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

Appendix H

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Appendix 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.

Tamworth Species and Ground Preparation Trial

Aim

1.To compare eighteen species on their suitability for integrated farm forestry in the Tamworth, NSW district.
2. To compare 5 different methods of ground preparation to determine those most suitable for farm forestry in the Tamworth region.
3. To demonstrate spacing, pruning, thinning and management of integrated farm forestry systems for the Tamworth region.

Greening Australia (Northwest NSW) and NSW Agriculture established the trial in Tamworth, to select (and eliminate) species for use in commercial revegetation. The species for the trial were selected on a number of criteria including their ability to produce a commercial product (sawn timber, firewood, fodder, oil or farm timber); their conservation value (with a preference for local species and local provenances); their ability to survive and grow under Tamworth's biophysical conditions; and the familiarity of landholders with the species.

Since the trial was planted, a number of other species have come to our attention that may also be suitable for commercial revegetation in this region. Chinchilla white gum (*E. argophloia*), river red gum-flooded gum hybrids (*E. camaldulensis x E. grandis*), sugar gum (*E. cladocalyx*) and the locally-occurring western grey box (*E. microcarpa*) would be included in this trial if we were implementing it today.

The ground preparation trial was planned to test the differences between five methods commonly used by revegetators in the district. Deep ripping is the most widely used method, while cultivation is preferred for heavier alluvial soils. Mounding was not widely used in the district at the time of planning the trial and we intended to determine if the extra costs associated with this method were justified by faster growth, better survival, form or health. Mounding is now more widely used, partly due to observation of this and similar trials and party due to mounding equipment being more readily available.

Location
Just southeast of Tamworth located at the Tamworth Agricultural Institute

Site Description
Elevation
300m a.s.l

Slope
3^0

Landform
Mid slope in gently undulating landscape.

Aspect
East.

Original vegetation (probably)
Overstorey: *E. albens- E. melliodora* woodland.
Understorey: Grassland with Callitris glaucophylla, Brachychiton populneus, Acacia decora.

Rainfall
673 mm MAR.

Soil

The soil across the trial site is described as Red Brown Earth.

It has a medium clay topsoil, with gravel to 25mm. It is reddish in colour and the pH is slightly acid.

The subsoil is heavy red clay

Ground preparation

Ground preparation is one of the factors in the trial. Six treatments are laid out as subplots within the larger species blocks. Ground preparation treatments were applied in February 1997, by staff at the Tamworth Agricultural Institute. The treatments are summarised in Table 1.

Table 1 Ground preparation treatments Tamworth.

Number	**Ground preparation method**	**Notes**
1	Rip Mound and cultivate	Combined all three treatments.
2	Rip Mound and cultivate	Combined all three treatments.
3	Rip only	Ripped to 450 mm, single tyne.
4	Cultivate only	Cultivated with chisel plough, 1.2m wide
5	Rip and cultivate	Combined 3 & 4.
6	Mound and cultivate	Mounded with offset disk mounder with 4 pairs of disks., plus treatment 4.

Prior to planting, the stubble from the fodder crop was heavily grazed by sheep over late summer. In March 1997 after the weed control had been carried out, the paddock was sprayed with Round Up at 1.5L/100l. In late April the bare soil was sprayed with Goal at 4l/100l. This kept the soil bare until the following summer, and minimised the number of weeds present in the second year.

Establishment

Planting date
1-4 May, 1997 (Eucalypts and Casuarinas).
Sept, 1997 (Acacias)
The seedlings were planted into the prepared ground in weed-free, bare soil. The soil was wet as it rained during the whole planting time. The trees were planted with Potti-Putkis, to a depth where the root ball was just covered with soil. One-litre milk cartons supported by two bamboo stakes were used as tree guards. No mulch or fertiliser was applied at planting time. An anti-transpirant, 'Envy', was sprayed onto the foliage of the seedlings just before planting to provide protection from both frost and desiccation in the first few weeks.

The Acacias were not planted until spring to minimise the risk of deaths due to frost. The soil was moderately moist for this planting so the trees were watered manually using a trailer mounted water cart, at 2 l per tree.

In the initial plan we intended to include a seedlot of narrow-leaved peppermint (*E. radiata subsp radiata*) as a potential oil producing species. We were unable to obtain seedlings in time for planting in 1997 and 1998. In 1999 we decided to replant the vacant plots with Chinchilla white gum (*E. argophloia*). Unfortunately the ground preparation had settled down by this stage and the seedlings never thrived. At this stage we also replanted the white cypress pine (*C. glaucophylla*) plots with new seedlings to counter the high losses in this species in the first two years. The replacement seedlings have never thrived and are poor in comparison to the original seedlings

that remained in the plots, which we have left to grow on. Species 6 (*E. argophloia*) and 15 (*C. glaucophylla*) have therefore been excluded from most of the analyses in this trial. Brigalow - Species 14 (*Acacia harpophylla*) has displayed slow growth throughout the trial and was not measured in the 2002 monitoring.

Table 2 Species used and source and condition of seedlings, Tamworth Trial

Species used	Provenance	Treatment No	Nursery	Seed source	Size at planting	Health at planting	Container
Eucalyptus laevopinea	Tamworth	1	The Glasshouse,	GA collection	medium	healthy	Hiko
Acacia pendula	Edgeroi	2	Inland Botanics	Collected specifically	small	healthy	Hiko
Eucalyptus camaldulensis	Lake Albacutya	3	Inland Botanics	CSIRO	large	healthy	Hiko
Eucalyptus melanophloia	North of Wallangra	4	The Glasshouse, Inverell	Collected specifically	Medium	healthy	Hiko
Eucalyptus sideroxylon	Barrabra	5	Inland Botanics	Collected specifically	Medium	healthy	Hiko
Eucalyptus argophloia	Chinchilla bulk	6	SF NSW Gunnedah nursery	Unknown	Large	Healthy, some root constricti	Forestry tubes
Eucalyptus crebra	Pilliga forest	7	Inland Botanics	Collected specifically	Medium	healthy	Hiko
Eucalyptus melliodora	Loomberah	8	The Glasshouse,	GA collection	Large	healthy	Hiko
Eucalyptus albens	East of Narrabri	9	Inland Botanics	Collected specifically	Large	healthy	Hiko
Casuarina cunninghamiana	Macintyre River, Inverell	10	The Glasshouse, Inverell	Collected specifically	Large	healthy	Hiko
Acacia harpophylla		11	Inland Botanics	Collected specifically	Small	healthy	Hiko
Acacia implexa	Manilla	12	Inland Botanics	Collected specifically	Medium	healthy	Hiko
Eucalyptus macrorhyncha	Tamworth Hills	13	The Glasshouse, Inverell	Collected specifically	Very small	healthy	Hiko
Acacia homalophylla	Manilla	14	Inland Botanics	Colin Gyorgy, Manilla	Small	healthy	Hiko
Callitris glaucophylla	Inverell	15	The Glasshouse, Inverell	Glasshouse, Inverell	Very small	healthy	Hiko
Grevillea robusta	Mt Lindsay, Qld	16	The Glasshouse, Inverell	Petrie seeds	Medium	healthy	Hiko

Eucalyptus blakelyi	Tilbuster	17	The Glasshouse, Inverell	GA Armidale	medium	healthy	Hiko
Eucalyptus maculata		18	Inland Botanics	Unknown	large	healthy	Hiko

Trial design

The trial is a randomised split plot design with 4 replicates of 18 main plots. Within each mainplot there are six subplots. Species are assigned to the mainplots and ground preparation is assigned to the subplots. Each mainplot has 36 trees in 6 rows of 6, while each subplot makes up one row of 6 trees within each mainplot.

Weed control post planting

The residual chemical applied before planting (Goal) kept the planting rows relatively weed free in the fist year and reduced the weed competition in the second year. There was an explosion of saffron thistles in the inter-row areas in the first spring after planting and in the following year. Regular slashing between rows at least once every year controlled these weeds. After three years most of the trees were advanced enough to out-compete or overshadow most weeds. In some plots after five years, the ground cover is very low due to competition from the trees.

Since 24 months from planting the space between rows has been irregularly slashed to allow access for field days and to reduce fire risk.

Fertiliser.

We applied 50 g of DAP to each tree in September 1997, using Potti-Putkis to place the fertiliser under the soil about 300 mm from the base of the tree. Another 100g DAP was applied in October 1999. No fertiliser has been supplied since.

Pruning

The trees were lightly tip pruned annually until 1999, by removing the terminal third of any shoots that appeared to be turning into heavy branches or double leaders. This treatment was applied evenly to all species, where necessary. Some heavy lower branches were removed from all *Eucalyptus camaldulensis*, Blakely's red gum*E. blakelyi,* White box *E. albens* and Yellow box *E. melliodora* trees to allow access for a tractor and slasher between the rows for site maintenance. These branches were cut back to the branch bark collar using pruning loppers or a saw.

Stem straightness and branch form results should be read with the pruning regime in mind. We considered that landholders growing these species for commercial purposes would undertake a minimum pruning regime of early form pruning and removal of low heavy branches, in order to maximise the number of trees of suitable form when selecting trees for thinning. Therefore the trial is not a comparison of species in an unmanaged state.

Monitoring

The Tamworth trial was first monitored in September 1997. The only measurement taken at this time was survival. The trial was measured for height (May, 1998, May 1999, July 2000, December 2001 and October 2002), diameter at ground height (May 1999), diameter at breast height (dbh) (July 2000, Dec 2001, Oct 2002) form (July 2000), stem straightness (Dec 2001, Oct 2002), branching habit (Dec 2001, Oct 2002) and health (Dec 2001, Oct 2002)

On all but one occasion the measurements were carried out by David Carr (Greening Australia), John Turner (NSW Agriculture Tamworth), other Greening Australia staff and volunteers from the Tamworth region and from the University of New England. In October 2002, staff from NSW State Forests and Greening Australia NSW carried out the measurements.

Height poles were used to measure height, except in October 2002 when a Vertex hypsometer was used. Diameter was measured with forestry calipers.

In 2001, stem straightness, branching habit and health were measured on a subjective scale from 1 to 5, with 1 indicating a poor result and 5 indicating a maximum score. In 2002, only stem straightness and health were recorded, using a different method with a scoring scale from 1 (poor) to 6 (excellent).

Results and Discussion

Table 3. Summary results of the 1998 and 02 tree measurements by species, Tamworth trial.

number	species	Surv 98 (%)	Surv 02 (%)	Ht 02 (m)	DBH 02 (cm)
Species comparison trial					
	Age (months)	**12**	**65**	**65**	**65**
1	Eucalyptus laevopinea	88.89	74.3	2.93	3.65
2	Acacia pendula	78.47	68.1	2.46	3.93
3	Eucalyptus camaldulensis	100	99.3	4.27	6.6
4	Eucalyptus melanophloia	87.5	86.1	4.73	6.43
5	Eucalyptus sideroxylon	95.83	91.7	4.53	6.95
7	Eucalyptus crebra	96.53	90.3	3.23	5.2
8	Eucalyptus melliodora	90.97	81.9	3.46	5.51
9	Eucalyptus albens	95.14	88.2	4.35	6.28
10	Casuarina cunninghamiana	97.92	97.2	4.4	5.14
12	Acacia implexa	74.31	71.5	3.43	4.47
13	Eucalyptus macrorhyncha	84.72	71.5	3.01	3.85
14	Acacia homalophylla	65.97	*49.1*	1.83 *	
16	Grevillea robusta	89.58	59	2.94	3.9
17	Eucalyptus blakelyi	81.94	75.7	3.84	6.59
18	Eucalyptus maculata	91.67	75.7	5.33	6.01

No single species stands out as the best after 65 months in this trial. Rather, a number of species have similar results in both height and diameter. Spotted gum *Eucalyptus maculata* (now *C. maculata* (Hook) K.D.Hill & L.A.S Johnson) was the tallest species in the trial but Mugga ironbark *E. sideroxylon* had the highest mean diameter at breast height. The other four species that have performed well in the trial are Silver-leaved ironbark *E. melanophloia, E. camaldulensis, E. albens* and *E. blakelyi. E. sideroxylon* stands out from the other species in the volume index and when volume and survival are combined. *E. camaldulensis* had rapid early height growth but slowed down after 36 months. This may have been due to competition between trees as this species had the highest survival throughout the trial.

While *E. maculata* has grown steadily throughout the trial and finished as one of the better species, it is known to be frost-prone. Temperatures at the site during the course of the trial regularly reached –7°C, but during the winter of 2002 (after the last measurement), several temperatures below –10°C were recorded. This resulted in the loss of about one-third of the crown of about half of the spotted gums (*pers comm* Helen Ward, Greening Australia). Although full crowns have since re-grown, it will be interesting to see what effect this setback has on both growth and form.

The growth of *E. sideroxylon* in this trial supports the findings of Andrews (2000) that this species consistently grows well on a range of soil types throughout the north of NSW. Andrews also found that *E. camaldulensis* and *E. albens* were also widely planted and growing well in the region. This trial further supports that belief. *E. melanophloia* has not been widely planted, either in revegetation or farm forestry blocks, yet has performed very well in this trial. Natural stands in the region are known to regenerate thickly and grow relatively quickly, but little is known about the performance of planted seedlings. The species is more widely distributed in Queensland than in NSW. It has very dense wood and is used for fencing and farm construction (Boland *et al,* 1984).

Of the top six species in this trial, *E. maculata* was significantly straighter in the stem and had lighter branching than the other five species. Any species which had a mean stem straightness score of greater than 3.5, will have at least 50% of trees suitable for sawlog production, with the remaining trees to be culled. Only *E. albens* does not meet this criterion, with a mean stem score of 2.67. If the first thinning in this trial removes 50%of trees, there will be quite a number of poorly formed trees of this species remaining.

For branch scores, trees receiving greater than 3.5 were considered to be correctable by pruning, so at least half of all of the top five species are correctable, with the exception of *E. albens*, which had a much lower mean branch form score. The moderately strong correlation (0.61) between stem and branch scores in 2001 indicate that there will be enough trees to thin to 50% and leave reasonably straight, prunable trees except for *E. albens.* The good growth but poor form of *E. albens* indicates that this species will be best suited to products where form is less important, such as fence posts, firewood, honey, bioenergy and shelter. The few trees that are straight enough to be grown on as sawlogs, could either be milled for specialised purposes such as engineering uses, or retained for seed for future plantations.

Of the other five species, only *E. maculata* will not require pruning to produce suitable trees for sawlog production. *E. sideroxylon* in this trial has a high proportion of trees with double leaders starting from the base or in the first metre from the ground. This is also the case in the Wallangra trial reported later. This would easily be corrected by pruning one stem off at the base after about three years of growth. Quite a few of the stems of this species are sinuous and should be culled at the first thinning. The remaining stems are usually of good form and based on this trial, the trees remaining after the final thinning will be of very good form, providing the current trend continues.

E. melanophloia is also prone to double leaders, which mostly start at about 3 metres above the ground. These could easily be removed if noticed early enough; a situation which makes this species more favourable for farm forestry than industrial plantations. Small branches of this species are self-pruning, but larger branches will need to be cut. From observations of this trial, only very large side shoots should be removed before the first thinning, as more than half the trees will require little or no pruning at all.

E. blakelyi and *E. camaldulensis* required regular and sometimes vicious early form pruning, but responded well with some trees having good stem and branch form at 65 months. *E. blakelyi* had a high proportion of trees with poor branching, usually as multiple large branches high in the canopy.

The second group of species in the trial, in terms of growth, contains two of the speciality timber species, River oak *Casuarina cunninghamiana* and Hickory wattle *Acacia implexa. E. melliodora* and Narrow-leaved red ironbark *E. crebra* also feature in this group. Like *E. maculata, A. implexa* is frost tender and suffered some setbacks after the severe frosts of 2002. Some smaller trees were killed outright, while the form of other will no doubt suffer in the future. *C. cunninghamiana* had excellent survival throughout the trial and is one of the tallest species in the trial. As this species naturally has a slender and elongated growing tip, the height is not a good indication of growth and the dbh and the volume index give a more realistic view. The growth habit of this species also results in straight stems in most young trees. This is reflected in this trial with the river oaks having the highest mean stem score. Occasional trees have double leaders that are

easily corrected by early form pruning. The river oaks in this trial also had the highest branching score, indicating their light branching habit, with branches mostly at obtuse angles to the stem.

E. melliodora, one of the local species, has proven to be a slow grower when compared to some of the other eucalypts. This is supported by Andrews (2000) and by observations of tree planters in the region. While yellow box is recognised as a slower-growing species, it is still a popular choice for revegetation due to the diversity of uses, particularly for fencing, firewood and honey. The form and branching habit of some trees in this trial suggest that there is potential for some to be grown as sawlogs. *E. crebra*, one of the species preferred by sawmillers in the region, has not grown well in this trial. In the wild this species mainly grows on well-drained soils derived from sandstone or granite (Boland *et al,*1984), and the stand where the seed of these trees was collected is in the sandstone country around Baradine, in the NSW Pilliga Forest. It is likely that the heavy soils at this site have impeded this species growth. The form is as good as the main Eucalypt species in this trial, as would be expected from the good form shown by natural stands of this species (Boland et al, 1984).

Of the final group, with the slowest growth, the two stringybarks (Silvertop *E. laevopinea* and Red stringybark *E. macrorhyncha*) were expected to do better, as they are rapid growers in the hills surrounding Tamworth and the Peel Valley. However, conditions in these hills are likely to be more humid and cooler than the lower slopes of the valley where this trial is located. Neither species is naturally found growing under conditions like those at the trial site. The seedlings of *E. macrorhyncha* were very small and there were many losses in the first year. The remaining seedlings may have been set back by the slow start and never reached the potential of the species. *E. laevopinea* also had relatively low survival, which is likely to have been the result of frosts in the first year of the trial. On the Northern Tablelands, *E. laevopinea* is known to be susceptible to frosts which kill trees planted in lower slope positions.

Silky oak *Grevillea robusta*, well outside its natural range in this trial, may still have some potential, given the number of large trees growing on roadsides and streets throughout the region. Its form is excellent and it appears to cope with the harsher winter climate by shedding most of its canopy in winter.

Myall *A. pendula,* with similar growth in this trial to the last three species, is a known slow grower. Height growth has been relatively slow, but diameter growth puts it into 11th rank of the 18 species in this trial. The results show that it is growing in steady annual increments, with good survival. As this species only grows to a maximum height of around 13 m, height growth should not be directly compared with the Eucalypts in this trial, which reach mature heights of 20 to 30 m. Provided it can be encouraged through form pruning to grow a small log, it has potential as a speciality species. Its tolerance of very heavy soil, makes this species useful for the floodplains in the region where many other species will not grow. The natural form of young trees in this trial shows multiple straight stems. One or two leaders can be developed from the multiple leaders by tip pruning unwanted shoots. The branches of some trees are densely intertwined, while others are light and sparse. Any plantings of this species for timber should therefore use tight initial spacing followed by early form pruning and thinning to remove those trees that are uncorrectable by pruning.

The survival of most species has been good, with 10 of the 18 having greater than 80% survival after 65 months. Most losses occurred in the first year after planting, as is common in most plantings as seedlings are most vulnerable before they have established a deep root system. The exception was *Grevillea robusta,* which had the most deaths between 54 and 65 months. This was a very dry period for the region that would have stressed this species more than others. It is likely that the very cold winter of 2002 will have caused more losses in some species.

The other species with survival less than 80% were either small seedlings when planted, or grew slowly in the first year. Small seedlings *of Callitris glaucophylla,* Brigalow *Acacia harpophylla,* Yarran *A. homalophylla, A. pendula* and *E. macrorhyncha* most likely contributed to the early deaths in those species. *Acacia implexa* seedlings were large, but as this species is susceptible

to frost, it is likely that those species that did not rapidly grow thick basal stems were killed by the frost in the first year. These results emphasise the importance of using strong, healthy seedlings, and ensuring that the preparation for planting maximises early growth.

The mean health scores are not directly comparable between years, but the relative ranking of species is comparable. Those species that had significantly lower health scores in 2001 (E. albens, E. melanophloia and E. blakelyi) are different to the unhealthiest species in 2002 (*E. macrorhyncha, E. laevopinea, E. crebra* and *A. pendula*). This may be due to the different time of year in which measurements were taken. In 2001 the trial was monitored in December, when there are large numbers of leaf-eating beetles and sawflies present. The three species with the lowest health scores are all susceptible to attack by these insects and were frequently recorded on them. In 2002 the trial was monitored in October, before populations of leaf-eating beetles had built up to sufficient numbers to cause problems for the trees. At this time the district had been in prolonged drought and there would have been some moisture stress at the site. The unhealthiest species at this point are those that come from environments where moisture is more readily available than at this site, and may have been suffering drought stress.

The results from this trial are only preliminary as they are based on trees measured at a maximum age of 64 months from planting. However, they indicate early survival and growth and can be used as an indication of the potential of the species for farm forestry in the region. *E. sideroxylon, E. maculata, E. melanophloia* and *E. camaldulensis* have the most potential for sawlog production with good growth and form. *E. albens* and *E. blakelyi* have good growth but poorer form and should not be planted purely for sawlog production. These species should be planted for other purposes and the best trees managed for timber. The six species mentioned here are also suitable for firewood, farm timber and fencing timber. With the exception of *E. maculata*, these six species are local species and will make a significant contribution to biodiversity conservation if local provenances are used.

Casuarina cunninghamiana, Acacia pendula and *A. implexa* have the most potential for specialty timber production in the region. The former species has good growth and natural form and is useful for a range of high-value, appearance grade products. It is also a valuable firewood species, giving growers an option for thinnings. The two Acacias will require some form pruning and heavy thinning to produce small sawlogs, and thinnings could be used for firewood. *A. implexa* should not be planted in lower-slope, frost-prone positions.

Of the other species, *E. melliodora* is highly recommended for multi-purpose plantings to produce firewood and fencing material, the occasional sawlog, honey and wildlife habitat. While the growth is slower than some of the other Eucalypts, it is still sufficient to warrant planting. *E. crebra* is not recommended for the clay soils of the district, it may be suitable for sites with better drainage, closer to its natural range and soil types. The two stringybarks (*E. laevopinea* and *E. macrorhyncha*) are probably unsuitable for planting in the valley floors and lower slopes of the district, although the use of small seedlings in this trial may have affected their potential.

All the species recommended from this trial would benefit from some form of selection and improvement. Provenance trials that can be converted to seed orchards or seed production areas of single provenances should be established in the region for *E. sideroxylon, E. maculata, E. camaldulensis* and *C. cunninghamiana*. Simple selection methods for these and some of the other recommended species should be able to produce significant improvements in these species for regional use. Selection may also need to take account of each species abilities to use water if these species are to be used for dryland salinity amelioration.

Ground preparation trial.

Table 4. Summary results of the 1998 and 02 tree measurements by ground preparation treatments, Tamworth trial.

Number	Treatment name	Ht 98 (m)	Surv 98 (%)	Ht 02 (m)	Surv 02 (%)	DBH 02 (cm)
	Age in months	12	12	65	65	65
Ground preparation methods						
1	Rip + Mound + Cultivate	0.88	89.72	3.62	80	5.37
2	Rip + Mound + Cultivate	0.91	89.72	3.84	80	5.66
3	Rip only	0.93	90.83	3.78	80	5.61
4	Cultivate only	0.93	89.17	3.72	80.8	5.38
5	Rip + Cultivate	0.87	89.17	3.52	77.2	5.06
6	Mound + Cultivate	0.83	79.17	3.42	68.9	4.84

The different ground preparation treatments have resulted in slightly different responses from the species in this trial. The standard ground preparation for the region is to rip in advance of planting. In this trial this method has resulted in the best survival, height and dbh in all years or responses not significantly different to the best treatments. Deep ripping has the effect of shattering the subsoil, breaking hard cultivation pans and allowing moisture and tree roots to penetrate deeper into the soil than they could in unworked soil. The response to ripping in this trial is probably due to the presence of a cultivation pan at about 150mm deep caused by many years of continuous cropping. It is likely that a similar response would be obtained in many other sites in the Tamworth district with similar soils and a history of cultivation.

The “best-practice” method of ripping, then cultivating, then mounding are also ranked in the top few treatments for survival, height and dbh at each measurement. This method requires specialised equipment not available to most landholders and requires three passes with different implements on a tractor and so will be more expensive than just ripping alone. The main advantage of the combination of ripping, cultivating and mounding is that it provides a planting medium with a fine tilth that is easy to plant into using planting tubes such as Potti-Putki’s. This would not warrant the extra expense of this method.

Cultivation alone and ripping and cultivating together have had similar results to each other with cultivation alone mostly having better survival, height and dbh than when combined with ripping. It is possible that the cultivated surface on top of the rip line provides a wick for evaporation of soil moisture from the rip line, resulting in less moisture available to the tree and hence lower growth and survival than in soil that is just cultivated. Cultivation alone may encourage the tree roots to go wide rather than deep giving access to more moisture when it is available, however, this does not explain the relatively good survival of trees planted on this treatment under the drought conditions of 2001-02.

Cultivating the soil followed by mounding has consistently resulted in trees with the worst survival, dbh and height in the trial. This has also been observed in other plantings where survival has been very low using this form of ground preparation. It is likely that the tree roots are encouraged to initially explore the soft and fertile soil of the mound rather than go deep in search of moisture. If there is dry phase before they have reached the soil below the mound, the mound may dry out completely leaving the young seedling with insufficient moisture to support its leaf area. This may be exacerbated by the rapid early growth of the shoot as the tree exploits the extra nutrients available in the mound. When this method is combined with deep ripping it is likely that the roots explore both the mound and the extra moisture of the rip line. The mound also acts as mulch to hold soil moisture in the rip line and prevent evaporation of deep water to the surface, as appears to be the case with ripping and cultivation together.

It is interesting to note that while the treatments are significantly different, the differences are mostly small. The difference between treatments for height, survival and dbh is growing larger each year, so the slight differences may be quite substantial by the time the trees are mature. From this trial, I recommend that the practice of ripping is continued for similar soils in the Tamworth area and that mounding is reserved for the heavier black soils. Andrews (2000) found that the longer the ripping is done in advance of planting (up to two years), the better the tree growth. Mounding with cultivation should only be used in conjunction with ripping for best results.

Manilla species and ground preparation trial

Aim
To compare a range of species and ground preparation methods for agroforestry on the NorthWest Slopes of NSW.

Trial type
Split plot randomised complete block. Plots were established with 30 trees of each species and subplots were allocated on ground preparation treatments

Site Description
Elevation
440 m a.s.l

Slope
5^{0}

Landform
Side of a hill, mid-slope.

Aspect
East.

Original vegetation
White Box (*E.albens*) woodland with *Callitris glaucophylla, Brachychiton populneus, Acacia implexa, Bothriochloa macra.*

Rainfall
692 mm MAR.

Soil
The soil at the site is described as “Red-Brown Earth”. It is highly erodible and prone to compaction.

Site preparation
The site was selected in 1997 after a public call for sites, followed by site visits. The site is fenced in a large paddock and separated within this paddock by temporary electric fencing to exclude sheep.

The ground cover prior to planting consisted of native grasses, mainly *Bothriochloa macra*. The strips to be planted were sprayed out with glyphosate at the recommended rate in a 1.2 m wide band. The inter-row strips were not sprayed to avoid the risk of erosion.
Ground preparation

The site was prepared in accordance with the trial objective of testing different methods. Three different methods were used, each on two of the six rows in each replicate. Methods were in different combinations in each replicate. Two rows were ripped to 400mm deep using a single-

tyne ripper. Two rows were ripped to 400 mm and then cultivated with a multiple-tyne cultivator. The remaining two rows were ripped and cultivated and then mounded with an eight-disk mounding plough to form a low broad mound (400 x 1000mm). All ground preparation was carried out by the landholders using an 80hp tractor.

Establishment
Planting date 29th May 1997

Table 5. Species used and source and condition of seedlings, Manilla trial

Species used	Provenance	Treatment number	Nursery	Seed source	Size at planting	Health at planting	Container
Silvertop stringy *Eucalyptus laevopinea*	Tamworth	1	The Greenhouse, Inverell	The Greenhouse, Inverell	Medium	Good	Hiko
Myall *Acacia pendula*	Edgeroi, NSW	2	Inland Botanics	Inland Botanics	V. small	Poor	Hiko
River red gum *E. camaldulensis*	Manilla weir	3	Inland Botanics	GA collection	Tall	Good	Hiko
Silver leaf ironbark *E. melanophloia*	North of Wallangra	4	The Greenhouse, Inverell	The Greenhouse, Inverell	Tall	Good	Hiko
Mugga ironbark *E. sideroxylon*	Barrabra	5	Inland Botanics	Inland Botanics	Medium	Excellent	Hiko
Narrow-leaved Ironbark *E. crebra*	Pilliga forest	7	Inland Botanics	Inland Botanics	Medium	Excellent	Hiko
Yellow box *E. melliodora*	Loomberah	8	The Greenhouse, Inverell	The Greenhouse, Inverell	Tall	Good	Hiko
White box *E. albens*	10km E of Narrabri on Kaputar Rd	9	Inland Botanics	Inland Botanics	Tall	Excellent	Hiko
River Oak *Casuarina cunninghamiana*	Macintyre river, Inverell	10	The Greenhouse, Inverell	The Greenhouse, Inverell	Medium	Good	Hiko
Brigalow *A. harpophylla*	Narrabri	11	Inland Botanics	Inland Botanics	Small	Average	Hiko
Hickory wattle *A. implexa*	Manilla	12	The Greenhouse, Inverell	The Greenhouse, Inverell	Medium	Good	Hiko
Red stringy *E. macrorhyncha*	Tamworth Hills	13	The Greenhouse, Inverell	The Greenhouse, Inverell	Small	Average	Hiko
Yarran *A. homalophylla*	Manilla	14	Wildline nursery	Wildline nursery	V. small	Average	Hiko
White cypress *Callitris glaucophylla*	Inverell	15	The Greenhouse, Inverell	The Greenhouse, Inverell	V. small	Good	Hiko

Maintenance

No weed control was carried out after planting. The native grasses were slow to come back after the initial control, and were not considered to be causing serious competition to the trees after the

first year of growth. Given the sites erosion risk, we considered it important to leave the grass cover in place.

Thistles, nettles and other opportunistic weeds appeared in the first year of the trial and caused some losses due to competition.

Monitoring

The Manilla trial was monitored on 2/6/98, 14/5/99 and 24/10/2002. On each occasion the height of the trees was measured (height pole in 1998 and 1999, and a vertex hypsometer in 2002). In 2002 diameter at breast height was also measured.

Results/ Discussion

Table 6 shows the height and diameter of species over the years monitored and survival after 1 year (losses were relatively small in subsequent years for most species). Table 7 summarises the results of the different ground preparation treatments. Table 8 shows the results of the stem straightness scores and health scores for species in 2002.

Table 6. Initial survival, height and diameter growth – Manilla Trial

Species	**Survival (%) 1998**	**Height (m) 1998**	**Height (m) 1999**	**Height (m) 2002**	**DBH (cm) 2002**
Eucalyptus laevopinea	67	0.64	1.5	5.26	7.53
Acacia pendula	*	*	0.29	*	*
Eucalyptus camaldulensis	80	1.05	2.08	3.85	5.52
Eucalyptus melanophloia	82.5	0.78	1.49	4.38	5.9
Eucalyptus sideroxylon	92	0.98	1.55	4.17	6.07
Eucalyptus crebra	87	0.76	1.13	2.52	4.09
Eucalyptus melliodora	66	0.73	1.2	3.53	6.01
Euca;yptus albens	94	0.74	1.18	2.62	3.79
Casuarina cunninghamiana	83	0.8	1.25	4.91	6.52
Acacia harpophylla	42	0.23	0.41	*	*
Acacia implexa	77.5	0.57	1.13	3.86	5.32
Eucalyptus macrorhyncha	68	0.68	1.23	3.98	6.59
Acacia homalophylla	65	0.32	0.64	*	*
Callitris glaucophylla	37	0.19	0.35	*	*

Table 7 Tree growth relative to ground preparation method – Manilla Trial

Ground preparation method	**Ht (m) 1998**	**Ht (m) 2002**	**DBH (cm) 2002**
Rip, mound and cultivate 1	0.75	4.14	6.57
Rip, mound and cultivate 2	0.71	4.42	6.23
Rip and cultivate 1	0.66	3.86	5.91
Rip and cultivate 2	0.66	3.65	5.7
Rip only 1	0.57	3.39	4.35
Rip only 2	0.57	3.35	4.94

Table 8: Stem straightness and health scores for different species in October 2002. Scores range from 1 for poor to 6 for excellent.

Species	Stem score 2002	Health score 2002
Eucalyptus laevopinea	4.66	5.28
Casuarina cunninghamiana	4.23	5.26
Eucalyptus macrorhyncha	3.72	4.6
Eucalyptus melanophloia	3.72	4.5
Eucalyptus camaldulensis	3.45	4.09
Eucalyptus crebra	3.32	3.23
Eucalyptus sideroxylon	3.22	4.51
Eucalyptus melliodora	2.5	4.46
Eucalyptus albens	2.22	3.24

While *E. camaldulensis* was the tallest species after one years growth, it was ranked seventh in 2002, with *E. laevopinea* being significantly taller than all other species. *E. laevopinea* also had the greatest dbh in 2002. *E. laevopinea* also had both the highest stem straightness score and the highest health score. As for the Tamworth trial a number of species made up the top group in terms of overall performance. This group included the better performers at Tamworth ie. *E. sideroxylon, E. melanophloia* and *E. camaldulensis*. Unlike Tamworth however the stringybarks performed well (apart from lower survival after the first year), to the point where *E. laevopinea* was the best performing species by 2002. Red Stringybark *E. macrorhyncha* also performed well and by 2002 had the second largest mean dbh slightly more elevated position of the site and possibly lighter soil may well have better suited the stringybarks. *C. cunninghamiana* again performed well in terms of height and form however unlike the results from Tamworth its diameter growth was equal to many of the better performing eucalypts.

The ground preparation treatment “rip, mound and cultivate”, resulted in the best height and dbh growth in all years measured. There was little difference between the other two treatments, “rip only” and “rip and cultivate” but a general trend was apparent with better tree growth associated with increasing level of ground preparation. There were no significant differences in survival between ground preparation treatments in all years.

Wallangra species and ground preparation trial

Aim
1. To test the performance of 20 species with potential for integrated farm forestry in the northern part of the NSW North West Slopes.
2.To compare different ground preparation methods for use in agroforestry and environmental tree plantings.
3. To demonstrate spacings, species, methods and management appropriate for integrated farm forestry in northern NSW.

Trial type
Randomised complete block with mainplot/splitplot factorial design.

Location

Nearest towns: Wallangra (10 km), Inverell (major town 40 km SSE)

Elevation
470 m a.s.l

Slope
3%

Landform
Mid to lower slope in gently undulating landscape. Lower slope just above creek flats.

Aspect
North

Original vegetation
Overstorey: *E. albens- Angophora floribunda* woodland.
Understorey: Grasses, *Callitris glaucophylla, Maireana microphylla, Pimelea neo-anglica*.

Rainfall
770mm MAR (from property records).

Soil

The soil at the site is broadly described as black self-mulching clay. It is alluvial in origin and has some fine sand mixed with it from soil washed from the deep sandy country further up-slope. The clay is derived from Quaternary basalt rocks and the sand fromTriassic sandstone deposits.

David Carr (GAL) and Helen Ward (GANSW) undertook soil tests in December 2001. Three holes were dug to a depth of 1700mm with a 100mm hand auger.

The soil test results fit with the landholder Tim Robinson's description of the soil as "two foot of good black soil over white rotten rock".
Tim believed there was salt below the site but could not say at what depth or concentration.

Ground preparation

As ground preparation is one of the factors in the trial (represented in the subplots), this stage was carried out very carefully. After the site was selected in October, 1996 the area for the trial was sprayed out with MCPA and Round-Up to remove weeds.

The five ground preparation treatments are allocated to six rows in each replicate. They are; 1. Rip, mound and cultivate (repeated); 2. Rip only; 3. Cultivate only; 4. Rip and cultivate, and; 5. Mound and cultivate.

Ripping was carried out with a single-tyne rabbit ripper drawn behind a bulldozer to a depth of 450 mm. This was followed by cultivation (where indicated) using a multiple-tyne cultivator, 1.2m wide, which was drawn behind a tractor. The mounding was carried out last, by a grader pushing up soil from both sides of the planting line to form a mound approximately 800mm wide and 400 mm high. These mounds quickly settled to a height of approximately 300mm.

The common practice in the area for tree establishment in self-mulching black soils is to repeatedly cultivate to prepare a fine tilth and to remove weeds. This is similar to the practice undertaken for crops.

Establishment

The trial was planted over the course of several weeks in November 1996. Greening Australia staff and volunteers, including students from Inverell High School, planted the trial. Potti-Putki planting tubes were used. The trees were protected from rabbit browsing, dry winds and frost by one-litre milk carton tree guards supported by two bamboo stakes.

Seedlings

Table 9. Species used and source and condition of seedlings, Wallangra Trial

Species used	Provenance	Treatment number	Nursery	Seed source	Size at planting	Health at planting	Container
Eucalyptus sideroxylon		1	Inland Botanics			Healthy	Hiko
Casuarina cristata		2	Inland Botanics			Healthy	Hiko
Acacia pendula		3	Inland Botanics			Healthy	Hiko
Eucalyptus albens		4	Inland Botanics			Healthy	Hiko
Eucalyptus laevopinea		5	Darrell Priest, The Glasshouse, Inverell.			Healthy	Hiko
Acacia melanoxylon	Crawney Pass, Nundle, NSW	6	Darrell Priest, The Glasshouse, Inverell.	GA collection		Healthy	Hiko
Acacia homalophylla	Manilla	7	Darrell Priest, The Glasshouse, Inverell.	Colin Gyorgy, Manilla	Very small	Healthy	Hiko
Brachychiton populneus	Inverell	8	Darrell Priest, The Glasshouse, Inverell.	The Glasshouse	Very small	Healthy	Hiko
Acacia melanoxylon	*'Smithton,* Tasmania*'*	9	Darrell Priest, The Glasshouse, Inverell.	CSIRO ATSC		Healthy	Hiko
Eucalyptus macrorhyncha	West of Inverell on Warialda rd.	10	Darrell Priest, The Glasshouse, Inverell.	Collected for trial	Very small	Stressed	Hiko
Casuarina cunninghamiana	Gwydir river, Bundarra	11	Darrell Priest, The Glasshouse, Inverell.	Collected for trial		Healthy	Hiko
Eucalyptus cladocalyx	'Nana'	12	State Forests of NSW Inverell nursery	Bulk seedlot selected for bushiness.		Healthy	Square forestry tubes.
Eucalyptus crebra	Pilliga Forest, Pilliga-Baradine rd	13	Inland Botanics	Collected for trial		Healthy	Hiko
Eucalyptus camaldulensis	Macintyre river, Inverell	14	Darrell Priest, The Glasshouse,	The Glasshouse		Healthy	Hiko

			Inverell.				
Eucalyptus melliodora		15	Darrell Priest, The Glasshouse, Inverell.			Healthy	Hiko
Callitris glaucophylla		16	Darrell Priest, The Glasshouse, Inverell.	Inverell LEAP team	Very small	Healthy	Hiko
Acacia implexa		17	Darrell Priest, The Glasshouse, Inverell.	Inverell LEAP team		Healthy	Hiko
Eucalyptus melanophloia	20km N of Wallangra	18		Inverell LEAP team		Healthy	Hiko
Eucalyptus bicostata	Winterbourne	19		Nick Cobcroft,		Healthy	Hiko
Grevillea robusta	NE NSW	20		Bulk seedlot,		Healthy	Hiko

Trial design

The trial design is a randomised split-plot design that has 20 species in main- plots and six ground preparation methods in sub-plots. There are four replicates, with each replicate forming a line of plots parallel with the next replicate. Each plot has 36 trees in six rows of six.

Maintenance

The grass and weeds around each tree were sprayed with glyphosate herbicide in a radius of 1 m in summer 1997 and 1998. The spaces between the rows were also slashed prior to a field day in 2000. During monitoring in 1997 and 1999, a few trees were also hand-weeded where there were particularly bad weeds present.

Monitoring

The trial was monitored in November 1997, Nov 1998, June 1999, December 2001 and February 2003. Some of the results from the 1999, 2001 and 2003 monitoring are presented here. In the two most recent monitoring events, the trees were measured for height (m), dbh (cm) and survival (as a function of recording height) and scored on the basis of stem straightness, branching habit and health. Other observations were recorded about insects or diseases present, damage from wind or animals, and presence of weeds.

In December 2001 and February 2003 we used an 8m telescopic height pole and forestry calipers.

Not all species were monitored in each year, due to a lack of time and to the fact that some species were clearly not performing well at the site. Species 10 (*E. macrorhyncha*), Species 7 (*A. homalophylla*) were planted as small seedlings and had poor growth and low survival as a result. Species 5 (*E. laevopinea*), 8 (*Brachychiton populneus*), 17 (*A. implexa*) and 20 (*Grevillea robusta*) also had poor survival and were not measured in 2003. Species 16 (*Callitris glaucophylla*) has grown slowly so we have only measured its height and survival so far.

Results

A summary of the results from the monitoring undertaken in 2003 is presented in Table 10. Only survival results from the 1999 monitoring are presented. Table 11 summarises the mean performance indicators by ground preparation treatment.

Table 10. Mean tree performance indicators by species, Wallangra trial. (* = not monitored)

Species	Species name	Survival 99	Hgt 03 (m)	DBH 03 (cm)	Survival 03 (%)	Stem straightness 03	Branching score 03	Health score 03
19	Eucalyptus bicostata 'Winterbourne'	41.7	8.4	11.37	40.97	5.22	4.73	5.11
1	Eucalyptus sideroxylon	66.7	7.59	12.6	63.89	4.87	4.25	5.06
15	Eucalyptus melliodora	59.7	7.34	11.59	45.14	4.42	3.51	4.84
18	Eucalyptus melanophloia	87.5	5.81	7.71	80.56	4.44	4.27	4.66
4	Eucalyptus albens	66.7	5.79	8.54	56.25	4.14	3.59	4.41
12	Eucalyptus cladocalyx 'Nana'	41.7	4.64	8.94	25	3.74	3.15	4.83
11	Casuarina cunninghamiana	81.2	4.31	4.79	83.06	5.1	4.56	4.97
13	Eucalyptus crebra	76.4	4.29	7.09	68.06	4.78	4.28	4.87
9	Acacia melanoxylon 'Smithton'	45.8	4.2	8.69	20.14	4.62	3.29	4.18
3	Acacia pendula	66.7	3.68	6.38	63.98	3.85	2.89	4.97
2	Casuarina cristata	65.3	3.49	4.23	46.53	4.49	3.77	5.04
14	Eucalyptus camaldulensis	70.8	2.79	4.39	50.69	1.98	1.94	3.23
16	Callitris glaucophylla	49.3	2.18	*	43.75	*	*	*
5	Eucalyptus laevopinea	9	*	*	2	*	*	*
6	Acacia melanoxylon 'Crawney'	48.6	*	*	10	*	*	*
7	Acacia homalophylla	*	*	*		*	*	*
8	Brachychiton populneus	43.7	*	*	0	*	*	*
10	Eucalyptus macrorhyncha	*	*	*		*	*	*
17	Acacia implexa	20.1	*	*	0	*	*	*
20	Grevillea robusta	29.2	*	*	0	*	*	*

Table 11 Mean tree performance indicators by ground preparation treatment (February 03 monitoring), Wallangra Trial.

No.	Treatment	HtF03 (m)	DBHF03 (cm)	Survival F03 (%)	Stem F03	Branch F03	Health F03
4	Rip, Mound and Cultivate1	5.11	7.92	35.65	4.42	3.76	4.69
3	Rip and Cultivate	5.07	8.07	39.85	4.28	3.7	4.72
1	Mound and cultivate	5.02	8.73	37.5	4.07	3.7	4.59
2	Rip only	4.92	8.1	38.1	4.35	3.64	4.68
5	Rip, Mound and Cultivate2	4.9	7.88	35.42	4.4	3.73	4.68
6	Cultivate only	4.77	7.47	42.82	4.31	3.59	4.73

There were highly significant differences ($p<0.001$) between species for all variables, but there were significant differences between ground preparation treatments for only some variables. These variables are height, diameter and health in 2001, and diameter and stem straightness in 2003.

Species 19 (*E. bicostata*), 1 (*E. sideroxylon*), 15 (*E. melliodora*), 18 (*E. melanophloia*) and 4 (*E. albens*) were the tallest. *Casuarina cunninghamiana* (species 11) is the tallest of the non-eucalypt

species. The ranking of species on dbh is different to that for height, Species 18 (E. melanophloia) is not ranked in the top group, however Acacia melanoxylon (species 9) and E. cladocalyx 'Nana' (species 12) are ranked fourth and fifth respectively.

In 2003 the significant difference in health score between species ($p<0.001$) is mainly due to the poor health score for species 14 (*E. camaldulensis*). The differences were more pronounced in 2001, with species 18 (*E. melanophloia*) and species 4 (*E. albens*) having the lowest mean scores. Observations recorded during monitoring in 2001 show that both these species had high levels of insect attack on their leaves.

Discussion

The major findings of the Wallangra trial are;

1. that *Eucalyptus bicostata*, *E. sideroxylon* and *E. melliodora*, are the best of the species trialed based on growth, survival, health and form. A second group *of E. melanophloia, E. albens, E. crebra, E. cladocalyx* 'Nana' and *Casuarina cunninghamiana* have also performed sufficiently well to be recommended for agroforestry applications under similar conditions;

2. that *Casuarina cristata, Acacia melanoxylon* 'Smithton' and *A. pendula*, though much slower growing than the best eucalypts, have performed sufficiently well to be considered for small scale commercial plantings for specialty uses;

3. that under the conditions of this trial, *E. laevopinea, A. implexa, Brachychiton populneus, A. melanoxylon* 'Crawney'*, E. macrorhyncha, E.camaldulensis, Grevillea robusta* and *A. homalophylla* have not grown fast enough or have had such poor form or survival, that they cannot be recommended (although the poor performance of *E. camaldulensis* has not been observed in any other trials throughout the region in recent times, the poor result from this trial may be a provenance effect); and

4. that in black alluvial soils, the technique of cultivation followed by mounding to prepare the ground is better than other techniques for tree growth, but may have an effect on tree health. The common technique of simply cultivating before planting, has resulted in poor growth, although survival is relatively high.

E. sideroxylon (red or mugga ironbark) was ranked second in height, first in diameter at breast height, second on health, third on stem straightness and fourth on branching habit after 75 months of growth. The survival of this species after 75 months (64%) is well above the trial average of 47%. In this trial, as we found in the Tamworth and Manilla trials (see preceding sections) and at Wee Waa, mugga ironbark tends to have two or more stems. These stems fork from near the base and may be due to early damage from frost. The presence of multiple stems is evident from an early age and would be easily corrected with light form pruning in the first year of growth. Apart from these form problems, the species has now performed in many trials over a wide variety of site conditions as one of the leading species. Mugga must now be considered one of the 'all rounders' for farm forestry on the Northwest Slopes and Plains.

E. bicostata (Eurabbie, southern blue gum) naturally occurs from south-western Victoria, along the Great Dividing Range to southern NSW and the ACT, with small outlier populations as far north as the Northern Tablelands of NSW. It is from this most northerly population, at Winterbourne, north-west of Walcha, where the seed was collected for this trial. The annual rainfall in the species natural range is 700-1200mm (Boland et al, 1984). The rainfall at this trial site is in the lower part of that range, with a higher level of evaporation. We originally included blue gum in the trial in response to a high level of interest in the species in the local area. We were also concerned that several *E. globulus* specimens (another southern blue gum, a closely related species) planted in the region had died in the 1997 drought, some as old as ten years. While the species has performed very well in this trial, the results were very variable between

replicates, with one plot having outstanding height and diameter (rep 2) and another having very poor growth and survival. The outstanding plot may have had atypical access to groundwater. The species requires trialing in a number of environments in the region to ensure it has the necessary long term survival characteristics to make it a farm forestry species contender.

2.6 Wee Waa species and provenance trial

Aim
1. To compare species suitable for commercial revegetation on heavy alluvial soils.
2. To compare provenance differences within these species.
3. To determine growth rates of commercial species.
4. To demonstrate the management of a large stand of trees for commercial purposes, including spacing, establishment and early pruning and thinning.

Trial type
Species/provenance elimination trial in a randomised row-column design.

Location
Map reference
Latitude:29^0 58' 45"
Longitude: 149^0 22' 48"
Nearest town
Wee Waa, 40 km south of property.

Elevation
100m a.s.l

Slope
0^0

Landform
Alluvial floodplain

Original vegetation
Eucalyptus coolabah – E. largiflorens open woodland, with grassland, *Acacia stenophylla, Capparis mitchellii* and *Alectryon oleifolius.*

Rainfall
550 mm MAR. (based on farm records)

Soil
Preliminary soil tests prior to laying out the trial indicated that the whole site was made up of deposits of alluvial cracking clays, with one section more hard-setting than the rest of the site. The two soil types are locally referred to as black soil and grey soil respectively. On the basis of this preliminary inspection, the trial was laid out with Replicates 1, 2 and 3 on the black soil and Replicate 4 on the harder setting grey soil.

Site preparation
The site was selected in conjunction with the landholders in August 1998. The trial is part of a series of tree projects in the paddock, along with seed production areas and saltbush plantings. There is no intention to graze livestock in the paddock in the short term, so the trial was not fenced from the rest of the paddock.

Ground preparation

The site was prepared for planting with an 18 month long chemical fallow, where the site was kept weed free with regular herbicide application. The fallow period included a mung bean crop which was ploughed back in. The whole paddock was agro-ploughed (250mm deep with tynes 400 mm apart) prior to planting to break up the cultivation pan and to allow better penetration for tree roots. The weeds on the site were initially cultivated into the soil. Prior to planting, the bare soil was sprayed with a residual herbicide, “Goal CT”, at a rate of 4l/ha. All gound preparation was undertaken by the owners Jim and Rhonda Cameron.

At the time of planting the soil was soft, spongy and moist. A section of hard-setting grey clay coinciding with the location of Replicate 4, needed to be scarified just prior to planting to make hand-planting possible. Planting was carried out by Greening Australia (Northwest NSW) staff and Jim and Rhonda Cameron.

Establishment
Planting date
The trial was planted in two stages, as some seedlings were not ready for planting at the first planting. All trees were planted with Potti-Putki tubes, fertilised with 5g of native “Osmocote” and protected with a 1l milk carton tree guard supported by two wooden stakes. The trees were watered after planting.

Some plots were incomplete or suffered losses between Sept 1999 and April 2000. These plots were filled in April 2000 with seedlings that were not big enough to plant in September 1999. The seedlots that received replacements in April 2000 are marked with an asterisk (*) in the “planting date” column of Table 12.

Seedlings
All seedlings were grown in Hiko trays at “Inland Botanics” nursery, owned and run by the property owners, Jim and Rhonda Cameron. Most of the seed for the project was supplied by the CSIRO Australian Tree Seed Centre, as part of their NHT-funded “Seed and Information Support for Commercial Farm Forestry” project.

Table 12: List of seedlot sources for species in Wee Waa trial

Treatment	Seedlot number	Species	Seed source	Date of planting
1	EUME15599	Eucalyptus melliodora	CSIRO	21/9/99
2	GRST17254	Grevillea striata	CSIRO	*21/9/99
4	EULAR11974	E. largiflorens	CSIRO	21/9/99
5	CAOB15796	Casuarina obesa	CSIRO	21/9/99
6	CACU15000	Casuarina cunninghamiana	CSIRO	21/9/99
7	EULAR16005	E. largiflorens	CSIRO	21/9/99
8	EUMIC16007	E. microcarpa	CSIRO	21/9/99
9	EUCA12500	E. camaldulensis	CSIRO	21/9/99
10	COCI20017	Corymbia citriodora	CSIRO	21/9/99
11	ACSA18165	Acacia salicina	CSIRO	*21/9/99
12	ACSA18539	Acacia salicina	CSIRO	*21/9/99
13	EULAR12644	E. largiflorens	CSIRO	21/9/99
14	ACVI19328	Acacia victoriae	CSIRO	*21/9/99
15	ACHA16577	Acacia harpophylla	CSIRO	*21/9/99
16	EUME19669	Eucalyptus melliodora	CSIRO	21/9/99
17	COCI20015	Corymbia citriodora	CSIRO	21/9/99
18	EUAR15504	E. argophloia	CSIRO	21/9/99
19	CACR17009	Casuarina cristata	CSIRO	21/9/99
20	CACU17186	Casuarina	CSIRO	21/9/99

	cunninghamiana		
21 ACCA14597	Acacia cambagei	CSIRO	21/9/99
22 EUCA19708	E.camaldulensis	CSIRO	21/9/99
23 CACU13512	Casuarina cunninghamiana	CSIRO	21/9/99
24 EUEX13818	E. exserta	CSIRO	*21/9/99
25 GRSTHaddon	Grevillea striata	Camerons	4/4/00
26 COCI20014	Corymbia citriodora	CSIRO	21/9/99
28 EUME15224	Eucalyptus melliodora	CSIRO	21/9/99
29 ACVI19330	Acacia victoriae	CSIRO	4/4/00
30 CACU15007	Casuarina cunninghamiana	CSIRO	21/9/99
31 CAOB13217	Casuarina obesa	CSIRO	21/9/99
32 EUSI19557	E. sideroxylon	CSIRO	21/9/99
33 CACR15239	Casuarina cristata	CSIRO	21/9/99
34 EUMIC16029	E. microcarpa	CSIRO	21/9/99
35 EUMIC16011	E. microcarpa	CSIRO	21/9/99
37 EUPIL15997	E. pilligaensis	CSIRO	21/9/99
38 ACVI19325	Acacia victoriae	CSIRO	*21/9/99
39 COTE18166	Corymbia tesselaris	CSIRO	21/9/99
40 ACSAGA213	Acacia salicina	GA NWNSW	21/9/99
41 CACR15628	Casuarina cristata	CSIRO	21/9/99
43 COTR11647	Corymbia trachyphloia	CSIRO	21/9/99
44 CACR14843	Casuarina cristata	CSIRO	21/9/99
45 ACSA17738	Acacia salicina	CSIRO	*21/9/99
46 EUEX17397	E.exserta	CSIRO	21/9/99
47 CACU15001	Casuarina cunninghamiana	CSIRO	21/9/99
48 EUAR13713	E. argophloia	CSIRO	*21/9/99
49 EUCR16006	E. crebra	CSIRO	21/9/99
50 CAOB15396	Casuarina obesa	CSIRO	21/9/99
51 ACST20018	Acacia stenophylla	CSIRO	21/9/99
52 ACST19333	Acacia stenophylla	CSIRO	*21/9/99
53 EUCR15146	E. crebra	CSIRO	21/9/99
54 EUSI19677	E. sideroxylon	CSIRO	21/9/99
55 ACST18523	Acacia stenophylla	CSIRO	4/4/00
57 ACCA18480	Acacia cambagei	CSIRO	21/9/99
58 EUCA19868	E. camaldulensis	CSIRO	21/9/99
59 EUCR13587	E. crebra	CSIRO	21/9/99
60 ATHE17108	Atalaya hemiglauca	CSIRO	4/4/00

Trial design
The trial design is based on a randomised row-column design there are four replicates of 60 plots, laid out as six columns of 10 rows of plots. Plots contain 16 trees in a four by four square.

Weed control post planting
The trial was regularly slashed and spot sprayed with Round Up CT to control weeds in the first year after planting. Inspections in March 2000, June 2000, November 2001 and February 2003 showed that there were few if any weeds competing with the trees. The severe drought of 2002-2003 restricted weed growth in that period.

Monitoring
The site has been regularly monitored by Jim and Rhonda Cameron, who have checked weed growth, kangaroo browsing, tree health, soil cracking and general growth. Greening Australia

(Northwest NSW) staff carried out survival monitoring in March 2000 and June 2000. Greening Australia and Jim and Rhonda Cameron also monitored the site in November 2001 and February 2003. During these monitoring events, we measured tree height, diameter at breast height (2003 only), stem straightness, branching habit and health, with the last three scored from 1 to 6 (McLeod, Vercoe and Robins, 2002). We measured height with an 8m telescopic height pole and dbh with a pair of forestry calipers. Survival was calculated from the number of heights recorded in each plot.

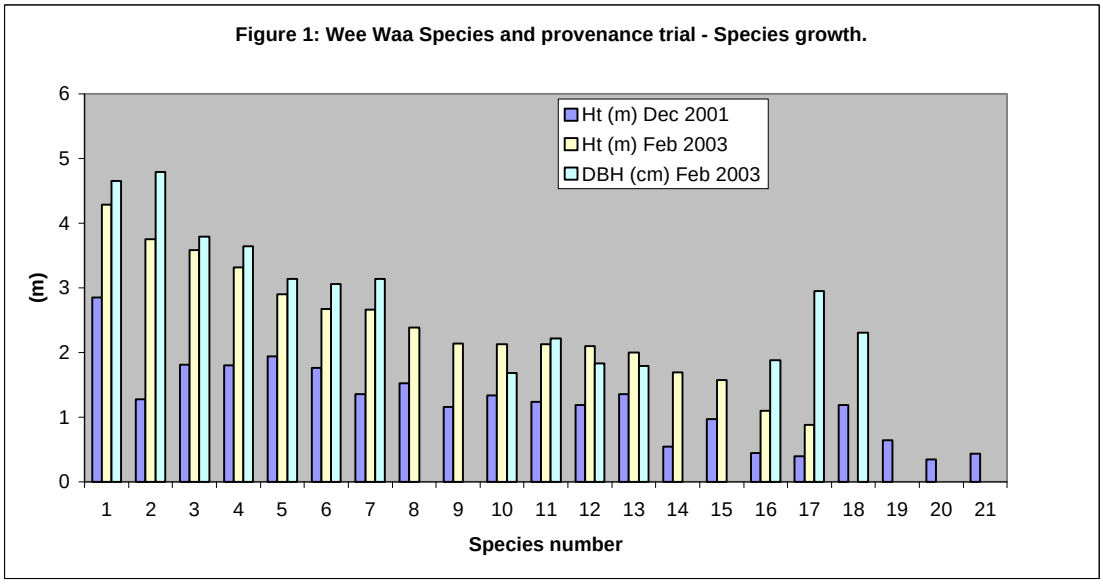
Several plots in Replicates 3 and 4 were not measured in 2003 due to severe browsing damage by kangaroos. The kangaroos browsed the trees as a result of the drought reducing their usual food sources. The trees should recover once browsing eases. Some species (*Acacia salicina* and *A. victoriae*) were not browsed at all and any Eucalypts taller than about 1.5 m were not affected. Casuarina species were most affected.

Species results

Table13 and Figure 1 shows the relationship between species in terms of survival and average height in 2001 and 2003 and average dbh (where measured) in 2003.

Table 13 Mean tree performance indicators by species, Wee Waa trial.

Species number	**Species name**	**% survival Dec 2001**	**% survival Feb 2003**	**Ht (m) Dec 2001**	**Ht (m) Feb 2003**	**DBH (cm) Feb 2003**
14	E. camaldulensis	98.34	95.1	2.85	4.28	4.65
13	E. argophloia	84.17	81.86	1.27	3.75	4.79
18	E. microcarpa	95.52	89.9	1.81	3.58	3.79
19	E. pilligaensis	91.77	81.52	1.8	3.31	3.64
20	E. sideroxylon	90.99	95.09	1.94	2.9	3.14
17	E. largiflorens	83.5	63.28	1.76	2.67	3.06
21	Eucalyptus melliodora	96.22	88.21	1.35	2.66	3.14
9	Casuarina obesa	93.4	76.32	1.52	2.38	0
3	Acacia salicina	92.02	87.65	1.16	2.14	0
7	Casuarina cristata	97.49	75.41	1.33	2.13	1.68
15	E. crebra	88.36	69.33	1.23	2.12	2.21
16	E. exserta	83.33	58.13	1.19	2.1	1.83
8	Casuarina cunninghamiana	95.7	74.46	1.35	2	1.79
5	Acacia victoriae	76.86	79.44	0.54	1.69	0
4	Acacia stenophylla	89.11	67.04	0.97	1.57	0
2	Acacia harpophylla	36.3	7.32	0.44	1.1	1.88
1	Acacia cambagei	54.72	28.51	0.39	0.88	2.95
10	Corymbia citriodora	73.87	29.07	1.19	0	2.3
11	Corymbia tesselaris	55	42.21	0.64	0	0
12	Corymbia trachyphloia	27.71	4.97	0.34	0	0
22	Grevillea striata	71.32	33.5	0.43	0	0



The tallest species in February 2003 were eucalypts, with *E. camaldulensis* (14)*, E. argophloia* (13)*, E. microcarpa* (18)*, E. pilligaensis* (19) and *E. sideroxylon* (20) the tallest species. *Casuarina obesa* and *Acacia salicina* were the tallest of the non-Eucalypt species. There are some notable differences in height ranking between 2001 and 2003, particularly for *E. argophloia* (Sp 13) which was a slow starter but in 2003 was ranked 2nd for height and 1st for dbh.

The survival of species over time is shown in Table 13. There is a strong correlation between height and survival for both years (r^2 = 0.79 and 0.83), with eucalypts having the best survival. Where losses have occurred, they appear to have mostly happened between planting and December 2001. However a number of species continued to suffer relatively large losses after 2001 (probably a result of drought), these included all the casuarinas, *Eucalyptus largiflorens* and *exserta*, *Grevillea striata*, *Corymbia citriodora* and *trachyphloia* and *Acacia. stenophylla, harpophylla* and *cambagei*.

Seedlot results

At the time of writing a full analysis and interpretation of the performance of different seedlots of the different species was not available. However there was considerable variation in growth and survival among the seedlots of some species. Of the species that had multiple seedlots the following trends were evident:

1) *C. citriodora* – all seedlots low for survival and growth
2) *E. camaldulensis* – all seedlots high for survival , all seedlots high for growth but one seedlot significantly better (No. 22, see table 12 for seedlot code).
3) *E. crebra* – large variation in survival between seedlots (No. 59 had the lowest survival rate) but little variation in growth rates of survivors.
4) *E. microcarpa* – only small differences in survival (all high) but one seedlot significantly lower than the others (No. 35 had relatively poor survival), all high for growth with one seedlot significantly better than the others (best performer No. 8).
5) *E. sideroxylon* and *E. melliodora* – all provenances of both species performed very similarly.
6) *A. salicina* – one of four provenances had poor survival by 03 (No. 40), others high, one seedlot high growth (No. 12), three only moderate.
7) *A. stenophylla* – one high and one low (No. 55) for survival but growth rates similar for each seedlot.
8) *A. victoriae* – one provenance consistently high survival, other provenances only moderate survival but with very large variation between replicates. One seedlot high growth one moderate and one low. (No. 14 was the best performer in terms of survival and growth)

9) *C. cristata* – two provenances high and two moderate to low for survival (No 19 was the lowest), all provenances very similar for growth (moderate).
10) *C. cunninghamiana* – two high and three moderate for survival, 3 moderate and 2 low for growth (Seedlots 20 and 30 were the poorest performers all round).
11) *C. obesa* – one seedlot (No. 5)high for survival the other two moderate, all provenances very similar moderate growth rates.

Further Information

A full discussion and analysis of the results of these trials and others from Northern NSW will be reported later in 2004 in the publication "Final Report for RIRDC project AFT02-68 by David Carr Greening Australia Ltd" which is currently in preparation

References (other than those listed in the main body of the publication)

McLeod, I.W., Vercoe, T.K. and Robins, L. (2002) *Establishment of field trials and demonstration plantings for farm forestry*. Report to RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Program.