the Darling Downs have been planting it for shelter or slope protection, simply because it appears to grow well and be easy to establish. A number of Tree Care extension officers have been recommending it for on-farm plantings for shade on dairy farms. This was based on observation, firstly of its high frost tolerance, secondly of its high growth rates. Today it is possible to say that tipuana will grow very well over much of subtropical Queensland. Although easy to establish, and a copious seed producer, it does not seem to have shown any weed potential.

2.4 Notes On Other Candidate Species

When the list of Queensland timber species (Cause et al. 1989) is matched with that of Everist's fodder trees and shrubs (Everist 1986), a surprising number of species could theoretically have a dual role. Here we treat only those where there is additional grounds for being interested in them.

Alphitonia excelsa - Red Ash

Red ash has timber properties listed as “*ornamental turnery, decorative veneer, panelling, joinery, flooring*” (Bootle 1983) but is presently non-commercial. The browse value has been highlighted by Everist (1986). It is deciduous over a prolonged period but the in vitro digestibility of the fallen leaf is very low (Lowry 1995). The species is mentioned here because it is widespread, and appears to regenerate vigorously and grow fast as a pioneer tree. It can form dense stands with straight unbranched stems. It is probably not worth establishing *de novo*, but where already present awareness of its dual role may enable useful management.

Albizia basaltica - Dead finish

This is a small tree that is widespread over inland regions. It is regarded as a good browse shrub and probably takes its name from its deciduous habit, when (the leaflets being very small and turning brown on senescence) the grazer sees the last green feed vanishing from the landscape. Unfortunately the name is applied also to some other inland trees that lose their leaves in drought. It is mentioned here because it does have dual value. The log, although of small size, is apparently highly prized by wood turners. This has been evident from the prices asked by the rare wood dealers, and by enquiries directed to the Forest Research Centre, Gympie. The wood is extremely hard and dense (1200 kg/m³), deep red with yellow outerwood, and takes a high polish. The tree may be too difficult to establish but where present it should be looked after and managed carefully.

Albizia canescens

This is an endemic species with no common name. Herbarium notes indicate it can be of similar habit and size to siris, but in the Townsville area it does not grow as large. Isolated trees look similar to siris but both flowers and pods are very different, both being smaller and less conspicuous. It is found scattered through eucalypt woodland and is surprisingly hard to distinguish because it has an open canopy and glaucous grey-green foliage like many eucalypts. It appears nowhere common and has probably been gradually disappearing through loss of seedlings under continuous grazing. It almost certainly has fodder value and would probably have wood value similar to rain tree if clear boles could be obtained. It may be of interest because of its apparent ability to thrive in drier habitats.

Albizia chinensis

This species was ignored by the author because he had previously seen it in a wet tropical environment, assumed it was suitable for wet areas only, and that there it seemed inferior to *Albizia falcataria* in most respects. However promising results are being obtained in a University of Queensland project at Mt Cotton experiment station in Southeast Queensland (R. Gutteridge unpubl) and the tree has been established in the semi-arid tropics (see Appendix 4).

Albizia retusa

This species appears, from herbarium material and notes, to be very similar to siris, and has similar large flat pods. However it has a more restricted distribution, being found in dry rainforests only on Cape York (Shelbourne Bay, Iron Range, Lakefield). This restricted distribution does not mean that it would not thrive elsewhere. It may in fact be a species whose value is waiting to be discovered.

Brachychiton acerifolius - Flame tree

All the *Brachychiton* species are good fodder trees (Everist 1986), and the kurrajong is one of the best-recognised native browse species. The surprise is that some have the timber properties listed by Bootle (1983). All have very soft low density wood, but this may have number of applications such as “stage sets, hat blocks” - apparently similar to imported balsa.

Dalbergia sissoo

Dalbergia species are tropical tree legumes found in Asia and the Americas that yield the extremely valuable but largely depleted rosewoods, such as Brazilian rosewood (*D. nigra*). *D. sissoo* is hardly known in Australia but is a species that has been planted widely because of multiple roles, ease of establishment, and hardiness on a range of harsh sites (NAS 1979). According to the National Academy of Science account, *D. sissoo* is the only species that does not have very valuable timber. This appears to be a mistake, because a subsequent review by the Winrock Foundation (Anon 1990) is quite explicit : “ . . . one of India’s finest cabinet and furniture woods. The timber value lies in its colour and grain, strength, elasticity, and heartwood durability. It is esteemed and widely used from early historic times in such uses as: highly decorative furniture, panelling, veneers, bentwood and carvings .. “. It is also regarded as a moderately good fodder.

The species is mentioned here because it has been incorporated in the BrowseNet plots at Brian Pastures, and has performed very impressively. These trees grew 3.2 m in height in 2 years, and at 4 years are taller than but not as bushy as tipuana. As indicated in Appendix 4, a North

Queensland grazier has not only seen the potential for a dual-purpose role but has already started pruning trees to obtain good stem form. This species is certainly deserving of further attention.

Gmelina leichardtii, *G. dalrympleana* - White Beech

These are two closely similar native species, closely allied to *Gmelina arborea*, and well known as a valuable timber although supplies have virtually ceased. It is being tried in agroforestry planting but appears to be rather slow growing. It is deciduous, and the fallen leaves are relatively large and membranous but do not have the extraordinarily high digestibility found in *Gmelina arborea*. It is mentioned here because when this fallen leaf is mixed with mature spear grass rumen organisms digest the mixture better than either separately. This has major implications for agroforestry systems in the wet-dry tropics.

Khaya senegalensis - African Mahogany

There has been some interest in testing this species in Australia because of its fine timber and ability to grow under drier conditions (Cameron and Jermyn 1991). It is said to be used as a street tree around Darwin. It is mentioned here because of the observation that the large leaves are palatable to cattle and that it is deciduous. Impressive 5-10-year-old trees can be seen at the QDPI site at Parkhurst outside Rockhampton and in the savanna section of the Townsville Palmetum - both sites with severe dry season - and at Forest HQ in Ingham.

Leucaena leucocephala - leucaena

Leucaena was first hailed as the pre-eminent multipurpose tree - fodder, green manure, fuelwood, pulpwood, land rehabilitation. In tropical Australia it is well known as a fodder tree. For this purpose it is hedged or otherwise managed for browse, and the question of wood production does not arise. However in the search for new lines resistant to the psyllid that has ravaged leucaena world wide, some of the most productive lines have been those that are strongly arboreal (M. Shelton pers. comm.). In particular "Tarramba" (K636) is noteworthy for producing a single straight stem. This opens the possibility of using it in a dual purpose regime, perhaps for production of treated poles.

Melia azedarach - White cedar

Although not having the near-icon status of red cedar, clearwood from white cedar is of very high value. Both species are in the Meliaceae, a typical rain forest family. However white cedar is found over a very wide range of habitats in Australia, including semi-arid areas. The leaf has an exceptionally high digestibility (Vercoe 1986) and is known as a fodder tree in India. In drier areas of Queensland it has been said to be fed to dairy cows (Everist 1986). References to it as a poisonous plant refer only to the fruits, and to toxicity to monogastric animals, not ruminants. White cedar is conspicuously deciduous (senescing leaves are bright yellow), but the leaf drop occurs rather early in the dry season (May, June) and this may detract from feed value of the fallen leaf. However, according to Dr Tony Irvine (CSIRO, Atherton) it may shed leaf more than once in the year in response to dry conditions. This may well make it of value at a more nutritionally strategic time.

Melia volkensii

This tree is closely related to the better known and widely distributed white cedar, but has only a narrow range in Africa. However its importance there in local systems has recently attracted attention for its wider agroforestry application, particularly for browse (Milimo 1994). It is also

said that isolated trees are pruned to obtain clear stems (Blomley 1994). These observations are of interest because the species is already present under evaluation for wood production in Australia. According to Dr Paul Ryan it has been performing well in a semi-arid environment in trials conducted by the QFS Forest Research Centre, particularly at the Noonbah site near Longreach. Thus it fulfils all the criteria of interest in this project: it has browse value, yields good timber and is deciduous.

Paraserianthes toona (*Albizia toona*) - Mackay Cedar, Red Siris

The rich red heartwood of Mackay cedar is responsible for its trade name. It is a well-known rain forest timber (Kyleston and Eccles 1990), supplies of which have almost stopped reaching the market, but which is being still sought by furniture makers and craftsmen. It is stocked intermittently by Lazarides Timber Agencies in Brisbane and slabs were being offered by several suppliers at the Brisbane "Timber and Working with Wood Show" for \$200-400. At a weekend rural market in the Mackay area, 1 m slabs salvaged from private land were being sold off the back of a utility ; even for one with a major defect the price asked was about \$40.

Mackay cedar is of interest to this project because, like many rainforest trees, it can be found occurring naturally well away from closed forests. It is present in open vegetation on coastal headlands and in dry creekbeds on Mt Stuart behind Townsville.

The fodder value is unknown, but unlike siris, it has a very finely divided leaf with very small leaflets. Thus it is unlikely cattle would be able to access fallen leaf. It is presumably nitrogen fixing, and could be expected to have a promotional effect on pasture.

It is one of the species included in some CRRP plantings, so there would be some opportunity to test the tree-grass interaction in the future.

Planchonella pohlmaniana - Velvet leaf, yellow boxwood

A common native tree of North Queensland, said to be good browse and one of only three for which Everist (1986) notes cattle eat fallen leaf. The author has no data on this species. The timber is said to be very even-grained and easy to work but probably does not have distinctive attributes that would make it a high-value timber (Bootle 1983). Probably not worth establishing de novo but if already present deserves careful management.

Samanea saman (*Albizia saman*) - Rain tree, monkey pod.

Although this is best known from a plethora of wooden handicrafts, mostly from the Philippines, the wood has a range of uses. It is one of the few species where a thin radial section of a large tree can be worked without checking or cracking. Coffee tables made in this way display the entire cross section with strongly contrasting dark heartwood and pale sapwood. It is an excellent shade tree in much of the tropics, including North Queensland. However with large isolated trees there is a tendency for massive branches to crash without warning, so that liability-sensitised councils are now tending to remove rain trees. It seems that any large stems are actively sought after by wood workers in North Queensland who have thus become quite familiar with the timber.

The rain tree definitely prefers a wetter climate than siris, but is by no means confined to the wet tropics.

It has already been documented as a fodder tree (NAS 1979). This is mainly in relation to a high production of nutritious pods which fall in November in the Townsville area and would be a valuable energy supplement for grazing animals. However the species is also deciduous in August-September and has quite large leaflets. It is the only species other than siris for which a feeding trial with fallen leaf has been carried out (Lowry 1995). When fed to sheep it had a very low digestibility but this was offset by a surprisingly high intake, due, we believe to rapid fragmentation (Kennedy and Lowry 1996). The material would probably be utilised if falling into mature pasture but this has yet to be determined.

The rain tree is also one of the species that can unequivocally promote grass growth; this is easily observed in the Townsville area and is the subject of one of the earliest publications on this effect (Jagoe 1948).

Taking these considerations together one could say that in those areas where it can be established the rain tree would be a valuable agroforestry species.

Santalum acuminatum, *S. lanceolatum* - Sandalwood

Sandalwood is definitely a dual-purpose tree (triple, if one counts the fruit). It is valued as browse by graziers in the northern Australia savanna regions. It is also the only “forest product” that comes from this region. The wood, although in small sizes, has a high value because of the tenacious fragrant sesquiterpenes that cause it to be used for such purposes as incense sticks. Collection of sandalwood in Queensland takes place under tenders let out by the Queensland Forest Service, mostly on land under grazing lease. If they happen to appreciate the fodder value of the tree, this can cause some angst with certain producers. It is probably this situation that influences some of the responses detailed in Section B. If a leaseholder manages to raise a crop of any high-value native timber would he really own it?

The biology of sandalwood is bizarre, being a root parasite, but there is increasing interest in cultivating it, particularly in Western Australia (Rado 1994). A prospectus for doing this on a large scale is currently on issue.

Table 1 *Expected Suitability of Dual-Purpose Tree Species for Different Agro-ecological Zones*

- almost certainly unsuitable
 * can be found in the region but probably marginal
 ** appears suitable for the region concerned.

Tree Species	Zone (see map)					
	2	3	4	5	8	9
<i>Albizia lebbbeck</i>	*	**	**	*	*	**
<i>Albizia procera</i>	○	**	**	○	○	○
<i>Tipuana tipu</i>	**	**	**	*	*	*
<i>Gmelina arborea</i>	*	**	**	○	*	**
<i>Paraserianthes toona</i>	*	**	**	*	○	*
<i>Samanea saman</i>	*	**	**	○	○	**
<i>Melia azedarach</i>	**	**	**	**	**	**

Agro-ecological zones from: W. McLennan (1996). *Australian Agriculture and the Environment*. Australian Bureau of Statistics, Canberra.

2.5 References To Section 2

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APPENDIX 1.

New results on feed value of deciduous trees in pasture.

Although this is essentially a review project, new experimental results obtained during the course of it have a direct bearing on the effect on animal nutrition of having deciduous trees in pasture. These results were obtained with an *in vitro* rumen simulation system for measuring the rate and extent of plant fibre digestion by a rumen fluid inoculum. The system had been used extensively on a wide range of lignocellulose substrates. We have already used it to show that there are important differences between the way tree leaf and tropical grasses are fermented (Kennedy and Lowry 1996). We then tested the hypothesis that, when fallen tree leaf and mature tropical grass, both very low-quality substrates - were fermented together, there would be more effective fermentation - i.e. more fibre digested - than when either was fermented separately. This was a novel hypothesis based on: (1) a suggestion from a series of experiments in Townsville that the effects of legume supplements in promoting fibre digestion were greater than could be accounted for by the protein in the legume. (2) the very different nature of the lignocellulose in tree leaf and tropical grass, suggesting opportunities for different micro-organisms to exploit different parts of the ecosystem. (3) any adverse constituents in the two substrates are likely to be very different and thus "dilute each other out". On the other hand, as we were using rumen fluid from an animal on a conventional grass diet, there might very well be short-term inhibitory effects with an unconventional substrate, effects that would not be seen *in vivo* because the rumen microbial population would adapt.

In a series of experiments we incubated separately mature spear grass and the fallen leaf of a number of species of interest and also a 1:1 mixture of spear grass and fallen leaf. The fibre (neutral detergent fibre) digestion in the mixture was measured directly, and was also calculated as that which would be expected from the digestibility of the individual substrates measured in the same experiment. Unfortunately fallen leaf from some tree species most of interest to this project was not available.

Tree	Fibre Digestibility of mixture (%)		
Species	Expected	Actual	Difference
<i>Brachychiton australis</i>	40.2	42.6	+2.4
<i>Eleocarpus grandis</i>	37.2	27.4	-9.8
<i>Gmelina arborea</i>	52.9	54.4	+1.5
<i>Gmelina leichardtii</i>	38.8	42.4	+3.5
	28.7	31.4	+2.7
	39.9	42.8	+2.9
<i>Flindersia</i> sp.	40.8	23.7	-17.1
<i>Macaranga tanarius</i>	43.7	41.2	- 2.5

Clearly there were interactions, and they were highly species dependent.

The large depressions are likely an artefact of the batch *in vitro* system and would be unlikely to be as drastic *in vivo*. The *Flindersia* leaf in the experiment was fed to sheep in limited quantities and eaten quite readily. However, the negative results do indicate that there may be contraindications to the use of some deciduous trees in pasture.

With both *Gmelina* species there was a promotion of fibre digestion that has since been reproduced in other experiments. As has been noted elsewhere fallen leaf of *Gmelina arborea* has a remarkably high digestibility in terms of total dry matter. However, it has a rather low fibre content. This should provide less opportunity for any enhancement effects on fibre to be observed, but in fact there was a measurable increase. The increased fibre digestion was accompanied by increased volatile fatty acid production, showing that this was not an artefact of analysis but that indeed more energy would be liberated for the animal.

It is hard to see why this positive effect should not be obtained *in vivo*. If so it has exciting implications, namely that animals grazing pastures in which leaf fall of the appropriate species is occurring will perform considerably better than we would otherwise expect.

APPENDIX 2.**List of Mobile Sawmillers (Yellow Pages, 8 May 1996)**

NAME	ADDRESS	PHONE
<i>Cairns and Districts</i>		
Mobile Milling & Carrier	9 Nimble Road Mt Garnet 4872	(070) 97 9242
<i>Townsville & Districts</i>		
None		
<i>Rockhampton & Districts</i>		
Magnum Mobile Sawmilling	Thomas Road Homebush	(079) 59 7139 018 70 8417
Goodmans Portable Sawmilling	Lot 9 Doboola Road Yeppoon 4703	(079) 39 5685 015 76 0442
<i>Maryborough & Districts</i>		
On Farm Sawmilling (Allan Hodges)	14 Connection Road Mooloolah 4553	(074) 94 7485 015 572 771
<i>Sunshine Coast & Districts</i>		
Allan's Mobile Sawmilling	Andersons Road Yandina 4561	(074) 46 7615
Dinasaw Green Mobile Sawmillers	Lot 7 Justin Road Doonan	(074) 49 1318
Portable Milling Services	20 Crittenden Road Glass House Mountains 4518	(074) 93 0144
<i>Beaudesert & Districts</i>		
Evan Harvey Enterprises Pty Ltd Mobile Sawmill	Lot 47 Teviot Road Jimboomba 4280	(07) 5546 9542
<i>Great Northern District W.A.</i>		
(Not Mobile but works with furniture grade timbers) Gisborne Timber Products	Wandoo Way Bridgetown 6255	(097) 61 2355
<i>Northern Rivers District</i>		
None		
<i>Northern Territory</i>		
None		

APPENDIX 3.

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Mr Peter Foxwell, Townsville.
Mr David Gough, Manager, Timber Research, QDPI, Indooroopilly 4068.
Mr Andrew Grodecki, Coordinator, Tree Care Extension Program, Department of Resource Management, Indooroopilly 4068.
Dr Graham Harrington, CSIRO, Atherton.
Mr Kevin Hogan, Jambin 4702.
Dr Tony Irvine, CSIRO, Atherton.
Mr Dave Jermyn, Botanical and Forest Inventory Officer, QDPI Resource Management.
Dr Rod Keenan, Officer in Charge, Tropical Forestry, QDPI Atherton Q 4883.
Mr Gareth Lazarides, Lazarides Timber Agencies, Eagle Farm Q 4007.
Dr Paul Ryan, Queensland Forest Research Institute, Gympie.
Dr David Taylor, Queensland Forest Research Institute, Gympie.
Mr John Wildin, Howes Road, Farnborough, Yeppoon.

Tree Care Extension Officers

Mr Rod Collins (Ingham)	Mr Peter Fraser (Bundaberg)
Mr Alan Bragg, Mr Brett Perez (Atherton)	Mr Ernie Ryder (Rockhampton)
Mr Simon O'Donnell (Gympie)	Ms Eleanor King (Longreach)
Mr Bob Baldwin (Murgon)	Mr Peter Voller (Dalby)

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Mr Peter Pomeroy, Research Forester, Forest Research Institute, Cardwell.
Mr & Mrs A. Rosser, Eungella.

APPENDIX 4.

A Queensland grazier shows the way

Mr and Mrs Ron Holme have had an active role in the grain and pastoral industry, first in Western NSW, then Central Queensland, and then North Queensland. In 1996 they have broken new ground when, with their son Richard, they brought in a 1500-tonne sorghum crop from “Glen Dhu”, a family property 100 km south of Mt Garnet, and thus very much in the semi-arid tropics.

As well as being a highly successful grain producer, Ron Holme is also something of a visionary about the use of fodder trees in such country. He saw a role for *Albizia lebbbeck* several years ago. . .

“Because it grew equally well on all soils, from Fitzroy River flats at Rockhampton to much poorer soils from Charters Towers to Derby. . . You’ve only got to look at the grass under those trees, the way it says green, so much of it . . . the trees must be giving the grass a real boost . . why don’t they do more research on that ? When you look at that hard country around Charters Towers, and these trees are doing so well, so much leaf on them, pods falling off, its all good feed. . . I cant understand why more blokes aren’t trying to get them going on their properties. ”

Mr Holme reads actively and consults widely, but whatever the advice on a particular species, he still has a tendency to plant a few rows himself “ just to see what it looks like”. At “Glen Dhu” he has thriving trees of siris, *Albizia procera* and *Albizia chinensis*, the latter well outside what I consider its normal range. In February 1995 Mr Holme planted some *Dalbergia sissoo* to see how it performed as a fodder tree. In subsequent reading he was impressed by the very high value attributed to the timber in some overseas publications. Noting in August 1995 that his trees were growing well but becoming bushy, we went out and pruned off the side branches in order to give a chance for a clear stem to develop and leave a possible timber option for the future.

This action neatly encapsulates the intention of this project and may be the first purposeful move toward dual-purpose agroforestry !

SECTION B

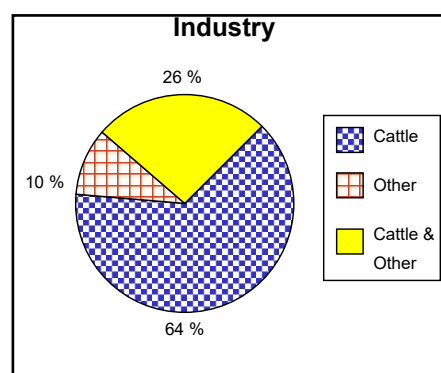
**J.A. Seebeck:
Survey of Landholders**

3. RESULTS OF SURVEY

Summary

A questionnaire, modelled in part on one used by RIRDC in southern states, was sent to some 400 producers, most individually, some via LandCare groups or Tree Care Extension Officers. All landholders were in northern Australia, most in various parts of Queensland. The survey was selective, in that most of those it was directed to were expected to have some interest in trees; the aim was to ascertain the present knowledge, attitudes and needs among a group who would be expected to be the first to adopt new results in agroforestry. There was a good response rate (38%) from those directly addressed, with many respondents supplying detailed written comment in addition to filling in the questionnaire. These notes also showed that there were some remarkable individual initiatives and a considerable amount of information on the performance of particular tree species waiting to be collected and analysed.

It was difficult to make any simple comparison with previous survey results because of the climatic and ecological diversity of the properties in Queensland. However in general respondents were less interested in trees for shelter, salinity control and fuel wood, and more for wood production, soil and wildlife conservation, or fodder. Sawn timber production was awarded the strongest importance, a little surprising in that we had expected most tree planting in Queensland to be for forage purposes. For the latter purpose, most respondents considered only leucaena.



Most respondents had planted trees to an extent greater than as shelter around house or yards. Losses were attributed to misadventures after planting (insects, animals, drought) rather than site factors. However there was probably some awareness of establishment problems because there was strong support for workshops or other training measures in this field.

Although there was strong interest in trees for environmental purposes there was a lively awareness of the potential for some to act as woody weeds, suggesting a sophisticated recognition that whatever approach is taken to trees on farms, active management is likely to be necessary.

*The concept of planting a tree that could be used for both wood and animal production, as proposed in this report, appeared to be novel to all respondents (with one notable exception). Respondents approved of the concept but were understandably wary in the absence of further information. However it was interesting that the most promising tree species for this purpose, siris (*Albizia lebbek*), was known to most respondents, and was widely seen as growing at a size and vigour in accord with the aims of this project.*

Compared with southern states, a higher proportion of pastoral land in Queensland is under grazing lease, and there was concern expressed in some responses about the future freedom of the lessee to harvest trees, particularly native species, that had been planted by himself. This is of legitimate concern for the development of agroforestry.

3.1 Introduction

This section reports on the results of a survey to ascertain the opinions within the pastoral industry of landholders' perceptions and needs and the feasibility and probability of the uptake of an agroforestry system based on dual purpose tree species in northern Australia. For the survey, the proposed agroforestry system was described as *"one in which trees produced feed for animal production while they were in their growth phase and providing a return on the timber when the tree reached maturity"*.

Prinsley (1991) showed that the status of agroforestry in Queensland in 1991 was that fewer than 10% of farmers had planted trees in the previous two years. Prinsley's study also identified the reasons why farmers planted trees, planting preferences, the purposes for tree establishment, the reason why trees failed to establish, and the reasons for not planting trees. The present survey endeavoured to determine the likelihood of the uptake by the landholders of an agroforestry system based on dual purpose tree species, as well as establishing the current awareness of landholders to agroforestry and the importance that landholders put on the issues identified by Prinsley (1991).

As well as the wet/dry areas of northern Australia, the survey covered other areas of Queensland with a range in both property size and rainfall (Table 1). The respondents included beef producers, sheep producers, dairy farmers and those involved in mixed farming. The respondents were very generous with their time and information, with some actually providing very detailed data about their experiences in agroforestry. While some of the extra data has been included in the report, to fully utilise the data and respondent's experiences, further interaction would be required.

3.2 Method

A questionnaire was developed to attain an indication of landholders perceptions of agroforestry, the importance they put on such systems particularly the proposed dual purpose system, the impediments to such a system to gain an insight into the areas for future research requirements, needs and benefits, education programs, and areas of collaboration. The questionnaire also sought opinions on those issues which were included in the publication *"Australian Agroforestry - Setting the Scene for Future Research"* (Prinsley 1991) that were thought relevant to northern Australia (Appendix A). We considered an attempt at a comprehensive survey impractical. Instead we wished to establish if there were enough informed interested producers to be the basis for further development.

A covering letter explaining the objective of the project and the questionnaire was attached to the questionnaire and distributed to those primary producers in contact with the Division of Tropical Animal Production (**Group A**), those primary producers who had previously shown an interest in fodder purpose trees (**Group B**) and all Landcare groups in Queensland (**Group C**), and through the cooperation of individual Tree Care Extension Officers of the Queensland Department of Natural Resources who indicated that there would be potential respondents in their areas (**Group D**). While these are selected groups it was one way of distributing to a spread of landholders predominantly in Queensland within a short timeframe and with limited resources. This was done using a scale of one to five on importance and one to six on agreement, depending upon the questions.

Of the 321 questionnaires distributed to those with known addresses, 21 were returned 'not at this address'; of the 149 Landcare groups in Queensland 44 groups responded, with some returning more than one totalling 61; and 33 were received from the Tree Extension Officers in north Queensland and four from the Bundaberg area. The Longreach area was unable to distribute until late in July due to illness. To date eleven have been returned but have not been included into the set of data. The data has been analysed separately and differences in results reported in the various sections. Therefore the total number of questionnaires returned, averaged a return rate of

38% for the 3 groups with known addresses. Of the people completing the questionnaire, there were several who supplied extra information. Some respondents extended invitations to see their plots and expressed the desire for further involvement in outcomes that may eventuate from the project.

Table 1 *Industry, property size, rainfall and location data (Question 1 a, b, c, e)*

Group	INDUSTRY			Size Mean±Std Dev (hectares)	Range in Size of properties	Rainfall mean±Std Dev (mms)	Rainfall Range	Location Spread
	Cattle	Cattle + other	Other					
Group A	26	9	0	15765±22475	16-80972	739±460	450-1270	N Charters Towers/Nth NSW/Katherine
Group B	6	9	3	22555±54278	9-220000	746±242	254-1157	Mt Garnet/Chinchilla/ Barcaldine/Kimberley WA
Group C	34	17	6	6069±9592	8-36437	914±629	330-4000	N Cairns/Stanthorpe/ Chinchilla
Group D	27	3	6	311±1320	1-8000	2007±793	900-4400	Atherton Tablelands & Bundaberg
TOTAL	93	38	15	8986±23509	1-220000	1071±761	254-4400	

3.3 Analysis of data

The statistical package Minitab was used to analyse the data. The response rate for each question has been included in each table, because the recipients of the questionnaire were not obliged to answer all questions but only those questions for which they had an opinion. The mean is the average mean of the ratings from 1 to 6 for agreement and 1 to 5 for importance. The means with asterisks beside them are there to highlight that there was a significant difference between the rating of the four groups (CSIRO Divisional mailing list, a group interested in fodder trees, Landcare groups, Tree extension in the areas of Cairns, Ingham and Bundaberg). In these cases the mean cannot be classed as the average for the whole response group, but it should be noted that there was a difference in the perceived opinions which may be important for future reference in terms of education programs, research or communication.

3.4 Results

3.4.1 General understanding

The response rate for each of the questions in this area was high. The mean of the response showed that there was *moderate agreement* to all issues. This result shows that there is a positive awareness of the benefits of agroforestry systems with a belief that there should be more programs to heighten further awareness of landholders and the provision of government incentives. Some of the incentives cited by landholders were:

- Tax relief
- Ownership of trees
- Help with establishment costs
- Free seedlings.

The well recognised benefit of the tree legume, leucaena, may be influencing the attitudes of beef producers. The mean rating of *moderate agreement* of trees for cabinet timber shows that landholders are aware there is a market for such timber.

Table 2 *General Understanding of following issues (Question 1)*

ISSUES		Total Response (n=160)	Mean (1-6)	Rating
(a)	I believe that agroforestry systems could make my property more productive	150	5.11	Moderately agree
(b)	I believe that agroforestry systems have the potential to increase my income	149	4.76	Moderately agree
(c)	I believe that government should provide incentives for their establishment	152	5.36 ^x	Moderately agree
(d)	I believe there should be programs in place to heighten awareness	153	5.39	Moderately agree
(e)	I know that large increases in beef production have been obtained by planting the tree legume leucaena	129	5.23 ^y	Moderately agree
<i>The following questions are based on trees that support both wood and animal production</i>				
(f)	I believe there would be markets for logs of short length but high quality (cabinet) timber	139	5.30	Moderately agree
(g)	I understand that the leaves of such trees produce very good feed for livestock particularly in the dry periods	120	4.78 ^z	Moderately agree

There was significant differences between the Groups in response to some of these issues as noted by ^x P = 0.05; ^y P = 0.001; ^z P = 0.010.

With regard to the issue of provision of government incentives, agreement was highest in Group C (Landcare) and Group D (Tree extension groups). This suggests a more coordinated response, possibly more recognition of the difficulties in establishment.

Group D showed significantly less agreement than the other three groups in the perception of large increases in beef production from planting leucaena and that leaves of trees such as *Albizia lebbbeck* produced very good feed for livestock. This could be explained by the fact most of the respondents in this group were dairy farmers and that there was a lack of awareness of the benefits to dairy cattle or the perception that there is adequate pasture.

The means of the data for this question from those questionnaires distributed in the Longreach area showed that there were no areas of difference except that they were not as aware of the benefits of leucaena for beef production.

Other comments made by respondents :

- A respondent has found that there are tropical fruit trees which produce timber, and both leaves and fruit can be used for stock feed. Examples given were mango, jackfruit.
- Others have the opinion that a system established now will have the potential to increase income for the next generation. They see it as more for the long term than for the immediate future.
- Others have the perception that there is a positive awareness for agroforestry systems, but that time and cost are the reasons against the initiative.

3.4.2 Purposes for an agroforestry system

Table 3 reports the importance given by the respondents to the purposes for a system cited by Prinsley (1991). In the present survey, it was found that shelter, shade, soil conservation, promoting wildlife, post poles production and feed production rated overall as of *moderate importance*. Sawn timber production just made a rating of very important. Salinity control was of *little importance* as was preventing salinity and waterlogging. Firewood only rated of *little importance*. Forty-five respondents contributed a rating to the "other purpose" category and this averaged out as of *moderate importance*.

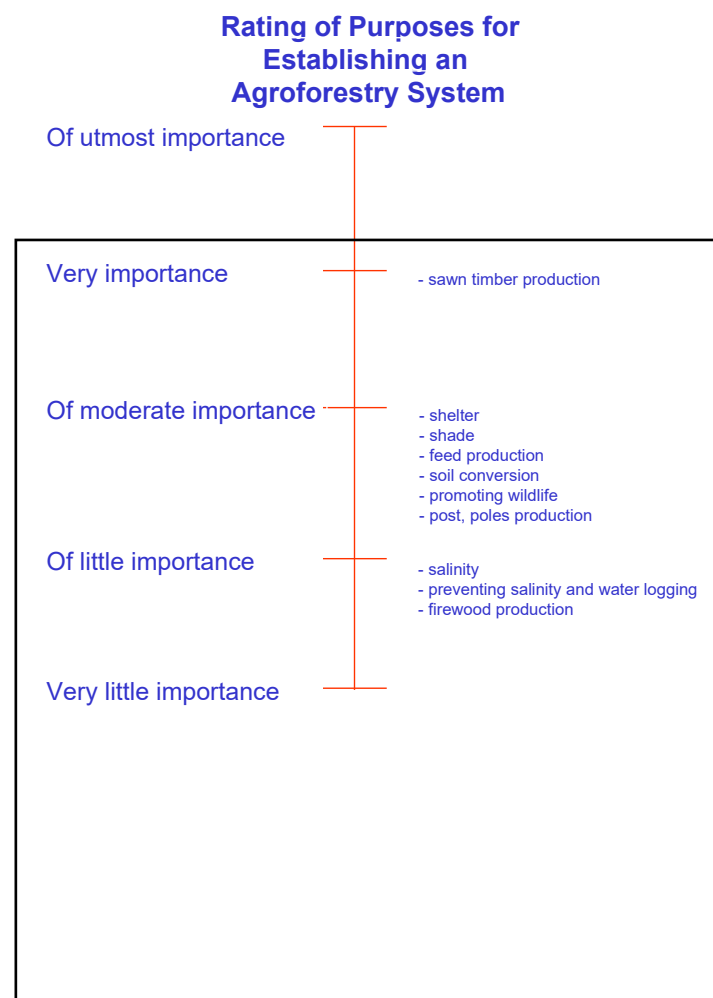


Table 3 *Results of ratings of the following purposes for establishing an agroforestry system on the landholder's property (Question 2)*

PURPOSES		Total Response (n=160)	Mean (1-5)	Rating
(a)	Shelter	149	2.89 ^w	Of moderate importance
(b)	Shade	149	3.08 ^x	Of moderate importance
(c)	Soil conservation	146	3.23 ^y	Of moderate importance
(d)	Salinity control	146	2.12	Of little importance
(e)	Preventing salinity & waterlogging	145	2.21	Of little importance
(f)	Promoting wildlife	146	3.05	Of moderate importance
(g)	Sawn timber production	149	3.51	Very important
(h)	Post, poles production	146	3.08	Of moderate importance
(i)	Feed production	147	3.16 ^z	Of moderate importance
(j)	Firewood production	143	1.89	Of little importance
(k)	Other	55	2.89	Of moderate importance

There were significant differences between the groups in the importance respondents placed on some of the purposes listed as noted by

^w P = 0.010; ^x P = 0.001; ^y P = 0.05; ^z P = 0.001.

Group D was the group that placed the highest importance on shelter and shade, which is understandable in that the group consisted mainly of dairy farmers. Group D also rated soil conservation higher than the other groups although only marginally higher than Group B, again presumably reflecting greater awareness or dedication to planting trees. Group D placed little importance on feed production as a purpose for planting trees, which also corresponds with their response to Question 1 (g). Again this could be a reflection of lack of knowledge or it could be because they are from a high rainfall area.

As well as rating those given purposes in Table 3, a number of others were supplied by the respondents (see Appendix B).

The means of the data from the questionnaires distributed in the Longreach area showed there were some differences in the landholders' needs. They rated shelter, shade and feed production higher than those in Table 3.

3.4.3 Experiences of tree establishment

There were 146 responses to the question "*Have you carried out any tree establishment on your property?*" of which 118 (81%) were "yes". A small number of those responding to "yes" included those who had "planted trees around the house and yards" and "managing regeneration of natives" which included brigalow for control of salinity. Eighteen of the 36 "yes" from the Tree Extension respondents had used the Community Rainforest Reforestation Program (CRRP).

The examples given by those respondents who have planted trees varied, from those experimenting with a few trees to planting many acres. The species were mainly leucaena, fodder trees, eucalypts, rainforest, cabinet woods (including exotic as well as native). Despite the variety of activity there were no respondents who had planted trees for the dual purpose of wood and forage. The respondents' perceptions of why trees failed to survive were mainly drought, frost, browsing by small animals/livestock, lack of knowledge and too dry. The respondents did not include any management issues such as site preparation for failure.

Table 4(a) Tree establishment and preferences (Question 4 and 5)

Group	Responses to tree establishment		No of responses to Yes/No preference		No of responses actually stipulating preference	
	Yes	No	Yes	No	Native	Exotic
Group A	21	9	12	17	9	3
Group B	14	3	6	11	3	3
Group C	47	13	39	16	38	1
Group D	36	3	28	9	27	-
TOTAL	118	28	85	53	77	7

Sixty two percent responded that they had a preference (native or exotic). Of that preference 77 respondents preferred native while 7 preferred exotic. The remaining 53 said both native and exotic had their benefits.

Table 4(b) Responses with regard to the tree *Albizia lebbbeck* (Question 11)

Group	No. of responses to "Is <i>Albizia lebbbeck</i> growing on your property"?		No. of responses to "Is the tree/s large?"		No. of responses to "Is the tree/s healthy?"		Responses to "Do you think the tree could be a weed problem?"		
	Yes	No	Yes	No	Yes	No	Yes	Do Not Know	No
Group A	19	15	12	5	14	3	2	3	14
Group B	14	3	5	9	10	3	-	-	14
Group C	25	32	11	13	20	4	2	3	20
Group D	4	34	3	2	6	0	10	1	4
TOTAL	62	84	31	29	50	10	14	7	52

The responses in the above table are specific to the tree *Albizia lebbbeck*. The four groups acknowledged the existence of the tree growing on their properties. Group B, predominantly people interested in fodder trees had the greater proportion while Group D the lowest. The

responses to growth implied equal proportions of large vs medium and small while 83% of the trees were considered healthy. Respondents noted borers and lack of water as the main impediments of growth. Seventy-one percent noted that they did not perceive *Albizia lebbeck* as a weed problem or one in the future, 7% did not know and 20% thought it may become a weed problem. The Bundaberg and Gladstone areas were the only areas noted by respondents where it may become a weed problem. One respondent had not realised the potential of the tree because it had grown so well. Others could see the potential based on their experience with *leucaena*.

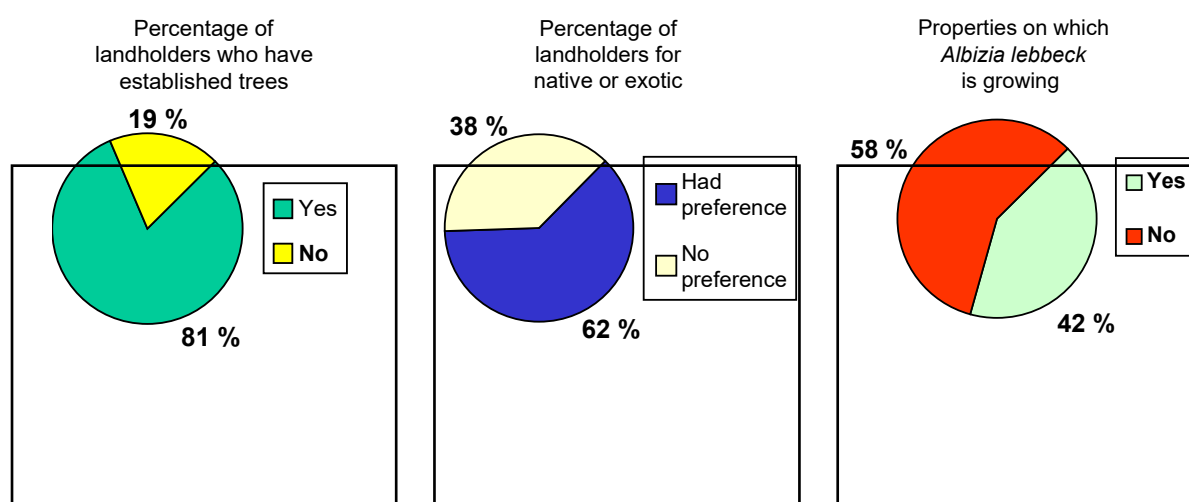
Table 5 Assistance (Question 6 and 7)

Group	Awareness of assistance schemes etc		Responses to use of assistance if there was any		
	Yes	No	Yes	Possibly	No
Group A	3	31	19	10	4
Group B	3	14	9	7	1
Group C	27	31	43	9	6
Group D	29	8	32	4	2
TOTAL	62	84	103	30	13

It was found that more than half the respondents were not aware of the existence of assistance schemes. Table 5 shows that more respondents from the LandCare and tree extension groups were aware of schemes. While the response to using a scheme if it was available was high, the respondents answering *possibly* and *no* cited the following reasons for not using schemes:

- Issue of guarantee of ownership of the timber and a landholder's rights to harvest timber. Some of the landholders query whether the timber is theirs to harvest if given assistance and their rights may be lost depending if the land is leasehold or freehold.
- Belief that too much assistance can water down enthusiasm.
- Entire legislative system in regard to timber production needs overhauling to clarify the legal position of the millers/growers.

The respondents supplied examples of their experiences in establishing trees. These are listed in Box 1 (above).



EXAMPLES AND COMMENTS OF RESPONDENTS

- Leucaena (40 ha irrigated and 20 ha dry land), *Albizia lebbeck* (2 ha).
- We have planted a number of NF trees to decide which are the best species to plant on a larger scale. All have been planted as seedlings (except leucaena) and have found that direct seeding will be necessary unless very cheap labour is available.
- Established a trial plot of 3 acres of *Albizia lebbeck*.
- Leucaena. Planted from seed and had poor seed strike due to inferior planter and lack of reliable knowledge. Have since bought a good planter and gained knowledge from other switched on producers but have not had rain in last 5 years.
- We have had forestry assistance and have planted 2,000 odd trees.
- We have planted:
 - 30 acres hoop pine plantation
 - 3 acres hoop pine and cabinet timbers mixed
 - 100 acres agroforestry hoop pine.
 - 4 acres spotted gum and gimpie mesmati plantation.
 - 5 acres of River Red Gum and casuarinas wet area salinity control.
- We have planted fodder trees, eucalyptus, and 7 plantations (approx. 3,000 trees).
- Forest plots/shade clumps/fence lines (thousands probably).
- We have about 2500 trees planted (in plantations). These are all species of eucalypt and have been established over the last 25 years.
- Planted 700 hardwood species 1981 (through forestry program); 350 hardwood species in 1990 which we propagated ourselves.
- Have established feed trees, trees for shelter belts and long term timber.
- Brigalow scrub rejuvenation and creek bank revegetation. Purpose: - salinity control, erosion control and providing a natural corridor habitat - also 'squaring off paddocks' on creek bank.
- Tree planting has included (1) 2 ha commercial cabinet timber species, (2) Riparian rehabilitation, (3) Trees for shelter and shade.
- Established 3,000 timber trees mixed eucalypts rainforest timber trees.
- Have planted 14 acres (in conjunction with CRRP) with hoop pine. Have planted more than 1,000 rainforest seedlings for shade and timber production. Also planted 75 powlonia trees for quick shade trees.
- Experience includes a major planting of wind break/shade trees for dairy cattle.
- Have planted 15,000-20,000 assorted native species comprising *E. grandis*, *E. clocziana*, *E. microcorys* etc. and assorted rainforest sp, e.g. hoop pine, maple etc.
- Have been planting trees since 1978. Eucalypts and mixed cabinet wood (handful of exotic cabinet woods as well). Ongoing planting maintenance programme. Records kept. Also general revegetation especially along water courses. About 10,000 trees

Table 6 **Woody Weed/Browse Trees (Question 1 f and g)**

Group	Responses to if have any woody weeds?		Browse Trees	
	Yes	No	Yes	No
Group A	30	4	22	10
Group B	14	4	16	2
Group C	49	9	34	18
Group D	22	14	10	25
TOTAL	115	31	82	55

The common definition for woody weeds is: shrub, or any woody plants not eaten by cattle but competing with pasture. There are two types: native tree regrowth and invasive exotic species.

The important aspects noted in this survey in relation to native woody weeds was, (1) the brigalow regrowth when acacia was dominant, and, (2) it was found that brigalow regrowth was mentioned more often than eucalypt regrowth e.g. iron bark, blue gum, spotted gum, box. There were others highlighted such as lime bush, currant bush, lantana and rubbervine but these were found localised in the expected areas.

Some respondents said they had the problem of woody weeds under control and two methods cited were control spraying and slashing.

The examples given for exotic woody weeds were rubber vine and lantana in the north, chinee apple in the Townsville and Charters Towers area. They were found to be highlighted relatively less than expected. The tobacco bush was found in the wetter areas. Prickly acacia, a major woody weed (even though it has been found to be of some nutritional value), did not feature very much. Few respondents highlighted it as a woody weed. *Acacia farnesiana* was noted by a few landholders even though it is less common than prickly acacia.

A number of respondents said they had browse trees, but relatively few species were nominated. Those nominated as browse trees were Kurrajong, belah, bauhinia, wilga, fig, lime bush, wild peach, brigalow suckers, leucaena, red ash and wattle. As expected, there were no prominent browse trees cited by the tree extension respondents from the very high rainfall areas except for one who cited wattle.

Training workshops

The overall response to the need for workshops in the areas of training for site preparation, planting, weed control, pruning, thinning and insect control were all rated between of *moderate importance* to *very important*.

Table 7 *Results for importance of areas required for training and maintenance of trees (Question 8)*

Areas for training at workshops	Total Response (n=160)	Mean (1-5)	Rating
(a) Site preparation	140	3.78 ^x	Very important
(b) Planting	138	3.81 ^y	Very Important
(c) Weed control	140	3.68	Very important
(d) Pruning	138	3.55	Of moderate importance
(e) Thinning	138	3.50 ^z	Of moderate importance
(f) Insect control	136	3.56	Of moderate importance

There was significant differences between the Groups in response to some of these areas for training as noted by ^x P = 0.050; ^y P = 0.050; ^z P = 0.050.

There were some areas for which the groups differed in their rating for importance. Group D and Group B rated site preparation, planting and thinning of lesser importance than rated by the other two groups. This difference may be a reflection of a greater awareness of the importance or difficulties of these techniques within Groups B and D.

The means of the data from the Longreach area were in agreement to that in Table 7.

Other comments made by the respondents in connection with workshops were:

- Perception that a total mix of trees in such a system would be self supporting in regard to insect control
- Experience of one who has attended workshops was that site preparation is the most important issue
- Fire prevention should be included in maintenance issues at workshops
- Insect control is of lower importance to other areas of training, because control depends on species selection and suggests that only those tree species resistant to insects be used
- The use of machinery should be included in training workshops especially if areas for planting are large
- That some of the workshops held by Universities were overpriced and that this would inhibit attendance
- That farmers do not have the time to establish and maintain trees

3.4.4 Important causes for failure of tree establishment

Prinsley (1991) showed there were many causes for failure of trees to establish. These causes were included in the questionnaire. The respondents rated drought/lack of water as *very important* and weed competition, wrong species, stock damage, insect damage, frost, eaten by wild animals, poor techniques were *of moderate importance*. Those causes for failure which rated of *very little or no importance* to *of little importance* were salinity, did not germinate, fire, waterlogging, wind damage and disease.

Table 8 *Causes for failures of trees to establish (Question 9)*

Causes for failure		Total Response	Mean (1-5)	Rating
(a)	Weed competition	102	3.43	Of moderate importance
(b)	Drought/lack of water	117	4.01 ^w	Very important
(c)	Stock damage	104	3.10	Of moderate importance
(d)	Insect damage	104	2.62	Of moderate importance
(e)	Frost	106	2.56	Of moderate importance
(f)	Salinity	97	1.45	Very little or no importance
(g)	Eaten by wild animals	112	2.81	Of moderate importance
(h)	Poor techniques	101	2.91	Of moderate importance
(i)	Wrong species	105	3.29	Of moderate importance
(j)	Did not germinate	85	2.09 ^x	Of little importance
(k)	Fire	96	1.78 ^y	Of little importance
(l)	Waterlogging	95	1.60	Of little importance
(m)	Wind damage	99	1.95 ^z	Of little importance
(n)	Disease	96	1.90	Of little importance
(o)	Other	29	2.59	Of moderate importance

There was significant differences between the Groups in response to some of these areas for causes as noted by ^w P = 0.001; ^x P = 0.050; ^y P = 0.050; ^z P = 0.050

Group D was somewhat different in its perception of the importance of causes for failure of trees to establish. For drought/lack of water, failure to germinate and fire, they gave a rating lower than the other three groups, while for wind damage they gave a higher rating than the other three groups. Presumably this reflects Group D is located in a high rainfall area.

There were differences in importance between those in Table 8 and that analysed from the Longreach area. Insect damage, poor techniques, wrong species were all rated more important but weed competition of lower importance.

A number of other reasons and examples for failure were given by respondents. They included:

- Grass competition
- Sprayed by extension workers
- Site preparation very important on compacted soils
- Lack of knowledge
- Inconsistent care
- Laziness
- Timing of planting
- Lack of fires
- Lack of money to fence correctly - considers that this is the main reason many people do not replant
- Supplied seedlings were root bound

3.4.5 Reasons for not planting trees

The response to 'Potential reasons for not planting trees' was approximately 77%. Prinsley (1991) found the economic/financial reasons were rated higher than technical reasons. However, the results from this survey suggested that the technical reasons for not planting trees were nearly as important as the economic and financial reasons. Competition with agriculture was not considered an important reason for not planting trees.

A number of respondents commented that they considered agroforestry systems long term and that the benefits would be for the next generation but if it could be shown that there were benefits in the short term their perceptions may change re cost of establishment, maintenance, fencing costs and incentive.

There was significant differences between the Groups in response to one of the potential reasons as noted by $\chi^2 P = 0.001$.

The rating given for each reason was consistent between the groups (i.e. not significantly different) for each suggestion except for the lack of knowledge suggestion. In that, Group B was significantly lower presumably because of their historically expressed interest in planting fodder trees while the Group A was the highest.

The data from the Longreach group rated cost of fencing, lack of knowledge, previous failures, hard to establish higher than that in Table 9 and rated no economic benefits lower.

Other comments made by respondents were:

- There are no reasons for not planting trees and that management of trees is very important.
- Time involved
- Political issues of who owns the timber and the rights of what to do with the timber
- Would like to see cost/benefit analyses to justify the planting of trees
- No perceived economic benefits. Studies of the benefits should be divided into short term and long term
- Not enough labour available - E Darling Downs
- Type of land inhibits the transport of water to trees
- Lack of suitable species
- Lack of extension
- Biodynamic methods need greater support

It must be noted that the perception of some is that tree planting should only be carried out on that land not suitable or useable for anything else.

Table 9 *Potential reasons for not planting trees (Question 10)*

Potential Reasons for not planting trees		No. of respondents (n=160)	Mean (1-6)	Rating
<i>Economic/Financial</i>				
(a)	Cost of establishment	131	4.70	Moderately agree
(b)	No economic benefits	117	3.53	Slightly agree
(c)	Cost of maintenance	127	4.26	Slightly agree
(d)	Cost of fencing	124	4.35	Slightly agree
(e)	No incentive	122	4.07	Slightly agree
<i>Technical reasons</i>				
(f)	Lack of knowledge	116	3.72 ^x	Slightly agree
(g)	Previous failures	103	2.91	Slightly disagree
(h)	Hard to establish	111	3.65	Slightly agree
<i>Competition with agriculture</i>				
(i)	Loss of land	113	3.04	Slightly disagree
(j)	Competition from trees	106	2.55	Moderately disagree
(k)	Incompatible with agriculture	107	2.36	Moderately disagree

3.4.6 Likelihood of managing the proposed scenario

These questions examined the perceived need for training in looking after the trees or if it would be more appropriate to employ a specialist contractor. The result was that the respondents *slightly agreed* to *moderately agreed* that they would be able to tend pruning and thinning if the process was demonstrated. They *slightly disagreed* about employing a specialist mainly due to cost and availability. The respondents were in general agreement (*slightly agreeing* to *moderately agreeing*) that there would be financial gain especially in the long term and that it would be more acceptable with some government support.

Table 10 *Examining the likelihood of managing the proposed dual agroforestry system (Question 12)*

ISSUES		Total Response (n=160)	Mean (1-6)	Rating
(a)	I believe I would be able to plant the trees and tend to the pruning and thinning	120	4.43	Slightly agree
(b)	I believe I would be able to plant, prune and thin the trees if the process was demonstrated to me	117	4.87 ^x	Moderately agree
(c)	I believe it would be more suitable to employ a specialist contractor	116	3.17	Slightly disagree
(d)	I believe it would be more acceptable with some government support	123	4.89	Moderately agree
(e)	I believe there would be financial gain in diversifying to this system	116	4.41	Slightly agree
(f)	I believe the initial costs of setting up would be expensive but very beneficial in the long term	115	4.58	Moderately agree
(g)	I understand there is a traditional sawmill in my area to mill the logs	108	4.44 ^y	Slightly agree
(h)	I believe it would be more appropriate to use a portable sawmill contractor	112	4.25	Slightly agree

There were some significant differences between the Groups with respect to their perceptions of being able to manage a dual agroforestry system noted by ^x P = 0.050; ^y P = 0.010.

Group D were less convinced that they would be capable of managing after demonstration than the other groups. Group B was in less agreement than the other three groups about having a traditional sawmill in the area, presumably reflecting the location of members of that group.

Most agreed that there were appropriate sawmills and portable sawmills in their district. The respondent's general interpretation of government support was as previously noted in 3.4.1.

There were no differences found between the means of Table 10 and the data analysed from the Longreach area except that Q9 (g) which disagreed that there were traditional sawmills in their area.

3.4.7 Priorities of Respondents

The respondents made additional comments about the areas that they see as important issues and come under the areas of Economics/Benefits, Management, Research, Marketing and Other.

Economics/Benefits

- There needs to be more information available on the economic basis of these projects. The largest deterrent for these type of projects is lack of economic information
- Recognition that the current depressed state of sheep and cattle industries mitigate against producers becoming interested in adopting new production systems unless financial benefits proved beyond question
- Agrees that agroforestry systems are an excellent idea but shortage of funds inhibit improvements

- In my opinion agroforestry returns on capital are too long term. The returns from dairying and potatoes far outweigh the return from trees.
- The benefit (risk reduction) of putting in a variety of trees should be considered
- Cost would stop the employment of a specialist contractor
- Labour is too expensive

Management

- Irrigation issues also require addressing i.e. the amount of water/tree, types of irrigation setups. Possibility of growing cash crops in between rows of trees in the first few years?
- On this property regeneration is so vigorous that country can only be economically cleared for horticulture or high-priced field crops e.g. watermelons.
- Experience in " " area is soils are either very wet or very dry - water resistant. Intend to contour swale - swales drain when too wet: irrigate when dry, and plant trees on swale banks.
- Need more work on managing the native timber we already have, and how to utilise that to its maximum. Should be government incentives in this area before we establish new timber areas.
- Farmers right to remove and clear timber if at all necessary in order to improve timber production such as selective thinning of particular areas.
- It should be made clear that eucalypts are the only timber producing trees for agroforestry. These can be planted at 3 metres x 3 metre spacings then thinned and culled at 10 years. Improved pastures are very successful when grown under thinned and culled eucalypts.
- The right to harvest naturally regenerated timber. In most cases we spend time and money thinning to give the better saplings a better chance for quicker growth with the view of harvesting at a later date.
- Landowners need to be given a guarantee of total ownership of the trees and therefore the choice of when or whether to harvest.
- Agroforestry systems should be encouraged nation wide via incentives (financial or other). Also the entire legislative system in regard to timber production needs overhauling to clarify the legal positions of the millers/growers etc.
- Timber consultants in the private sector that are qualified through previous training and practical experience. The government should be able to tap into this available knowledge by giving "creditation" to people with a demonstrated ability and knowledge.
- Access of stock needs consideration
- Government approval is required at present to harvest timber on leasehold land
- Believes that too much assistance can water down the enthusiasm of the individual
- Believes trees should be cost assessed and that their value added to the property if selling property
- Quality assurance during growing very important

Research

- It is important to know which trees are best suited for each situation. Information is required about suitable trees for our purposes.
- Cattle probably need to be kept away from trees for a much longer period than is normally acknowledged. Probably at least ten years depending on seasons and growth rates. Always a few trees that do not grow properly.
- With the huge regrowth situation would like to experiment with a "thinning out" leaving potential timber trees at a selected spacing. Particularly *E. tereticornis* and *E. crebra*.

- To enable us to establish young trees, we will have to wait for better rainfall years to come back first. It is impossible to do this during our present drought.
- There is a need to get planting away from straight lines - I practice keyline swales to increase soil moisture and fertility. "Water for Every Farm" by P.A. Yoeman and "Permaculture: A Designers Manual" by B. Mollison are worth reading to understand what I mean.
- I consider it would be uneconomical for individuals to try these schemes on a trial and error basis. Some practical experience would be necessary. Soil types suitable for each tree would also need to be clarified as well as climatic conditions. If this could be done and your offer of assistance was readily available, I feel sure that people with properties in suitable areas would take advantage of some of the schemes you suggest, benefiting themselves in the long run.
- Agroforestry that does not require exclusion of animals at establishment e.g. Hoop pine has a lot of appeal
- Using a portable saw mill contractor would depend on size of trees
- Continuing dry summers makes it hard to establish trees
- Genotype selection for feed/wood quality
- Response to lime and phosphorus
- Tolerance of sodic artesian irrigation water
- Benefits of specific rhizobial/mycorrhial additions
- Comparative grazed ungrazed plots

Marketing

- There is a very large gap between what the farmer gets for the trees he sells and what the sawmill sells for dressed timber e.g. sawmills make lots, farmers not that much.
- I believe we are facing a shortage of good hardwood (sawn). It is this aspect which interests me the most.
- Market opportunities for young fast grown timber of short lengths
- Specialist marketing needed to ensure product viability

Other

- The significance of a plantation or two of timber as a source of farmers' retirement benefits if they want to hand over a viable, not-loaded-with-debt property to a child.
- I believe that anyone with timbered country who selectively clears, should be allowed, or given incentives as it is a form of agroforestry.
- It has taken 25 years to discover how well *E. argopholia* grows in the Tara area and feels it is a worthwhile investment for the future even though it does not have fodder value, therefore has no interest in growing *Albizia lebbek*.

3.5 Discussion

The results of the survey are encouraging in that the perceived awareness of agroforestry is increasing. It also shows that the culture of those in the cattle industry are changing. Whether it is through necessity or perceived benefits the landholders are diversifying into other industries. Tree establishment appears to be an accepted area in which to diversify while many have actually established areas on their properties. While the native species appear to be the preferred option there is a growing preference for both native and exotic if the benefits can be shown, for example, the uptake of the tree legume leucaena.

There appears to be a low awareness of assistance schemes to most groups. In Group D, the Tree Extension group, there is a high awareness which may be due to the support of the extension workers from the Department of Natural Resources and in particular the introduction of CRRP scheme. A small number of respondents cited a number of reasons for not using any government scheme. While it was only a small number, their reasons appear valid because of their experience. Landholders should be made aware of the reasons before considering investing capital in case the reasons also apply to them.

The research priorities for establishing trees in Australia were found by Prinsley (1991) to be (a) wind breaks, shelter breaks and shade, (b) ecology and management of native vegetation on farms, (c) economics, economic modelling and marketing, (d) insects, (e) Weeds, (f) social research and extension, (g) genetics, breeding and species selection, and specifically for Queensland, research into how trees affect soil processes, including erosion and pasture; further research into options for multi-purpose management of vegetation, and guidelines to sensible clearing; and, research to ensure that newly introduced fodder species do not become weeds.

While Prinsley (1991) found that the main purposes for farmers planting trees was mainly for windbreaks, shelter and shade, this study found that there were other purposes rated with the same importance - soil conservation, promoting wildlife, post, poles production, and feed production with sawn timber rated higher than the others. It was expected that shade would have been given a higher rate of importance especially with the general move of the cattle industry into lot feeding. The move towards lot feeds places more emphasis on the use of British breeds of cattle with the proportion of zebu cattle decreasing. Also it has been shown by Turner (1982) and Finch (1986) that reproduction, in particular fertility is affected by heat stress. This is an instance where it appears that the results of research may have been transferred to the industry in the 1980s and notice taken with the transfer to increase in zebu content, but when circumstances change those results have been forgotten.

While the respondents could see that the need for training in the areas of site preparation, planting and weed control as very important, these areas (management of tree establishment) were not cited as a cause for failure of trees to establish, except for one respondent, quote "site preparation is very important on compacted soils". This area may need more consideration as landholders while *moderately disagreeing* that "Competition with Agriculture" was a potential reason for not planting trees, it was perceived that some landholders were planting trees on less useable land.

Drought and lack of water were rated as very important reasons for failure of trees to establish. In the management and research sections of Priorities of Respondents some landholders have noted areas where they see the problem should be addressed. Some have begun to experiment with irrigation and irrigation setups, contour swales, keyline swales including noted publications, and tolerance to artesian irrigation water. Not surprisingly some viewpoints were highly individual and strongly held.

While the results of the survey showed that respondents rated the economic/financial reasons for not planting trees comparable with the technical reasons, the perception was from comments made throughout the questionnaire that costs and benefits (short, medium and long term) were a very important area and one which respondents see the need for more information to justify the planting of trees. Prinsley (1991) also found that this area was a priority area which required more research and suggested the use of models, in particular systems models which would allow for the incorporation of other disciplines and inclusion of the variables some of which are rainfall, soil type and fertility, different tree species, and property size.

It was found that those respondents who have been experimenting with different tree species have much to contribute to a database. As Prinsley (1991) states, a useful project would be to collect all unpublished data and store in databases such as the TREDAT database which has recently been reactivated in the Department of Natural Resources.

A respondent from Tara, south west of Brisbane has been experimenting for many years, and has found that salinity has only been recently recognised as a potential problem. It has been found that the Brigalow soils can have fairly high salt concentrations at depth and that the removal of timber and the subsequent cultivation has brought the salt closer to the surface. While the respondents rated salinity as a cause for failure of trees to grow of very little or no importance, it nevertheless could become an important problem in the future. It was noted in the July 1996 issue of *Focus*, that while Queensland has a relatively small area affected by dryland salinity, the problem could well increase as the impacts of widespread clearing are felt over time. In 1991 it was estimated that 10,000 hectares were affected with a proposed increase to 15,000 hectares by 2000.

The proposition put forward of schemes assisting landholders to establish trees was accepted by the respondents. Most would be happy if the scheme allowed all expenses of establishment and maintenance to be tax deductible in the year of expenditure. The scheme would have to be flexible to allow the landholder to make judgements on planting at particular times. Some landholders have expressed reservation about receiving assistance, as they feel there is the danger of clawback e.g. royalties by the Government. They would prefer maintaining full ownership of the timber.

Other issues seen to be costly are fencing and watering. The respondents with experience of establishing trees did not indicate the method of fencing. Such publications as *Regreening Australia - Caring for Young Trees 2*, (Nan Oates 1990) illustrates the wide range of equipment and methods that landholders have the option of using whether it is a small scale operation or one which requires large mechanical planters. Another publication for landholders to use in their pursuit of improved productivity and land sustainability is *Tree Tops*, published by the Kondinin Group (1993). While it covers all Australian states, it contains many case studies from farmers and includes many cost effective solutions to all areas. The Department of Primary Industry has also published information for landholders covering Managing Existing Forests, Growing Trees and Tree Uses in their publication *Tree Notes*. However, none of these publications mention the use of stump planting from large seedlings grown in raised seedbeds which is effective with siris (Lowry 1992).

It was noted by some respondents that while there are traditional sawmills servicing their areas, they have found that milling decorative timbers for cabinet and furniture making is a highly specialised trade and that it should be put in the hands of those suitably trained and experienced to get the best results in both yield from the log and suitability for the intended use. They expressed the opinion that portable sawmills may not be the most effective way of milling this timber. It is suggested that further economic analyses should be performed on the feasibility of incurring extra costs of transporting logs to specialised mills by recovering the increase in yield and suitability vs the costs of transporting.

Respondents from the Bundaberg region were the only landholders who had experienced *Albizia lebbbeck* as a potential weed problem. One landholder had not realised the potential worth of the tree and felt that it would make an excellent agroforestry plot if kept under control. The four groups involved in the survey covered quite a large area of Queensland and the general opinion of the remainder was that the trees were not and could not be perceived as a potential weed problem in the future.

The legume, leucaena has obviously proven itself with large increases in beef production and some of the respondents expressed that for feed leucaena could not be replaced, but because many have realised the impact that native tree fodder has had in dry years, they can also see the potential of *Albizia lebbbeck* as a feed and timber tree.

In conclusion, the survey shows that there is a growing perception by landholders for the establishment of trees and the development of agroforestry systems. Many expressed that more research should be done to show the potential benefits of the existing natives. Because most have experienced severe drought conditions recently and cited it as an important issue for not planting trees, it is obvious that issues such as water and the costs (including monetary and time) are potential deterrents. Most admit if it could be shown that there could be short term benefits, they may take the risk to invest in agroforestry systems. Incentives such as extension assistance, tax deductions and changes in legislation particularly ownership issues, would also assist in changing attitudes.

Funding bodies such as the Meat Research Corporation could be approached about the possibility of producer demonstration sites to stimulate interest. A notable feature of the survey was the number of respondents from various parts of Queensland willing to be involved and willing to share their experience and sites. Some were willing for the proposed system to be trialed on their property.

As it takes considerable time to get useful results from research, it is essential to derive as much information as possible from trials and experience already available. In proposing an agroforestry system, there is a balance of diversification to reduce risk vs increase in potential income. From the survey, ease of establishment obviously is a very important factor in risk reduction. Thus, drought tolerance and need for minimal fencing to keep out animals are important factors to be considered.

The question is therefore what research is necessary. What are the gaps in knowledge that research will have to address? what is the possibility of collaboration between the various agencies? and, what further research would have to be done to model such systems using an on-farm model to cater for the variations in size of property, rainfall, soil types, and other important variables to indicate the short, medium and long term benefits to the individual landholder and the community?

From this survey we are hopeful that the research and development necessary to develop dual-purpose agroforestry could proceed through cooperating landholders.

3.6 References

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APPENDIX A. Questionnaire and letter sent to respondents

27 May 1996

Dear Landholder

We are sending you this letter because we think that you have at some time expressed interest in the use of trees on the land.

The RIRDC have commissioned the Division of Tropical Animal Production to carry out an:

"Assessment of the potential for an Agroforestry System for northern Australia based on trees that support both wood and animal production".

We would be grateful if you could respond to the attached questionnaire. Please do not feel obliged to answer all questions but only those which you have an opinion. While agroforestry practices can include:

- fodder production from trees and shrubs, both naturally grown and planted
- shelterbelts for livestock
- Silvopastoral systems, including grazing in natural woodland and in broadacre planted widely spaced commercial timber trees
- trees for shade,

we believe that it should be possible to develop agroforestry systems in northern Australia based on trees producing feed for animal production while they are in their growth phase and providing a return on the timber when the tree has reached maturity.

The information gained from you will allow us to assess if such systems are or can be trialed; what research may be necessary before such trials can take place; any gaps in knowledge that research will have to address; and, the probability of the uptake of such a system and the viability of it.

We would like to establish your present involvement or possible future involvement in an agroforestry system on your property. We have included information about an envisaged agroforestry system within the questionnaire for your comments.

We hope that you participate in this questionnaire as your input will be valuable.

Can you please return the questionnaire as soon as possible in the envelope provided.

Yours sincerely

Brian Lowry

Jayne Seebeck

QUESTIONNAIRE

A commissioned survey of farmer organisations in all states was carried out in 1991 by the Rural Industry and Research Development Corporation (RIRDC). While constraints such as time and funds limited the survey it raised a number of issues. Some of these issues are relevant to the study of the potential for an Agroforestry System for northern Australia based on trees that support both wood and animal production. The following questions are to gain some indication of your perception and needs.

Q1 *Please rate from 1 to 6 your opinions about each of the following statements.*

ISSUES	Strongly disagree	Moderately disagree	Slightly disagree	Slightly agree	Moderately agree	Strongly agree
I believe that agroforestry systems could make my property more productive	1	2	3	4	5	6
I believe that agroforestry systems have the potential to increase my income	1	2	3	4	5	6
I believe that government should provide incentives for their establishment	1	2	3	4	5	6
I believe there should be programs in place to heighten awareness	1	2	3	4	5	6
I know that large increases in beef production have been obtained by planting the tree legume leucaena	1	2	3	4	5	6
<i>The following questions are based on trees that support both wood and animal production</i>						
I believe there would be markets for logs of short length but high quality (cabinet) timber	1	2	3	4	5	6
I understand that the leaves of such trees produce very good feed for livestock particularly in the dry periods	1	2	3	4	5	6

Please supply the following information

- (a) Size of property
- (b) Location
- (c) Typical rainfall
- (d) Type of soil
- (e) Industry your property supports? *Cattle* *Sheep* *Other*
- (f) Do you have a woody weed or wood regrowth problem on your property?
Any comments?
- (g) Are there any native browse trees or shrubs on your property?

Q2 *In your opinion how important is each of the following purposes for establishing an agroforestry system on your property? Please rate purposes on your first reaction.*

PURPOSES	Very little or no importance	Of little importance	Of moderate importance	Very important	Of utmost importance
Shelter	1	2	3	4	5
Shade	1	2	3	4	5
Soil conservation	1	2	3	4	5
Salinity control	1	2	3	4	5
Preventing salinity & waterlogging	1	2	3	4	5
Promoting wildlife	1	2	3	4	5
Sawn timber production	1	2	3	4	5
Post, poles production	1	2	3	4	5
Feed production	1	2	3	4	5
Firewood production	1	2	3	4	5
Other	1	2	3	4	5

Q3 *Please describe other opinions on purposes or agroforestry systems you believe that need to be recognised?*

.....

.....

.....

.....

.....

Q4 *Have you carried out any tree establishment on your property?*

Please describe

.....

Q5 *Do you have a preference for exotic or native trees ?*

If yes, which trees?

.....

Q6 *Are you aware of any government assistance schemes to assist in tree planting? If so, which schemes?*

.....

.....

Q7 *Would you use a scheme if it was available to you?*

.....

Q8 *Would training workshops be useful for establishment and maintenance of the trees?*

	Very little or no importance	Of little importance	Of moderate importance	Very important	Of utmost importance
Site preparation	1	2	3	4	5
Planting	1	2	3	4	5
Weed control	1	2	3	4	5
Pruning	1	2	3	4	5
Thinning	1	2	3	4	5
Insect control	1	2	3	4	5

Q9 *In the commissioned survey it was found that there were many causes for failure of trees to establish. If you had failures, which of them have you found to be the important causes of failure of trees to establish on your property? Please rate on importance.*

Causes for failure	Very little or no importance	Of little importance	Of moderate importance	Very important	Of utmost importance
Weed competition	1	2	3	4	5
Drought/lack of water	1	2	3	4	5
Stock damage	1	2	3	4	5
Insect damage	1	2	3	4	5
Frost	1	2	3	4	5
Salinity	1	2	3	4	5
Eaten by wild animals	1	2	3	4	5
Poor techniques	1	2	3	4	5
Wrong species	1	2	3	4	5
Did not germinate	1	2	3	4	5
Fire	1	2	3	4	5
Waterlogging	1	2	3	4	5
Wind damage	1	2	3	4	5
Disease	1	2	3	4	5
Other	1	2	3	4	5

Q10 *In the survey there were a number of reasons prioritised why trees were not planted. Can you rate in importance from 1 to 6 your potential reasons for not planting trees.*

Potential Reasons for not planting trees	Strongly disagree	Moderately disagree	Slightly disagree	Slightly agree	Moderately agree	Strongly agree
<i>Economic/Financial</i>						
Cost of establishment	1	2	3	4	5	6
No economic benefits	1	2	3	4	5	6
Cost of maintenance	1	2	3	4	5	6
Cost of fencing	1	2	3	4	5	6
No incentive	1	2	3	4	5	6
<i>Technical reasons</i>						
Lack of knowledge	1	2	3	4	5	6
Previous failures	1	2	3	4	5	6
Hard to establish	1	2	3	4	5	6
<i>Competition with agriculture</i>						
Loss of land	1	2	3	4	5	6
Competition from trees	1	2	3	4	5	6
Incompatible with agriculture	1	2	3	4	5	6

AN AGROFORESTRY SCENARIO

The siris tree (*Albizia lebbbeck*, also known as "acacia", "flea tree", or "Kimberley rain tree") is native to parts of northern Australia and has been introduced widely as a shade tree. You may recognise it the tree from the accompanying drawings of its leaves, seed pod and flower. Siris provides good quality feed directly from the leaves, flowers and pods, and also from its promotion of pasture below the canopy. Although, like leucaena, a tree legume, it is very different in many ways. One important difference is that we think it would be most valuable for animal production as a large free-standing tree, rather than hedged for browsing. Elsewhere in the world, siris is also known to yield high-quality timber. Why not combine these uses? Although several other tree species are of interest, siris seems the best bet for an agroforestry system for both wood and animal production in northern Australia.

Although this scenario has not been tried in Australia, and much research is still needed, an optimistic projection from present information suggests a system something like this:

- | | |
|---------|--|
| Year 1 | Planting container-grown or bare-rooted seedlings at 100 stems/ha in strips along fence lines or selected sites within larger paddocks. Planting costs comparable to leucaena. Protect from grazing. |
| Year 2 | Planted areas excluded from grazing. Emerging trees protected from rabbits, wallabies, mice. |
| Year 3 | Pasture may be grazed if managed carefully, but trees still need protection. Commence pruning of elite trees to ensure clean stem form to 3 metres. |
| Year 4 | As above. Trees begin contributing to animal production, increasing thereafter. |
| Year 5 | Cattle have uncontrolled access. Commence thinning of unwanted trees, or cutting to maintain them as browse. High pruning of selected trees to 5 metres. Final tree density of 2-5 stems/ha. |
| Year 6 | No further management needed. |
| Year 8 | Green crowns of remaining trees now large enough to withstand removal of lower crown without destroying log form, and thus form a standing reserve of feed for drought conditions. Utilisation in this way would delay wood harvest but provides useful options. |
| Year 10 | Animal production in planted areas now double that before planting and continues to increase. |
| Year 20 | Log harvest, carried out by specialist operator dealing in short logs of high-quality timbers for interior and decorative use. Returns comparable to those from rain forest timbers in short supply. |

Q11 *Is the above tree growing on your property or in your area?*

Are the trees large and healthy?

Do you think the tree could be a weed problem?

Other comments?.....

Q12 *The following questions examine the likelihood of your acceptance of this system*

	Strongly disagree	Moderately disagree	Slightly disagree	Slightly agree	Moderately agree	Strongly agree
I believe I would be able to plant the trees and tend to the pruning and thinning	1	2	3	4	5	6
I believe I would be able to plant, prune and thin the trees if the process was demonstrated to me	1	2	3	4	5	6
I believe it would be more suitable to employ a specialist contractor	1	2	3	4	5	6
I believe it would be more acceptable with some government support	1	2	3	4	5	6
I believe there would be financial gain in diversifying to this system	1	2	3	4	5	6
I believe the initial costs of setting up would be expensive but very beneficial in the long term	1	2	3	4	5	6
I understand there is a traditional sawmill in my area to mill the logs	1	2	3	4	5	6
I believe it would be more appropriate to use a portable sawmill contractor	1	2	3	4	5	6

Thank you for your participation,

Brian Lowry

Jayne Seebeck

APPENDIX B. Respondents' opinions on purposes for an agroforestry system additional to those in questionnaire (Question 3)

- Nitrogen fixing and Carbon dioxide fixing
- Nitrogen fixing trees should have priority as most lacking in the tropics
- Trees which produce stock fodder and also good timbers and these should be used to provide fodder over lifetime during which time young trees are planted and producing fodder when the mature trees are then harvested for timber
- Some cattle producers have deliberately sought multipurpose trees i.e. fodder production in off peak season, nitrogen fixation, cabinet timber, honey production.
- Purposes should be for windbreaks, erosion control, wildlife habitat, stock feed
- Encourage birdlife which in turn control external parasites, plant insects and rodents. Alter microenvironment of grasses in exposed paddocks.
- **The native trees in Q2 will do the survival job (proved in 1993, 1994 and 1995). The immediate problem is that these trees are scattered and it would be much better if paddocks of same paddocks were available - would have to be planted. A point of interest is that properties in this shire that have large areas of edible timber are known as “drought free” or about that.**
- Amelioration of climatic conditions e.g. frost and wind affects.
- Production of native seed, production of natural oils, possibility of fuel production specialist medicinal uses, specialist food supplies.
- Need to protect native scrubs for future use and to encourage regrowth. Species such as Gidea which is the predominant yard and hence construction timber because of its termite resistance is all but cut out.
- To create biodiversity.
- Grow trees that are browse legumes, can stand severe frosts to -14 °C, that can be flooded by ponding and high in protein in droughts.
- Wildlife corridors. Riparian buffer zone. Wind breaks.
- Benefits to the air we breathe and to rainfall patterns.
- To provide a better ecological balance there by minimising the devastation caused by locusts and cicada plagues.
- Flower, leaf and pod production.
- Stream bank stabilisation. Shading out of weeds: grass pests.

- Growing natives for foliage/birds, nuts, also oils. The country on our property is naturally open downs.
- The general health of the eco system.
- Maintain or increase wild life (birds) to control insects. Wind breaks. Soil improvement.
- Flowers, olives.
- An important part of an ongoing permaculture system.
- Planting on steeper slopes.
- Wildlife corridors. Riparian rehabilitation.
- The riparian method of planting trees on creek banks and steep slopes as agroforestry systems is used on flat land that I use to produce an income from dairy farming.
- To stop depletion of natural forests encourage timber industry growth.
- Dual purpose tree (valuable timber) and cattle production. Trees used as animal food irrelevant in wet tropical context.
- I strongly believe native varieties of trees should be maintained or re-established in selected pockets on all properties over e.g. 100 acres and such programs should be subsidised.
- My interest is mainly in shade trees for dairy cattle in summer.
- Native forest food plantation.
- Water quality improvement. Stop spread of woody weeds.
- Basically the more wood produced in this fashion protects the eco-system. Research and knowledge in these techniques will prove invaluable for future wood production. This work is supportive to the environment rather than degrading.
- Animal welfare: shade, shelter. On farm production reduces transport costs, fuels etc. Trees help with greenhouse gases. Micro-climate and fertility change. Trees reduce or cure most land degradation problems. Established trees reduce woody weed problems (e.g. groundsel, lantana).
- When applied at sufficient scale, i.e. several properties in unison, catchment wide benefits arise → broadscale environmental benefits.

SECTION C:
**Future Research and
Development Needs**

4. FUTURE RESEARCH AND DEVELOPMENT, NETWORKS AND INSTITUTIONS

4.1 Research

Although the information gathered in this report points to the value of the species highlighted, in many cases it would be slim evidence on which to expect a landholder to commit resources. Research is necessary to positively confirm the benefits and attempt to estimate them. This involves phenology and agroecology of the trees, and nutritional evaluations with animals. Both could be done with existing material. There is also a need to assess any risks, namely the possibility of the trees becoming a weed problem.

1. Tree-grass interactions - it is important to know which tree species of interest can promote grass, and try to obtain some estimation of the effect..

- a. Locate sites where the species of interest are growing in situations that allow some assessment of the effect of tree on grass below the canopy. No site is likely to be ideal, the hope is that by surveying many sites it will be possible to build a reliable picture.
- b. At chosen sites record grass comparative condition below and outside the canopy at selected times. Set up enclosures to measure production if possible. Collect grass samples to measure nitrogen content and digestibility.
- c. Species in order of importance are: tipuana, forest siris, yemane, red siris, .

2. Animal Nutrition

a. Tipuana. A direct feeding trial should be conducted with tipuana to unequivocally confirm the high feed quality indicated but not so far demonstrated. Fresh material is readily available from existing trees in localities in SE Queensland.

b. Yemane. Feeding trial with green leaf to confirm forage quality (or take this as read from one publication ?). Leaf material would be available from Lannercost and Kennedy State forests (North Queensland). The logistics of collecting, drying and transporting the leaf would be more difficult than with tipuana but achievable if the resources are available. It is possible that animal work could be done at Townsville

c. Forest siris. Fresh material would be available from roadside regeneration.

d. Fallen leaf/pod.

Tipuana. Estimate dry matter production in fallen fruit, determine protein content and in vitro digestibility. Supply known amounts of seed to sheep and cattle to check acceptability and ability to crush the seeds to access protein.

Tipuana, Yemane. Obtain fallen leaf of tipuana and yemane (important !) to feed to penned animals. Sufficient leaf of yemane should be available from the trees in the Shell plots but the logistics of collecting it are more difficult than with fresh leaf. It would be desirable to get enough for a digestibility trial, even more to feed it in mixture with spear grass. However even an indication of voluntary intake would be valuable.

A wider, but highly relevant study, would be to perform *in vitro* digestibility determinations with a range of grasses and fallen tree leaf to map out the cases where there is a positive interaction.

Look for field locations in which it may be possible to directly observe cattle eating fallen leaf of any relevant tree species.

3. Growth and Sylviculture

Immediately seek cooperating producers with newly established trees to carry out pruning treatments in order to have indications of the best way to obtain clear log form. Several respondents from the survey could be approached for this purpose.

The Browse Net sites and Shell Trials could yield much data on tree survival, growth and phenology that has not been collected for lack of resources. Also study growth of wayside stands of forest siris.

Participate in a recently rejuvenated TREDAT to build up a clearer picture of the performance of each species.

4. Wood Quality

In general there is not such an immediate requirement for work in this area, in that any results are not likely to affect planting decisions. However two strategies are proposed.

1. Obtain standard forest industry data on grade recoveries and wood properties for the species of interest. This would mean obtaining the funding to carry out evaluation through the system established by the Queensland Forest Service under the plantation hardwoods initiative. One would then have to locate trees of suitable size and form to yield a log for evaluation, under ownership where it will be possible to harvest them for research purposes, and arrange transport of logs to the experimental mill.

2. Explore wood utilisation through the woodcraft industry.

One possibility would be to employ mobile milling to obtain billets of siris heartwood from wayside trees. This wood to be given to selected wood working clubs for distribution to those members who participate in a competition for best object made from siris timber. Participants to also provide information on their experiences and opinions on working with it. Prizes awarded, but products become property of the project.

This would generate some information but would also generate greater interest and awareness of siris timber and agroforestry in general. The collection of articles would become a resource to promote the project.

5. Potential Woody Weed Problems

Woody weed problems have arisen in Australia, sometimes with trees such as *Acacia nilotica* that were introduced for forage. As its use as a fodder tree has increased, concern about leucaena spreading as a weed into non-pastoral areas has also grown. This is an aspect that has to be considered for each species, with particular concern with those that are free seeding and easy to establish. There are one or two places where siris is said to appear as volunteer plants. These sites should be examined, although given its wide distribution it seems most unlikely siris could have any weed potential. Any form of pastoral land use will involve tree management in some form. Trees that confer real production benefits justify more intensive management. Producers in the survey (Section B) seem to accept this double-edged aspect.

6. Linkages and resource people

In carrying out this project, particularly the survey, one has become increasingly overawed at the diversity of organisations and individuals that are relevant to any furtherance of this project. This is not helped by major structural changes in the Queensland government departments concerned. However as we see it key groups are as follows.

1. **Tree Care Extension Officers in the Department of Natural Resources.**

The 10 regional officers are all involved in facilitating establishment of trees on farms, although in very diverse environments. Through their help it would be possible to have the ideas of this project incorporated in new planting and to have access to recent planting for gathering data. They and the Brisbane coordinator Mr Andrew Grodecki, have already helped considerably in finding respondents to our survey.

2. **QDPI**, in relation to the **Browse Net sites** at Brian Pastures and Rockhampton. The sites are a resource for ongoing study, and the QDPI officers concerned are vital to any ongoing project.

3. **Community Rainforest Reforestation Program.** So far JBL has had only limited contact with the CRRP, which seems to have distinctive local features in each area. The priority here is to make contact and try to incorporate into the program the species with a dual-purpose role highlighted in this project. CRRP tends to be limited to the wetter areas and operates only on freehold properties, while most pastoral land in northern Australia is leasehold. However there would still be a considerable area in which the concepts of this project are applicable.

4. **Forest Research Institute.** Under the **Australian Trees Section** planting trials of native hardwoods are in progress in several areas, including semi-arid. Most of the species are not relevant to this project but useful information has already been obtained from Dr Paul Ryan's group, who have also a significant awareness of tree-animal interactions.

5. The **RIRDC agroforestry** trial at Mt Mee, managed by Dr David Lamb of the University of Queensland is of obvious interest, especially any results on tree-grass interactions that might be obtained as the stand develops. Dr Lamb has already collaborated in terms of access to collect fallen leaf.

6. **Land Care** groups are too numerous and diverse to consider as an entity here. For those where the main concern is land degradation by woody weed invasion, it may be difficult to think about planting trees for productive purposes. However from the survey a number of individuals have expressed interest in any further developments.

7. **Individual Producers.** Some of the producers who responded to the survey specifically invited us to look at their trees and wanted to explore the proposed agroforestry system further. One interesting implication from the responses is that beef producers who have some involvement in cropping seem much more prepared to undertake tree establishment.

8. **“Properties and End Use of Plantation Hardwoods”.** This is a project that is part of the Plantation Hardwoods Initiative of the Queensland Forest Service. As indicated elsewhere this is dealing with species not relevant to our proposal, but does provide an avenue for obtaining wood quality data if suitable logs can be located. The key person is Mr David Gough, Manager, Timber Research.

9. **LEAP - LandCare Environment Action Program** - Earlier in 1996 a number of groups were operating in SE Queensland and were seeking advice on choice of tree species. This looked a very promising prospect then, less so now.