Greening Australia
New South Wales Inc.

NEW ENGLAND
NORTH WEST
REGIONAL DEVELOPMENT
BOARD

A Manual for Planted Farm Forestry for the Northern Inland of New South Wales

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May 2004

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NEW ENGLAND NORTH WEST REGIONAL DEVELOPMENT BOARD

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1. Introduction

Imagine the year 2050. The Northern Inland of NSW is a thriving region with a stable population and healthy towns. There are still the same towns as in 2004, but they are all financially better off. There is a strong farm sector providing valuable commodities to local, national and international markets. The most noticeable difference is that there is also a strong farm forestry sector.

Across the landscape a mix of tree plantings and native forests provide economic and environmental benefits, and support and protect the agricultural enterprises. Various timber belts and agroforests, stocked with valuable clearwood sawlogs, complement small centres of intensive plantation development and areas of sustainably managed native forests. A few co-operatives have established to process and kiln-dry some of the logs into more valuable sawn timber.

The number of secondary industries is expanding to take advantage of the high quality wood available from a range of native and exotic timbers.

There is stable employment in the harvesting and wood processing industries and in complementary industries such as electricity production from wood gas turbines. There is even a vigorous trade in carbon, biodiversity and salinity credits on the Newcastle Stock Exchange. The level of river water salinity in the Namoi and Border Rivers has long since stabilised and the Northern Tablelands has become a well-sheltered biodiverse landscape. Sound far-fetched? It's possible, but would take time, commitment and enterprise to get there. An old cliche in forestry is that the best time to plant a tree is 25 years ago and the second best time is today! If we do not allow ourselves to imagine what our future could be like, then the future will simply happen to us. However if we start planning now, using ideas like farm forestry, we can create a positive future for our region, ourselves and our children.

As the above 'future scenario' suggests, farm forestry as a landuse has the potential to provide both economic and environmental benefits to farmers and their communities. It shows real promise in managing soil water recharge in salinity prone landscapes, particularly on many parts of the northwest slopes. It also has the potential for enhancing current revegetation efforts in many over-cleared landscapes of the region. Such efforts aim to minimise habitat fragmentation and biodiversity decline. In addition, where farm forestry is carefully planned, there are also shelter, erosion control and nutrient cycling benefits to adjoining or co-existing agricultural enterprises. On top of all this it has the potential to pay its own way, diversify farm incomes, and expand regional secondary industry opportunities.

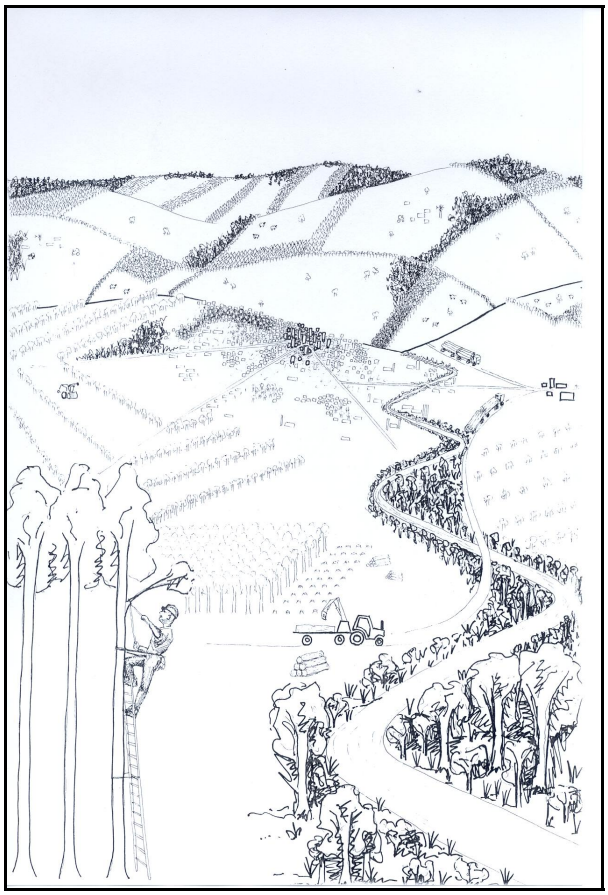


Figure 1: A vision splendid : a diverse and self-sustaining landscape which incorporates agriculture, farm forestry and native vegetation.

There are of course risks involved in entering, what is for this region, essentially a new industry. The profitability of any particular farm forestry venture is not guaranteed. On the face of the current wood supply situation, producing timber should be a safe bet. Timber supplies from native forests in Northern NSW (and world wide) are contracting, and at the national level, Australia currently imports more wood than it exports (Love, *et al.* 1999). In addition, timber prices have remained reasonably stable over recent decades compared to other primary products that have generally declined in price (Love, *et al.* 1999). However, many wood products are produced and traded nationally and internationally. So producers elsewhere in the country or the world can potentially (and often do) service local markets for wood. Marketing arrangements and relationships are already established and gaining access to markets is one of the bigger challenges new timber producers face. Market access can be particularly difficult for small-scale producers in a region such as ours where processing and marketing infrastructure is limited.

Like all commodity markets, prices can fluctuate from time to time and particular wood products can fall in and out of favour with consumers or be superseded by products more cheaply produced. Farm foresters in our region therefore must develop best practice production systems, produce quality products, have the ability to access markets and be competitive in the national and global market place if profitability is to be realised. All this is the face of imperfect knowledge. Currently there are very few farm foresters in the Northern Inland NSW who have planted, managed and marketed a timber crop through a full harvest rotation. Regionally, the practical experience and knowledge base of farm foresters is limited.

The simple message is that farm forestry has the potential to provide landholders with many benefits but there are plenty of challenges as well. Farm foresters prepared to plan carefully, do their homework and commit to high standards of production, whilst addressing market realities, have the best chance of realising the potential economic rewards and not just the environmental ones.

This publication aims to provide locally relevant information to better inform farm foresters and to help them face the challenges and maximise the full range of benefits.

2. About this Publication

The aim of this publication is to provide concise and current information that will assist landholders venturing into farm forestry. It assumes that the reader is principally interested in wood production but also wants as many other benefits as can be practically catered for from their farm forest. This book deals exclusively with planted forests and does not cover timber production from managing existing native forests.

The introductory chapters (1-7) on planning, production systems, planting configurations, setting targets, and the concluding Chapters (10-13) on stand management and planting for multiple benefits are necessarily general in nature but with a regional bent. They are designed to provide guiding principles and ideas for farm foresters who can then develop their own ways of growing and marketing wood to suit their farm and personal requirements. This information has been sourced from the literature, experienced local tree growers, forestry experts, and the authors' experiences.

Chapters 8 and 9 concentrate on a series of 'best bets' in terms of species selection and establishment practice specifically to suit the landholders of the Northern Inland of NSW. They draw on specific information gained locally from surveys, trial plantings and other landholder experiences from within the region.

The publication has not been designed to be an entirely stand-alone authority on farm forestry. Any prospective farm foresters are encouraged to undertake their own research to increase their knowledge base and to assist with planning and decision-making. A review of the publications listed in the References & Further Information and Contacts Chapters (18 & 19) may help to facilitate this. Also, where detailed information is available from local sources (e.g. comparative growth data from local trials) these have been provided as appendices on the attached compact disc (CD). The CD also contains detailed descriptions of the current legislation, and wood products and markets currently relevant to farm forestry as well as copies of a number of pertinent extension publications.

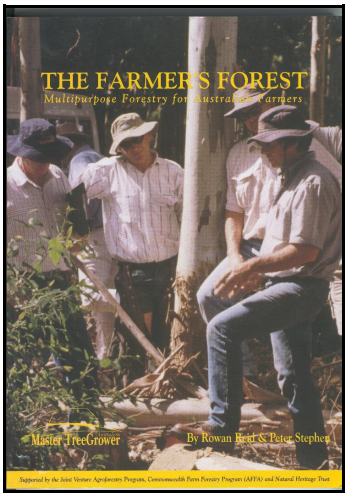
Figure 2: Field days on farm forestry are often a good way to get "hands on" information.

This publication is a joint effort between Greening Australia NSW (GANSW) and the Northern Inland Forestry Investment Group (NIFIG) and is funded by the Natural Heritage Trust (NHT) and Australian Government Department of Agriculture, Fisheries and Forestry (AFFA) and NSW Department of State & Regional Development. It draws heavily from information gained during the following NHT funded projects that have been conducted in the Northern Inland region of NSW:

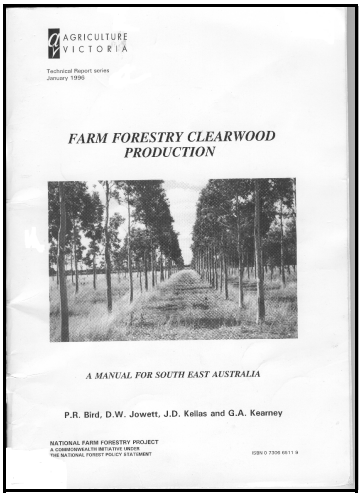
1) Native Species Industries (1996-99) ;
2) Northern Tablelands Farm Forestry Project (1997 to 2000);
3) Optimising the Growth of Farm Planted Trees (1998-99);
4) Low Rainfall Farm Forestry on a Landscape Scale (2000–03); and
5) Farm Forestry Support—Species Trialling Support Project (2000-2002).

It has also sourced the recent literature concerned with farm forestry in the other medium to low rainfall zones of southern Australia.

The following general references on farm forestry provide excellent information on design principles, multiple benefits and use, the silviculture of stands, stand measurement, farm forestry economics and case study examples. They explore the subject area in detail and should be read alongside this book.



- The Farmer's Forest : multipurpose forestry for Australian farmers - Rowan Reid and Peter Stephen (2001) : RIRDC Publication No R01/33.



- Farm Forestry Clearwood Production - a manual for south-east Australia - P.R. Bird, *et al.* (1996) : Victoria Agriculture, Technical Report Series.

- Design Principles for Farm Forestry : a guide to assist farmers to decide where to place trees and farm plantations on farms - Nick Abel, *et al.* (1997): RIRDC Publication No 97/048; RIRDC/LWRRDC / FWPRDC Joint Venture Agroforestry Program.

3. Timber Production Systems

When most people think of forestry (including farm forestry) they envisage large blocks of trees densely planted to form a forest (closed canopy) structure. Indeed a significant part of the world's wood is produced under such a scenario from extensive forest plantations grown in high rainfall environments. Traditional plantation forestry (or industrial forestry) tends to produce large volumes of a variety of wood products, but often a high proportion of lower grade products, and relies on large scale and low inputs for profitability. Trees are planted densely and are often grown without early thinning or pruning to keep management costs down. Poor form and lower branch development is constrained by inter-tree competition. It represents a low input extensive timber production system. It is well suited to producing low value products such as pulp or firewood or, with longer rotations, a combination of products which may include poles, peelers (veneer logs) and low and high quality sawlogs. The logging rotation time of such a system is very much determined by site quality and rainfall, with short rotations (less than 40 years for sawlog production) only possible in high rainfall zones.

Figure 3: An example of an extensive timber production system.

The timber production systems at the other end of the management intensity scale concentrate on producing high value products in low volumes on a per area basis. Plantings are either well spaced at establishment (i.e. <500 stems/ha) or thinned early to ensure retained stems grow quickly (this is essential particularly in the lowest rainfall areas). Consequently, the more open grown trees often require pruning to keep good form and to control lower branching (see Chapter 10). The appropriate pruning of lower branches allows the development of clearwood (timber without knots) in the log. This intensive timber production system specifically targets high value wood products such as logs aimed at the veneer market or sawlogs to produce appearance grade products and cabinet timbers. Short rotation times can still be achieved in medium to low rainfall environments provided trees are well spaced early.

Figure 4: An intensively managed timber production unit on a farm near Kentucky.

Either timber production system or aspects of both systems may suit particular farm foresters in our region. However, the current lack of markets for low value products, and the slower per hectare growth rates of plantations possible in much of our region (compared to high rainfall areas), suggests that the more intensive system is likely to be favoured by local farmers.

4. Timber Production in Our Region—is it really viable?

The commonly perceived view of forestry (i.e. extensive production in densely grown forests or "industrial" forestry) has led to the widely held belief that timber production is only possible from such a system. If this were true, farm forestry would be relegated to only the eastern and highest parts of the Northern Tablelands and timber production would not be considered in the medium to low rainfall environments of the rest of our region. This paradigm is one of the factors responsible for the lack of planted farm forestry ventures in Northern Inland NSW to date.

It is also commonly assumed that individual tree growth rates are slow in medium to low rainfall environments with harvestable logs expected to take 80 to 100 years or more to grow. This assumption is incorrect if planted trees in the medium to low rainfall zones are managed appropriately. A recent survey of 3 to 10 year old farm-grown trees in the Northern Inland of NSW (Andrews, 2000 - see Appendix A) found many examples of Spotted Gum *Corymbia maculata* and River Red Gum *Eucalyptus camaldulensis* trees growing at 3 to 4cm trunk diameter increment per year, with well over 2m in height growth per year. Some examples of these growth rates were recorded at Wee Waa, a relatively low rainfall area. Similarly, recently measured 4 year-old Shining Gum *E. nitens* trees at 2 different locations on the Northern Tablelands near Armidale achieved the same or slightly higher growth rates (S. Andrews pers. obs.- see Appendix B). If such growth rates could be maintained these trees could reach harvestable log size in 15 to 20 years! Clearly, the potential for growing timber trees in reasonable harvest rotation times is not restricted to places like Ebor or south of Walcha in our region.

Figure 5: A 6 year old planting of River Red Gum near Breeza.

Figure 6: A 3 year old Shining Gum in a wide-spaced planting east of Armidale .

It is true that timber productivity rates (m^3 produced per ha per year) are related to average annual rainfall of the planting site. At some point on a declining rainfall gradient, **timber-only** returns compete poorly with the returns of other land uses such as grazing or cropping. A good indication of this point is where large industry players are prepared to invest in plantation timber production. Recent industry interest in the Walcha area (and similar rainfall zones elsewhere in the state) suggests that sites with around 900mm average annual rainfall and higher are attractive for **timber-only** production. A recent assessment by NE–NWFIG (2002 - Appendix C) predicts that with good management, quite attractive internal rates of return between 5% and 7% are possible under current market conditions in the Walcha area from plantation Radiata Pine *Pinus radiata*. Over the long term, such returns are likely to compare favourably with the returns from grazing enterprises in this area.

At the other end of the rainfall scale, and in land systems highly suited to agricultural production (especially cropping), the returns from timber are far lower than those achievable from agriculture. An extreme example of this is illustrated by a recent study conducted by NSW Agriculture (Hean and Signor, 2001). They used economic modelling to compare the profitability of sawlog production from a plantation with cropping and grazing land uses on black soil farmland on the Liverpool Plains (about 650mm annual average rainfall). The results of the study are summarised in Table 1 which expresses the likely relative profitability of each land use in terms of net present value (see glossary) over a 30 year time period.

"Viable farm forestry in the medium to lower rainfall areas requires timber production systems and planting configurations that complement not replace agricultural production systems."

Table 1 - Net Present Value of different enterprises on a black soil site on the Liverpool Plains under a best economic case scenario for each enterprise over a 30 year period. (Hean and Signor, 2001).

Enterprise	NPV$/ha
Timber Plantation	$ 135
Grazing	$1228
Cropping	$3274

Clearly, if the above predictions are anywhere near accurate, there are strong economic disincentives to practice **timber-only** production in this particular landscape of the region, despite it returning a positive (profitable) return. Of course, the relative differences in profitability of the enterprises would be less on sites which are not as highly suited to cropping.

The key message from the above discussion is that complete replacement of agricultural production by timber production is increasingly unattractive economically the further down the rainfall gradient you travel (and the more suitable the land for cropping). This is especially so if "industrial" plantation style timber production is practiced. This is not necessarily due to lack of profitability, or slow tree growth rates, but more to do with the opportunity costs of using the land for timber production instead of agricultural production. However, replacing agriculture with forestry is not what farm forestry is about. Farm forestry is very clearly about integrating wood production with agricultural production on the farm. It also means taking advantage of the many natural resource management benefits of appropriate farm forestry plantings (i.e. farm forestry is not just for commercial timber returns). Indeed, measures to control various forms of land degradation with trees may well be essential to ensure long term productivity of certain landscapes.

If woody vegetation is required to protect a riparian zone, expand a buffer around a wildlife corridor or isolated bush remnant, control recharge across a paddock in a high salinity hazard landscape or provide stock and crop shelter, it would make sense to include trees with commercial potential. Even in low rainfall areas, tree growth rates can be substantial and it is quite conceivable to produce wood profitably. Viable farm forestry in the medium to lower rainfall areas in particular, requires timber production systems and planting configurations that complement not replace agricultural production systems.

5. Planning for Farm Forestry

To optimise the possible benefits and minimise the risks from a farm forest, farm foresters need to plan. Farm forestry is a land use just like any other farm enterprise and ideally should be integrated with property planning using the same principles. The planning process is likely to include:

1) Setting goals or objectives for the whole farm and the farm forest;

2) Considering the farm family's long-term goals, succession plan and desire to invest;

3) Considering the climate, soil and land resources, other physical features and the existing farm infrastructure of the property and their suitability to various forestry enterprises;

4) Considering the existing farm infrastructure. Roads and tracks in particular may need repositioning or upgrading to cope with timber harvesting machinery;

5) Identifying problem areas and land degradation issues that particular farm forestry options may be able to ameliorate;

6) Considering the landholder's own labour and capital resources and how much of these can be applied at various stages of a farm forestry activity;

7) Examining carefully potential market and product opportunities (can I grow the appropriate species to the size and quality that matches the market requirements? – see Chapters 7 & 8);

8) Reviewing the type of farm forestry production systems that may be suitable;

9) Considering the current agricultural enterprises and how best farm forestry can complement and be integrated with them;

10) Reviewing the legislative requirements for farm forests (see Appendix D); and

11) Identifying the most appropriate locations and planting configurations for the farm.

There are several popular methods of designing for farm forestry. One of the most useful is the "diagnosis by design" method developed by Rowan Reid of the School of Forestry at the University of Melbourne and used successfully in the Master Tree Grower program. It is detailed in Appendix G and the reference "The Farmers Forest" (Reid and Stephen, 2001).

6. Planting Configurations

The number of different planting patterns possible on farms is only limited by the imagination of the farmer. Most configurations, however, are based on variations of three basic patterns:

1) Blocks;
2) Belts; and
3) Wide-spaced plantings.

Blocks: A traditional 100 ha plantation is one example of a block planting design, as is a circular 0.5 ha woodlot placed next to the homestead to grow firewood. They are characterised by being compact with a small perimeter to area ratio and can be of any shape that fits their purpose. Typically, trees are established at relatively high densities (800 stems/ha and above) and the focus of management is usually for wood production, with agricultural production a minor consideration. Less commonly, a block planting may be principally for nature conservation, degraded site rehabilitation or riparian protection with single trees scattered throughout managed intensively for timber.

The advantage of a block configuration is the efficiency of establishment, management and harvest of a compact single purpose production unit. The disadvantage is that unless the blocks are small, timber production displaces agricultural production entirely. They are best suited to:

1) The higher rainfall areas of the region where timber production is at least as economically attractive as the agriculture that block planting displaces;

2) Areas on farms in the medium to low rainfall parts of the region where for some reason agriculture is less feasible or desirable for the site (e.g. due to constraints of topography, paddock shape or due to the aesthetic requirements of the landholder); and

3) Areas on the farm where a treed block will assist in land degradation control (e.g. a patch surrounding an eroding gully or a saline scald, a specific ground water recharge area, a buffer area adjacent to an isolated bush remnant, corridor or recreated habitat).

Block plantations or woodlots remain the most common configuration of farm forestry plantings throughout the Northern Inland. This is probably due to the economies of fencing at establishment and also to the commonly held paradigm that wood production must occur in block plantations. Indeed, the vast majority of planting trials and demonstration plantings established in recent times by Greening Australia and State Government Agencies have been in blocks.

Belts: A common example of a belt planting is a paddock windbreak. They are characterised by a linear shape and have a high perimeter to area ratio. Typically, trees are established in multiple rows and again at relatively high densities. Management usually aims for multiple benefits including timber production, paddock shelter, and corridors for wildlife. If aligned across the slope and especially in a series, belt plantings can be used to intercept lateral flows in sloping landscapes of high salinity hazard. Series of belts also considerably improve livestock, pasture and crop shelter from wind (Cleugh, 2003). If aligned with and adjacent to drainage lines and streams they can also assist with riparian zone protection. Where a series of belts are established with a high and regular frequency across a paddock they form alley farms. The best examples of alley farming occur in southern Western Australia where the system aims at optimising soil water use (for salinity recharge control) in addition to comprehensive crop, pasture or livestock shelter. An alley farm has recently been established at Pine Ridge on the Liverpool Plains by NSW Agriculture.

The advantages of belt plantings include:

1) Establishment is efficient due to the long continuous rows available for preparation and planting and the possibility of utilising existing paddock fencing at least on one side; and

2) They displace only narrow strips of agricultural land and can provide multiple benefits to adjacent crops and pastures and their landscapes.

The disadvantages include:

1) Trees in the edge rows often grow faster and with uneven crown development and timber growth compared to mid-row trees;

2) Narrow belts may lose their sheltering effects under a clearwood management regime where trees are thinned and clear-bole pruned; (see Chapter 10) and

3) The high edge to area ratio may subject trees (particularly edge trees) to windthrow, climatic exposure and high levels of insect attack.

Various belt configurations are well suited to farms in the Northern Inland. There are countless examples of belt plantings for crop and livestock shelter across the region, particularly on the Northern Tablelands. Few, however, have been designed or managed as farm forests.

Wide-spaced plantings: Trees are established to form a woodland or open woodland structure (as opposed to a forest) with agricultural activities (usually grazing) occurring right up to the boles of individual trees. They are established within the bounds of existing paddock fencing by excluding livestock during the establishment phase. Trees can be established at relatively low densities (<200 stems/ha) or at moderate densities (around 400 stems/ha) to allow for substantial culling.

Figure 7: An example of a planting consisting of multiple belts across a grazing paddock near Kentucky.

The focus of management is very much for the co-existence of timber production with agriculture on the same site. Open-grown trees naturally develop large low branches so intensive pruning for clearwood production is virtually mandatory. Wide-spaced plantings can provide productive utilisation of broad recharge areas in high salinity hazard landscapes, mimic original woodlands in structure to assist in biodiversity conservation, and provide pleasing 'see-through' aesthetics. They are well suited to the high rainfall zone where rainfall is often in excess to the requirements of the pasture and competition between trees and pasture is low for much of the time. They are also well-suited to rotational grazing management systems where livestock have only short duration access to each paddock. Short grazing time minimises the risk that livestock will chew the bark of timber trees.

The advantages of wide-spaced plantings include:

1) Establishment costs are low on a per hectare basis due to the lower seedling density required and the lack of fencing;

2) Establishment and management of each individual stem is enhanced because of easy access; and

3) There is a minimal displacement of agricultural activities and maximum shade for livestock.

The disadvantages include:

1) Intensive pruning intervention is required to maintain tree form and control lower branching;

2) There is a risk of livestock damaging the trunk and bark of trees;

3) The volume of timber produced per hectare is low; and

4) They require careful attention to tree spacing to balance timber production against pasture or crop production (i.e. minimise competition).

There are very few examples of wide-spaced plantings in the Northern Inland of NSW. Their absence from the higher rainfall zones is surprising given the potential for timber production from wide-spaced trees to be complementary to pasture production in these environments. The most common are those plantings that encircle homesteads in extensive cropping districts. However, the principal functions of these are usually aesthetics and shade and shelter for the human occupants rather than any desire to combine timber production with agriculture.

Figure 8: An example of a wide-spaced planting near Armidale which combines timber production from pruned trees with cattle grazing.

7. Target Logs and Stands

To facilitate the planning of a farm forestry enterprise, the grower should consider the type of timber products they might produce and the target log that suits these products. Although it is difficult to anticipate what markets will require in 30 to 40 years time, having a clear product objective will streamline and direct management. Current timber products grown or marketed in northern NSW include the following:

1) Framing timber
2) Flooring and panelling
3) Veneer and plywood
4) Farm fencing timber
5) Structural and engineering timber
6) Furniture timber
7) Outdoor furniture
8) Pegs and stakes
9) Treated timber
10) Woodchip/pulpwood
11) Firewood
12) Reconstituted wood

Other small niche products might include craft woods (e.g. turning blanks) and specialty furniture timbers.

Each of these products is considered in more detail in Appendix E in terms of description, log specifications, species preferences and market outlook.

Generally, logs suiting veneer (if you are within economic haulage distance to a veneer mill), flooring, panelling and furniture are likely to realise the highest value provided they meet individual market requirements such as species, size and defect level. Extensively grown softwood plantations are increasingly supplying framing timber and the market is keenly competitive. However, many of the smaller local mills throughout the region still supply this market. Structural/engineering timber may be a market suitable for farm-grown ironbarks and other high strength or durable species. However, timber density and strength from open-grown or fast-grown trees may be lower than that obtained from trees currently harvested from native forest. There are currently no real markets available in our region for pulpwood or chips for reconstituted wood but this may change with an expansion of softwood plantations around Walcha. Currently, the returns from firewood largely reflect harvesting, processing and transport costs with very little, if any, return to the grower. This also might change in the future as 'old wood' from rung-bark woodlands on the tablelands and slopes declines and harvest sustainability issues are faced.

Growers should be aware that any trees or stands of trees they grow might be able to be broken down into a number of product classes. These product groups will achieve different prices and may have different markets. For example, a single tree may yield a section of high value veneer log, another section of sawlog, a section of pulpwood or firewood and a percentage as waste.

Figure 9: Flooring, structural timber and outdoor furniture from timber grown in the region.

Table 2: Indicative relative stumpage returns for different log classes.

Timber class	Stumpage price per m^3
Veneer Logs	$ 100
High Quality Sawlogs *	$ 40
Low Quality Sawlogs #	$ 15
Firewood	$ 5

*** These might be the largest, straightest logs with lowest defect levels that fall outside of the veneer log specifications, with the resulting sawn timber suiting a variety of relatively high value markets.**

 # These might be smaller or curved or defective logs with lower sawn wood recovery or producing lower value products (e.g. pallet timber).

The aim for the farm forester with a small volume of logs should be to maximise the production of high value products and minimise the volume of low value ones. Price differentials between different quality logs can be quite large. Table 2 lists the relative log prices currently achievable by some coastal producers to existing processors for different product logs (S. Andrews pers obs, but dependent on harvest size, species, distance of the forest to the processor and site accessibility).

Farm foresters can get a guide to likely log specifications for various markets by visiting processors and gaining a feel for their markets and their production costs (i.e. what features or defects in logs discount the price most during processing). Processors are certainly able to give you timber species preferences and define the dimensions of the logs they want and at what minimum volume they are likely to do business. A recent visit (April 2003) to the veneer mill at Big River Timbers Grafton, for example, revealed that knot-free logs are highly prized for the high proportion of clean (face) sheets of veneer that can be peeled from them. At the time, such logs were in short supply, premium prices were negotiable and single truckloads of logs (around 30m^3) would have been considered a tradable volume. Larger processors rarely deal in such low volumes.

Examples of current log specifications for various products can be found in Appendix E. Growers should be aware that many published minimum log specifications to suit particular markets may describe logs far smaller and more defective than what processors actually prefer. Small growers, therefore, are unlikely to gain access to markets if the log consignment consists of a large proportion of the 'minimum' spec logs. Growers who target logs to exactly what the customer wants, rather than the minimum they might accept, are likely to be more successful.

Generally, farm foresters will have greatest marketing flexibility when targeting the production of the highest quality log specification. A veneer log can certainly be utilised for sawing, pulp or firewood but the reverse cannot be said for a pulp log. High quality stands and logs have the following characteristics:

1) ***Logs of large diameter*** – all other features being equal, the wider the log , the greater the recovery of sawn products. Also, the lower the concern with growth stresses, the higher the proportion of high value grade timber and the larger the dimensions possible for sawn boards (Reid & Stephen, 2001). Currently, trees over 50cm diameter breast height (DBH) are likely to produce logs attractive to a large array of markets.

2) ***Log length*** – longer logs provide for larger volumes, and consequently, lower handling costs per tree and lower fixed costs in milling and drying. In current markets, log lengths are often preferred in multiples of 2.4m with a 100mm allowance for error. 6.1 and 4.9m are the commonly preferred lengths but always check with the buyer for their requirements.

3) ***Straightness and taper*** – straight cylindrical trees have much lower processing wastage than curved or strongly tapering logs and less problems with compression and tension wood and off-centre piths. Veneer logs have specifications for 'roundness' and logs that are ovoid in cross-section or fluted may not conform to this market.

4) ***Knot-free*** – knots (from branch stubs) can produce holes in sawn boards lowering their strength and marketability. They can also allow entry for rot and decay. Some markets may take advantage of knottiness as a timber feature (e.g. cypress pine), but clearwood is generally preferred in most markets.

5) ***Tree age*** – young trees irrespective of size, often have lower timber density and other timber quality concerns. For example, in fast grown smaller diameter eucalypt logs, growth stresses may cause difficulty in processing (such as end splitting, bow and spring, see Appendix F). Early growth in pine (juvenile wood) is of low strength and difficult to dry, resulting in many millers preferring trees older than 25 years (Reid and Stephen, 2001).

6) ***Defects*** – logs free of defects are the most valuable. A variety of defects such as growth stresses, brittle heart, kino veins, discoloration and decay, shakes and collapse and checking can affect the marketability of logs. See Appendix F for more details on potential defects.

7) ***Species*** - processors prefer well-known species with consistent wood quality characteristics and marketability. For example, a recent survey of sawmillers of the New England found that Sydney Blue Gum *Eucalyptus saligna* represented only a small proportion of the logs processed but was one of the most preferred plantation species (CARE 1999). Figure 10 shows the species processed and preferred by sawmillers as reported in the survey.

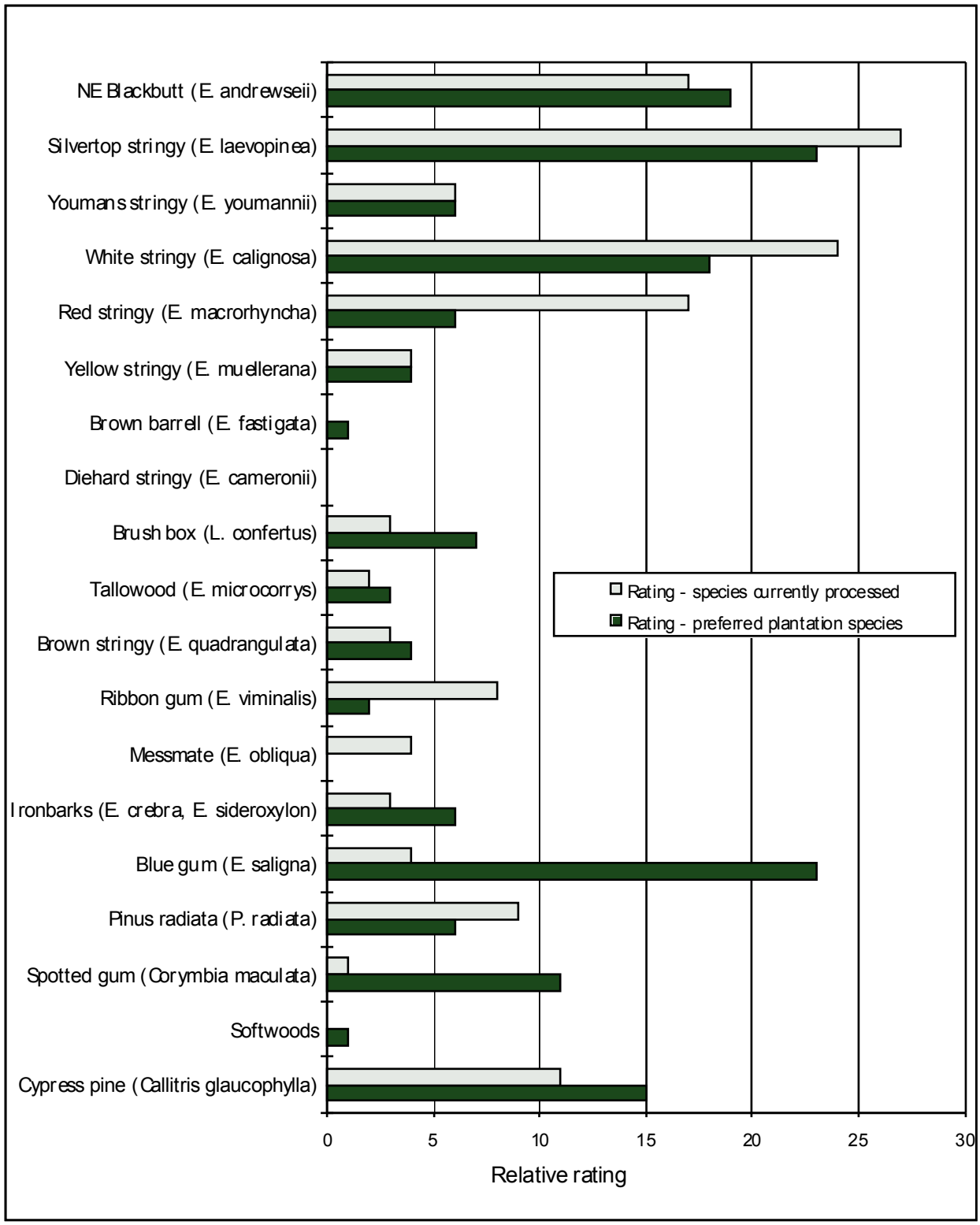


Figure 10: Timber Species Processed and Preferred-New England Sawmills (reproduced from CARE, 1999). The bars on the chart represent relative ratings for each species by the sawmillers surveyed. The light coloured bars represent the relative throughput by species currently processed. From the graph, the Stringybarks currently make up the bulk of the species processed by New England sawmillers. The dark coloured bars indicate what the sawmillers would prefer to process if species are to be grown in plantations. From the graph, sawmillers have a high preference for Stringybarks but would like much more Blue Gum, Brush Box, Ironbark and Spotted Gum than they currently process.

8. Species Selection

Correct species selection for farm forestry is critical. Unfortunately, up until recently the information available on species selection for farm forestry for the Northern Inland region has been based on 'best guesses' (see Appendix Q). Tree selection advice has largely been derived from information collected elsewhere in Australia or by attempting to translate species performances in native forests to farm planted forests. Typically, long lists of potentially suitable species have been provided, but in reality, a very limited number of species have any real potential at this stage of knowledge. For example, a variety of references and field notes suggest that the stringybarks (e.g. *Eucalyptus laevopinea, calignosa, macrorhyncha*) as a group have planted forest potential, presumably because they form the basis of the native forest harvest on the tablelands and slopes. In most recent trials and demonstration plantings however, except for a very few on ideal sites (see Appendices B,H,I) the stringy barks have performed very poorly in terms of survivorship and growth rate both on sites on the Northern Tablelands and Northwest Slopes and Plains.

Species with commercial potential for planted farm forestry should have the following characteristics:

1) Adapted to grow vigorously under the climatic and biophysical conditions of the desired site, especially with tolerances to environmental extremes which challenge survival in our region such as frost, long periods of moisture deficit and flooding in some areas;

2) Able to provide the desired outcomes of the planting including the multiple benefits to the landscape and adjacent agricultural enterprises;

3) Produces the desired log efficiently (trees grow at acceptable rates and with good form);

4) Produces commercially acceptable wood products (i.e. timber is known, desired and accepted by the market place);

5) The available genetic material is highly suitable for farm forestry and/or the species is subject to tree improvement and development at regional and national levels; and

6) Preferably have a track record in the region in terms of timber production from planting through to final harvest and marketing.

Recent demonstration, species and provenance trials (see box), establishment surveys and market surveys conducted by various organisations over the last 10 years in our region have helped with providing information on the first four points above for the most promising species (Andrews, 2000; Andrews, 2002; CARE, 1999; Carr, 2004; Royal, 2001). So too has recent wood quality research conducted on these species from other regions (e.g. Washausen, 2003; Washausen *et al,* 1998). Some of these species are also currently subject to tree improvement programs although none of the programs specifically target the Northern Inland of NSW. Unfortunately, only one species, Radiata Pine, has had any sort of track record in terms of timber production from planted trees on farms in our region.

The Wongwibinda eucalypt provenance trial is the only large scale replicated trial of potential farm forestry species on the Northern Tablelands. Ninety six different provenances of 20 different species have been established and monitored as part of the trial. The site is located on the property ' yerra binda', situated near the locality of Wongwibinda between Guyra and Ebor. The property is owned by Chris and Margot Wright. The site is located on top of a basalt slope with a westerly aspect on chocolate soil and the average annual rainfall of the site is just over 900mm. Details of the trial and the results to date can be found in Appendix B and Carr (2004).

The most promising species for the Northern Inland are listed in Table 3. Table 4 lists many species that have potential but have yet to be widely proven. Growers should be cautious in basing plantings on these species without more detailed research on their site requirements or marketability.

Table 3: Tree species with the most potential for planted farm forestry in the Northern Inland of NSW. (Part 1)

Northwest Slopes and Plains					
	Site suitability	**Growth rate**	**Form**	**Market recognition of sawn timber**	**Available genetics and extent of tree improvement**
A. Most suitable species		*Scoring explained below for each category*			
River Red Gum (and its hybrid) ***E. camaldulesis, E. camaldulensis x grandis***	XXX	XXX	XX	XX	XXb
Mugga Ironbark ***E. sideroxylon***	XXX (flooding intolerant)	XX	XX	XX	XXb
B. Likely to be suitable with further investigation or development or for specific sites					
River She-oak ***Casuarina cunninghamiana***	XXX	XX	XXX	X	XX
Chinchilla White Gum ***E. argophloia***	XX?	XX	XX	X	XXb
Spotted Gum ***Corymbia maculata/ variegata***	X	XX	XXX	XXX	XXb

Site suitability: XXX=Grown to maturity in a wide range of sites in the region, XX= Grows in a variety of sites but sensitive to some environmental extremes, XX?= As for previous but only known from recent plantings (<10 years), X=Suitable for selected sites only.

Growth rate: XXX=High – in excess of 1.5m average height growth per year in well managed stands, XX=Moderate – between 0.7 and 1.5m average height growth per year in well managed stands.

Form: XXX= Most stems in an average stand have good form, XX = Some stems in an average stand have good form, X= Only a few stems in an average stand have good form.

Market recognition of sawn timber: XXX= Highly marketable species well recognised in many regional and national markets, XX= Well known locally from native forest harvests and/or from some markets nationally, X= A minor species in most markets to date.

Available genetics and extent of tree improvement: XXX= Subject to extensive tree selection and breeding with proven genetic material available for the region, XX= Good genetic material (seeds) available from natural selections, XXb= As for previous and subject to selection and breeding elsewhere in southern Australia with similar environments to the region, X= Requires selection and breeding for the region.

Table 3: Tree species with the most potential for planted farm forestry in the Northern Inland of NSW. (Part 2)

Northern Tablelands					
	Site suitability	**Growth rate**	**Form**	**Market recognition of sawn timber**	**Available genetics and extent of tree improvement**
A. Most suitable species	*Scoring explained below for each category*				
Radiata Pine ***Pinus radiata***	**XXX**	**XX**	**XXX**	**XXX**	**XXX**
Shining Gum *E. nitens*	**XX?**	**XXX**	**XXX**	**XX**	**XXb**
B. Likely to be suitable with further investigation or development or for specific sites					
Brown Barrel ***E. fastigata***	**XX?**	**XX**	**XXX**	**XX**	**XX**
Forest White Gum ***E. nobilis***	**XX?**	**XX**	**XX**	**XX**	**XX**
Manna Gum ***E. viminalis***	**XXX**	**XX**	**X**	**XX**	**X**
Sydney Blue Gum ***E. saligna***	**X**	**XX**	**XXX**	**XXX**	**XX**

Site suitability: XXX=Grown to maturity in a wide range of sites in the region, XX= Grows in a variety of sites but sensitive to some environmental extremes, XX?= As for previous but only known from recent plantings (<10 years), X=Suitable for selected sites only.

Growth rate: XXX=High – in excess of 1.5m average height growth per year in well managed stands, XX=Moderate – between 0.7 and 1.5m average height growth per year in well managed stands.

Form: XXX= Most stems in an average stand have good form, XX = Some stems in an average stand have good form, X= Only a few stems in an average stand have good form.

Market recognition of sawn timber: XXX= Highly marketable species well recognised in many regional and national markets, XX= Well known locally from native forest harvests and/or from some markets nationally, X= A minor species in most markets to date.

Available genetics and extent of tree improvement: XXX= Subject to extensive tree selection and breeding with proven genetic material available for the region, XX= Good genetic material (seeds) available from natural selections, XXb= As for previous and subject to selection and breeding elsewhere in southern Australia with similar environments to the region, X= Requires selection and breeding for the region.

Table 4: Unproven tree species likely to have potential for planted farm forestry in the Northern Inland of NSW.

North West Slopes and Plains	
Western Grey Box *E. microcarpa*	Good performance in recent trials, flood tolerant, timber poorly known (see Appendices A & H).
Silver-leaved Ironbark *E. melanophloia*	Good performance in some trials, intolerant of poor drainage and flooding (see Appendix H).
Eurabbie *E. bicostata*	Spectacular growth rate where groundwater is accessible. The most drought tolerant of the southern blue gums but sensitive to moisture stress compared to most of the other listed species.
Swamp yate *E. occidentalis*	Under selection nationally for low rainfall environments. Recently established in Greening Australia trials (see Appendix I).
Hickory Wattle *Acacia implexa* Myall *A. pendula* Cooba *A. salicina* River Cooba *A. stenophylla*	Potential craftwood species that grow on a variety of sites but to date with poor form. Hickory wattle has performed best in a recent trial at Tamworth but is sensitive to frost.
Northern Tablelands	
River She-oak *Casuarina cunninghamiana*	See notes in following section - low growing on the tablelands but has good form and interesting timber.
Eurabbie and Tasmanian Blue Gum *E. bicostata and E. globulus*	Performed well in Wongwibinda provenance trial. Susceptible to insect attack. Only moderate wood quality (see Appendix B).
Blackwood *A. melanoxylon*	Specialty cabinet timber, widely grown but somewhat frost sensitive. Needs special management or intensive pruning to grow straight.
Mountain White Gum *E. dalrympleana*	Widely planted in environmental plantings - very frost and cold tolerant. Performed well at Wongwibinda, but requires considerable pruning to control poor form.
Messmate Stringybark *E. obliqua*	Performed well at Wongwibinda. Timber known in the market place. Yet to be widely planted.
Silvertop Stringybark *E. laevopinea*	Highly marketable and well known timber. Good growth rates and good form possible but only when planted in well-drained, hilltop or ridge situations. Very poor performance elsewhere.
White-topped Box *E. quadrangulata*	A species of the eastern fall. Performed well at Wongwibinda, yet to be trialled elsewhere on the tablelands.

River Red Gum *Eucalyptus camaldulensis*

Distributed along rivers and flood plains throughout inland Australia including much of the local region. Also one of the most common tree species planted on farms throughout the North West Slopes and Plains.

Adaptability: Grown on a wide variety of sites throughout the region. Establishes easily and vigorously even on poorly prepared sites. Tolerant of drought, flooding and most frosts. Reported in some literature to perform poorly on deep sands and poor soils, but in recent Greening Australia demonstration plantings, the species established well on such sites and outgrew all other species to date [Appendix I & Andrews (2002)].

Multiple uses: A local native species suitable for biodiversity conservation, although the genetics used for farm forestry are likely to pollute local gene pools (see Glossary). Sheds lower branches and requires shrub rows in windbreaks for effectiveness. Deep rooted and effective at utilising accessible and even saline ground water (especially salt-tolerant provenances such as "Lake Hindmarsh"). An ideal species for effluent irrigated plantations.

Growth and form: The fastest growing tree species recorded for the Northwest Slopes and Plains in most Greening Australia species trials, demonstration plantings and during a survey of farm grown trees (Andrews, 2000). River Reds and their hybrids have also outgrown most other species in recent State Forests salinity species trials (Royal, 2001 and Dobson pers.com.). Has a tendency to spread its crown if open grown with heavy low branching and only a proportion of stems in most stands grow straight (average of 36% of trees surveyed by Andrews, 2000). Needs to be established at suitable high densities to allow relatively heavy culling of poorly formed trees and the retained stems will require pruning.

Wood quality and marketability: Produces a heavy hard red timber with most examples derived from native forest harvests. Used for a wide variety of products from sleepers and heavy construction to flooring and furniture (Boland, *et al.* 1984 and Kater, 2002), also known to produce good firewood. Farm grown trees have yet to be harvested and processed in the region.

Available genetic material and tree improvement: Several provenances have been trialled in various plantings in the region with the 'Lake Albacutya' provenance performing the best in terms of height growth and form (Andrews, 2000). The Australian Low Rainfall Tree Improvement Group (ALRTIG) suggests that the 'Laura' provenance is also a good performer (ALRTIG, 2002) and that northern Australian provenances should be avoided. The recent poor performance of 'Mareeba' provenanced River Red Gums at a Greening Australia trial planting at Lower Quipolly confirms this. Yates have also recently developed hybrids of *E. camaldulensis* with *E. grandis* (for sawlogs) and *E. globulus* (for pulp). The E. *camaldulensis x grandis* hybrid (Saltgrow ™) is currently under investigation in State Forests salinity trials in the Liverpool Plains and in a number of Greening Australia trials and demonstration plantings at Tamworth, Breeza and Gravesend. Early growth rates are similar to, or slightly better than, *E. camaldulensis* but the hybrid generally exhibits better form. However, Kater (pers.comm.) reports that the hybrid performed poorly (low drought tolerance) in 2002 established trials in the Upper Hunter. River Red Gum has been identified by the ALRTIG as a species worthy of tree improvement for low rainfall zones nationally. Currently, genetically improved seeds are available from the Forest Products Commission (WA) clonal seed orchard and a CSIRO seedling seed orchard in southern NSW. The clonal seed from Western Australia was recently (Autumn 2003) used by Greening Australia to establish River Reds in several trial plantings at Bingara, Gravesend and at Lake Keepit.

Track record: Although planted in many areas of southern Australia by several generations of farmers, farm planted and grown timber from *E. camaldulensis* has yet to be marketed to any degree other than for firewood.

Five year old River Red Gum in a trial planting at the NSW Agriculture Tamworth Agricultural Institute.

Four year old River Red Gum being bole pruned at a demonstration planting at Gunnedah.

Figure 11: Red River Gum.

Mugga Ironbark *Eucalyptus sideroxylon*

A relatively common and widespread species of inland eastern Australia. A frequently planted farm tree of the Northwest Slopes and Plains.

Adaptability: Copes with shallow and poor soils but performs best on good agricultural soils (Andrews, 2000). Tolerates frost and drought but is intolerant of poor drainage and flooding. Suggested as being complementary in its site suitability to River Red Gum (ALRTIG, 2002) such that Mugga can be grown on harder country away from flood plains. In practice there is a wide range of overlap between the two species. Most non-flooding farms of the region could support mixed plantings of both.

Multiple uses: A local native species suitable for biodiversity conservation, although the genetics used for farm forestry may pollute local gene pools. Known as a nectar and pollen species. Considered an important feed tree for the endangered Regent Honey Eater.

Growth and form: Slower growth rate than *E. camaldulensis,* particularly as a seedling, but among the faster growing species recorded during a survey of farm planted trees (Andrews, 2000), especially on good soils. Highly variable in form, with an average of 25% of stems with acceptable form (varied from 4% to 75% in individual plantings surveyed by Andrews, 2000). Frequently subject to 'butt sweep' (Figure 12) especially where trees have been guarded with poorly installed milk cartons.

Wood quality and marketability: Currently harvested in the region from native forests, used for sleepers and heavy construction timbers (Boland *et al,* 1984). Ironbarks (including Mugga) from the Pilliga forests are the principal species used to produce Insultimber™ fencing products. Logs from native forests produce hard, red, dense and durable timber. Farm grown trees are likely to reach a marketable size at earlier ages, consequently with a larger proportion of sapwood and probably lower density timber. This may well make the timber more versatile. Local sawmillers would prefer more ironbarks than they are currently accessing for processing (CARE, 1999 - see Figure 10).

Available genetic material and tree improvement: Mugga Ironbark and the closely related Red Ironbark *E. tricarpa* have been identified by the ALRTIG as species worthy of tree improvement for low rainfall zones nationally (ALRTIG, 2002). To date, no particular superior provenances have been identified, and plantings have been established from unselected seed collections from various localities. "Anglesea" is known as a poor provenance. A CSIRO established seed stand in southern NSW is expected to produce seed in the near future, but there is a need to establish seed orchards in the Northern Inland of NSW.

Track record: Although extensively planted on farms in many areas of the Northern Inland, farm grown timber from *E. sideroxylon* has yet to be marketed to any degree. This is likely to be the case for most farming areas of southern Australia.

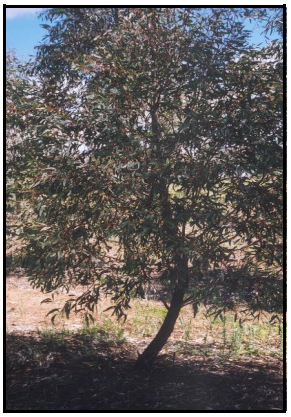


Figure 12: A young Mugga Ironbark exhibiting significant butt sweep.

Figure 13: Five year old Mugga Ironbark at Gunnedah.

River She-oak *Casuarina cunninghamiana*

Occurs naturally along streamsides from southern NSW to northern Australia and has been widely planted on a variety of sites on farms throughout the Northern Inland. It typically has relatively good form (57% of stems surveyed - Andrews, 2000) and its growth rates are comparable to most eucalypts of the region except River Red Gum. Like other casuarinas, it has wide dark medullary rays that add an interesting feature to the moderately dense reddish wood (Boland, *et al.* 1984). The acceptable growth rates on a wide variety of sites, interesting timber and especially the good form of the species, make it a likely farm forestry candidate for the Northwest Slopes and Plains. The timber from the species has not been marketed to any large degree. The timber is difficult to season as it is prone to collapse. After drying, it must be reconditioned or planed.

Chinchilla White Gum *Eucalyptus argophloia*

Occurs naturally only over a small range in southern inland Queensland. Has recently (since the late 1990's) been widely planted in demonstration and trial plantings throughout the North West Slopes and Plains. Early growth rates are slow but once established grows at similar rates to Mugga Ironbark [Early growth rates of between 0.4 to 1.4m in height /year have been recorded in recent Greening Australia demonstration trials for trees 2 to 4 years old (Ward & Andrews, 2003 , Appendix I]. It has proven to withstand drought and frost as a young tree on many soil types - especially heavy clays - but is unlikely to cope with extended flooding. In nature it has excellent form compared with most inland eucalypts, hence the interest in trialling the species as a farm timber tree on low rainfall areas. Like most inland eucalypts, the timber is reported to be heavy and red in colour. It has yet to be marketed to any degree. Seed should only be purchased from the Australian Tree Seed Centre as there are a number of poor seedlots available.

Figure 14: River Oak in a trial at the Tamworth Agricultural Institute .

Figure 15: Chinchilla White Gum at 3 years of age at Lower Quipolly.

Spotted Gum *Corymbia maculata/variegata*

Naturally occurs mostly east of the ranges from southern NSW to central Queensland, extending more inland in the north. Once recommended as being very suitable as a farm forestry tree for the Northwest Slopes and Plains due to its drought tolerance (compared to other coastal species), good growth rates, acceptable form and well recognised versatile timber. Planted in a wide variety of locations on North West farms. However, large losses and damage to young plants due to frost was recorded during the drought year of 2002, causing a reassessment of its suitability for the region (Ward and Andrews, 2003, Appendix I). Even well-established saplings up to age 5 years suffered significant damage or death. Selection and breeding for frost tolerance is warranted or otherwise the species should only be planted in protected or upper slope locations free of heavy frosts. The brown timber has been marketed extensively in eastern Australia for a variety of products ranging from tool handles, general construction timber and poles to veneer and flooring. The species has been selected by the ALRTIG for breeding development for low rainfall zones and a seedling seed orchard has been established in southern NSW (ALRTIG, 2002). CSIRO trials have found the "Guyra" provenance from the upper Henry River area to be the most frost tolerant.

Figure 16: Young spotted gum at Tamworth.

Radiata Pine *Pinus radiata*

An exotic species, the most extensively established plantation timber species of the Northern Tablelands, principally in State Forests plantations but also widespread as farm plantings. Detailed information is available on its establishment and management (see Maclaren,1993).

Adaptability: Grows well on a wide range of sites from sandy soils to chocolate basalt, highly frost tolerant. Establishes and grows poorly on lower slope positions and wet or waterlogged sites (as do all other timber species investigated on the Northern Tablelands to date).

Multiple uses: Excellent as a windbreak tree if branches are maintained down to ground level, likely to utilise soil water at rates similar to any tree species with the same leaf area index. Since it is an exotic species, it is less desirable for biodiversity conservation and often disliked aesthetically.

Growth and form: The fastest growing tree species both in terms of average height (over 1m/yr) and diameter (approximately 2cm/yr) recorded in a recent survey of farm grown trees on the Northern Tablelands (Andrews, 2000). Also has the highest proportion of stems having good form (93%). The survey, however, did not include Shining Gum (see next section). In terms of wood productivity, *Pinus radiata* grown as a block planting should yield between 8 and 20m^3/ha/year depending on the site and silvicultural management (NE-NWFIG, 2002, Appendix C).

Wood quality and marketability: Well known and recognised regionally, nationally and internationally. Utilised for a wide array of products from veneer and furniture down to pulp. The principal species used in house framing in Australia. Good sawing and recovery qualities though somewhat soft, low density and non-durable. Subject to large-scale production and vertically integrated 'big business', making it difficult for small growers to access markets and compete on price. However, ideal for 'joint venture' arrangements with industry in the high rainfall zone, with such opportunities possible in the Walcha area in the near future. To date, very little clearwood production is practiced in the extensive state plantations or on many farm woodlots – higher quality end of the market may be a suitable niche for farm foresters.

Available genetic material and tree improvement: Has undergone the most selection of any timber species in Australia with various superior clonal varieties currently available.

Figure 17: Radiata Pine in a windbreak planting south of Uralla.

Radiata Pine (cont)

Track record: Unmanaged stands established in the 1970's have been unsuccessfully marketed by early growers despite all the favourable timber characteristics and market recognition of the species. Probably a reflection of the low quality logs produced in such stands and the lack of a 'critical mass' of supply (NE-NWFIG, 2002). One of the most committed local growers, Jon Taylor of Kentucky, actively manages for high value products and markets thinnings in the form of treated fencing and landscape logs. He is yet to market final crop trees. Final crop trees have long been harvested from the large state resource, providing logs to mills producing products ranging from pallet timber, landscape supplies, structural timber to plywood (NE-NWFIG, 2002).

Shining Gum *Eucalyptus nitens*

A southern Australian species with a natural distribution in high rainfall environments extending from Tasmania to the higher points of the Barrington Tops and areas east of Ebor. Widely recognised as a pulp species in the southern states but also being grown-on to produce sawlogs in some farm forests. A preferred plantation species in the cold areas of New Zealand and South Africa.

Adaptability: Only recently trialled on farms of the Northern Tablelands, has good frost tolerance, grows well on a variety of sites but prefers deeper and better soil types. Intolerant of poor drainage. Intolerant of extreme frost – a recent farm planting in the lower parts of the Furracabad Valley suffered high losses due to severe frost and waterlogging. Low tolerance to moisture stress, may require careful spacing on shallow soils or lower rainfall areas on the western side of the tablelands. Grown widely on the Dorrigo Plateau and nearby Ebor areas in last 10 years, and several large plantations have been established in the Yarrowitch and Nowendoc areas south and east of Walcha in the last five years.

Multiple uses: Sheds lower branches as it matures, windbreaks may require shrub rows to provide low shelter. Potentially high water use due to rapid growth. A non-local eucalypt species for most areas but likely to provide foliage and bark habitat similar to native species. The species' bluish juvenile leaves are often found to be attractive.

Growth and form: The fastest growing timber tree found to date for the Northern Tablelands and often with good form. Four-year-old trees of almost 10m in height and 15cm in DBH have been recorded from the Wongwibinda and Armidale areas in recent trial and demonstration plantings established by Greening Australia (Appendix B). Some farm-grown trees in southern Victoria have reached 60cm in DBH by age 13 years. Requires good soil preparation, adequate nutrition and effective early weed control for the species to realise its rapid growth potential. Inattention to these factors results in stunted and poorly formed trees.

Figure 18: Three year old Shining Gum near Armidale.

Shining Gum (cont)

Wood quality and marketability: Unknown for the region. Produces light coloured timber of relatively low density for a eucalypt. Usually considered a pulp species and grown widely for this purpose in southern Australia, although some plantation managers pulp early thinnings and retain better trees for sawlogs. Boland, *et al.* (1984) suggest that its uses include general building, flooring, joinery, panelling, furniture as well as pulp. Young plantation trees are likely to have considerable growth stresses and the species is difficult to dry. Recent sawing studies (Washusen, 2003) have shown that when quarter sawn, sawing distortion was well contained and the timber was easier to dry with low levels of drying degrade. He suggests well managed logs, processed appropriately, should supply a high proportion of high quality timber.

Available genetic material and tree improvement: Subject to considerable selection and breeding improvement in Tasmania and seeds from this source are currently available. In a recent eucalypt provenance trial established at Wongwibinda north east of Armidale, the best performing (growth and form) top 7 provenances in the trial of 96 different seed lots were all *E. nitens (Appendix B).* The Tasmanian selected provenance was part of the trial but did not perform significantly differently to other provenances of Shining Gum (was ranked 3rd overall). See Table 5 for best performing provenances.

Track record: Currently no trees have been grown through to harvest age on the Northern Tablelands and few farm grown trees have been harvested for sawlogs elsewhere in the country. However, the species is extensively planted on farms in Victoria, Tasmania and southern Western Australia with expectations of sawlog harvests. Sawn timber products have been produced from native forest logs in the southern states.

Brown Barrel *Eucalyptus fastigata*

A highland species ranging from southern highlands of NSW to the Northern Tablelands – common in the Ebor area. Not yet widely grown on farms but performed well in a recent eucalyptus provenance trial at Wongwibinda on basalt and in demonstration plantings at Tia and Nowendoc (Appendix B). Did not perform as well in a demonstration planting on sedimentary soils east of Armidale (S. Andrews, pers.obs.). Timber is said to be similar to the closely related Mountain Ash *E. regnans*, which is used for a wide variety of purposes, (Boland, *et al.* 1984). The species requires trialling on a variety of sites spread across the tablelands to test its suitability but at this stage would seem a good candidate for high altitude basalt sites. Provenances from other northern parts of its range are more frost tolerant as are high altitude provenances. Brown Barrel with the best growth rates are from low altitude southern provenances.

Figure 19: Above - Mature Brown Barrel near Ebor (photo courtesy of Hugh Harris).

Below - Young Brown Barrel south of Walcha.

Manna, Ribbon or White Gum *Eucalyptus viminalis*

Naturally distributed from Tasmania to the Northern Tablelands of NSW (where it is widely distributed and common). Widely grown in environmental plantings throughout the New England and known to cope in even the toughest conditions of cold and frost on most soil types. Recorded as one of the fastest growing species in a survey of farm plantings in the region. (Andrews, 2000), but in recent trials performed similar to *E. saligna* or about 70% of the growth rates of *E. nitens*. Timber harvested from native forests is currently processed and marketed as flooring by Fennings Timbers Walcha and Gloucester. Despite its reputation as being well adapted to the majority of sites on the Northern Tablelands, and the apparent marketability of the timber, the species often has poor form in farm planting situations. Requires considerable selection and breeding for good form.

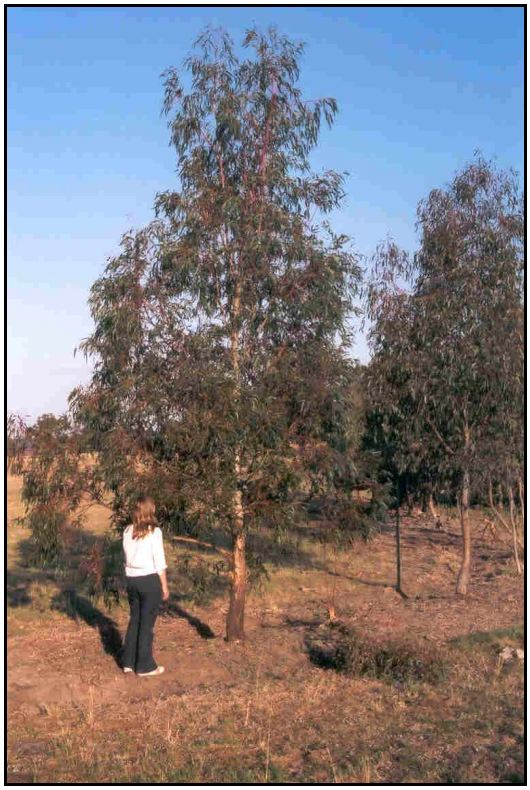


Figure 20: Four year old Ribbon Gum ("Tallaganda provenance") near Armidale.

Sydney Blue Gum *Eucalyptus saligna*

A high rainfall east coast species with a natural distribution that includes high elevation sites on the eastern parts of the Tablelands. Tolerant of moderate frost only and is therefore likely to be restricted to upper slope positions on the Northern Tablelands. Recent (2002 and 2003) autumn plantings north and east of Armidale and east of Guyra have been severely frost damaged. Individual tree growth rate should equal at least *P. radiata* on good sites after seedlings have become established. Averaged approximately 50%-70% of the growth rates of *E. nitens* in recent trials and demonstration plantings on the tablelands but has had mixed results in trials in other parts of the State (Johnson & Stanton, 1993). Has good form but with a tendency for heavy lower branching if open-grown (i.e. requires pruning). A well recognised and even sought after species with the timber harvested and marketed throughout eastern Australia including locally (from native forests). A favoured species for appearance grade products although known to have many faults (such as grub holes and gum veins) in some areas (Kater, 2002). Young logs may give problems with spring, bow and splitting. A common plantation species throughout eastern and southern Australia, although yet to be grown on farms to any degree locally.

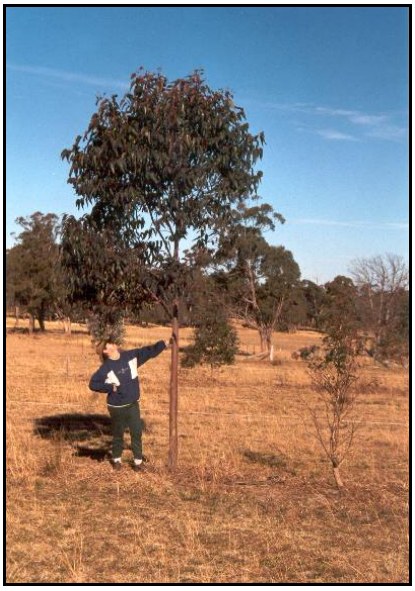


Figure 21: Three year old Sydney Blue Gum near Armidale.

Forest White Gum *Eucalyptus nobilis*

Closely related to *E. viminalis* but naturally occurs in tall forests in areas of higher rainfall, otherwise similar in most respects. Less frost tolerant but usually of better form, may be a better option on more favourable sites. The timber is currently harvested from native forest for the same market as *E. viminalis*.

Recommended Species Mixes

At this stage of understanding, farm forestry plantings in the Northern Inland of NSW should comprise mostly of the best performing provenances of species from the 'A' lists in Table 3 for each sub-region (see the next Section, Table 5 for provenances information). Growing these species should minimise risk, both in terms of long-term suitability of the species to the site and marketability of the timber. Species from the 'B' lists are also suitable for appropriate sites and can be added to plantings of 'A' list species to add diversity and provide wider marketing options. Table 4 list species and others that growers discover during their own research should be considered worthy of trialling, but should not form the basis of large scale plantings at this stage.

Growers should be wary of establishing a large variety of species. Diversity needs to be weighed against economies of scale and critical mass for marketing purposes. A planting that generates 200m^3 of sawlogs of one species, or two 100m^3 lots of two species, may be marketable, especially if processors know the timber. A harvest that generates small 20m^3 lots of each of 10 different species may be much more difficult to market, particularly if some species are unknown to industry.

Accessing seedlings and seeds of the various recommended species and provenances is detailed in the following chapter.

9. The All Important Establishment Stage

Growing trees commercially requires the best growth possible to reduce the time until the trees can be harvested. It is generally considered that the most important time in the trees growth phase is the first two years. Giving them the best conditions then will give them a flying start. A stand full of trees that take 3 or more years to reach a metre in height is unlikely to produce timber profitably. Yet such growth rates are commonplace in environmental plantings on farms throughout the Northern Inland and are apparently acceptable to many growers (Figure 22). A much higher commitment to thorough stand establishment is required to optimise the growth of trees for commercial forestry purposes.

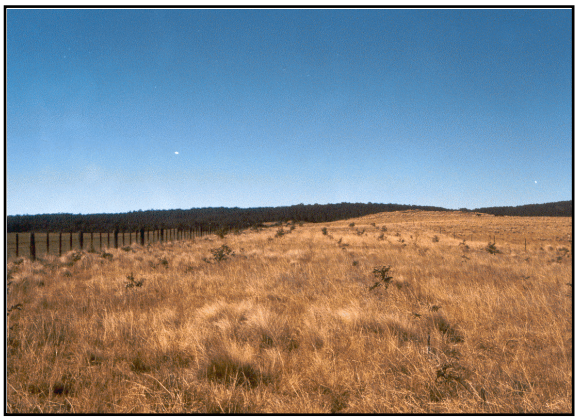


Figure 22: A 2.5 year old planting of Manna Gum near Guyra with a heavy weed burden and poor growth rate. Farm forestry plantings should never look like this.

Effective establishment and the long-term performance of a farm forest are also considerably affected by site selection. Generally, trees grow best on deep, fertile, well-drained soils and poorest on shallow, stony, infertile sites (just like the relationship between soil characteristics and agricultural productivity). Trees grew faster on previously cropped or improved pasture sites compared to native pasture sites according to the survey results of Andrews (2000) - see Figure 23. This result undoubtedly reflects the differences in average site quality of cropping soils compared to the quality of sites that usually support native pasture. Lower slope positions on the Northern Tablelands have long been recognised as poor sites to establish trees. Most of these sites are very frosty and often have poor drainage and are unsuited for farm forestry plantings of any species.

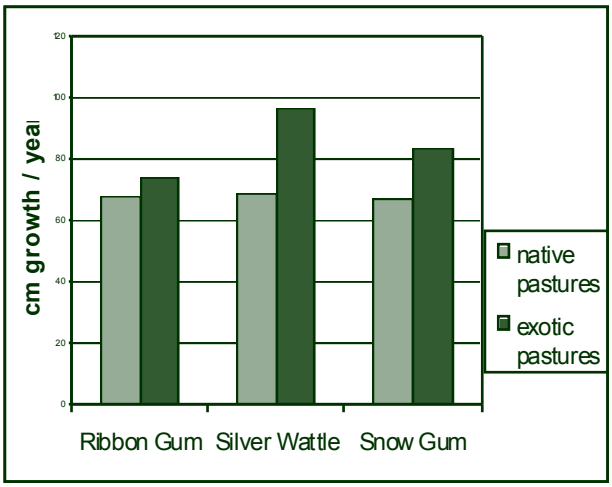


Figure 23: The average growth rates of 3 to 10 year old Ribbon Gum, Silver Wattle and Snow Gum planted on farms of the Northern Tablelands relative to the type of landuse that occupied the site prior to planting (Andrews, 2000).

Once a suitable site has been selected, successful establishment that optimises tree growth can be achieved by having:

1) A planting bed with friable, well-aerated and uncompacted soil;
2) Good moisture availability throughout the soil profile;
3) No competing weeds and low weed seed burdens in the soil at the time of planting;
4) Healthy well grown seedlings available at planting;
5) The planting conducted when there is a low risk of climatic extremes;
6) No significant weed cover within 1m of each seedling **for at least 2 years after planting**;
7) Good levels of soil fertility throughout the establishment phase; and
8) Freedom from herbivores of all kinds but especially hares, wallabies, rabbits and livestock.

There are likely to be an array of practices and machinery suitable for achieving the eight points listed above and each farmer should consider their own situation in this regard and make use of available equipment. However, the following 12-step prescription has given good results throughout the region on most soil types. Details of each step and any likely exceptions or alternatives are discussed in later paragraphs.

Step 1 – Fence the planting site having due regard for the livestock and other herbivores that you wish to exclude.

Step 2 – Graze down or slash the site if there are heavy accumulations of herbage – this step makes other site preparation easier but is optional.

Step 3 – Deep rip the areas destined for planting beds to approximately 500—600 mm in depth. Conduct two or three rips 0.5 to 1m apart under proposed planting beds, either with twin or triple rippers or with multiple passes of a single tyne ripper. Conduct ripping 6 to 12 months prior to planting and when the soil is dry or just moist (never wet) to ensure good soil shatter at depth. Planting beds will be approximately 1 to 1.5m in width for each row of trees.

Step 4 – Commence a fallow over the planting beds either with a knockdown herbicide or by cultivation at least 12 months prior to planting. The commencement of a fallow can precede step 3 by a short time period (<1 month) if desired provided the soil does not become too wet for effective ripping. Maintain the planting beds weed free at all times from fallow commencement right up until the time of planting.

Step 5 – Access suitable seed for the desired species and contract nurseries to grow seedlings (or commence propagation if doing it yourself). This should be done approximately 9 to 12 months in advance of planting but consult with nurseries for their time-frame requirements. (See Appendix J)

Step 6 – Form up the planting beds into mounds. Mounding is highly recommended in wet areas and high rainfall areas (i.e. much of the tablelands). Mounding is optional or undesirable on well-drained sites or on sites where moisture availability may be low during the early establishment phase (hot, dry environments and/or sandy soils or soils of low water-holding capacity).

Figure 24: A linkage mounding plough preparing planting beds near Armidale.

Step 7 -- Cultivate the planting bed and prepare to a good tilth. Consider a vegetable patch - this is the soil surface conditions to aim for. Cultivation dries soil and brings to the surface otherwise buried weed seed, and for these reasons, should be conducted early in the fallow period, if not right at the start. The fallow can then be maintained by herbicide application alone and this practice conserves most of the rainfall that infiltrates the soil.

Step 8 – Apply a residual herbicide such as simazine, Goal®, Forest MixWDH ® and EUCMIX-preplant WDH® about 1 month prior to planting. (consult the product label for rates, application technique and safety considerations).This step should only be contemplated if the soil surface is well prepared, bare of litter and dead herbage and preferably moist. Herbicides such as these are wasted if applied to cloddy or rough surfaces or sprayed onto accumulated dead plant material.

Note that only Forest Mix® (Pines) and EUCMIX pre-plant WDH® (Eucalypts) are registered for use in the establishment of forestry plantings. An off-label permit is required to use simazine or Goal® (and other pre-emergent or residual chemicals) for this purpose. If applied correctly, this step should maintain planting beds weed free for 3 to 9 months after planting.

Step 9 – Plant seedlings. If simazine has been applied wait until 25 - 30mm or more of rainfall has fallen on the planting beds before planting. Install tree guards if required (protecting from rabbits or hares) and water seedlings in. For best results plant native species in early spring on the slopes and plains and mid to late spring on the tablelands. If possible, avoid drought years for tree establishment. *Pinus radiata* should be planted in winter.

Figure 25: A small 1.2m rotary hoe is ideal for planting bed preparation (after ripping). This one has prepared a large-scale planting west of Tamworth.

(A) *(B)*

Figure 26: Tree planting using a planting tube (Photo : Hugh Harris).
Examples of planting tools - (A) planting tube and (B) planting spade.

Step 10 – Keep the area (1m radius) around tree seedlings **weed free for at least two growing seasons** or until such time as the canopy of the tree shades weeds out from this area (see Figure 27). This step is the one most often left out by tree growers in our region, yet it is probably **the most important step** to optimise the growth of farm planted trees. Appropriate knock down and residual herbicides can be applied as shielded sprays (no contact with foliage of the tree seedling) after planting, before or whenever weeds germinate. Grass specific herbicides such as Fusilade® can be applied as an overspray, but always consult the product label.

Step 11 - Fertilise the young trees about a month after planting. (If planted in autumn or winter wait until early spring for this step). Use a multi-nutrient horticultural blend, a 'starter', or a nitrogen phosphorus fertiliser such as DAP to give the trees a good start (100 - 150g per seedling applied 200 to 300mm from the base of the seedling to avoid burning). Chicken manure or commercially available composted pellets such as Dynamic Lifter is also suitable (200 - 300g per seedling applied 200 to 300mm from the base of the seedling to avoid burning). A pinch of slow release fertiliser at planting is inadequate for rapidly growing farm forestry species and probably a waste of effort.

Do not bother with Step 11 if Step 10 has not been completed effectively, you will only fertilise the weeds.

Step 12 – Maintain the fences, monitor for pests and diseases and **KEEP UP WITH STEP 10**.

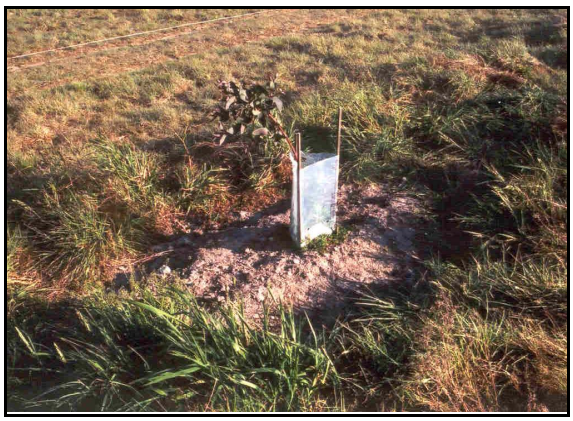


Figure 27: Tree seedling with 1m weed free zone.

Growers who adhere to the 12 step process listed above are likely to achieve excellent survival rates and the optimal growth rate possible for the species under the prevailing site conditions. However, all steps may not be appropriate for all sites - exceptions and alternatives are discussed below.

Ripping: Deep ripping may not achieve a great deal on heavy cracking clays since these soils swell, contract and self-mulch. Grower experience with heavy clays, however, is that seedlings establish well and planting is much easier if these soils are deep tilled and worked up several times at the start or during the fallow period. Deep ripping should be conducted with caution on very erodable soils, especially the granite soils of the tablelands. It should be conducted along the contour or otherwise for short runs (<20m) down slope and cross-ripped on such soils. There are several examples on the tablelands where new gullies have been started as a result of ripping prior to tree planting.

Long fallows: In a 1998/99 survey of farm grown trees in the Northwest, the growth rate of many tree species was positively associated with the length of time the planting site was fallowed prior to planting (see Figure 28, Andrews 2000). Long fallows conserve soil moisture (especially important on the slopes and plains) and reduce the weed seed burden. A 12 month fallow, particularly using herbicides after the planting beds have been prepared, kills germinating weeds both summer active and winter active. Fallows shorter in duration miss either or both of these weed groups. Reducing seed burdens of both summer and winter active weeds assists with post-planting weed control. Long fallows for moisture conservation are less important on soils with low water-holding capacity (e.g. some of the sandy ridges of the Liverpool Plains and the lighter red soils of 'cypress' country). On these sites, planting beds should be prepared and planted in response to good moisture conditions. If the fallow happens to be short, post-planting weed control will need to be thorough.

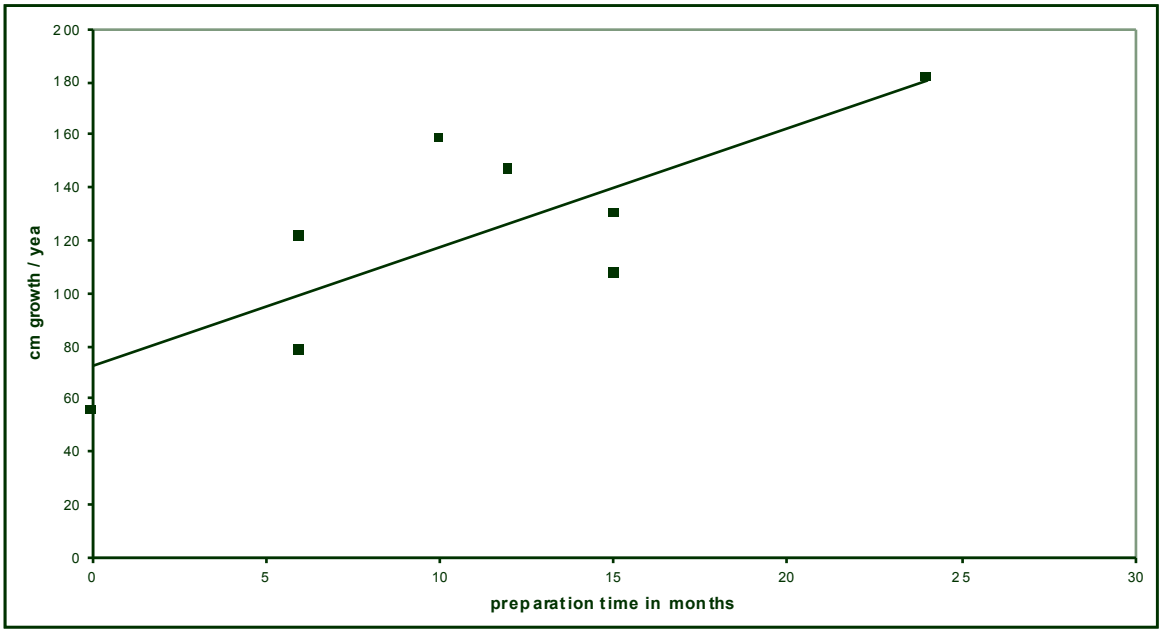


Figure 28: The relationship between average growth rate of 3 to 10 year old spring planted River Red Gums planted on farms of the North West Slopes & Plains and the length of fallow prior to planting (from Andrews, 2000).

Accessing seedlings and seed: Growers should take responsibility for the genetics of their tree crop since genetics have a large bearing on growth rates and more importantly tree form (i.e. significant impact on returns and costs). Sources of improved or selected seed, or known superior provenance seed or seedling stocks for each of the most promising species for the Northern Inland are listed in Table 5.

Table 5: Suggested provenances or cultivators and current sources of seed of the most promising farm forestry species for the Northern Inland of New South Wales.

Species	Suggested provenances or cultivators	Source
River Red Gum *Eucalytus camaldulensis*	"Lake Albacutya" "Laura" WA clonal seed orchard stock—two selections one for salinity tolerance, the other for growth and form (the latter recently planted in trials, yet to be proven in Northern Inland)	Australian Tree Seed Centre (ATSC), CSIRO Forestry and Forest Products Phone: (02) 62818211, email: atsc@ffp.csiro.au. WA Forest Products Commission. Seed Technologies Section Phone: (08) 9334 0302 email: seedcentre@fpc.wa.gov.au.
Saltgrow ™ hybrid *E. camaldulensis x grandis*	Available as seedlings only	Yates Botanicals, Saltgrow Pty Ltd Phone: (02) 9763 9200 email: saltgrow@yates.com.au.
Mugga Ironbark *E. sideroxylon*	None identified	Local seed collectors (see Appendix J) or collect your own from several trees of best form from several locations (refer to Doran 1991, Appendix K).
River She-oak *Casuarina cunninghamiana*	None identified	Local seed collectors (see Appendix J) or collect your own from several trees of best form from several locations (refer to Doran 1991, Appendix K).
Chinchilla White Gum *E. argophloia*	Chinchilla	ATSC.
Spotted Gum *Corymbia maculata/variegata*	Inland provenances	ATSC.
Western Grey Box *E. microcarpa*	None identified	Local seed collectors (see Appendix J) or collect your own from several trees of best form from several locations (refer to Doran 1991, Appendix K).
Silver-leaved Ironbark *E. melanophloia*	None identified	Local seed collectors (see Appendix J) or collect your own from several trees of best form from several locations (refer to Doran 1991, Appendix K).
Eurabbie *E. bicostata*	"Winterbourne" - both for tablelands and slopes and plains	Local seed collectors (see Appendix J) or collect your own from several trees of best form from several locations (refer to Doran 1991, Appendix K).
Swamp Yate *E. occidentalis*	"Katanning" - recently planted in trials yet to be proven. Good performers elsewhere in southern Australia = "Grass Patch", "Bundeleer", and "Red Hill". "Esperence" is poor.	ATSC.

Table 5: Suggested provenances or cultivators and current sources of seed of the most promising farm forestry species for the Northern Inland of New South Wales. (cont.)

Species	Suggested provenances or cultivators	Source
Myall *Acacia pendula* Cooba *A. salicina* River Cooba *A. stenophylla*	None identified	Local seed collectors (see Appendix J) or collect your own from several trees of best form from several locations (refer to Doran 1991, Appendix K).
Radiata Pine *Pinus radiata*	GF 19 - Seedlings only	State Forests Tumut Nursery Phone: (02) 6947 4803.
Shining Gum *Eucalyptus nitens*	"Mt Erica", "Captains Flat" "Barren Mt" and "Mt Toorongo" have all formed well at Wongwibinda as did "Hastings" - Tasmanian clonal seed orchard stock.	ATSC. Tasmanian Seed Centre Phone: (03) 6233 8165 email: neil.mccormick@forestry.tas.com.au
Sydney Blue Gum *E. saligna*	High altitude provenances. "Styx River" provenance was the best performer at Wongwibinda (Appendix B).	ATSC and local seed collectors.
Brown Barrel *E. fastigata*	"Victorian border-granite", and "Brindabella R." provenances performed well at Wongwibinda (Appendix B) but use local provenances if in doubt about cold.	ATSC.
Manna Gum *E. viminalis*	"Sth Tallaganda SF" provenance performed well above other provenances at Wongwibinda (Appendix B).	ATSC.
Forest White Gum *E. nobilis*	"Ebor" and "Styx R." provenances performed well at Wongwibinda (Appendix B).	ATSC and local seed collectors.
Tasmanian Blue Gum *E. globulus*	All provenances were OK at Wongwibinda.	ATSC and commercial seed merchants.
Blackwood *Acacia melanoxylon*	Yet to be identified, local provenances have poor form and small stature, provenances from TAS and VIC that have good form in nature have been trialled with good success at Dorrigo (Sandstrom, pers. comm; Carr, 2004). These include Timvalle, Cascade and Otway.	

Commercial nurseries rarely have large stock of the right seedlings sitting on shelves available at a moments notice. Growers must plan ahead, source the correct seed and provide nurseries with sufficient time to propagate and grow stock ready for planting. Contact details for the commercial nurseries and seed collectors that occur in the region can be found in Appendix J.

Cultivating planting beds: This can only be achieved on arable sites and provides two advantages:

1) Aerates and loosens the soil well to facilitate hand-planting, guarding and the early root growth of seedlings; and

2) Provides a well-tilled bare soil surface for the use of residual herbicides.

Cultivation should be avoided on hard setting soils and very stony sites such as some of the chocolate soils on the tablelands. Some growers suggest it is unnecessary on sites with a low weed status (e.g. native pasture of warm season perennial grasses) and that ripping is sufficient soil disturbance with further cultivation only allowing opportunity for weed invasion (John Lemon, pers.comm. Gunnedah Research Station, Department of Infrastructure Planning and Natural Resources). Landholders should consider their own situations and try different methods. Omitting the construction of a well-tilled planting bed may restrict the use of residual herbicides, which means that post-planting weed control may require an increased use of shielded knockdown sprays.

Ground preparation trials at Tamworth showed a slight but significant improvement in seedling performance where planting beds were ripped-mounded and cultivated as compared to ripping alone (Figure 29). Virtually any conventional ploughing machinery is suitable but narrow chisel ploughs, twin disc mounding ploughs (see Figure 24) and rotary hoes (Figure 25) usually work best, as cultivation is restricted to the planting beds rather than the whole area.

Weed control: Weed control is the singularly most important part of successful farm forestry tree establishment. Poor weed control will result in lower survival and slower growth of trees. While this may be acceptable for some other farm plantings, it can make farm forestry ventures commercially unviable. If you want healthy trees growing quickly, you must undertake good weed control. (Weeds being any plant other than the crop tree).

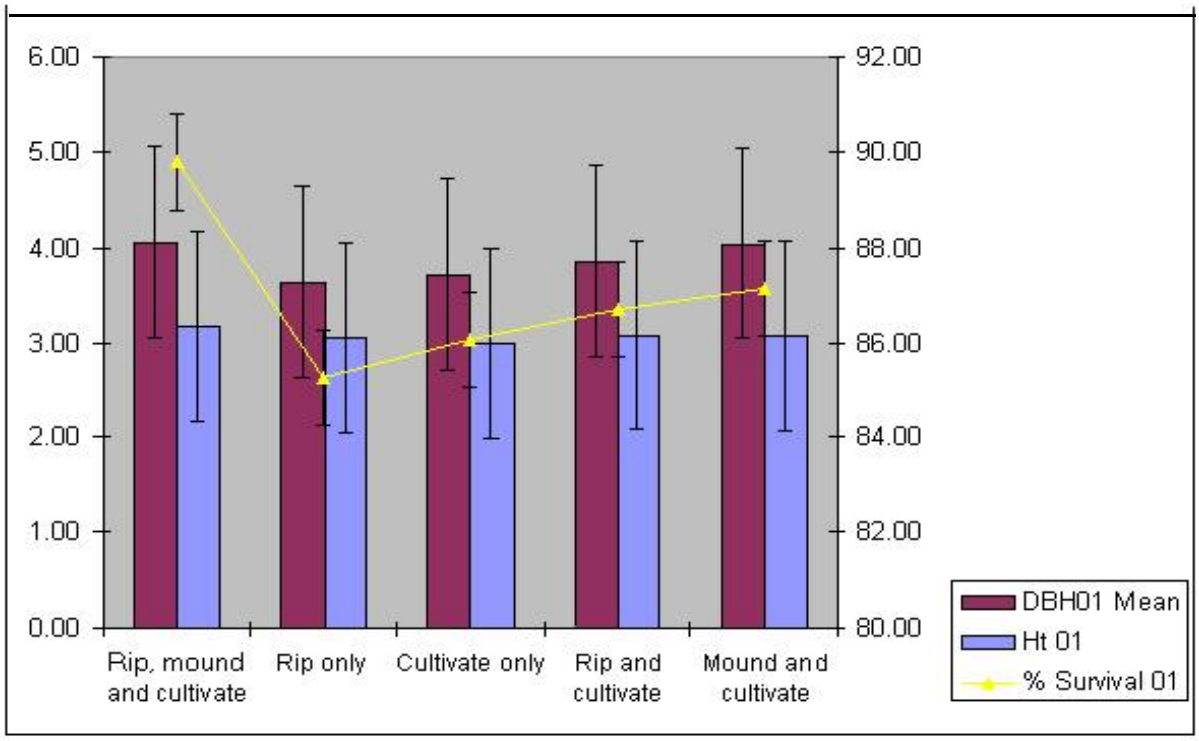


Figure 29: Tamworth Agroforestry Trial : Growth response to ground preparation methods 4 years after planting.

The critical time for weed control is in the first two years of growth but weed control starts long before the trees go in the ground. The main problem with weeds in farm forestry plantings is that they compete with the trees for moisture and to some extent for nutrients. As the trees get older they shade out weeds and push their roots beyond where most weeds can reach so the competition problem is lessened. But in those first few years the weeds and the trees are competing in the same zone of the soil.

The effective application of residual herbicides pre-planting can save considerable time and labour in weed control after planting (consult the product label for rates, application technique and safety considerations). Application at this time is straightforward and efficient as there are no other plants in place. Note that if using simazine, the chemical must be applied to moist soil and be incorporated soon after by rainfall or by a light cultivation. If not incorporated, the chemical breaks down under sunlight. Apply the 30/30 rule before planting. Allow 30 days and at least 25 - 30mm of rain to fall on the planting bed. This ensures that concentrated chemical is not introduced to the root bole of the seedling during planting.

Post-planting weed control was found to be one of the most important factors associated with tree growth on the tablelands during the study by Andrews (2000) - see Figure 30.

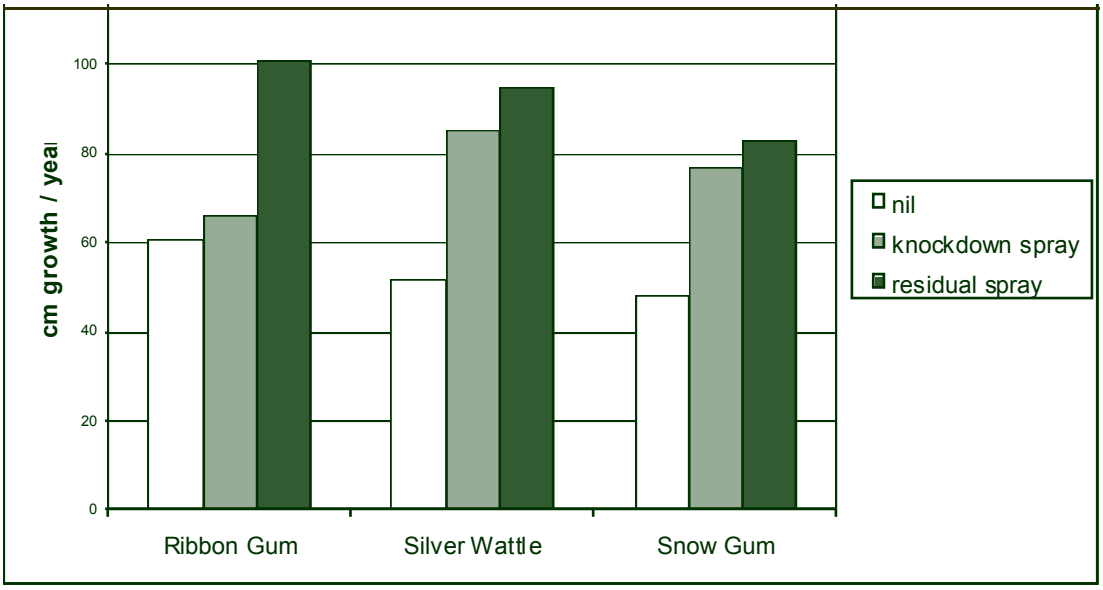


Figure 30: The average growth rate of 3 to 10 year old Ribbon Gum, Silver Wattle and Snow Gum planted on farms of the Northern Tablelands, relative to the type of post-planting weed control used (from Andrews, 2000).

Planting time: For the Northwest Slopes and Plains planting is best timed to avoid the risk of heat and moisture stress to tree seedlings (i.e. avoid summer). Provided planting bed preparation has been thorough and good stores of soil moisture have been conserved, spring is the best season to plant since early seedling growth coincides with increasing soil temperature. Autumn and winter plantings tend to stall and early seedling growth is slow until the following spring. Autumn and winter should be preferred, however, on soils that are freely draining and of low water-holding capacity. On such soils there is a high risk of the soil drying out faster than the seedlings can extend roots downwards in a dry spring. Its best under these circumstances to have seedlings well established prior to the commencement of the warmer months. Post-planting weed control must be exemplary when plantings are conducted in autumn or winter. Weeds become established over the cooler months and become highly competitive just at the time when tree seedlings commence rapid growth in the early spring. This phenomenon is suspected to have caused the trend in the survey result of Andrews (2000) in which there was a high correlation between lifetime tree growth rate and the season of planting (see Figure 31).

On the Northern Tablelands planting time does not appear to be as critical, although most tree planters avoid late autumn or winter establishment for fear of frost damage. Spring is again preferred (late spring if frosts are a concern), because seedlings commence growth immediately and are well established prior to the next winter.

Throughout the Northern Inland frost-sensitive species should only be planted in spring. Spring planting allows seedlings to maximize growth (stem thickness at ground level and total height) so they may only be damaged, not killed by any severe frost in the following winter.

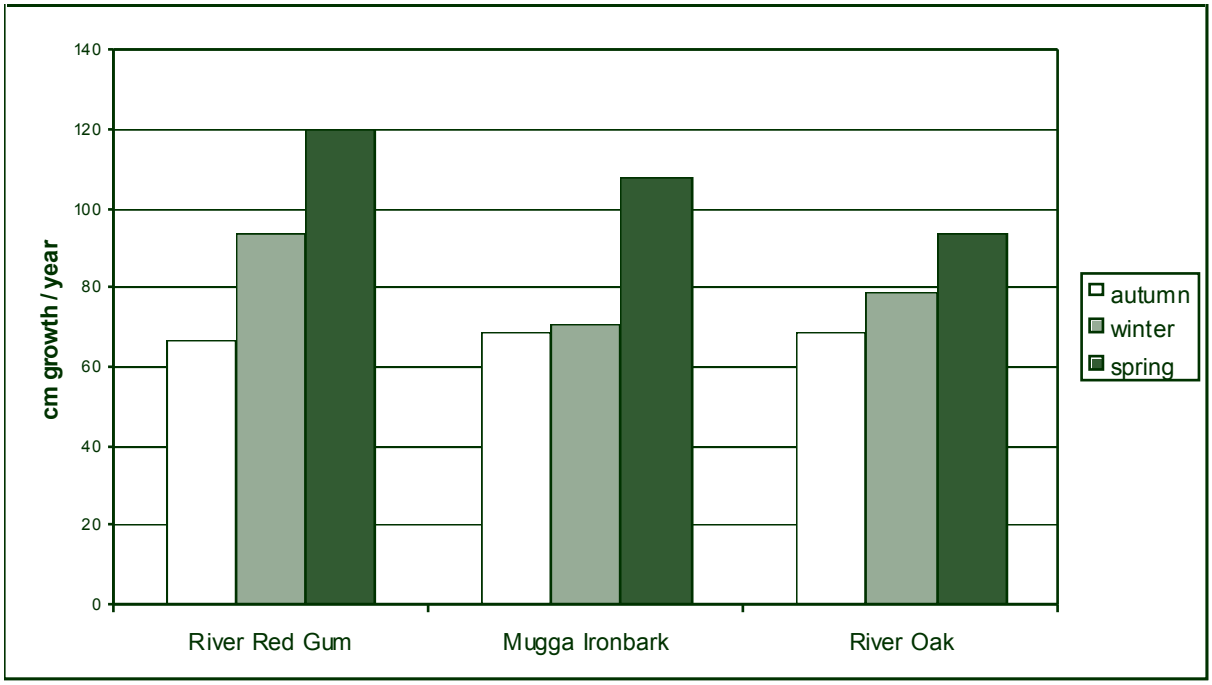


Figure 31: The average growth rate of 3 to 10 year old River Red Gum, Mugga Ironbark and River Oak planted on farms of the North West Slopes and Plains, relative to the season in which they were planted (from Andrews, 2000).

Guards: Growers must decide whether individual tree guards are warranted as they add significantly to the cost of tree establishment. Individual guards are usually installed to protect seedlings from hares and rabbits. Kangaroo, wallaby and livestock damage can only be cost effectively controlled by other measures such as appropriate fencing. If trees are established under ideal, weed free conditions at the start of a growing season, they can often grow rapidly and reach sizes where browsing by hares and rabbits causes only minor damage. Results will certainly be improved if ideal establishment practice coincides with effective hare and rabbit control. However, if rabbit and hare populations are at high and difficult to control levels, individual guards will be necessary. Recent demonstration plantings conducted by Greening Australia near Yarraman failed due to rabbit damage. Milk cartons with two bamboo stakes or plastic sleeves (e.g.' gro-tubes') with three larger stakes are the most popular in the region. Milk cartons are the cheapest but if hares are a real problem, taller plastic sleeves are preferable.

Mulch: The use of mulch is often proposed to enhance tree seedling establishment. Indeed, if applied thickly (75mm or more) and spread for about 1m surrounding each tree, mulches such as hay, sawdust or leaf and woodchip mulch can conserve moisture and suppress weed growth for effectively long periods. Unfortunately, suitable mulching adds considerably to the cost of tree establishment and is rarely cost effective (e.g. Jute matting cost 15 times that of herbicide weed control in a recent study by George and Brennan, 2002). Small and thin applications of mulch do little for tree growth. In a survey of farm grown trees on the tablelands, sawdust-mulched trees had growth rates that were no different to unmulched trees (Andrews, 2000). In fact, mulched trees were slightly slower growing on average than unmulched trees in that study. In cold areas mulch can prevent the ground from warming up through the day resulting in progressively colder conditions.

Costs: Indicative costs for establishing forestry planting at the time of publication are provided in Appendix L.

10. Managing Stems and Stands

Farm forestry is more than just the correct establishment of the right trees in the right place and waiting for them to grow into logs. The stand and individual trees will require management as they grow. The degree and type of management will depend on the site, the species and the production system being practiced. Important management practices include:

1) Correct selection of initial planting density and arrangement;
2) Appropriate rate and timing of thinning; and
3) Appropriate application of pruning.

Planting density and arrangement: Where block or belt plantings are established and early thinning is not anticipated, plantings are often established at high density. The rationale is that inter-tree competition for light is intense and trees develop narrow crowns and shade out lower branches, consequently heavy branching is minimised and lower branches are shed as the trees grow (i.e. the need for pruning is eliminated or reduced). For the high rainfall zones of the region, 3m row spacings with 2.5 to 3m plant spacing along the rows are common configurations (1333 to 1111 stems/ha respectively). For lower rainfall environments 4m row spacings are more common with 3 to 4m plant spacing (833 to 625 stems/ha). Plantings established at densities lower than these are unlikely to gain any tree-form benefit from inter-crown competition, and pruning intervention will be significant if producing high value logs. Using high establishment densities, pruning costs are lower, there is a greater selection of stems to retain at thinning time and at harvest, but establishment costs are higher.

In the case of wide-spaced plantings, or where early thinning and therefore a commitment to pruning is anticipated, planting density can be lower. In this case, considerations such as the final crop tree density and the likely proportion of planted stems expected to attain the characteristics of the target log (i.e. the genetic merit of the seedlings), will determine establishment density. For example, in a wide-spaced planting the desired harvest tree density might be 50 stems/ha (approximately 14 x 14m spacing). If using genetic material where the trees have variable form (e.g. unselected provenances of *E. viminalis* – tablelands or *E. sideroxylon* – slopes and plains) or there are uncertainties with survivorship or growth rate, a relatively high establishment rate such as 400 to 700 stems/ha may be necessary to allow for losses and a high proportion of cull trees. For species or seedlings where tree performance is more certain (e.g. *P. radiata* or *E. nitens* – tablelands or *Casuarina cunninghamiana* – slopes and plains), establishment rates may be much lower (e.g. 200 to 300 stems/ha) and still allow for a good selection of final crop trees. Under these planting densities, pruning costs are expected to be higher, overall timber production per hectare lower but with significantly lower establishment costs/ha.

Thinning: Thinning involves the removal of a proportion of the trees in a stand so that growth of the stand is concentrated on the remaining stems. The retained stems, freed from competition, grow more rapidly reaching market size sooner. Generally, the trees of best form and growth potential are retained. The heavier and earlier the thinning is conducted, the faster the growth rate of retained trees. The timing and degree of thinning any particular stand is determined by the site quality and the production system being practiced. In wide-spaced plantings where inter-tree competition is not an issue (i.e. the site is never fully stocked even at harvest time), trees of poor form or growth potential are culled rather than thinned. This can occur at any time and as soon as the poor performers become evident. In stands where inter-tree competition is being used to control tree form and limb development, the degree of thinning used to assist growth rate must be traded-off against the need for inter-crown competition to control branching. Under these circumstances, several light thinnings over the life of the stand may be required to reduce the stand from establishment density to final harvest tree

density. In stands where pruning is used to control form and branching, thinning can be conducted early and at a high rate.

Figure 32: A stand of River Red Gum being thinned in a woodlot near Gunnedah.

Access to markets for small diameter logs can also affect thinning practice. Some growers may elect to delay thinning until logs are of a commercial size, so that the products generated cover the costs of thinning. However, the prospects for commercial thinning in our region are currently very limited due to the lack of markets. It must also be realised that harvest scale is very important for low value products such as those produced from small diameter logs. Even where markets exist, commercial thinning harvests from small farm forests may be below a minimum viable volume for the market.

In the high rainfall zone the silviculture of plantation eucalypts is fairly well known and documented (Florence, 1996; Hillis & Brown, 1984; Mason, *et al.* 1997). Much of the theory and 'rules-of-thumb' regarding the timing and degree of thinning (eg the use of live crown ratios) have been developed on the premise that access to light is a major limiting factor to growth. The recent publication of Black and Simpson (2001) *Thinning Hardwood Plantations – A Guide for Northern NSW*, comprehensively covers the subject and is recommended to readers, especially those practicing farm forestry in the high rainfall areas of the region. (It occurs as appendix M in the attached CD).

In the medium to lower rainfall areas of the Northern Inland, access to moisture rather than light may well be the most limiting factor for tree growth. Intuitively, the lower rainfall environment here would dictate much wider spacing, and indeed, to grow trees to market size rapidly means each stem must get plenty of soil to explore for moisture. This would suggest that the 'rules of thumb' for thinning practice developed in the high rainfall zone might be less applicable in much of our region. The exact optimal spacing for any given site in the Northern Inland cannot be pre-determined, however, an adaptive management approach should assist farm foresters in this regard. A sample of stems should be monitored for diameter growth regularly, and when the rate of growth drops off, the stems are obviously beginning to compete for resources. To maintain growth rate, thinning at this point is suggested. See Abed & Stephens (2003) *Tree Measurement Manual for Farm Foresters*.

Grower experience with diameter monitoring will eventually suggest the basal area of the planting that a site can sustain. The basal area of a stand is the sum of the cross-sectional areas of all the stems in a stand expressed as m^2/ha. The cross-sectional area of a stem is measured at breast height (1.3m above the ground) – see Glossary. Knowing the basal area limit for a site is important for estimating final crop tree density and therefore choosing appropriate thinning rates. If through DBH (Diameter Breast Height) monitoring the farm forester determines that the stands growth rate flattens out at about 20m^2/ha basal area, they can then determine a final tree stocking rate for a particular target log.

In this case, if the target log is 60cm DBH (i.e. each tree will be 0.28 m^2 in basal area), then full stocking at final harvest will be about 70 trees/ha (i.e. 0.28m^2 basal area/stem x 70 stems/ha = 20m^2 of basal area/ha). Thinning schedules should therefore aim to eventually reduce the number of stems to this level (that is, if maximum wood production per hectare is one of the aims).

Basal area limits for any particular site will vary according to site quality and rainfall. For our region they are likely to range from 10 to 15m^2 on lowest quality and rainfall sites (shallow soils, 500mm rainfall) to 40 to 50m^2 on the best quality sites with highest rainfall (deep soils, >1500mm rainfall). Note that belt plantings can often sustain higher basal area limits per hectare than block plantings on similar sites. This is due to lateral water movements from upslope moving into a belt (effectively raising available moisture) and the ability of edge trees to explore soil outside of the crown limit of the planting. The same is true of plantings established on high water tables where trees access ground water as well as rainfall (see Figure 33).

Pruning: Pruning can be utilised to improve tree form, control branch development and produce wood clear of knots. It is especially valuable when trees are widely spaced for rapid growth and there is a lack of inter-crown competition to control tree form. Three forms of pruning are likely to be utilised by farm foresters to grow quality logs:

1) Form pruning - used to assist in maintaining apical dominance in a stem;

2) Pre-emptive pruning - used to restrict undesirable branch development and growth; and

3) Clear-bole pruning - used to remove lower branching on that part of the trunk of a tree destined for the production of a clearwood log.

Pruning schedules suitable for a number of species or species groups have been devised for parts of southern Australia by Bird, *et al.* (1996 - See Appendix N). The principles of each type of pruning are summarised below.

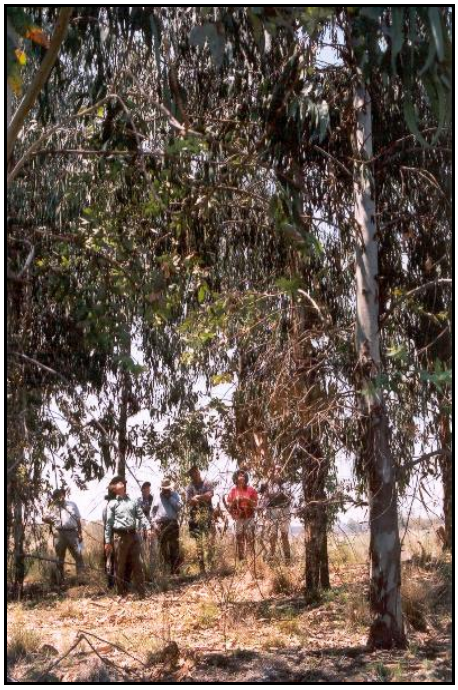


Figure 33: In a Greening Australia species trial at Wallangra, a small stand of Eurabbie *E. bicostata* ***has achieved spectacular growth in this 700mm-rainfall area. Many stems are over 20cm DBH and up to 13m tall at age 6 years. The basal area of this plot is already approaching 15m^2/ha and still growing despite dry seasons. The trees are obviously accessing groundwater and the site is likely to support a much higher stand basal area than the site quality, and average rainfall, would suggest.***

Form pruning: The aim of form pruning is to produce a straight single leading stem on each tree. It is particularly important in the first few years of growth in widely spaced or early-thinned trees where opportunities for culling are limited. It involves removing double leaders or large steep angled branches that may grow on to compete with the main leader. In the first few years, it is quickly achieved with a pair of secateurs. For species with strong apical dominance such as Radiata Pine, Shining Gum and River Oak, early form pruning is usually all that is necessary (and then only for a small proportion of the stand). Once a single leading stem has become established it usually dominates to maturity. Considerable attention to form pruning is necessary for species that have weak apical dominance, such as the Acacias. For these species form pruning may be required at short intervals for some years and at least until the tree has reached the height where the target log has become obvious.

Pre-emptive pruning: Pre-emptive pruning occurs before the clear-bole pruning stage. It is the removal or 'tipping' of large branches (> 25mm in diameter) that occur on that part of the tree trunk that is still too small to be completely bole pruned (i.e. < 8 to 10cm in diameter - see below). The aim is to prevent the limbs becoming too large. Removal is preferred provided only a small proportion of the canopy is pruned at one time. If there are several large branches in the canopy likely to become problematic, but their complete removal would drastically reduce the overall amount of foliage available to drive tree growth, then only part of each branch can be removed (tipped). This reduces the amount of foliage available to the branch, slowing its growth. No more than 50% of the foliage in the canopy should be removed at any one visit (Bird, *et al.* 1996).

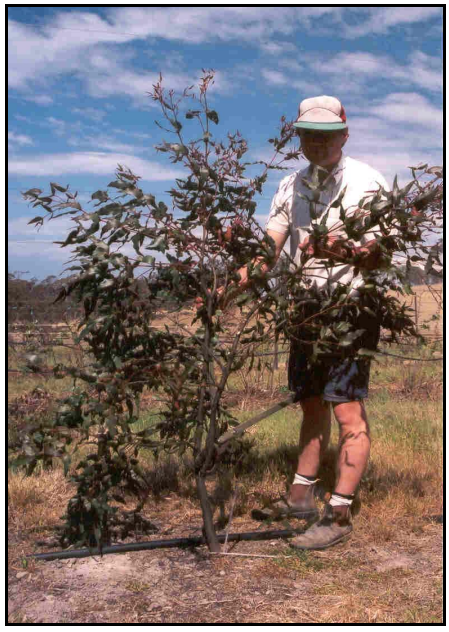
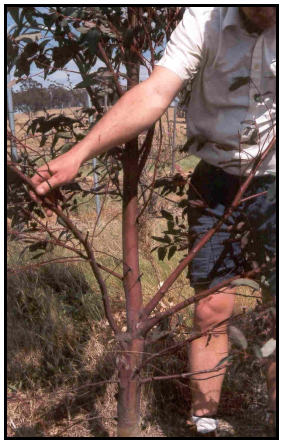


Figure 34: A young Forest White Gum with multiple leaders. If this tree is to be retained the best leader should be selected and the others pruned off.



(a)

(b)

Figure 35: This young Sydney Blue Gum is developing large lower branches. (a) These should be pre-emptively pruned . The branches could be pruned off near the trunk. However, if they constitute a large proportion of the crown they could be tipped as illustrated in (b).

Clear-bole pruning: .

This process is explained in detail in Bird, *et al.* (1996) - an extract from this book follows:

"Clear-bole pruning (or clearwood pruning) is the removal of branches on that part of the lower trunk that exceed about 8 - 10cm diameter. All branches are removed regardless of size. Aim to retain 3-4m of foliage after pruning - this will be difficult to achieve on poor sites and on outer rows of woodlots and timberbelts. The age to begin clear-bole pruning depends upon the growth rate of the trees, but usually commences when the tree is 4-5m tall.

Unless pruning is done at least annually (and preferably more often) many branches will greatly exceed 30mm and may require a chain-saw to remove. Healing of the stub will be prolonged, possibly predisposing the wood to infection. The amount of callus tissue over the stubs will also be large and the target minimum knotty core will not be attained.

When pruning, do not cut off the collar between the branch and the trunk - cut very close to the collar but not flush with the trunk. That will allow callus tissue to seal over the cut stub. To prevent bark-stripping when sawing off heavy branches, lighten the load by cutting higher up the branch and then trim the stub at the correct position. Alternatively, make an undercut before sawing off the branch, supporting the weight with one hand. With eucalypts it is important to prevent bark-stripping damage to the cambium - such damage slows healing and allows decay organisms to degrade the trunk.

The ultimate aim is a straight 6.1 m butt log with a knotty core of around 16-18cm. The 16cm target diameter over stubs (DOS) might be obtained if the DOS after pruning was 13cm, but even with the greatest diligence the largest DOS for the pruned log may end up around 17cm, with ultimate defect core of around 20cm. Neglect for any one year in the pruning cycle may increase the defect core to 25cm or more, and markedly reduce the value of the log. This must be avoided. Also, if the interval between pruning is too long the branches will be large and, allowing for the less frequent visits, the pruning costs may be more than doubled as a result.

The largest single DOS determines the log quality . A sawmiller will soon discover the result of failure to prune on time and will pay accordingly for the logs! In order to obtain the best price for a stand of pruned trees it may be necessary to have the pruning standard authenticated through a "Pruned Stand Certification Service" Do not plant more trees than can be comfortably handled by on-farm labour in the pruning cycle, unless a contractor is to do the work. If clearwood pruning begins at year 5, and is completed at year 9, it would be unwise to have planted another large block requiring clearwood pruning in this period. Much better to plant 1 or 2ha each year (perpetually) so that there will eventually be 5 or 10ha to prune each year (with 5 different age classes). It is hard to consistently cope single handed with more than 5ha in a year.

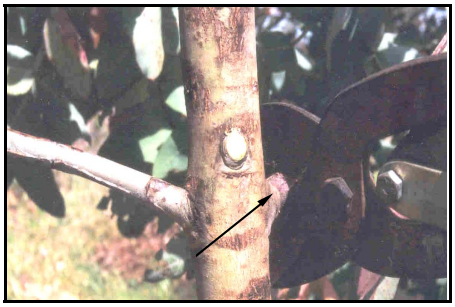
The optimal season for pruning appears to be in any dry spell during late autumn and winter, this should avoid severe fungal infection. Cut out rather than prune trees that are unsuitable for timber, unless they are to be retained for shelter".

Details of Pruned Stand Certification occur in Appendix O.

Figure 36: The first "lift" of bole pruning being conducted on a Shining Gum growing near Armidale.

(a)

(b)



(c)

Figure 37a: The pruning cut is too far from the trunk leaving an excessive branch stub which will result in a large knotty core in the log.

Figure 37b: The cut is too close to the trunk damaging the branch collar, which will prolong healing and risks the entry of disease.

Figure 37c: This is a correct cut just outside the branch collar (shown by arrow). The stub will heal over rapidly with minimal enlargement of the knotty core in the log.

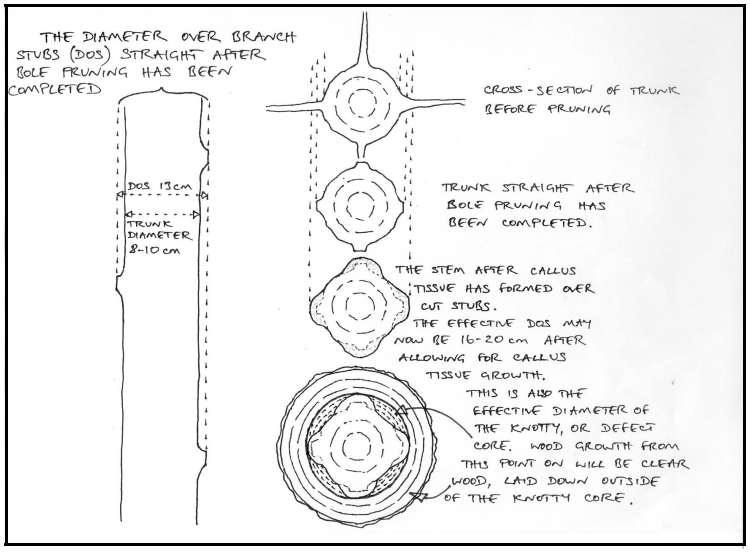


Figure 38: An unpruned pine log showing branch stubs extending from the core to nearly the outer edge of the log. Boards cut from such a log will be knotty.

11. Farm Forestry and Shelter

The use of treed belts for sheltering livestock, pastures and crops is well recognised by the majority of landholders, particularly those living on the Northern Tablelands. Appropriately designed and sited shelterbelts can have the following benefits:

1) Enhanced survivorship of new-born lambs and recently shorn sheep in cold, wet, windy conditions;
2) Enhanced productivity of most classes of other livestock under similar conditions (less energy is consumed to keep warm);
3) Providing shade for livestock;
4) Reducing the physical damage of winds on the leaves of pasture and crop plants;
5) Reducing plant knockdown (lodging) of crops at times of high winds;
6) Reducing evaporation in crop and pasture paddocks, allowing more moisture to be available for plant growth; and
7) Reducing wind erosion.

Cleugh (2003) recently reviewed the results of the National Windbreak Program (NWP) launched in 1993. The NWP investigated the productivity benefits of windbreaks to crops and pastures in a variety of locations throughout Australia. Cleugh (2003) reports productivity benefits to crops and pastures due to well-designed shelterbelts of between <5% to over 20% depending on location. The important factors to consider in windbreak design (Cleugh, 2003) include:

1) Height – the taller the windbreak the larger the area protected (up to 30 x the height (H) down wind), with the greatest wind speed reductions occurring in the region that is between 3 to 10 x H of the windbreak down wind. Windbreaks that include rows of fast growing tall trees will be the most effective.

2) Length – the longer the windbreak the greater the area sheltered. Windbreaks should be at least 20 x H long.

3) Porosity – the denser the windbreak (the lower the porosity) the greater the reduction in wind speed. Contrary to popular belief the NWP found that dense windbreaks sheltered just as much area as more porous windbreaks and more effectively (i.e. the supposed turbulence effect of very dense wind breaks was not apparent when investigated in the field). Multiple rows of vegetation will ensure denser windbreaks.

4) Continuity – gaps along the length of the windbreak causes significant reductions in effectiveness. Gates should therefore be located at the ends of windbreaks. If windbreaks consist of multiple rows, any occasional gaps that may form in individual rows due to tree losses will not impair overall effectiveness.

5) Evenness in porosity — the density of the foliage should be as even as possible from the ground to the top of the trees. Stock browse lines, or trees with their lower branches pruned, cause wind funnelling under wind breaks, reducing their effectiveness. Shelterbelts consisting of farm forestry plantings managed for clearwood will require some non-pruned rows or shrub rows to ensure top to bottom foliage cover.

6) Orientation – windbreaks are most effective when they are oriented at right angles to the prevailing or the problem wind. Deviations of up to 30° from the perpendicular can be catered for with long windbreaks but the sheltering effect declines rapidly the further the windbreak deviates from this angle of wind direction.

For the Northern Inland region, most problem winds are either from the north west (warm drying winds) or west and south west (coldest and strongest during winter). Although, some north easterlies can also be drying on the North West Slopes and Plains and south easterlies can also be wet and cold on the Northern Tablelands.

Generally, shelterbelts orientated north - south provide protection from these winds but landholders should consider their own situation and whether local topography affects wind direction.

7) Upwind features - other features such as remnant vegetation, tall crops and other windbreaks up-wind increase the effectiveness of windbreaks. Windbreaks organised into series or multiple parallel belts less than 12H apart successively improve shelter and are more effective than single windbreaks alone.

8) Landscape factors – hill and ridge top and saddle locations for windbreaks improve the area sheltered compared with other topographic positions.

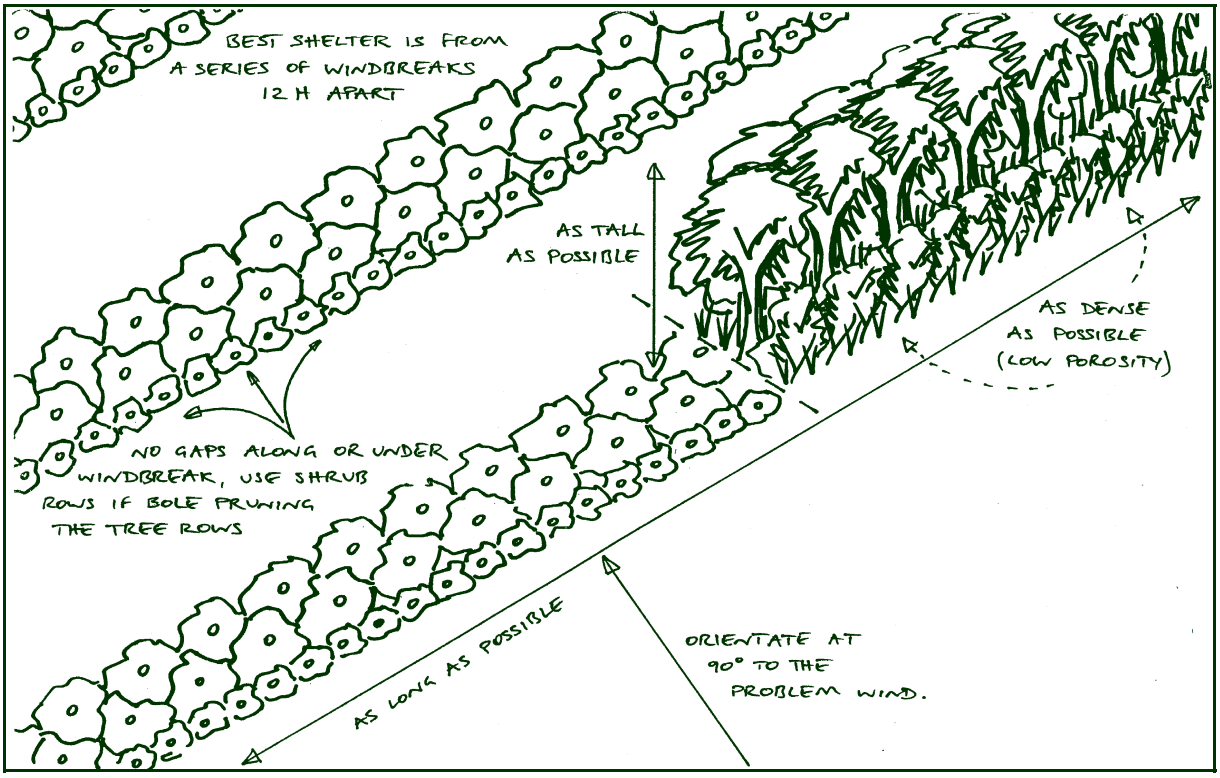


Figure 39: Diagrammatic representation of all characteristics desired in an effective shelterbelt.

12. Farm Forestry and Biodiversity

Farm forestry can provide worthwhile contributions to biodiversity conservation on farms but plantings must be carefully designed for this to be realised. Farm forestry plantings in isolation are often not particularly biodiverse or especially good at providing habitat. Marketing requirements and species suitability considerations (see Chapters 7 and 8) often restrict the number of species used in farm forests and consequently, limit the diversity of habitat resources provided. Consider Table 6 which illustrates the relative provision of various habitat features under different land uses in what would be a wooded landscape. Whilst treed land uses obviously provide more habitat features than crops or pastures alone, even multi-species forestry plantings lack the number and variety of habitat resources compared to remnant bush.

Table 6: The relative quality of habitat resources provided by different land uses in a hypothetical farm landscape once dominated by diverse woodland or forest.

Habitat Feature	Pasture or Crop	Single species farm forest	Multi-species farm forest	High quality remnant vegetation
Tree canopy and foliage	*	X	XX	XXX
Tree trunks and bark	*	X	XX	XXX
Nectar pollen and fruit	*	X	XX	XXX
Hollow branches and fallen logs	*	*	*	XXX
Understorey shrubs	*	*	*	XXX
Grass & herb layer	X to XXX	X	X	XXX
Litter layer	X	XX	XX	XXX

*= No resource, X= limited or uniform resource, XX= a variety of resources, XXX= a full range of resources

Farm forestry can be valuable for biodiversity conservation under the following conditions:

1) Where more than one species is grown for timber, especially where the species are quite different in flowering time, foliage type and bark type;

2) Where adjacent stands are established at different times to create patchiness in the landscape;

3) Where local species are used;

4) Where areas of reconstructed habitat, especially with a variety of native shrubs, are included in farm forestry plantings; and

5) Where forestry plantings are used to effectively buffer and enlarge areas or corridors of remnant bush, or reconstructed habitat.

A recent RIRDC publication by Salt, *et al.* (eds) (in press) details the ways farm foresters can design and manage their stands to improve biodiversity.

Managing for biodiversity can of course be beneficial to timber production in the farm forest. Outbreaks of insects can significantly affect the productivity of timber producing trees (see Appendix P). One way to counter the significance of any such losses is to ensure that there is habitat diversity in the landscape so that conditions are suitable for a whole range of insect predators and parasites.

To date, farm forestry has been relatively under utilised in landscape management for biodiversity in our region. This is particularly the case in areas where remnant woodlands and forests have been over-cleared and significantly fragmented, such as many of the cropping districts of the Northwest Slopes and intensively pastured areas of the Northern Tablelands. Lindenmayer (2000) in a recent study of softwood plantations in southern NSW found that plantations of pine (long considered relative biological deserts) supported surprisingly diverse wildlife communities where patches of remnant forest remained scattered throughout. However, different species varied in their ability to utilise plantations as habitat. Presumably, many species could utilise or disperse through the relatively simple habitat of the pine plantation provided other key resources (e.g. tree hollows, shrub thickets, fallen or heaped eucalypt logs and particular flowers and fruit) were maintained in adjacent patches of remnant bush.

This phenomena could be used to good effect in rural landscapes where farmers are reluctant to set-aside and revegetate with non-commercial tree and shrub species the significant areas required to re-establish effective habitat cover. Barret, (2000) considers that remnant or revegetated wildlife corridors should be at least 50m wide and that patches of remnant woodland or forest less than about 10ha are too small for the conservation of many bird species and for their own long-term viability.

However, many farmers are reluctant to set-aside corridors of even 20m in width, or interested in enlarging small remnants above 5ha (S. Andrews, pers. obs.) Farm forestry plantings therefore have the potential to improve this situation, despite them being in themselves only low to moderate quality habitat. Commercial timber stands could be designed to improve the overall size and function of remnant or revegetated habitat by assisting in attaining critical size and minimising edge effects. Blocks, belts and wide-spaced plantings could all serve such a purpose (see Figures 40 and 41). It must be stressed that farm forestry plantings used in such a manner should be designed to assist and complement remnant or revegetated areas of habitat, not be replacements for them.

(a)

(b)

(c)

Figure 40: The landholder is concerned about linking areas of remnant habitat in a paddock but can only afford to set aside 15m of land from commercial enterprises to revegetate with local native habitat species (a). This width is somewhat sub-optimal for effective wildlife corridor function. However, if returns from timber (and probably shelter and salinity control) can offset lost agricultural productivity, a wider area may be considered for revegetation. Figures (b) and (c) are possible farm forestry configurations that would aid in wildlife corridor function but improve the commercial return of the net area planted to trees.

(a)

(b)

(c)

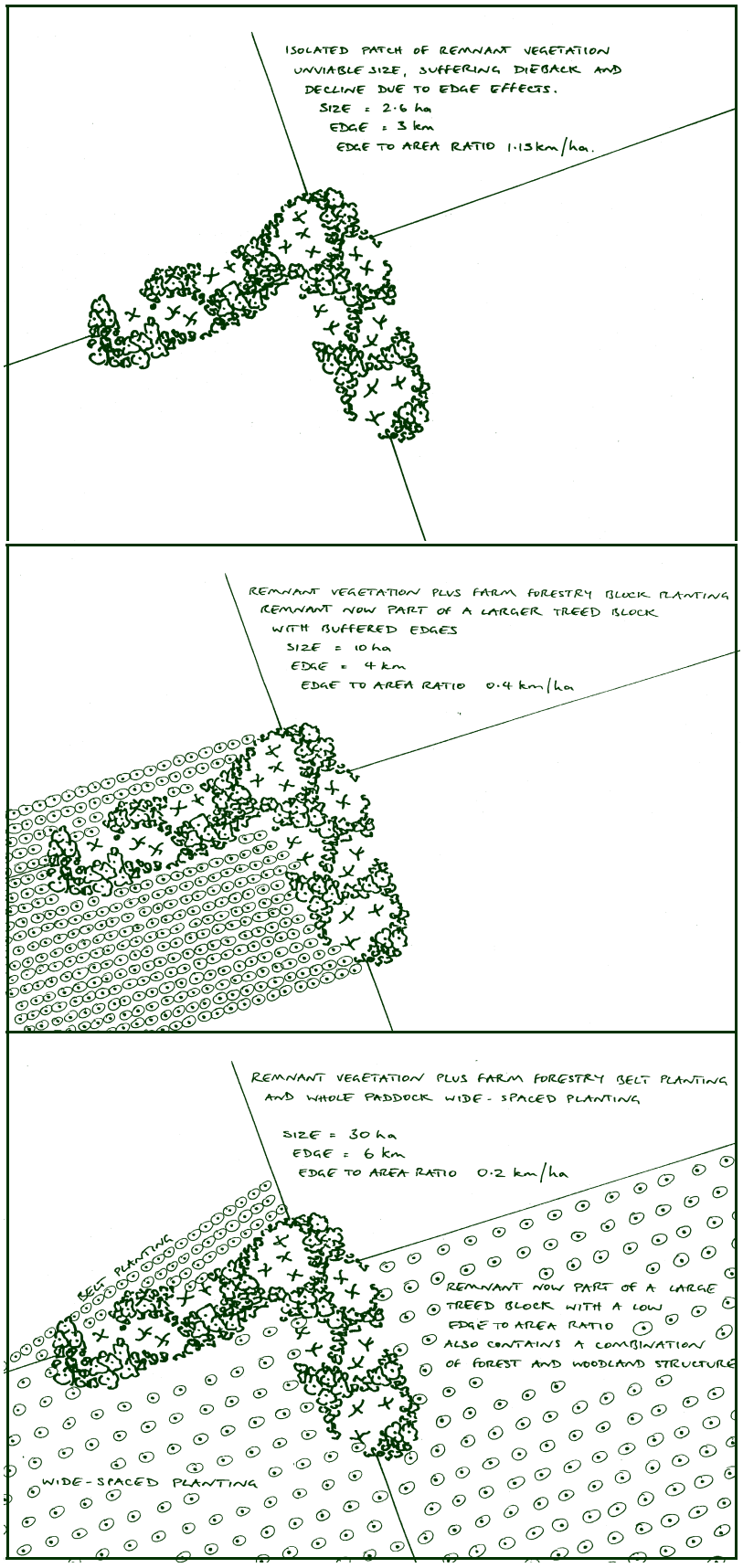


Figure 41: An isolated woodland remnant on the farm, which is under 2ha in size, has a high edge to area ratio, retains many habitat features but is in decline due to dieback. The illustrated farm forestry options (b and c) would consolidate the remnants shape, buffer edge effects and enlarge it to a more viable size.

13. Farm Forestry and Salinity Control

What is salinity?

Salinity is a significant land and water degradation issue for many of the medium to low rainfall regions of southern Australia (particularly the 550 to 750mm rainfall zone). Within the Murray Darling Basin there are significant stores of salt in most soils, especially soils with moderate to high clay content. The salts, sourced from rainfall, wind deposits and various parent rock materials, have accumulated over millennia during our very stable geological history. The salt stores have accumulated in the soil below the root zone of the native vegetation. Water table heights were stable prior to the arrival of Europeans due to native vegetation utilising most of the rainfall that fell on the soil surface. The small amounts of water passing through the soil and reaching the water table were kept in equilibrium with the amount of water discharged into springs, drainage lines and deeper ground water stores.

It is generally accepted (Walker, *et al.* 1999) that conversion of native vegetation to crops and pastures in recent times has resulted in:

1) A reduction in the depth of the root zone;

2) A reduction in the amount of water utilised in the root zone; and

3) Greater leakage to the water table (often in excess of the discharge capacity of the landscape).

Salinity problems occur where:

1) Water tables rise into the salt store zone of the soil;

2) Stored salt becomes mobilised (i.e. becomes dissolved in the ground water);

3) Salt is transported, via water tables rising closer to the surface and via lateral ground water flow, to areas of discharge in the landscape (e.g. salt scalds) and/or to the river systems (increasing river salinity).

Where the water table rises to within 2m or less of the soil surface (depending on soil texture), water and salts can move into the root zone and onto the surface via capillary rise.

Salinity problems tend to occur in areas of moderate rainfall. Sites with annual rainfall in excess of 900mm generally have salts flushed through the landscape and are unlikely to have concerns with salinity.

Salinity problem areas of the region.

Many areas on the Northwest Slopes and Plains have recently been identified as high salinity hazard landscapes (Northern Salinity Team, 2003 and Sinclair, Knight & Merz Pty Ltd (SKM), 2003). SKM have comprehensively reviewed the ground-water flow systems of the region. Information on the characteristics of groundwater flow systems is essential in designing farm forests for salinity control (see later sections). Known salinity locations are listed below along with the name of the ground water flow system for each locality as described in SKM (2003).

1) The red soil landscapes from Tamworth to Gravesend (Carboniferous Metasediments);

2) Horton Valley (Lava Fields);

3) Liverpool Plains (especially on the margins – Upper Narrabri Formation LP);

4) Goran Lakes Catchment (Goran Lake);

5) Bellata (Lava Fields, Upper Narrabri formation);

6) Pilliga outwash (Pilliga Outwash);

7) Uralla to Bundarra (Accretionary Sediments);

8) Inverell to Ashford (Lava Fields, Accretionary Sediments and Low Relief Granites); and

9) Emmaville, Bonshaw, Tenterfield (Permian Acid Volcanics, Accretionary Sediments and Low Relief Granites).

There are also localised soil salinity/alkalinity problems in many areas of the Northern Tablelands. They occur on the edges of basaltic landscapes and in low relief landscapes with light soils derived from granite or meta-sediment (trap) parent materials.

If there are no significant land use changes made, it is predicted that large areas in the Macintyre (> 60 000ha) and Namoi catchments (>20 000ha) will experience water table rises to within 2m of surface over the next 20 to 50 years. It is also expected that significant increases in river salt loads will occur in the Namoi, Gwydir and the Border Rivers river systems over this time (MDBC Salinity Audit, 1999).

Solutions to salinity

Three courses of action are often suggested to deal with salinity:

1) engineering solutions such as ground water pumping, interception works and evaporation pan schemes, to lower water tables or transport saline water or salt elsewhere;

2) adapting production to cope with or utilize saline land or water (e.g. salt tolerant pastures, saline aquaculture); and

3) improving the water use of the enterprises conducted on the soil surface to reduce leakage and stabilize or lower water tables.

For the Northern Inland it is generally thought that improving the water use of the enterprises conducted on the soil surface is the most cost effective option (S. Donaldson, pers. comm.). Various studies have shown that enterprises incorporating trees use more water than those based on perennial pasture which use more water than those based on annual crops and pastures (Stirzacker, *et al.* 2002 and Walker, *et al.* 1999). The higher the rainfall of a site and the more transmissible the soil profile, the greater the difference between these enterprises in terms of leakage to the water table (see Table 7). Farm forestry is a commercial enterprise likely to have very low rates of groundwater recharge. Indeed, farm forests have the potential to use more water than rainfall on some sites (where the trees have access to ground water) and therefore have the capacity to lower water tables.

Table 7: Indicative deep drainage rates (leakage) from various land uses in different rainfall zones in southern Australia (compiled by Murphy (2003) from a variety of water use studies reported in the literature from 1993 to 2001).

	Indicative amount of drainage (mm/yr)		
	Annuals	Perennials	Trees
High Rainfall (>650mm)	100	50	5-10
Medium Rainfall (400-600mm)	20-50	10-20	2-3
Low Rainfall (<400mm)	1-2	1-2	<1

Designing farm forests to control salinity

Designing farm forestry systems to control salinity presents some challenges. Trees have limited impact on leakage much beyond the extent of their crowns when grown in a forest situation and, at best, up to 50m away in wide-spaced belts (Walker, *et al*, 1999). Simply establishing a block planting on a small part of the farm may not substantially improve the recharge situation over the whole landscape in most cases (probably only recharge directly under the planted block). Depending on the landscape, plantings often need to be well spread across it to be effective. Given the relative profitability of timber production compared with agriculture in the medium to low rainfall zone where salinity is a problem (see Chapter 4), farm forestry designed for salinity control is often a case

of determining the least area of trees necessary to be effective. Determining the actual extent and configuration of forestry plantings required, and indeed whether tree plantings will be effective at all against salinity in any particular landscape, requires some knowledge of the ground water flow systems operating on the farm.

It is beyond the scope of this publication to provide details of farm forestry planting designs to cope with all of the different salinity, groundwater, landscape and enterprise mix scenarios possible for the Northern Inland of NSW. However, some of the general principles are provided below with some examples relevant to particular landscapes. Stirzacker, *et al.* (2002) considers in detail the design of tree plantings for salinity control in a variety of southern Australian landscapes and groundwater, slope and soil conditions. SKM (2003) have recently assembled the available information on the ground water flow systems of the region. Readers are referred to these publications to expand their own knowledge on the subject area.

For landholders to begin designing farm forestry for salinity control they need to address two basic questions:

1) What proportion of the landscape needs trees for recharge control?

2) Where in the landscape should the trees be placed to be most effective for recharge control and the interception of laterally moving groundwater?

What proportion of the landscape should be treed for recharge control?

Determining the proportion of a landscape requiring trees as compared to agriculture to balance overall water use, requires information on:

1) The amount of annual rainfall and how much infiltrates the soil;

2) The relative water use of the agriculture; and

3) The relative water use of the farm forest.

The higher the rainfall of a site, and the poorer the water use of the agriculture, then the higher the proportion of the landscape that needs to be treed to maintain water balance. For example, a well-managed response-cropping regime or perennial pastures may utilise nearly all rainfall on a farm near Moree in a 550mm rainfall zone. Trees would not be necessary for recharge control. In contrast, long-fallow annual cropping or a poorly managed pasture may leak in excess of 200mm annually to the groundwater on a site east of Inverell with 800mm annual rainfall. In this case, treed areas occupying in excess of 50% of the landscape may be required to maintain water balance. Most farms in our region are likely to have a soil water balance situation intermediate between these extremes and the proportion of the landscape requiring tree cover would vary accordingly.

Consider a theoretical Tamworth location with 500mm of annual rainfall entering the soil (the balance is evaporated or runs off). The current perennial native pasture system uses 450mm/year when well managed, and the most appropriate farm forestry enterprise would be based on River Red Gums with a potential water use of 700mm/year. Deep drainage under the pasture would equal 50mm/year (amount of infiltration minus the water use of pasture). Deep drainage under trees would equal minus 200mm/year (amount of infiltration minus the water use of trees) provided the trees could access the water table.

Theoretically, the following response in the water table height would occur under different proportions of the landscape being dedicated to trees:

1) In an all pasture scenario (no trees), 50mm of deep drainage would occur each year and the water table would rise;

2) If 20% of the area was under appropriately located trees and 80% under pasture no net recharge would occur. The extra water use of the trees on 20% of the area would balance

the leakage of the pasture on the other 80% of the area and the water table height would would remain stable;

3) If half the area were occupied by trees and the other half by pasture, 75mm of ground water would be utilised per year on average and the water table would noticeably fall until it reached a depth inaccessible to the trees.

The above example is somewhat simplistic since annual rainfall rarely equals 'average'. Additionally, there are often water contributions to the system from up slope, and pastures vary dramatically in water use and their ability to facilitate infiltration depending on their management and seasonal conditions. It also does not consider the configuration of the tree plantings and assumes the trees are not competing with pasture for moisture (i.e. only taking moisture in excess of the pastures requirement). However the basic water balance 'accounting' is a sound way of estimating a starting point in determining tree cover requirements.

What configuration should the farm forests be?

As a general principle, improving water use across the landscape using appropriate tree/crop/pasture systems such that deep drainage rates equal pre-clearing levels should mitigate any salinity problems whatever the ground water flow system.

However, because of the relative profitability of agriculture versus timber production, strategic use of forestry plantings are likely to be preferred to a general blanket approach.

To achieve salinity control with targeted farm forestry plantings will require Information on:

1) how recharge occurs;

2) how ground water moves in the landscape; and

3) the characteristics of discharge sites.

Where distinct groundwater recharge zones can be identified these are high priority sites for block plantings.

Where groundwater moves laterally at shallow depths (i.e. within reach of tree roots) belt plantings aligned along contours can be used to intercept ground water moving from up slope. On highly transmissible soils, belts can be widely spaced. (See shaded box below).

Where recharge control is necessary on flat sites, or where heavy soils restrict lateral flows, belts may need to be closely spaced (e.g. alley farms) or farm forests should take the form of wide-spaced plantings.

The width of treed belts and their distance apart for different climates and landscapes are considered in detail in Stirzacker,et al. (2002). They indicate that effective belt spacing is determined by the transmissivity of the landscape and therefore the capacity of the inter belt zone to transmit water laterally through the soil. Low transmissivity sites require close belt spacing and high transmissivity sites can have wide-spaced belts. Belt width will be determined by knowing the proportion of the landscape requiring trees (see previous section in the text) and the distance between belts. Gently sloping areas, particularly with heavy soils of low permeability, resist the lateral movement of water in the soil profile and require trees to be closely spaced to effectively control recharge. In these cases, an alley farm type configuration would be most suitable (interbelt spacing of 50m or less) with each tree belt being quite narrow (e.g. 1 to 3 rows). In contrast, steep light-soiled sites have the capacity to transmit water rapidly, and tree belts can be well spaced (several hundred metres apart). In this case, each tree belt must be quite wide to maintain the appropriate proportion of the landscape under trees (e.g. 10 to 50 rows).

Where ground water movement over much of the landscape is deep in the soil, or underlying rock, and only accessible near discharge sites, belt of block plantings can be established just up slope to form interception plantings. The level of ground water flow will determine the size and width of such plantings.

Some examples of farm forestry planting configurations for targeted salinity control for the Northern Inland follow.

A) In Lava Field groundwater systems such as those that occur in the Horton Valley, east of Bellata, the upper slopes of the Liverpool ranges and in the Inverell, Delungra area (SKM, 2003), a farm's groundwater landscape may have the following characteristics:

- shallow soils over fractured rock on hilltops where rapid infiltration/recharge is occurring through the rock and drainage is largely vertical, recharge is occurring throughout the other parts of the landscape but contributes less than these hilltop areas ;
- transmission of groundwater laterally is via lava flows deep under the soil (i.e. not accessible to plant roots); and
- discharge occurs at varying points of the landscape where the lava flows approach the surface (on benches) or come into contact with some other geologic feature or the basement geology under the basalt.

Under such a scenario, priority recharge and saline discharge control may be best achieved with:

1) block plantings on the hilltops to minimize recharge at this point in the landscape; and

2) block or belt plantings just upslope from discharge sites to intercept laterally moving groundwater before it contributes to discharge.

Plantings further upslope from this point are likely to be less effective since the ground water is inaccessible and moving below the root zone.

B) In a Low Relief Granite landscape (e.g.. southwest of Uralla, Tingha, east of Graman) the groundwater landscape may have the following characteristics:

- the soil is likely to be relatively shallow over impervious bedrock;
- ground water is transmitted rapidly particularly through and along the sandy A horizon;
- recharge is occurring right across the landscape including hilltops and all side slopes down to near discharge areas; and
- discharge occurs close to the drainage lines where heavier soils occur.

In this case recharge control needs to occur across the landscape to be most effective. Trees can be established in well-spaced 'contour' belts since water moves laterally quickly and close to the surface where it is easily accessed by tree roots. Interception plantings low in the landscape are likely to be poor performing due to frostiness and waterlogging. Salinity control is likely to rely on across landscape recharge control and less on discharge interception.

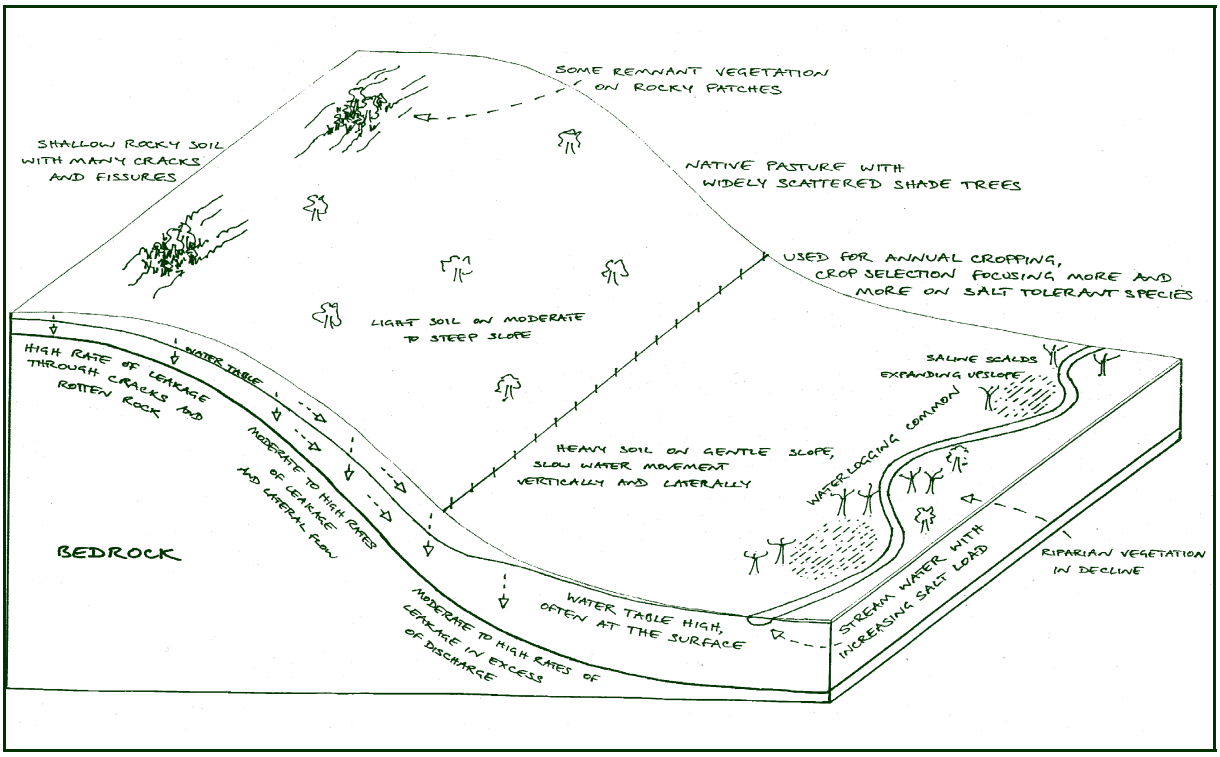


Figure 42a: A conceptual landscape on the Northwest Slopes affected by salinity.

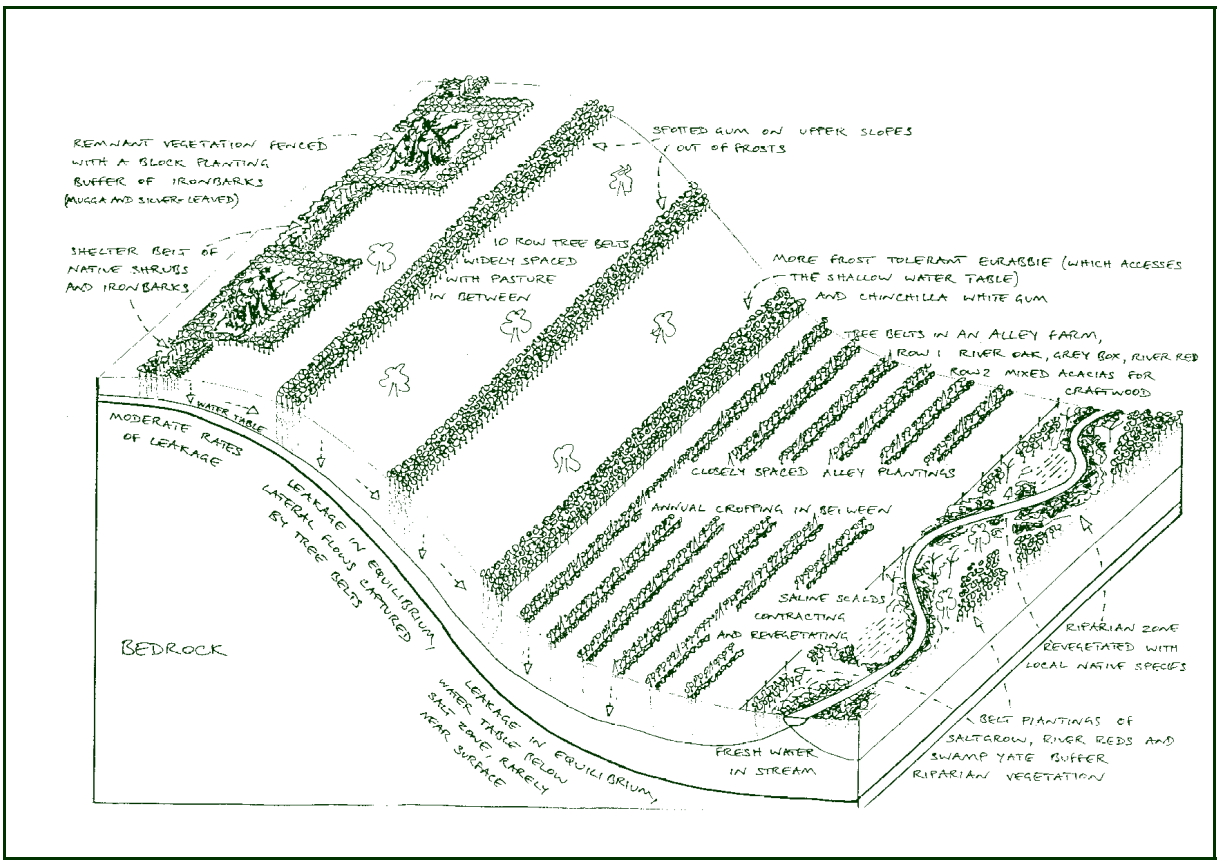


Figure 42b: The variety of farm forestry plantings possible to alleviate the salinity problem. Where a block planting, spaced belts or an alley farm configuration is most appropriate is illustrated. In all cases agriculture and timber production co-exist to optimise economic and environmental benefit.

Salinity control in practice

At the current state of knowledge it is not possible during the planning stage for a landholder in the Northern Inland to gauge the exact proportion of trees for the landscape and where farm forests should be strategically located on the property to control recharge and balance water use precisely. This is so even with access to appropriate ground-water experts and suitable technical measuring and modeling equipment. Designing and conducting farm forestry to control salinity must be an evolving process using an adaptive management approach. In practice, landholders will first address areas where a salinity/alkalinity issue concerns them or is directly impacting on farm productivity. The following paddock level approach is suggested:

1) Seek expert advice on the type of groundwater flow system operating in your landscape and the possibility of influencing recharge using farm forestry plantings;

2) Identify the recharge areas and any discharge sites that may benefit from interception plantings;

3) Investigate the likely leakage rates of your current agricultural enterprise on the recharge area – (see Ringrose-Voase,*et al.* 2002, Martin (ed), 2002);

4) Review any information on the water use of the trees you intend using. [Water use of forests have been estimated at 1000 to 1400mm/year in southern Australia where water is unlimited, (Stirzacker, *et al.* 2002), but may be much less than this if rainfall or access to the water table is very episodic];

5) Estimate the proportion of tree cover required in recharge control areas, balancing the leakage rates of the agricultural enterprise against the expected water use of the trees in excess of rainfall;

6) Estimate the configuration of the forestry plantings that might be suitable for the paddocks slope, soil type and groundwater flow system (see Stirzacker, 2002; and SKM, 2003);

7) Establish appropriate monitoring sites to measure depth to the water table;

8) Establish some 'test' farm forests under the best bet configurations your research has indicated;

9) Monitor trends in the water table height; and

10) Adjust the planting configuration accordingly bearing in mind that the water use of the trees will increase as the trees grow towards maturity and/or the basal area limit of the site.

Funding for salinity control

Salinity is one of the most significant natural resource management issues currently facing Australian society. Its control is a funding priority of both state and federal governments, particularly for the Murray-Darling basin. A core element in the current catchment planning investment blueprints for each of the three inland catchments of our region (soon to be managed by two Catchment Management Authorities) is to encourage land use practices to improve recharge control. Farmers embracing the appropriate establishment of farm forests in high salinity hazard landscapes are likely to be able to take advantage of significant government incentives for this activity in the near future.

14. Co-operative Farm Forestry

The biggest bane to farm foresters is the lack of economies of scale in timber production and therefore the lack of competitiveness with large-scale producers in timber commodity markets. Selecting niche markets and conducting intensive production of high value products goes some way towards overcoming this basic problem. However, even niche and high quality markets can be quite large, and issues such as continuity of supply and minimum harvest volumes can make marketing by small producers difficult. The solution is for small growers to band together and form co-operatives or farm forestry networks.

The marketing advantages of farm forestry networks or co-operatives include:

1) Allowing aggregation of smaller sale lots and the opportunity to match continuity of supply with customer requirements;

2) Improving the opportunities to market low quality products/thinnings and final harvest logs;

3) Allowing collective bargaining power as a supplier of timber products (optimising prices received);

4) Providing opportunities to form alliances with processors, and/or exploring opportunities for capturing returns from timber processing or value adding (optimising marketing opportunities and prices received); and

5) Allowing collective bargaining and amassing a critical mass of resource to improve the capture of any potential returns from environmental credits (eg. salinity or carbon credits).

Operating collectively also provides other advantages in addition to better marketing including :

1) Allowing members to collectively bargain for Natural Resource Management funding from catchment management organisations or other funding bodies to establish farm forests – (minimising establishment costs, improving environmental and adjacent land use benefits);

2) Collectively acquiring appropriate establishment, silvicultural and harvest machinery (minimising establishment costs, silvicultural costs and harvesting costs);

3) Providing a forum for members to pass on their experiences with:– species selection, establishment practices, spacing on different sites, timing of and extent of pruning and harvest practices (i.e. allows collective Research & Development); and

4) Improving opportunities for training eg. group courses such as Master Tree Growers, forest inventory and silviculture, and sawing, processing and wood technology.

Farm forestry networks currently exist in each Australian State and Treegrower co-operatives trade in Queensland (3), Victoria (3), Tasmania (1), South Australia (1) and Western Australia (1) (Gill, 1999). Gill (1999) details the procedures for forming and operating Treegrower Co-operatives in Australia.

15. In Summary - tips for making it all pay

- Timber production systems aimed at producing high value products are likely to be the most suitable for the majority of farm foresters of the Northern Inland.

- Design plantings to control land degradation and to integrate into agricultural production – multiple returns are then possible from farm forestry plantings. Timber only returns compare poorly with agriculture in medium to low rainfall areas of the region, large plantation style timber production systems that displace agriculture are not recommended. Plantings based on small blocks, belts, and alley farms or wide-spaced plantings are more likely to complement agriculture.

- Target the production of the fattest, longest, straightest logs with no or low defect levels.

- Wherever possible, select proven species known to the market place to form the basis of farm plantings. Only a small range of species appears suitable for planted farm forestry in the region at this stage. The most suitable includes River Red Gum and Mugga Ironbark for the slopes and plains and Radiata Pine and Shining Gum for the tablelands.

- Restrict the number of different species planted; diversity needs to be balanced against critical mass of supply.

- Correct management of the establishment phase is critical to the success and viability of tree plantings for farm forestry. Good establishment in the Northern Inland requires long fallows, well-prepared planting beds and, above all, **effective weed control**.

- Effective management of stands is required post planting, appropriate thinning and pruning will need to be practiced to ensure the fast growth of the target log.

- Long, dense, even and tall belt plantings make the best shelterbelts.

- Farm forestry plantings can assist in biodiversity conservation on farms, particularly where they are used to buffer small pockets of remnant vegetation or narrow corridors of remnant or revegetated habitat.

- Plantings designed for recharge control in high salinity hazard landscapes offer considerable benefits to farmers and their landscapes. Such plantings are the most likely to attract financial incentives from funding bodies for natural resource management objectives.

- Gang up! Individual farm foresters are small suppliers of timber and face considerable marketing challenges in terms of harvest scale and continuity of supply. This can be resolved by working co-operatively with many other farm foresters, either by forming farm forestry networks or tree grower co-operatives.

16. Glossary

Basal area - the cross-sectional area of a tree at breast height (1.3m above the ground). Basal area is usually given for a stand of trees and is expressed in m^2/ha. This represents the total of the basal areas of all trees in a stand.

Basal area limit - any given site has a maximum basal area that it can sustain irrespective of the number of trees per hectare. The basal area limit can be reached with a large number of small trees or a smaller number of large trees. The basal area limit is determined by rainfall and site quality.

Cutting or harvest cycle - the period of time between major harvesting events in a stand. For plantings that are clearfelled, it represents the time taken from planting to harvest.

DBH - diameter at breast height (1.3m above ground level).

Fully Stocked - when a stand is fully stocked it has reached its growth potential and the basal area limit for the site. Growth on any particular tree can only come at the expense of other trees in the stand. To get appreciable growth the stand needs to be thinned and the basal area reduced.

Genetic pollution - relevant in a planted farm forestry context where superior provenance trees (for timber production) are brought into a farm landscape that has its own local population of native trees. Refers to the transfer of genes (i.e. by cross-pollination) from the brought in trees to the local trees. This occurs when the forestry species either is the same species as the local trees, or is a closely related species and hybridisation is possible. The risk is that the imported genetic material will swamp or weaken the local gene pool of a species and contribute to a decline in biodiversity.

Internal rate of return - The discount rate at which the net present value (see glossary) of an investment equals zero. An investment is considered worthwhile if the internal rate of return exceeds the governing discount rate (usually predicted CPI or some long term secure interest rate but can be any rate set by the investor) over the term of the investment.

Net Present Value (NPV) - the sum of all future cash flows from an investment, discounted back to the present day value using a discount rate equal to the required rate of return. The cash flows used are net cash flows (i.e. revenues less annual operating costs, less initial capital outlay). Essentially, it determines whether or not the investment in an asset (e.g. the costs of establishing and managing a plantation) will add to the current level of wealth. If the NPV is positive, it is generally deemed that the asset investment is worthwhile, while if NPV is negative, the investment is not worthwhile.

Rotation - the number of years it takes to grow a stand to the required tree size or maturity.

Stand - a group or planting of trees with sufficiently uniform characteristics to be considered a discrete management unit.

Stocking - the number of trees per unit area (no./ ha).

Transmissivity - refers to the ability of a soil landscape to allow the movement of water through it. Slope and soil texture and structure determine the level of transmissivity. Heavy soils on low slopes transmit water slowly, light soils on steep slopes transmit water rapidly.

17. Index of Appendices

Appendices occur on the Compact Disc (in pocket inside back cover)

A) Executive Summary: Optimising the Growth of Farm Planted Trees - A survey of farm tree and shrub plantings of the Northwest Slopes and Plains and Northern Tablelands of NSW.

B) A summary of the main findings of the NHT funded "Northern Tablelands Farm Forestry Project".

C) Economic Aspects of Growing Softwood Plantations on Farms in the New England Region.

D) Farm Forestry Legislation.

E) Timber product specifications for Northern NSW.

F) Common defects of logs and wood.

G) Designing Farm Forestry Systems: A framework for the development of appropriate farm forestry and agroforestry designs by Peter Stephen and Rowan Reid. Greening Australia Field Notes, 2/00, March 2000.

H) A summary of the species and site establishment trials established at Manilla, Tamworth, Wallangra and Wee Waa as part of the NHT funded "Native Species Industries" Project.

I) A summary of the NHT funded "Low Rainfall Farm Forestry on a Landscape Scale" project.

J) Nurseries and seed collectors from the North West of NSW - Contact Information.

K) How to Collect Native Tree Seed Easily.

L) Indicative Costs of Tree Establishment on Farms of the Northern Inland of NSW.

M) Thinning Hardwood Plantations - A Guide for Northern NSW.

N) Pruning Schedules for *Pinus radiata*, Eucalypts, Acacias and Casuarinas for Southern Australia, by Bird,*et al*. 1996.

O) Pruned Stand Certification.

P) Insect Pests of Farm Forestry Plantings.

Q) Species Selection for Farm Forestry on the Northern Tablelands, Slopes and Plains of NSW by David Carr, Greening Australia Field Notes, 98/3, December 1998.

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Internet resources

Australian Forest Growers - http://www.afg.asn.au.

Australian Government Department of Agriculture Forestry and Fisheries – http://www.affa.gov.au (follow the links to forestry).

Australian National University Market Reports - http://sres.anu.edu.au/associated/marketreport/index.html

Rural Industries Research and Development Corporation - http:// www.rirdc.gov.au (follow the links to Agroforestry and Farm forestry).

CSIRO Division of Forests and Forest Products – http://www.ffp.csiro.au.

NSW State Forests – http://www.forest.nsw.gov.au.

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