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

Appendix A

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May 2004

OPTIMISING THE GROWTH OF TREES PLANTED ON FARMS -

A survey of farm tree and shrub plantings of the Northwest Slopes and Plains and Northern Tablelands of NSW

NHT Funded Project No. DD1309.97
Final Report

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November, 2000

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EXECUTIVE SUMMARY

Greening Australia has recently completed a Natural Heritage Trust funded survey of farm tree plantings across the Northern Tablelands and Northwest Slopes and Plains.

The aim of the survey was to determine with greater confidence the:
1) species best suited to a site;
2) best practice ground preparation and establishment technique for plantings;
3) likely growth rates of various species on different sites; and
4) the species with greatest potential for farm forestry.

A total of 57 plantings from 13 farms on the Northern Tablelands and 62 plantings from 27 farms on the Northwest Slopes and Plains were examined during the survey. At each planting a representative sample of each tree and shrub species were measured for height and diameter growth, survivorship and proportion good form (timber species only). The site characteristics (e.g. soil type, slope position, altitude) were also recorded at each planting along with the ground preparation and planting techniques used by the landholder.

Average height growth rate was the variable used in most cases as the performance indicator. Average height growth and all other measures of growth were found to be closely related. Unfortunately there were few accurate measures of survivorship for this variable to be reliably used and this represented a limitation to the study.

To indicate the likely relationships between site and management variables and the growth rates of planted trees, data for the three most common species from the Northwest Slopes and Plains and the three most common species from the Northern Tablelands were examined statistically. Individual tree species data sets were compiled and then subjected to simple multi-variate statistical investigation. The data sets contained all site and management variables collected during the survey.

During data analysis many examples of confounding effects were found. This, along with the high variability in the data, made it difficult to accurately identify the management and site variables which were most important in predicting optimal tree growth. Therefore, conclusions or recommendations stated in this report have only been made where:

1) comparisons were made using a sufficiently large data set (i.e. information from many plantings and several different landholders);
2) trends were consistent across species or categories of a parameter being examined; and, where possible,
3) the results are supported from observations known from the literature or from generally accepted anecdotal evidence.

Species and site factors

The relative performance of the more frequently planted tree and shrub species planted on farms of the Northwest Slopes and Plains and Northern Tablelands are tabulated below.

Common Name	Botanical Name	N	Average Growth Rate cm / yr	Max. Growth Rate cm / yr	% Good Form	Average Annual Increment cm / yr / stem	Max. Ann. Increment
Northwest Slopes and Plains Species							
River Red Gum	*E. camaldulensis*	35	94	250	36	1.5	3.7
Mugga Ironbark	*E. sideroxylon*	21	85	213	25	1.6	3.3
River Oak	*Casuarina cunninghamiana*	20	84	173	57	0.9	2.8
White Box	*E. albens*	18	77	175	13	1.4	2.6
Yellow Box	*E. melliodora*	14	77	183	20	1.7	3.5
Sugar Gum	*E. cladocalyx*	10	72	187	27	0.5	1.1
Spotted Gum#	*Corymbia variegata/ maculata/ citriodora*	12	71	209	25	1.6	4.4
Northern Tablelands Species							
Radiata Pine	*Pinus radiata*	16	104	167	93	1.8	3.3
Mountain White Gum	*E. dalrympleana*	20	79	167	28	1.4	2.6
Snow Gum	*E. pauciflora*	28	76	210			
Silver Wattle	*Acacia dealbata*	34	76	210	48	1.4	3.3
Ribbon Gum	*E. viminalis*	34	70	167	28	1.4	2.8
Fern-leaved Wattle	*A. filicifolia*	18	66	179	43	1.4	2.6
Wattle-leaved Peppermint	*Eucalyptus acaciaformis*	22	65	143			
Black Sally	*E. stellulata*	25	61	143			
Leightons Green Cypress	*Cupressocyparis leylandii*	18	49	95			
Red-stemmed Wattle	*A. rubida*	26	44	100			

N = number of plantings from which data was recorded
# data amalgamated for these closely related species

On the Northwest Slopes and Plains river red gum *Eucalyptus camaldulensis* was the most consistent species in terms of high survivorship (even on sites with little ground preparation) and growth rates. It was also the most frequently planted species.

Few significant associations between site variables and tree growth rate were evident from the Northwest Slopes and Plains data , only the growth rate of mugga ironbark was found to be associated with site factors. The growth rate of this species was positively associated with a landform / rainfall gradient from the slopes to out onto the flood plains - growth rate was on average higher on the plains than the slopes and probably reflects the impact of soil quality (better soils on the flood plains) and possibly altitude.

On the Northern Tablelands the exotic radiata pine *Pinus radiata* was on average the fastest growing tree species both in terms of height growth and diameter increment. Several eucalypts, including mountain white gum *E. dalrympleana*, snow gum *E. pauciflora* and ribbon gum *E. viminalis*, and silver wattle *Acacia dealbata* also had high average growth rates, and in terms of maximum growth rates, matched or exceeded *Pinus radiata*.

Many of the species planted on the tablelands grew more slowly when planted in lower slope positions compared to mid-slope and upper slope topographic positions. Ribbon gum growth rates were significantly higher on northerly aspects compared to other aspects. Snow gum had higher growth rates on sites where drought followed planting compared to sites which had average or better rainfall years following planting. There were no significant associations found between tree growth rate and soil parent material, altitude, average rainfall of the site, or estimated site drainage.

Establishment methods

It was found that site selection and establishment methods generally influenced tree growth rates more significantly than did site physical characteristics. The following site selection and establishment factors were recorded for each planting:

- year planted
- season of planting
- whether the site was deep ripped
- soil preparation and pre planting weed control methods
- plant spacing
- length of time a site was prepared prior to planting
- land use of the site prior to planting
- machine versus hand planting
- tree guards used
- mulch used
- post planting weed control methods
- watering methods
- source of seedlings

On the Northwest Slopes and Plains there were no obvious trends in the data nor significant relationships found between the growth rate of planted trees and the following establishment factors: year planted, the use of deep ripping, machine versus hand planting, tree guards used, mulch used, watering methods and source of seedlings. There were insufficient sites utilising post-planting weed control methods to evaluate this management practice.

The season of planting was significantly associated with the growth rates of river red gum and mugga ironbark, growth rates of both of these species were higher when planting was conducted in spring compared to winter or autumn.

There was a general trend of higher growth rates for most species on sites which were prepared using a combination of herbicide and cultivation methods. This was when growth rates were compared to sites prepared using herbicide or cultivation alone or on unprepared sites. The trend was not statistically significant, however, for any species.

Growth rates of mugga ironbark were significantly positively associated with average plant spacing. This relationship was not apparent for other species.
The growth rates of most species were positively associated with the length of preparation time prior to planting (on average the longer a site was prepared and maintained as fallow prior to planting, the better the growth rate of seedlings). The relationship was statistically significant for river oak, mugga ironbark and spring planted river red gum. The relationship was, however, confounded with the relationship between tree growth rate and the variable 'landuse prior to planting ' for most species, with sites previously cropped often also having long preparation times prior to planting (both factors were associated with higher tree growth rates).

The growth rates of most species were higher on sites previously cropped or improved pasture compared with sites that were native pasture. The relationship was statistically significant for mugga ironbark and river oak.

On the Northwest Slopes and Plains a relationship between the use of tree guards and the proportion of stems growing into well-formed trees (suitable for timber) was found for eucalypts. The proportion of river red gum and mugga ironbark trees that had good form was significantly higher where seedlings were unguarded compared to trees guarded with 'gro-tubes' or milk cartons. Plantings guarded with milk cartons had the lowest proportion of trees with good form.

On the Northern Tablelands there were no obvious trends in the data nor significant relationships found between the growth rate of planted trees and the following establishment factors: season of planting, soil preparation and pre planting weed control methods (all sites were prepared in some way), machine versus hand planting and tree guards used. The source of seedlings was unknown or of mixed origin for many of the plantings surveyed and virtually all sites were deep ripped. There was insufficient variation in 'plant spacing' across sites and the methods of 'post-planting watering' to evaluate these management practices.

The year of planting was significantly associated with the growth rates of most species, plantings established in the late 1980's and early 1990's had tree growth rates that were lower than those planted later in the 1990's. The author interprets this relationship to have resulted from the generally improving methods of tree establishment practiced by landholders over the last decade rather than any growth curve response or age effect. Age of planting was confounded with all of the establishment methods subsequently found to be associated with tree growth rate.

The growth rates of most species were positively associated with the length of preparation time prior to planting. The relationship was statistically significant for ribbon gum, silver wattle and snow gum.

The growth rates of most species were higher on sites previously cropped or improved pasture compared with sites that were native pasture. The relationship was statistically significant for silver wattle.

The growth rates of most species were higher in plantings that were not mulched compared with sites where seedlings were mulched with sawdust. The relationship was statistically significant for ribbon gum and silver wattle, however it was confounded with the relationship between mulching and the length of preparation time prior to planting. Sites with long preparation times tended also not to have been mulched.

The growth rates of most species were higher on sites where post planting weed control was conducted compared with sites that were untreated. The relationship was statistically significant for silver wattle and snow gum.

Species with timber potential

Several of the more frequently planted and better performing tree species of the Northwest Slopes and Plains and Northern Tablelands surveyed during this project appear to have timber production potential.

A farm-based timber industry has yet to develop on the Northwest Slopes and Plains and Northern Tablelands of NSW. The results of the survey suggest that for the slopes and plains, timber production from river red gum, spotted gum, mugga ironbark and possibly river oak given its good form (and provided markets could be found) have considerable potential. With average diameter growth of 2cm or more per year recorded for the eucalypt species on well prepared sites, the production of a target log of 60cm diameter at breast height (dbh) is achievable in 30 years or less. Given the relatively low rainfall, growth rates of this magnitude may only be maintained with careful thinning management to optimise spacing or where sites have access to soil water additional to rainfall. Careful selection of seedling stocks with good form would also be advantageous for the eucalypts, although superior provenances or seedling stocks may already be available for river red gum and spotted gum.

On the Northern Tablelands, farm grown ribbon gum and mountain white gum have the potential to fit the existing local markets, ribbon gum being the preferred species (D. Carr pers. comm.). Considerable selection for better form would be necessary for these species. Given that the growth rates of the eucalypts on well managed sites are similar to those described above for the slopes and plains, target logs could also be achieved within reasonable harvest rotation times with appropriate spacing management. Clearwood *P. radiata* production also has potential, although industrial grade unmanaged pine may be difficult to market given the extent of national and international softwood plantation resources currently reaching harvest age. River oak and the acacias have the potential to serve niche furniture markets although the issue of borers in the acacias needs further investigation.

How some successful tree growers do it

Jack Warnock of Narrabri and John and Michelle Lynn of Glen Innes each had excellent examples of tree plantings with high average growth rates and excellent survivorship. Many of the highest growth rates recorded during the survey were found at plantings established by the Lynns and Jack Warnock.

Each of these successful tree growers believe the key to their respective tree growing achievements lie in thorough and timely site preparation prior to planting. Both growers cultivate their planting sites and maintain long weed-free periods prior to tree planting with strategic use of herbicides. Jack Warnock maintains a fallow of up to 2 years prior to planting and the Lynns approximately 12 months. Planting is conducted largely in the spring , timed to coincide with rain, and seedlings are watered in at planting. No further watering is conducted. The Lynn's incorporate gypsum at the cultivation stage on their heavy black soil. Both growers control weeds where necessary in the early years post planting with strategic shielded herbicide applications.

The attention to detail and thoroughness is a characteristic of both Jack Warnock and John and Michelle Lynn. Their efforts have resulted in high tree growth rates even in difficult planting environments and with plantings dominated by native tree and shrub species.

Birchall forestry trial

An innovative forestry trial was established in 1994 near Breeza NSW on the property 'Tathra' which is owned by Jennifer and Colin Birchall. The trial site was located on a black soil plain with a high and saline water table. The trial was designed with help from the Department of Land and Water Resources.

Unfortunately, due to circumstances beyond the Birchall's control, the planting was established in a drought year with only four to five months fallow prior to planting in April / May. Normally tree planting sites on 'Tathra' have at least a 12 months fallow period. Other problems were encountered with seedling quality and various climatic extremes over the life of the trial. The variation in seedling quality unfortunately compromised the scientific validity of directly comparing some of the species' performances measured during this project. However, the high rates of survivorship and reasonably good growth of many species, despite successive droughts and floods, highlights the suitability of the better performing species for difficult sites such as this. Species with high survivorship rates (>70%) and good growth rates included:

1) river red gum *Eucalyptus camaldulensis* sub species *albacutya*
2) river red gum *E. camaldulensis* sub species *obtusa*
3) western grey box *E. microcarpa*
4) mugga ironbark *E. sideroxylon*
5) yellow box *E. melliodora*
6) river cooba *Acacia stenophylla*

Identifiable trends from the results

It was obvious from the results of the survey that many factors influence tree growth and that many of these factors are inter-related. There were also differences in the influence of various site and management factors on the performance of different species. However, the following trends observed during this study corroborate the results of previous studies and the experience of landholders who have grown trees very successfully:

1) Management factors overall appear to influence tree performance more substantially than do physical site factors such as soil parent material, terrain and rainfall within each of the sub-regions of the Northwest (with the possible exception of the affect of lower slope position on many species performances on the Northern Tablelands).

2) Notwithstanding the above, selection of the highest soil quality site (especially on the slopes and plains) for plantings is likely to lead to higher growth performance of planted trees and shrubs.

3) Thorough site preparation and weed control is paramount to optimizing the growth of trees. The length of time the site has been prepared prior to planting appears to be important. Sites prepared with long fallows are likely to have less of a weed seed burden and have better moisture conservation (especially important for sites on the Northwest Slopes and Plains) than short fallowed sites. Such management minimises weed competition and maximises the soil moisture available to seedlings.

4) Post-planting weed control, at least for the Northern Tablelands, also appears important for optimising planted tree and shrub growth, again probably due to competition minimisation.

Relationships revealed during this study which have not been observed substantially before include:

1) The influence of season of planting on the growth rates of trees planted on the Northwest Slopes and Plains; and
2) The relationship between the proportion of eucalypt trees with good form within a planting and the type of tree guard used.

Further research and trial plantings should be conducted to confirm these relationships.

Tree and shrub establishment - Guidelines for optimising planted tree growth

The following guidelines have been developed in response to the results of this study, with the information being provided by previous studies and the proven practices of the more successful tree growers recorded during the survey.

Activity	Northern Slopes & Plains	Northern Tablelands
Site selection	Highest soil quality site available (i.e. past cropping or improved pasture sites).	As for slopes and plains but avoid lower slope positions if possible.
Deep ripping	Use where soil compaction or plough pan development is suspected or where cultivation will not be used as part of ground preparation Results from this study indicate ripping as unimportant for subsequent tree growth.	Where soil compaction or plough pan development is suspected. No information on the effectiveness of deep ripping for the Northern Tablelands was forthcoming from this study.
Ground preparation and weed control	Combination of initial physical cultivation (possibly include deep chisel plough if not ripped) to improve water infiltration and tilth for planting, plus strategic knockdown herbicide application to maintain weed-free fallow, without disturbing soil, to conserve moisture. Avoid cultivation where there is a high erosion risk and where hard setting soils are a problem.	As for the slopes and plains.
Commencement of ground preparation and length of fallow prior to planting	At least 12 months prior to planting preferably up to 24 months.	At least 6 months prior to planting preferably up to 12 months.
Season of planting	Data from this study suggest spring plantings are best (possibly early spring if heat stress or drought is a high risk) – although this needs to be confirmed by other research.	Possibly any season. No data is available for winter plantings but ensure stock is hardened.
Fertiliser	Fertilise according to soil test result as if planting a high yield crop or pasture. Especially if planting into a native pasture site. Consider gypsum application on sodic, and / or sulfur deficient and / or heavy soils. (many of the floodplain clay soils are known to be responsive to gypsum).	Fertilise according to soil test result as if planting a high yield crop or pasture. Especially if planting into a native pasture site.

Activity	Northern Slopes & Plains	Northern Tablelands

Planting method	Machine or hand plant.	Machine or hand plant.
Tree guards	If growing eucalypts for timber avoid the use of milk cartons. Use grow tubes if plantings are small scale or particularly valuable or if hare and rabbit damage is a high risk.	Carefully consider the economics of guarding large scale plantings. Tree guards may well be unnecessary if ground preparation is thorough and site, fertilser and fallow period recommendations are adhered to.
	Carefully consider the economics of guarding large scale plantings. Tree guards may well be unnecessary if ground preparation is thorough and site, fertilser and fallow period recommendations are adhered to. (ie trees will rapidly grow out of the protection of the guard). Each individual landholders pest problems need to be considered. For very large plantings perimeter netting fencing may be more cost effective than individual tree guards.	Guarding late autumn and winter plantings may improve frost protection. Guard if hare and rabbit damage is a high risk.
Mulch	Unnecessary if ground preparation is thorough, may be helpful in short fallow or weedy sites.	Avoid the use of sawdust mulch if site preparation is thorough. Otherwise as for slopes and plains.
Watering	Dependant on soil surface wetness at planting, water at planting if dry – no other watering is necessary if recommended ground preparation and fallow length have been established.	As for slopes and plains.
Post-planting management	For sites where ideal fallow length has not been established - diligent post planting weed control and possibly watering for the first 12 months will be necessary to optimise tree growth - residual herbicide application at planting should also be considered as this effectively increases the weed free period.	As for the slopes and plains, although post-planting watering may only be necessary in droughts. Post-planting weed control will improve growth rates even for sites where ideal ground preparation and fallow length has been established.