A PRACTICAL GUIDE TO

Planting Tubestock Paddock Trees

John R Baker

Hovells Creek
Landcare

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Hovells Creek Landcare Group and the author acknowledge the Traditional Owners of the lands that we all live and work on across Australia. We pay our respects to Elders past, present and emerging.

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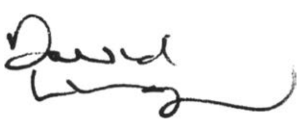
‘Road to Cowra’ by Peter Simpson, oil on canvas, 2008
View of the Hovells Creek valley from Mount Darling
Commissioned by John & Liz Baker and gifted to the Cowra Art Gallery

Preface

Almost 55% of Australia's land mass is used for agricultural production. Extensive areas have been degraded over the past two centuries, leading to biodiversity loss, soil erosion, secondary salinity, and a range of other environmental problems. How we manage the land and tackle these problems has important implications for natural resource management, not only for reversing environmental problems, but also for maintaining agricultural productivity.

This means that practical approaches to better land management, like those conducted by the Hovells Creek Landcare Group (HCLG), are crucial. These approaches are best guided by robust empirical science, which demonstrates the immense value in improved management of natural assets on farms. To this end, over the past decade, there have been many strong collaborative links between HCLG and the Sustainable Farms project in the Fenner School at The Australian National University. Daniel Florance from Sustainable Farms has completed many surveys on reptiles in the landscapes managed by members of HCLG. Ph.D student Jackie O'Sullivan has established research sites for woodland reptiles on John and Liz Baker's property and on Gordon and Trudi Refshauge's Riverslea property. There has also been fascinating and important work on paddock trees by HCLG that was funded through a NSW Environmental Trust grant awarded to them for the period 2016–2019 – work that forms the basis of this book.

A Practical Guide to Planting Tubestock Paddock Trees is an excellent contribution towards improved knowledge and better management of natural assets on farms. This is because it is underpinned by years of practical experience in restoration. For example, it has highlighted key issues in tree restoration and management of which few people would be aware – the advantages of planting in autumn rather than spring and the problems caused by J-rooting in tubestock. These and many other important findings are why all farmers and rural property owners interested in better managing their land should read this terrific book.



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Acknowledgements

This guide draws on the practical experience of Hovells Creek Landcare Group (HCLG) members who participated in a NSW Environmental Trust-funded paddock tree planting project, which saw more than 2000 paddock trees planted between 2016 and 2020 across 23 member properties. Thanks go to these members for their interest, support and commitment to the overall project. Sincere thanks also to the Trust for their support with the project and for being a very approachable and professional organisation to work with.

Valuable early editorial suggestions on this guide were received from Keith Hyde, an active HCLG member and Hovells Creek property owner and enthusiastic tree planter. Dr Gordon Refshauge, Chairman of HCLG, has been a consistent supporter of the writing and publication of this guide. Dr Damon Oliver, of the NSW Department of Planning and Environment, checked the various references to bird life in the area and made other very helpful contributions. He was also a strong supporter of and collaborator with HCLG in implementing the 'Saving our Species' project. Finally, Professor David Lindenmayer provided valuable editorial suggestions, kindly wrote the Preface and provided encouragement for the publication of the guide.

I was originally prompted to write the guide after many discussions with a tree enthusiast from the district, to whom I owe a real intellectual debt. Over the years our interactions have been a great source of ideas, provocation and stimulation on the subject of tree growing and planting.

I have been collecting information on tree planting for many years. Unfortunately, I have lost sight of the origin of a few of my notes, so I acknowledge the contribution of some unnamed sources whose ideas contributed to this guide.

Unless indicated otherwise the photographs were all taken by me. The book was edited and produced by Suzannah Macbeth, formerly of Sustainable Farms at the ANU, who was a pleasure to work with.

Finally, my thanks go to my wife Liz, who was an active partner with me in our various tree planting endeavours at our Old Graham property at Hovells Creek, and who has been unfailingly and patiently supportive of the writing of this guide.

John R Baker
January 2024

Foreword

This guide is about paddock trees, a key element in the cropping and grazing lands of NSW, and about how to grow them successfully. It draws on lessons learned during our Landcare group's tree planting activities.

Hovells Creek Landcare Group (HCLG) was formed in 1995 and as a community group acts to organise field trips, on-farm workshops and field days, as well as managing funding support for on-farm projects for its members.

Since its establishment members have, through its various projects, fenced 29 kms of waterways, protected 130 ha of remnant vegetation from livestock, and planted 56,800 native trees/shrubs.

In May 2016 HCLG was awarded a grant of $89,990 by the NSW Environmental Trust for a project that involved the planting of 1,500 paddock trees in individual steel guards across 20 or more member properties.

The project was managed by Dr John Baker, then Deputy Chair of HCLG, and by the time it ended in 2020 more than 2,000 trees had been planted across 23 properties. Dr Baker, who together with his wife had been planting paddock trees and tree lanes on their Old Graham, Hovells Creek property since the early 1990s, launched into managing the paddock tree project with great enthusiasm. Drawing on his own previous experience, and on that of other HCLG members, as well as tapping into a wide range of other sources, Dr Baker produced a number of notes and YouTube videos on tree planting. He also undertook research into the two key issues of J-rooting and its problems, and the benefits of autumn planting over spring planting.

This guide is the distillation of all that knowledge and experience, and HCLG is publishing it to share our learnings with other tree planters. A PDF of the guide is available on the website and copies can also be ordered through the website.

Fuller details of HCLG's projects are on our website at www.hovellscreeklandcare.org.au and are also described in Chapter 14 of *Changing Times Changing Landscapes at Hovells Creek, NSW*, a 200-page history of the area published by HCLG in 2021 and available on the website.

Gordon Refshauge
Chairman
Hovells Creek Landcare Group

Introduction – why this guide?

Paddock trees are an important part of the ecosystem across the cropping and grazing lands of regional NSW. They contribute to the productivity of our farming enterprises and are part of what makes the landscapes of Central NSW visually attractive and liveable. This guide aims to provide practical advice on how to successfully plant paddock trees for our future.

Paddock trees provide habitat for hundreds, probably thousands, of species of animals. These range from small to medium sized mammals such as gliders, possums, koalas, flying foxes and microbats, through to birds, such as owls, nightjars, parrots and treecreepers, as well as reptiles, frogs and invertebrates, such as insects and spiders. Paddock trees have a dominant presence in what is very much a human modified natural system and landscape, providing critical flyways and stepping stones for the movement of birds and flying mammals. Paddock trees are often the oldest, largest trees remaining in the landscape. They usually contain hollows that take at least a hundred years to develop, and so are important to retain for wildlife habitat.

They are also important for our farming enterprises, offering shelter for stock, helping maintain soil integrity and providing visual amenity – with consequent economic and wellbeing benefits for farmers.

Unfortunately paddock trees are being lost at a steady and continuing rate through senescence (old age), severe weather events, insect damage, firewood gathering, and damaging farming practices, including loss from stubble fires. They must therefore be a high priority, both for conservation of existing paddock trees, and also regeneration through the targeted planting of young trees that can become the paddock trees of the future.

While a range of books, reports, videos, etc. have all made a compelling case for paddock tree planting to replace lost or dying paddock trees, there is a real dearth of reliable advice on the practical aspects of paddock tree planting. There are even some 'rural myths' or furphies surrounding paddock tree planting, with a few being 'propagated' by a minority of natural resource management (NRM) professionals.

Three 'rural myths' covered in this guide include ignoring the very significant benefits of autumn planting and downplaying the risks of spring planting. Another concerns the belief that J-rooting has no adverse impact on Eucalyptus tubestock development, with a Local Land Services NRM professional recently telling a landowner, 'Oh it doesn't make any difference whether they are J-rooted or not.' A final example concerns water crystals and a recent tubestock planting guide which discouraged the use of water crystals and stated, 'They can also suck moisture away from roots when it rains...'

Planting individual tubestock paddock trees requires a significant investment. There is labour involved in planting, and the cost of steel mesh guards, weed mats and tube stock all add up, not to mention the time and costs of any watering required during dry periods. An average cost of $75–$150 per tree, including a modest labour cost, is typical. This investment will reap rewards in the future and is an important part of land stewardship, but needless to say we need to ensure that any tubestock plantings have the best chance of success. Going back and replanting failed paddock trees is a tedious, expensive and time-consuming task, and too often is not done.

It is therefore essential that paddock trees be planted properly in the first instance, so as to maximise their survival. This guide is intended to provide practical advice on paddock tree planting across much of the Central West and Central and Southern Tablelands of NSW based on experience gained at Hovells Creek.

Hovells Creek is located between Boorowa and Cowra, near the intersection of four BOM weather areas: the Central Tablelands; Southern Tablelands; Central West Slopes; and South West Slopes. The guide does not pretend to be suited to the Snowy Mountains, Monaro, coastal areas of NSW or to other agricultural regions in Australia – though clearly many of the general practices described are highly transferable.

The target audience for the guide are those who are designing or overseeing paddock tree planting projects, including: Landcare Support Officers (LSOs); the committees of Landcare groups; NRM professionals and staff; shire and town councils; and mining companies needing to rehabilitate land after mining. The guide may also interest individual landowners who may be implementing large multi-year paddock tree planting projects or who are keen to drill down into the detail of good paddock tree planting.

Scattered paddock trees on the valley flats at Hovells Creek.
Oil on canvas painting by Peter Simpson, 2009.

At the core of this guide are lessons learned from Hovells Creek Landcare Group's (HCLG) paddock tree planting project, which saw more than 2,000 individual paddock trees planted across 23 member properties between 2016 and 2020. The project, funded by the NSW Environmental Trust, is described in Appendix 1. The parallel NSW Department of Planning and Environment's 'Saving Our Species' Superb Parrot project supported paddock tree protection and planting for a species that depends on large old paddock trees with hollows.

My first paddock tree planting experience was in 1992 on our Old Graham property at Hovells Creek. Over the following years we planted tree lanes and many small groups of paddock trees. Then, from 2016 onwards, I became project manager of the HCLG paddock tree project. As a former management consultant, senior public servant and academic, I read widely and shamelessly tapped into the practical experience of others who had been growing paddock trees for many years, so as to identify the key success factors. At the same time many practical lessons were learned, both from our personal plantings and from working with other HCLG members. I also undertook practical research and field trials into three key aspects of paddock tree planting: the benefits of autumn vs spring planting; the problem of J-rooting; and the use of water crystals. All three of these are covered extensively in the guide.

In the course of researching paddock tree planting I observed that there are many growers and tree planting contractors who are very experienced in propagation, growing and planting tubestock trees. However, there is no mechanism for their expertise to be shared more widely, and for commercial reasons some of them may be reluctant to share their knowledge.

The HCLG paddock tree project did not include any direct tree seeding, so that is not covered in this guide. However, its absence is not meant to indicate that it does not have an important role to play in tree revegetation, and certainly there are some very impressive treelanes and shelterbelts that have been direct seeded. If direct seeding is more appropriate for your circumstances, there is plenty of information available elsewhere.

Although this book aims to provide practical guidance on paddock tree planting, there is no one correct way to plant paddock trees. This book describes methods that worked on the HCLG paddock tree project at Hovells Creek, but there are variations and other approaches that can also be taken. Ultimately, my hope is that this book will provide useful insights that can contribute to the successful planting of more paddock trees over the coming years.

John R Baker

Key success factors for tubestock paddock tree planting

As a backdrop to the following chapters it is worth listing some key success factors for planting tubestock paddock trees:

1. Plant **high quality tubestock** sourced from a supplier with a good track record. **Avoid J-rooted plants** and **carryover stock** from the previous season.
2. Plant **suitable endemic tree species** in **suitable locations** and at **appropriate spacings.** Planting in **drainage lines and gullies** can help ensure good moisture availability.
3. Plant tubestock **in autumn rather than spring** so that they can **get their roots established over winter** and be able to handle dry spells in spring and summer without watering. Adding **water crystals** helps improve survival rates through dry periods. Always **water tubestock in well when planting,** unless they are part of a large-scale planting in which case they should be planted with good soil moisture.
4. Prepare a **suitable hole containing loosened soil** to plant the tubestock into. **Do not plant by simply using a Hamilton tree planter to make a hole for the tree in unprepared ground.** A battery powered drill and augur is good for digging the hole.
5. Use a **weed mat or mulch** to minimise weed competition and help keep soil moist round the plant.
6. **Protect individual tubestock from stock, kangaroos, hares and rabbits with a steel mesh guard** – 1200 mm high for sheep and 1650 mm high for cattle and sheep – or use a fence to exclude stock.

Fig 1.1: A yellow box paddock tree with a measured trunk diameter of 2.4m on the valley flats at Hovells Creek. The tree is probably at least 150–200 years old and in 2023 it stood in a paddock that had been sown to a fodder crop for sheep.

Chapter 1

Why Paddock Trees are Important

Paddock trees are an iconic feature of our landscape and a key contributor to the natural environment and to commercial farming. Innumerable insects, small animals and birds rely on paddock trees, including the vulnerable Superb Parrot which nests in hollows in old trees.

Paddock trees are declining, and a landscape without them is a very real possibility in the future. Fortunately, attitudes on farms are changing to be more supportive of retaining and replanting paddock trees. This chapter explains why paddock trees are so important – a necessary background to the remainder of this guide, which provides practical advice to support effective paddock tree planting.

Scattered paddock trees are usually large old eucalypt trees left standing from the historical clearing and thinning of the forests and woodlands that once covered much of temperate and semi-arid NSW. With their large spreading canopies and broccoli-like appearance, paddock trees are an iconic sight across the Australian landscape (Fig 1.1) and an important part of the woodland ecosystem in the grazing lands of the NSW sheep-wheat belt.[1] Whether as living, growing paddock trees or as dead 'stag' trees, their value to humans and to the natural environment is immeasurable.

Sadly, these remnant trees are disappearing from our regional landscapes, including from the grazing lands of the Central West, South West Slopes and Central and Southern Tablelands. Many of those that remain are now centuries old, and when they die they aren't being replaced, as farming practices generally have prevented the recruitment of new generations of trees. Dead paddock trees are too often seen only as a source of firewood, but they do in fact provide important habitat for many birds and animals. The fear is that if current trends continue most of our paddock trees, both alive and dead, may be lost in as little as 40 years.[2]

A glimpse of a future landscape without paddock trees

A drive in June 2023 from Yass to Boorowa, followed by a loop through Cowra and Frogmore, highlighted the aesthetic importance in the landscape of paddock trees. Parts of the landscape are well treed, while a few (Fig 1.2) are now nearly treeless. How different the drive will be in another 50–100 years when most of the existing old paddock trees will be gone.

Yes, there will be trees along the roadsides as regeneration is continuing to occur there. Yes, there will be tree lanes and shelter belts. But without an active ongoing effort to plant new paddock trees, the scattered paddock trees that currently dot the paddocks and hills will be gone and not replaced, creating a landscape that is nearly treeless in places.

The sheer beauty and aesthetics of a treed landscape is the most obvious reason to retain these important sentinels of biodiversity and productivity. Farmers and landowners who see themselves as custodians of their land are already alert to this, and many have a strong focus on protecting the environment, planting trees and shrubs, and protecting existing paddock trees. Others may not be aware that without active improvement through planting and protection, the future will see ongoing tree loss and an associated loss of natural capital. Unfortunately, there is also a small minority who have hardly planted a single tree in their life and are simply exploiting their land, leaving it in a worse condition than they found it.

Fig 1.2: Treeless paddocks between Frogmore and Boorowa.
An example and foretaste of a landscape without paddock trees.

Fig 1.3: A grazing paddock at Hovells Creek which was completely cleared of trees by the 1950s. In 2018 about 20 scattered paddock trees were planted across it in guards. They are now the paddock trees of the future.

Awareness of our impending loss

Do we as a community appreciate what we have and are at risk of losing? Ecologist Dr Mason Crane describes paddock trees as 'hot spots for biodiversity', having a massive positive impact on the surrounding land.[1] Their flowers and fruits are a source of food for birds, gliders, possums and insects. Cracks in their bark provide homes for geckos, spiders and a host of insects. Holes and hollows in their branches – which have often taken 100–150 years to develop – provide nesting opportunities not just for parrots and gliders, but also for wild bees and other animals. Dead paddock trees also provide important habitat for many animals.

Sadly, many paddock trees are being lost through senescence (old age), insect damage, severe weather events, damaging farming practices and fire. Their decline and the removal of dead paddock trees for firewood has been identified as a significant ecological threat to woodland habitats, which provide valuable flyways, connectivity, shelter, roosts, food and nesting sites for birds, bats, gliders, possums, reptiles, frogs and invertebrates. Paddock trees are especially important for the survival of threatened woodland birds such as the brown treecreeper, barking owl, superb parrot, grey crowned babbler and diamond firetail, as well as for threatened gliders and microbats.

Fig 1.4: A female superb parrot, which is vulnerable in part due to the loss of large old trees that it relies on for nesting hollows. Photo by Helen Fallow, NSW Department of Planning and Environment.

The superb parrot, which nests in the area, is very particular in its choice of nesting hollows in old paddock trees. A recent study in the ACT showed that less than 5% of all tree hollows surveyed were suitable for superb parrot nesting habitat.[3] So as these become fewer and fewer, there is a corresponding decline in available nesting sites suitable for this parrot.

Normally, in a natural woodland setting trees would be seen at all stages of growth, from small self-sets and saplings through to fully mature 'old growth' trees. This structural diversity of different age classes of trees can still be seen in woodland remnants on farms and roadsides where grazing is absent or intermittent. But where there is heavy and constant grazing pressure by stock and native and feral herbivores, self-set seedlings generally don't survive and there is no recruitment (establishment) of the next generation of trees. Consequently, in most grazed grassy woodlands very little natural replacement has taken place over the past 100–200 years (Fig 1.5).

Fig 1.5: Scattered paddock trees in a paddock of permanent pasture being grazed by sheep. Note the absence of any regeneration by self-sets and the absence of any younger trees.

Fortunately, in addition to large remnant trees occurring as scattered paddock trees, some do also occur as part of patches of on-farm remnant vegetation, or in travelling stock reserves. They also occur in road reserves and may receive protection as part of local councils' environmental management responsibilities – though on occasions such mature trees are removed on road safety grounds. As individual paddock trees in farm paddocks progressively die off, the trees in roadside reserves will become increasingly important.

Causes of paddock tree loss

There are many natural causes of paddock tree loss. In the regions covered by this book, leaf-feeding insects such as chrysomelid and scarab leaf eating beetles, together with various other psyllids and weevils, are principal causes. Typically, the impact of insect attack occurs not from a single defoliation event, but from repeated and severe defoliation over successive seasons.[4]

Such insect attacks are particularly severe when isolated trees are surrounded by areas of grassland which support the beetles and insects. Fewer paddock trees means that the remaining trees are relatively more susceptible to insect attack.

The damage caused by these waves of insect attack is often exacerbated by the already-compromised health of paddock trees that have suffered from multiple droughts and heat waves, fire, dryland salinity, waterlogging and nutrient issues.

Fig 1.6: Two senescent paddock trees seen in poor health in 2023, with replacement trees already planted within guards to the immediate left of each of them. They currently have multiple parrot and starling nests in them. The photograph from the 1930s shows the nearest tree when it was a healthy mid-sized tree, but since then the bark of both trees has been badly eaten by horses, both have termite nests in them and both were damaged by a major windstorm in 2021.

Heavy grazing by sheep or cattle under paddock trees can compact the soil or expose their roots, as can tilling. Most paddock trees are adapted to grow in low-nutrient environments, so manure from stock camps under trees and fertiliser spread on cropping paddocks can damage trees. Paddock trees are also vulnerable to fire, particularly as they age and develop hollow trunks (Fig 1.7 and 1.8).[5]

Even where isolated paddock trees are in good health and appear to coexist well with farming practices, the age of the existing trees mean that this is unlikely to continue. Unless younger trees establish, we are on a pathway towards a landscape with significantly fewer large old trees.

Fig 1.7: Hollow living Eucalyptus tree on fire in 2017 after a farm worker had burnt a pile of sticks near its trunk, with the fire then getting up inside the hollow trunk. The tree had a parrot's nest in it and microbats were seen flying out of the top of the trunk. Note the newly-planted tree lane behind the tree.

Fig 1.8: The same tree in 2023, six years later, after it had fallen down, been cut up and some of it had been removed for firewood. Note that the tree lane planted in 2016 is now well established. While this tree lane will benefit productivity and biodiversity, it will be many years before it provides the habitat that makes large old trees so important for wildlife.

Paddock trees, farmers and agricultural productivity

Paddock trees provide essential ecosystem services (the benefits that natural organisms and processes provide to humans) that are valuable for agricultural productivity and can provide a real economic benefit for farmers. They play a crucial role in helping manage salinity, improve soil quality, reduce erosion, and facilitate water percolation. The production benefits for livestock include the energy savings which result from sheep and cattle having access to the shade and shelter of paddock trees (Fig 1.9). Cattle and sheep fertility is reduced when they are subject to excessive heat, which is exacerbated when they have no access to shade. Lambing survival rates also benefit from the shade and shelter provided by paddock trees.[6]

Fig 1.9: Cattle seeking shade even under a small paddock tree. (The tree is a pepper tree, *Schinus molle,* an evergreen native of South America which has long been grown in Central West NSW and is found on many farms and in house gardens. While non-native trees can provide shelter, native trees are more suitable for the environment and provide many more benefits for wildlife.)

The birds, gliders and bats living in paddock trees can have valuable pest control benefits, while native bees and other insects living in the trees may provide valuable pollination for crops. Paddock trees can also be important in providing nectar and pollen to feed commercial apiary sites producing honey for human consumption.

Despite their benefits, paddock trees can also be in conflict with intensive agriculture, particularly as they often occupy productive areas of the landscape. In broad acre cropping and hay cutting, paddock trees can be seen by farmers as obstacles to the use of large-scale tilling machinery. In some areas, the switch to GPS control systems has seen corresponding active removal of paddock trees.

Old paddock trees should be retained regardless of location, given the disproportionate benefits they provide and the fact that replacement trees will take centuries to fulfil a similar role. However, new paddock tree plantings can be located in farming landscapes in ways that minimise conflict with agriculture – for example, corner or fenceline plantings in cropping paddocks (see chapter 2).

Changing attitudes to trees on farms

The attitude of farmers and landowners to trees on farms has changed significantly over time. Agreements to purchase land from the government in the mid to late 1800s often included tree clearing requirements. Despite the imperative to clear, many farmers retained some trees along creeks, on hills and in areas difficult to clear, plus occasional trees for shelter for stock.

The late Barry Gay of Willow Glen, Hovells Creek, reported in an oral history interview that as a boy in the 1950s his father would send him off on a Saturday to ring bark trees on their property.[7] Barry added that his father, when riding round their property on his horse, carried kurrajong seeds in his pocket which he would drop into the top of dead tree stumps (Fig 1.10). Kurrajongs were valued for sheep fodder during droughts. Consequently many kurrajongs in the area have a gnarled appearance from the occasions when they were lopped for fodder (Fig 1.11).

Later in life Barry Gay was responsible for planting a number of large tree lanes and shelter belts on his property, as well as individual paddock trees. His son and wife are now continuing the practice.

The current generation of farmers and landowners has, generally speaking, inherited the problem of paddock tree demise on their land. While they have an important role to play in addressing the challenge, their capacity is often limited, and funding programs that provide assistance are extremely valuable.

Fig 1.10: A kurrajong tree growing in the old stump of a Eucalyptus tree that was cleared many years ago. While such a young kurrajong is likely a self-set from seed dropped by birds, in earlier times many kurrajongs grew from landowners dropping seeds into stumps.

Fig 1.11: A kurrajong paddock tree that has been repeatedly lopped for drought feed for sheep.

Carbon sequestration

An important aspect of individual paddock trees, and even more so of tree lanes and shelterbelts, is their capacity for carbon sequestration.[8] Growing trees actively sequester more carbon, while older trees represent a significant store of carbon in the landscape – both above and below ground. While small scale and individual tree plantings cannot currently be used to earn carbon credits for the landowner (this may change in future), they nevertheless make a contribution to fixing CO_2 and thus to helping reduce global warming.

Stag trees

Even in death, paddock trees have an important role. These 'stag' trees often contain large holes and hollows which have taken many years to develop and which provide homes for parrots, bats, possums, monitor lizards and many others (Fig 1.12). Research by ecologists at ANU has shown that dead trees provide important roosts and enable landscape movement for birds such as raptors, corvids and parrots.[9] Unfortunately dead paddock trees are often hollow and thus very susceptible to fire. They can easily be lost to wild grassfires, stubble burns or when farmers burn piles of branches (see Fig 1.7 and 1.8).[5]

Fig 1.12: Dead paddock tree, or 'stag' tree. Holes in this tree's branches house the nests of a red-rumped parrot and a crimson rosella. The landowner has twice rejected offers from firewood merchants to buy the tree so that they can cut it up and sell it as firewood. The removal of dead wood and dead trees has been identified as a Key Threatening Process under the NSW *Threatened Species Conservation Act 1995.* This listing recognises the severity of the threat, which may adversely impact numerous species that are at risk of decline or extinction.

Why is there so little community concern or action over paddock tree loss?

Periodically environmental activists and others lobby and demonstrate over the loss and destruction of areas of woodland, whether it be for sawmill timber, export as logs, woodchips or for urban development. Such loss and destruction is visible and takes place in a discrete area at a particular point in time, which is what makes it possible to lobby and demonstrate against it.

On the other hand, the loss of isolated paddock trees is a slow, relentless and continuing process which has gathered pace over the past 50 years or so. Due to its incremental and scattered nature, it has flown under the radar, compared to concentrated clearing of forest or woodland patches that tend to attract attention. We take our paddock trees for granted, assuming that because they have always been there, they will be there in future.

The challenge is to raise community awareness and to expand the role of Landcare and of various state-based natural resource management advisory and executive bodies in addressing the issue. The solutions are two-fold: protection and improved management of existing large old trees, and an active effort to plant young trees which will be the paddock trees of the future.

Key takeaways from Chapter 1

Paddock trees are a key element of our landscape. Yet they are under threat. While acknowledging the magnitude of the task of replacing dying paddock trees, this guide aims to provide some practical advice on how we can replant and replace paddock trees as effectively as possible. Given how long such trees take to come to maturity, the sooner we can push on with such plantings in an effective way the better. There are so many reasons to get more trees back into our farm paddocks!

NOTES AND REFERENCES

1 Parts of this chapter owe a debt to an excellent 9-minute YouTube video, 'Scattered Paddock Trees', featuring Dr Mason Crane of the Fenner School of Environment and Society at the Australian National University, produced in June 2015 by Riverina Local Land Services.

2 Manning AD and Lindenmayer DB, 2009, 'Paddock trees, parrots and agricultural production: An urgent need for large-scale, long-term restoration in south-eastern Australia', *Ecological Management and restoration* 10(2): 126-135. Estimates from a range of sources put the date for the loss of most of our paddock trees from as soon as 40 years and as long as 150 years.

3 Rayner L, Stojanovic D, Heinsohn R and Manning A, 2023, *Breeding ecology of the superb parrot* Polytelis swainsonii *in northern Canberra,* technical report prepared for the Environment and Planning Directorate, ACT Government, Canberra.

4 Matusick G and Fontaine J, 2020, 'Causes of Large-Scale Eucalyptus Tree Dieback and Mortality: Research Priorities', *A report to the NSW Natural Resources Commission by the Terrestrial Ecology Research group of Murdoch University.*

5 Crane M, Lindenmayer DB, Cunningham RB, Stein J, 2016, 'The effect of wildfire on scattered trees "keystone structures", in agricultural landscapes", *Austral Ecology* 45: 145-153

6 Gordon Refshauge made a presentation on this subject to a HCLG General Meeting in 2019 and a full account of the research results he drew on is given in: Masters DG *et al.,* 2023, 'Shelter and shade for grazing sheep: implications for animal welfare and production and for landscape health', *Animal Production Science* 63(7): 623-644.

7 Hovells Creek Landcare Group, 2021, *Changing Times Changing Landscapes at Hovells Creek, NSW: 200 Years of History and Personal Recollections,* Hovells Creek.

8 For an overview of the role of eucalypt forests in the sequestration of carbon see: Mackey BG, Keith H, Berry SL, Lindenmayer DB, 2008, 'Part 1. A green carbon account of Australia's south-eastern eucalypt forests, and policy implications', *Green Carbon: The role of natural forests in carbon storage,* ANU Press, Canberra.

9 Manning AD, 2003, 'A multi-scale study of the Superb Parrot (*Polytelis swainsonii*): implications for landscape-scape ecological restoration', unpublished PhD thesis.

Chapter 2

Where to Plant Paddock Trees

The chapter starts by looking at planning paddock tree layouts and plantings, with habitat considerations very much in mind. Helping ensure that trees have access to soil moisture, through where possible planting along gullies and drainage lines, is seen as a way of increasing survival rates. Use of farm machinery in paddocks has implications for tree planting, with the need to allow space for machine access. Powerlines, views and sightlines are discussed as a consideration when planning tree layouts. Planting trees in clusters, in fenced-off rocky knolls, or even re-treeing open areas, are considered as alternatives to planting individual paddock trees.

Your reason(s) for planting paddock trees should determine where you plant them, and how your planting is designed and implemented. Some key reasons that might guide the location and layout of your plantings include:

- For a **bird or gliding mammal corridor with stepping stone trees,** plant a staggered corridor of trees, with no more than 20–30 m spaces between each tree.
- If you want to **create a tree cluster** as habitat for birds and other wildlife, then you might locate it at the intersection of several existing or planned tree lines. Tree clusters can benefit from having a mix of shrubs and trees to add extra structure and protection for small birds.
- If you are **replacing dead or senescent trees** then plant trees near to and around them. A good idea is to also plant clumps of dense shrubs around a paddock tree, with a stock-proof fence which allows them to remain ungrazed until they attain a decent size. Plantings around an existing tree can also help prolong its lifespan by protecting its roots from stock and from cropping.

- If you want to **re-tree a whole paddock as an environmental rehabilitation project** then you might scatter or randomly plant the trees. Alternatively – although outside the scope of this book – you can use the Greening Australia 'Whole of Paddock Restoration' (WOPR) approach which involves direct seeding of trees and shrubs on a paddock scale. This can be very efficient and cost effective and grazing can be brought back to the paddock, usually after 5 years.
- If you are **just adding additional trees to a paddock** which already contains some trees then you will simply use your own judgement re spacing and location, but where possible keeping to the 20–30 metre spacing rule to allow for inter-tree bird and animal movements.

Planning paddock tree planting

A good first step in planning is to download and print off an aerial or satellite photograph of the area from Google Earth or from the NSW SIX Maps. This will allow you to highlight landscape features like watercourses, gullies, dams, rocky outcrops, trees, woodland patches, buildings, fences and fencelines with trees and shrubs (birds use these a lot for movement and foraging habitat). You can then draw your proposed planting plan on the aerial photograph, using the minimum 20–30 metre spacing rule for scattered tree planting.

An important complement to aerial photographs is 'walking the ground'. Consider the lie of the land, the minor relief and undulations, where existing trees and shrubs are located, where stock tend to congregate at night or in bad weather, areas that get particularly wet in winter or dry in summer, and which parts of a paddock are particularly exposed. This is essential in order to fine-tune any conceptual layout.

If one of your reasons for planting is to provide habitat and/or movement corridors for native wildlife, then it is useful to understand what wildlife is present where, as well as how your property is situated in relation to other habitat features in the area. For example, Fig 2.1 shows the distribution of particularly prevalent bird species in two paddocks at Old Graham, Hovells Creek. Because we were interested in enhancing habitat for birds, this information was then used to inform decisions about where to plant paddock trees that could create links between these areas of habitat.

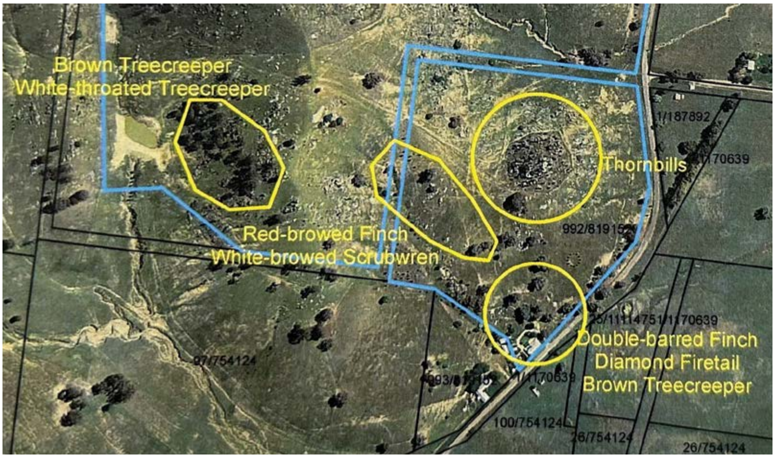

Fig 2.1: Distribution of key bird species on part of Old Graham, arising from a bird survey undertaken by ecologist Dr Damon Oliver (NSW Department of Planning and Environment) and used as an input when planning the layout of linking trees.

In addition to the bird distribution plan, a broader level habitat connectivity plan was developed by Ms Susie Jackson (Fig 2.2). It covered both Old Graham and other properties across the Hovells Creek area. The plan identified existing patches of open woodland and of possible new woodland (important potential wildlife habitat), as well as existing and potential new connections that would enable wildlife to move between areas of habitat. It was used as a guide for developing tree planting layouts for Old Graham.

Spacing

Paddock trees are typically planted 20–30 m apart in open paddocks to enhance their value as 'stepping stones' in the landscape. Small native birds, such as treecreepers, babblers, thornbills, finches, wrens and robins, will typically not fly for more than 50–100 m across open grassland, but will happily fly between a series of closer shrubs or trees. Gliding mammals are very mobile and regularly glide 20–40 m between trees, but many can't traverse gaps of much more than 75 m without descending to the ground, where they risk attack by foxes and feral cats.[1] Remember to allow for tree deaths and losses over the next 50–100 years by adopting closer spacings and putting in some additional trees.

Trees planted in tree lanes are usually much more closely spaced than paddock trees, often being planted only 5–10 m apart. However, in shelterbelts and tree corridors designed for shelter and wildlife habitat, a good rule of thumb is to plant around three times as many shrubs as trees, which has the effect of spacing trees more widely while establishing an understorey layer and a continuous vegetation strip.[2] This design is beneficial for small birds and other fauna, while also being effective at moderating wind speeds and creating shelter for stock.

Tree lanes and shelterbelts are often designed with gaps and corresponding gates in the fence at strategic points to enable vehicle access, particularly for emergency access during fire.

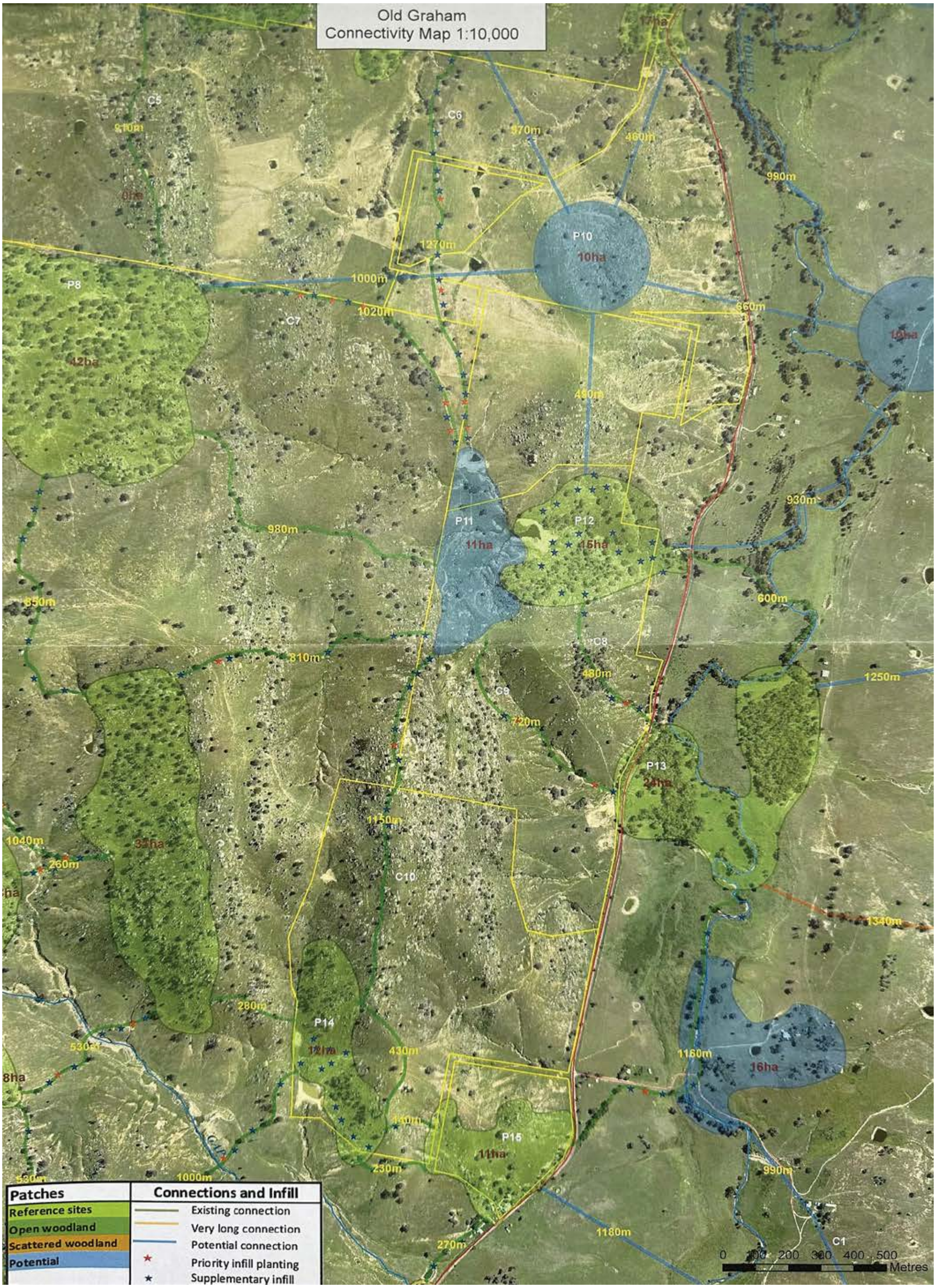

Fig 2.2: Habitat connectivity property plan of Old Graham used to help plan layout of linking trees and tree clusters. This plan was developed in 2016 by Ms Susie Jackson (NSW National Parks and Wildlife Service) as part of a wider contract with HCLG (funded by South East LLS), to develop similar plans for 10 other member properties. Ms Jackson also developed a masterplan covering 66,000 ha across the Hovells Creek area that suggested possible long-term connectivity planning options with adjoining areas.

Location

There are a number of key considerations to have in mind when locating and siting your paddock trees:

a. Wildlife corridors and stepping stones

Paddock trees, planted at 20–30 m intervals as stepping stones for small birds are best not planted in straight lines. Rather they can be staggered, with trees offset either side of a line, as this looks much more natural in the landscape. Incorporating existing living and dead paddock trees within such staggered corridor plantings, as in Fig 2.3, makes a lot of sense.

Tree corridors need to 'go somewhere' if we are to derive benefit from them. They need to link with or run between established patches of woodland or other habitat, so as to facilitate the movement of birds and animals between them. This linkage expands the effective area of habitat available to the birds and animals.

Fig 2.3 shows a staggered corridor, 480 m long and 60 m wide, of 36 tubestock trees planted in 2018. The corridor runs from a 12 ha patch of dry sclerophyll woodland (located uphill behind the camera) down to Frogmore Road. Beyond Frogmore Road, a 250 m gap was similarly planted by a neighbour, connecting to Hovells Creek. This created a continuous linkage between the belt of trees bordering Hovells Creek, which are visible running across the photograph in the distance, and the sclerophyll woodland area which principally comprised long-leafed box, red box, red stringybark and yellow box with some black cypress pine.

Fig 2.3: A staggered line of paddock trees planted so as to link a 12 ha area of woodland on the property with a belt of trees along Hovells Creek on a neighbouring property. The photo was taken in 2018 shortly after the trees were planted.

b. Availability of moisture — drainage lines and intermittent creeks

Planting tubestock in gullies and along drainage lines enables young trees to better access soil moisture and to benefit from runoff from occasional rainstorms (see Fig 2.4). This enhances initial survival and growth of trees during the first few years until they can get their roots down, reducing the risk of significant tree losses if planting is followed by a hot, dry spring or summer.

Fig 2.4: A gently sloping drainage line without erosion which provides more ground moisture for the trees than the adjoining slopes and hill. Nine paddock trees were planted in a staggered line to the pines at the top of the hill.

Occasional watering can also help reduce these losses, but it is often not practical to water paddock trees after planting. Trees may be in a distant paddock, there may not be a convenient source of water, the land may be quite inaccessible, or other tasks may simply take priority over watering.

Some drainage lines have existing trees and shrubs in them and so form natural bird connectivity lines. Birds are naturally attracted to drainage areas and typically access water from pools and seeps on a daily basis during the warmer months.

Planting trees in active erosion gullies can also help stabilise the gullies by causing a build-up of silt against both the actively growing trees and the steel guards protecting them. Fig 2.5 and 2.6 show how such a planting has not only grown over 20 years, but has also stabilised the gully.

Fig 2.5: River red gum trees seen in 2005, four years after being planted in 2001 as tubestock in an erosion gully. The water in the gully is from a recent rainstorm. The gully only ever flows after storms or heavy rain, except in particularly wet seasons when it flows lightly for a month or two.

Fig 2.6: The same trees in 2019, 14 years later. The trees and their guards (now removed) helped silt build up on the floor of the gully. There are also some river red gum self-sets growing in the gully bed to the right of the trees.

As Chapter 3 notes it is important to plant the appropriate species in such situations. For example, stringybark trees grow best on the ridges between drainage lines and are not well suited to planting in gullies or along drainage lines, whereas apple box prosper in such situations.

New tree plantings in or near gullies and drainage lines can be at risk of flood damage in high rainfall years, and may also die from having wet feet (from root rot) during unusually wet winters. The wet winter and spring of 2022 saw quite a lot of both autumn and spring-planted tubestock (planted in spring because of the forecast for wet conditions in spring and summer) die from wet feet, as water stood or flowed continuously in gullies that are normally dry. However, once trees are established this doesn't seem to be a problem.

c. Allow space for machinery and mower access

You may need to cultivate or mow round paddock trees, so they need to be spaced and sited with this in mind. Consider future possibilities as well – such as whether a grazed paddock is likely to be cultivated in future, or may simply require re-seeding.

Fig 2.7: Paddock trees in a paddock that has been sprayed out, harrowed and air-seeded with pasture grass. The tree at the left and the tree at the far right are well-located to cause the least impediment to machinery.

As an example, Fig 2.7 shows paddock trees planted in guards in what was previously a paddock of permanent pasture. A year after they were planted a decision was taken to spray out the paddock and reseed it. The photograph shows four guard-protected trees which, from left to right, demonstrate various spacing considerations:

- The guard of the nearest tree is attached to the fence, making it theoretically possible for machinery to work right up to the fence line while skirting the tree.
- The second tree's guard is about 1 m out from the fence, pushing machinery out from the fence.
- The third tree (middle distance) is in a guard that is 6–8 m out from the fence, which is too narrow a distance to allow the 13 m wide gang harrow and seeding machinery to get between it and the fence.
- The tree to the right is well out in the open, such that machinery can work around it.

The lesson from this exercise was that planting trees either adjacent to the fence or well away from it worked well, but that two of the four trees provided insufficient space for farm machinery to get between them and the fence. Consequently, when paddock trees were planted two years later in a second paddock, they were planted either along the fence (allowing sufficient space for the girth of the tree as it grows) or well away from it and spaced sufficiently far apart.

Similarly, when planting paddock trees in a house paddock, or along an access driveway, consider whether you may want a ride-on mower to fit between the trees and the fence or other infrastructure. Gaps too narrow for a ride on mower can necessitate either a smaller push mower or a great deal of whipper snipping.

d. Planting trees along fence lines

The nearest tree in Fig 2.7 is planted within a 1650 mm high steel guard fastened to the inside of the boundary fence that runs along the edge of the road reserve. This is an excellent way of adding trees to a paddock without intruding into the paddock and with half of the tree's dripline falling over the road reserve. This may be a particular consideration for tree planting associated with cropping areas, as correspondingly less of the paddock will be affected by shade or the allelopathy effect of eucalypt trees on plant growth and seed germination under the dripline.[3]

Some farmers worry about trees dropping branches on boundary fences. This may be true, but is unlikely to occur for many years with newly planted paddock trees, and is a small price to pay for the many benefits that trees bring.

Another benefit of such roadside fenceline plantings is that road reserves may have existing isolated mature trees in them, or in some cases isolated lengths of High Conservation Value

(HCV) vegetation communities which include many trees and shrubs. New roadside plantings can help provide a link between such patches of intact roadside woodland, with consequent benefits for wildlife movement.

The map in Fig 2.8 shows roadside vegetation in the Hovells Creek area and identifies lengths of Frogmore Road that fall into a high conservation category, including some with specific high conservation elements. Roadside plantings along the low conservation lengths of road would benefit the high and medium conservation value lengths by providing connectivity links between them.

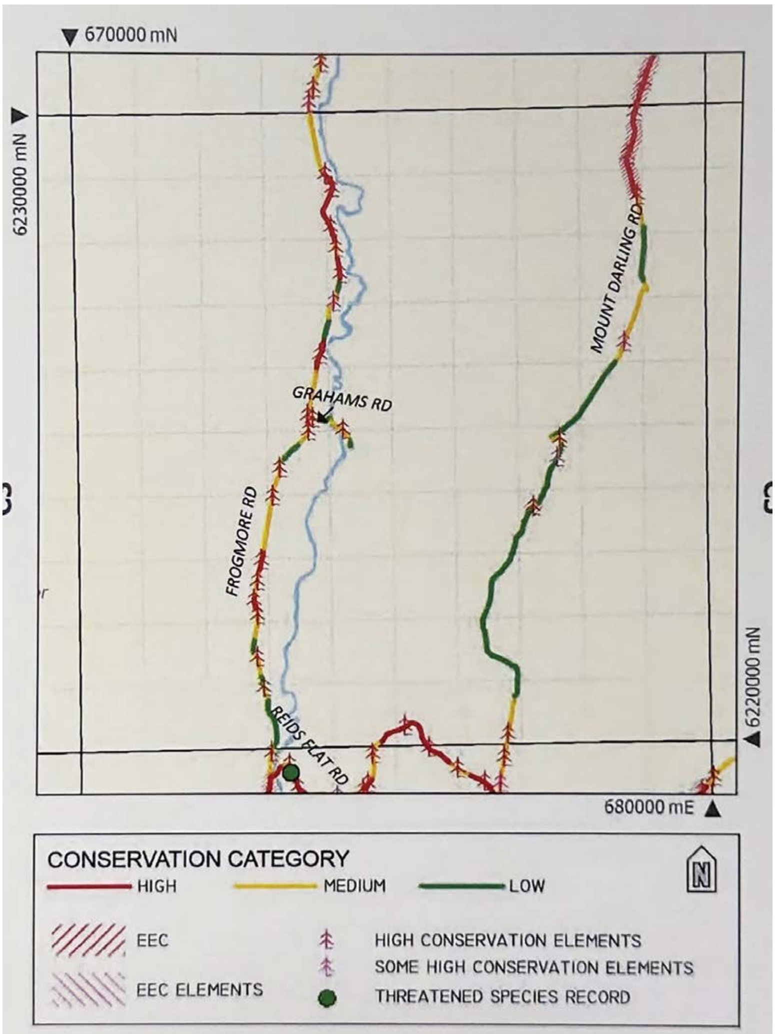

Fig 2.8: Roadside vegetation map for part of Hovells Creek, showing high, medium and low conservation categories for local roads, together with the location of specific high conservation elements and threatened species information.[4]

An alternative to planting trees within individual guards inside the road fence line occurs where a road boundary fence is in poor repair and needs replacing. An approach taken by some landowners is to build a new fence about 1–1.5 m inside the existing old boundary fence and to then plant a row of trees and shrubs within the fenced-off area so created. Fig 2.9 shows such a planting to the south of the village of Frogmore dating back to around the year 2000.

It is worth noting, however, that if the intention is to create a significant habitat patch and/or to provide shelter, then such strip plantings are more effective if they are wider, ideally >30m wide.[5] If the boundary strip is adjacent to existing roadside vegetation, this has the effect of creating an overall wider patch of vegetation, but if there is no other vegetation, then a wider, denser strip is more effective for shelter and biodiversity. If you are investing in a fence anyway, then it makes sense to capitalise on that investment by making sure the area fenced is actually large enough to enable you to create a decent strip.

Fig 2.9: Roadside tree plantings dating back to about the year 2000, planted between an old roadside boundary fence and a new fence built 1–1.5 m in from the old road fence line

Fig 2.10: Self-set eucalypts trees which grew after road re-alignment earthworks on Frogmore Road, Hovells Creek, and which died after being sprayed with herbicide by council workers. They are 9 m from the edge of the road pavement. This was a missed opportunity to allow trees to regenerate along the roadside to provide a link between other existing roadside trees.

e. Powerlines

Remember not to plant trees either under powerlines or too near to them. The legal easement for most powerlines is 10 m on each side of the powerline, so you need to ensure that when fully grown, the tree will not encroach onto the easement. Essential Energy recommends that trees be planted at least 15 m from powerlines.[6] Where trees are planted within the 10 m easement, or have large branches extending into the easement so as to possibly affect the powerline, then the electricity supplier can legally access a property to trim the trees.

Where a fenced off tree cluster is close to a powerline easement then an option is to plant 2–3 m high shrubs in that part of the cluster that sits under the powerline and within the easement.

f. Views and sightlines

If you are planting paddock trees near to a house, bear in mind their impact on views and sightlines. Small and apparently insignificant young trees grow into much larger trees and can block your view, so factor this into your layout planning. Conversely, consider where you might actually want trees planted to improve the view in the future, for example on bare hillsides.

Planting paddock trees in clusters

An alternative to planting individual paddock trees within their own steel mesh guards is to plant them as a cluster within a fenced-off area. Fig 2.11 shows a triangular cluster which on the right and at the back is bounded by existing boundary fences, each with a barbed top wire. The internal fence to the left (which adjoins sheep country) is a new construction without a top barb. Top barbs present a risk to some birds and gliding mammals which can get tangled on them, and should be avoided where possible, particularly around habitat patches.[7]

There is a trade-off involved here between the two alternative approaches. Using 2023 prices, the respective financial outlays would be as follows.

- **For individual plantings:** the cost of seven steel tree guards at $50–60 each plus 21 star pickets at $6 each, totalling up to $550 (noting that the guards can also be re-used for other paddock trees after a few years).
- **For the fenced triangle that utilises two already existing fences:** the cost of two installed corner assemblies at $180 each plus fencing along the 80m diagonal at $11 per metre, for a total of $1,240.

While the cost of the cluster arrangement is higher, the benefits are significant. An understory of shrubs can develop within such a cluster, which increases the value of the cluster for wildlife, and the larger fenced area enables future self sets of trees to grow, free of stock pressure. The triangular shape is particularly valuable in providing stock shelter for the adjoining paddocks, depending on the orientation. Densely planted clusters can be very effective stepping stone habitat for small vulnerable birds trying to cross farmscapes – but such clusters should ideally be no more than 20–30 metres from a paddock tree or from another cluster or woodland patch.

Fig 2.11: Fenced 1,100m² cluster containing 7 trees and 22 shrubs. The cluster adjoins a steep rocky slope covered with trees and shrubs and is linked by a series of stepping stone trees to another nearby smaller cluster and then to a much larger wooded area located behind the camera.

Fig 2.12: Trees and shrubs planted at Corrowong NSW within a circle made from a roll of 2 m wide steel reinforcing mesh. This should handle the stock pressure from sheep but not from cattle, although the addition of a few steel star pickets would give it added rigidity. Photo by D. Oliver/DPE

A particularly good option in intensive cropping paddocks is where a triangular cluster planting of trees and shrubs is positioned in the corner of the paddock. Corner plantings enable trees to be re-introduced to the landscape without interfering with large farm machinery working in the paddock. While there has been a tendency to shift towards larger paddocks (thereby reducing the corner space available for trees), smaller paddocks can be beneficial for managing crop-livestock rotations.

Another alternative to planting paddock trees within individual steel guards is to use steel reinforcing mesh or sheep mesh to produce a 6–8 m circle within which a number of trees and shrubs can be planted (Fig 2.12). A number of these circles can then be linked by planting stepping stone paddock trees between them.

Tree corridors along gullies and similar areas

The tree clusters described above often cover an area of between 500 and 1,500 m^2. A related approach, but covering much larger areas, is to fence off a gully or area subject to erosion and to plant trees across the whole area. Such a project was undertaken in 2023 on Willow Glen, with more than 2000 tubestock trees planted across a valley/gully (Fig 2.13) as part of a collaboration between the landowners and South East LLS.

Such corridors are often treated as shelterbelts, and there are a number of books and resources on how to effectively establish corridors for shelter and biodiversity purposes.

Fig 2.13 (above): A recent tubestock planting of more than 2000 trees across a valley/gully on Willow Glen, Hovells Creek. In this case the landowner covered the cost of fencing while South East LLS provided the trees and other planting material. Assistance in the planting work was provided by volunteers from the North Sydney Council Bushcare group and from HCLG (see section 5.6 in chapter 5).

Fig 2.14: Aerial photo dated late 2021 of tubestock tree planting done in 2008 by the late Tony Gay along fenced gullies south of Darbys Falls, with the Lachlan River on the right. Photo courtesy of Google Earth.

Re-treeing open areas

Sometimes the objective is to revegetate and plant paddock trees across an open paddock or grassy area which you know was previously treed, but which now has very few remaining paddock trees. Provided the whole area will be kept free of stock for 5–10 years then steel mesh tree guards are not required and it is economic to plant a large number of scattered tubestock paddock trees with only small plastic or cardboard guards to protect the trees from rabbits.

If you are uncertain as to whether the area was previously treed, then advice from an ecologist as to whether the area you are considering planting contains valuable native grassland habitat is important. In some cases native grasslands are naturally treeless, and these ecosystems are often extremely rare.[8] Planting trees into a valuable native grassland would be very detrimental to that ecosystem, and should not be done.

Case study: large scale paddock tree revegetation

Such a project was undertaken in autumn 2020 on the Grasmere property at Hovells Creek, within a 51 ha area of box gum and cypress pine woodland that included some open grassy cleared areas. The area was covenanted under a Conservation Agreement to the NSW Biodiversity Conservation Trust, and was already fenced off to exclude stock.

It was decided that three open grassy areas, comprising about 6.5 ha or 13 per cent of the total area, would be revegetated with scattered paddock trees. The aim was to help recreate a box gum grassy woodland environment, which typically averages 30–40 mature box trees per hectare.[9] Planting was done on the basis of a notional 7 m x 10 m grid, which gave 140 grid intersections per hectare. However, to imitate the scattered and widely-spaced character of box gum grassy woodland, and avoid regimented lines of trees, only half of the grid intersections were planted – on average 70 trees planted per hectare. Assuming that half of the trees might not reach maturity, this should give a final density of 35 mature trees per hectare.

To give the trees a scattered distribution the grid intersections to be planted were chosen using a random number table to replicate the head/tails spin of a coin, with the 1 or 0 in the table being replaced by 'yes' or 'no' in a listing used by the tree planter. The tree planter then walked along each rip line carrying a mix of tubestock trees and after 14 paces (approximately 10 m) checked the list to see if there was a 'yes' (plant here), or a 'no' (don't plant here). On that basis he then either did or did not leave a tree at that point, ready for planting.

Needless to say this required discipline by the tree planter, as random numbers can be very counter-intuitive. For example, the first 50 choices in the random numbers table were:

> yes, no, yes, no, no, yes, no, no, yes, yes, no, yes, yes, no, yes, no, yes, yes, yes, no, no, yes, no, yes, yes, no, no, yes, no, no, yes, yes, yes, no, yes, yes, no, yes, yes, no, no, no, yes, yes, yes, no, no, yes, yes, no

Interestingly out of the first 50 choices in the table there were 27 'yes' and 23 'no'.

455 trees were planted – 100 tubestock of each red box (*Eucalyptus polyanthemos*), yellow box (*Eucalyptus melliodora*), white box (*Eucalyptus albens*) and red stringybark (*Eucalyptus macrorhyncha*), plus 55 tumbledown red gum (*Eucalyptus dealbata*). These species were selected based on their representation in the adjoining woodland, although red box was deliberately under-represented because of its susceptibility to mistletoe infestation in the Hovells Creek area.

Preparing the ground for large-scale plantings

In preparation for planting the area in the case study was double-ripped with the two parallel rip lines 200 mm apart along planting lines spaced 7 m apart. The 0.5 m deep rips were made with a tractor-based single deep ripping tyne, at a time when the soil was damp but not wet (Fig 2.15). The objective was to crack the earth and lift it somewhat, but avoid it being so wet that the tyne simply slid through without cracking and lifting the surrounding earth.

The job was done in spring (September) 2019 to give the ground time to settle, and for any voids to collapse over the six months between then and the actual planting in autumn (April) 2020. The rip lines then provide an ideal planting environment, with loosened soil for the tree roots to penetrate.

Fig 2.15: The first rip using a tractor-based single tyne.

The tubestock were planted using a Hamilton tree planter to make a planting hole into the loosened soil between the two rip lines. The ripping also made it easy to push the canes into the ground (Fig 2.16). Predictably the young trees established their roots very quickly in the loose ripped soil. By ripping along the contours the rip line captured the surface runoff from heavy rain, to the benefit of the young trees, and avoided any erosion that might have resulted had the rip lines run in an uphill-downhill direction. This is particularly important in steeper country, but also difficult to achieve given safety considerations when driving tractors across a slope.

Fig 2.16: Tubestock planted at uneven spacings into a double rip line.

Interestingly, at a workshop on tree revegetation held in the area several years previously, an NRM consultant advised participants not to plant tubestock directly in a rip line, but to plant into a separate hole at least 300mm from the rip lines. They said this was to avoid the roots growing into and being aligned along the rip line, causing the mature tree to be unstable and suffer from wind throw.

However, discussions with five landowners who have planted tubestock trees into rip lines over a period of 20 years or more identified only one of them who had ever experienced such wind throw in their plantings, and it affected a very small number of trees in an exposed location. There is clearly a trade-off involved here between on the one hand the significant ease and growth benefits of their being planted into loosened soil, as distinct from the considerable amount of work involved in digging a separate hole. On the other hand there is the low risk of a very small number of trees being affected by wind throw through being planted in the rip line. Clearly the double rip lines 200mm apart, described in the preceding paragraphs, greatly reduce any windthrow risk that might result from a single rip line.

Fencing off and regeneration of rocky knolls[10]

Fencing off, excluding stock and encouraging regeneration of rocky knolls can be a very rewarding exercise (see Case Study in chapter 3). Rocky knolls often support different tree species to other areas of the landscape. Black cypress pine and sheoaks on rockier soil and outcrops, along with the remnants of dense shrub among them, are assets of great biodiversity value to landholders in landscapes with only limited native vegetation.

It is here where the highest diversity of small insectivorous birds often remain. These include the threatened flame and scarlet robins, seen in cooler months, grey-crowned and white-browed babblers, many thornbill species, and the rare and elusive speckled warbler that requires dense shrubs such as black thorn and hopbush in amongst thickets of black cypress pine. Protecting these drier shrubby pine woodlands from heavy grazing is an ideal first step in a farm revegetation plan, as these areas can then provide potential source populations of birds which can then move out across the landscape once new trees and shrubs have been planted within reach of the existing rocky outcrops.

Key takeaways from Chapter 2

Plan tree plantings to take account of existing landscape features and habitat connectivity. Consider the following:

1. Planting along drainage lines and intermittent creeks can greatly increase tree survival rates, particularly in dry times.
2. Planting along fencelines, or alternatively well away from them, is important where farm machinery might need to work in a paddock.
3. Don't plant under powerlines.
4. Avoid planting trees that might, as they grow, block valued sightlines from a residence.
5. Explore the option of planting some trees in fenced clusters rather than just in isolated tree guards.
6. Re-treeing large open areas is an option, but not in native grassland habitat. Aim for scattered paddock trees rather than regimented lines of trees.
7. Fencing off and planting some trees round rocky knolls is a great way of creating new habitat.

NOTES AND REFERENCES

[1] van der Ree R, Bennett A and Gilmore DC, 2004, 'Gap-crossing by gliding marsupials: thresholds for use of isolated woodland patches in an agricultural landscape', *Biological Conservation* 115(2): 241–249.

[2] Sustainable Farms, 2022, 'Managing natural assets on farms: Shelterbelts', available at www.sustainablefarms.org.au/resources

[3] Allelopathy is the biological phenomenon by which a chemical in the leaves of the eucalypt negatively affects plant growth and seed germination in the area under the tree's dripline. This is primarily understood to affect crops rather than pasture. However, it is worth noting that research shows that the productivity benefits of shelter trees near crops outweigh small declines close to the trees themselves.

[4] The map is taken from Boorowa Council's 2014 'Roadside Vegetation Management Guidelines' produced by Bathurst-based Applied Ecology P/L.

[5] Sustainable Farms, 2022, 'Managing natural assets on farms: Shelterbelts', available at www.sustainablefarms.org.au/resources

[6] Essential Energy, nd, 'Plan Before You Plant: A Guide to Planting and Managing Trees near Powerlines', available at www.essentialenergy.com.au/trees

[7] Lindenmayer DB, Macbeth SM, Smith DG and Young ML, 2022, *Natural Asset Farming: Creating Productive and Biodiverse Farms*, CSIRO Publishing, Clayton South, p61.

[8] Lindenmayer DB, Macbeth SM, Smith DG and Young ML, 2022, *Natural Asset Farming: Creating Productive and Biodiverse Farms*, CSIRO Publishing, Clayton South, p114.

[9] Rawlings K, Freudenberger D and Carr D, 2010, 'A Guide to Managing Box Gum Grassy Woodlands', *Caring for Country*, Dept of the Environment, Water, Heritage and the Arts, p4.

[10] While Pine Hill is described as a rocky knoll, it has a great deal in common with rocky outcrops. For an excellent overview of rocky outcrops see Michael D and Lindenmayer DB, 2018, *Rocky Outcrops in Australia: Ecology, Conservation and Management*, CSIRO Publishing, Clayton South.

Chapter 3

What Paddock Tree Species to Plant Where

This chapter discusses the need to select trees suited to the location where they are to be planted, and as an example details various species local to the Hovells Creek area. In times past some species have been selectively harvested, so the composition of current tree cover is not necessarily indicative of the tree cover at the time of European contact. Other tree species, such as red box, are under pressure as they have not only been selectively cut out, but are now proving particularly susceptible to mistletoe infestation. Climate change has implications for future tree plantings, and is part of a broader discussion on the use of non-local tree species.

What species to grow

It is important to plant tree species that are suitable for their location. The accepted approach is to plant local species,[1] given that they have long-established relationships and adaptations to and with the local soils, insects and birds. Within a local area, there is also considerable variation in soil and relief, which will also guide the choice of species.

Using Hovells Creek as an example, the local rock is granite, which comprises the hills and slopes, while the alluvial valley bottoms are mainly derived from riverine silt and eroded granitic materials. Only 30km to the south, at the village of Frogmore, the local bedrock changes to slate and ironbark trees (*Eucalyptus sideroxylon*) are widespread – so much so that a local road is called Ironbark Lane because of the ironbark trees that line it and dot the adjoining paddocks. Yet in the Hovells Creek area, with its granite bedrock, there are no ironbark trees (other than those that have been planted and are thriving!). This illlustrates how the mix of local tree species can vary significantly across quite short distances.

Relief and soils are an important variable that should not be ignored when making planting decisions. Taking two extreme examples, at Hovells Creek the hilltops and slopes are dotted with kurrajongs (*Brachychiton popolneus*), but these do not thrive on the valley flats given their preference for well-drained soils. However, river red gums (*Eucalyptus camaldulensis*) border most of the creeks, grow well on the flats and will also grow well if planted in the bottom of some of the erosion gullies on the lower slopes, but will not thrive on the hilltops.

Other tree species are more flexible. The tumbledown gum (*Eucalyptus dealbata*), found in the Boorowa and Cowra areas, grows well on the ridges and upper slopes, the gentler slopes and areas of the valley flat and floodplain.

Fig 3.1 lists some of the native tree species naturally found in the Hovells Creek area, or that are from neighbouring areas and have been found to grow well there. The table identifies those best suited for different areas: ridges and steeper slopes; gentler slopes and plateau; creek flats and floodplains; and river banks. While the list is specific to the area, similar principles in terms of species choice apply in other regions. So when planning paddock tree plantings, the challenge is to identify local tree species appropriate to the area. Driving or walking the area and noting what tree species are growing is a good start, but this can also be misleading because some species may have been selectively cut out and harvested over the years.

Selective historical harvesting of white cypress pine and red box

In the Hovells Creek area an early surveyor's notebooks and original survey plans for land portions in the area show that black cypress pine (*Callitris endlicheri*) and white cypress pine (*Callitris glaucophylla*) were both widely distributed across the hills and slopes.[2] However, because white cypress is termite resistant and is by far the superior timber for construction purposes, it has nearly all been cut out and what remains of the two species is mainly black cypress, with only isolated white cypress trees. As noted in the section on fencing off and regenerating rocky knolls in Chapter 2, grazing by sheep effectively prevents the regeneration of cypress pine seedlings, which explains why white cypress has been unable to recover.

Similarly, because red box (*Eucalyptus polyanthemos*) is a very durable timber, relatively resistant to termites, well suited for firewood and for infrastructure such as houses, shearing sheds and strainer posts, it has largely been cut out. Meanwhile apple box (*Eucalyptus bridgesiana*), widely regarded by locals as a 'rubbish' timber, is still widely present across the lower slopes, water courses and flats of the area.

Trees Suitable for Paddock Tree Planting at Hovells Creek for NSW Environment Trust Project – 2019 Plantings

Common name	Species name	Comments
Black cypress pine	*Callitris enlicheri*	Grow well but not currently available. Hard to propagate and seedlings grow slowly.
White cypress	*Callitris glaucophylla*	Grow well but not currently available. Hard to propagate and seedlings grow slowly.
Red stringybark	*Eucalyptus macrorhyncha*	Medium speed grower. Likes sandy soils. Bark can contaminate sheep fleece
Kurrajong	*Brachychiton populneus*	Slow grower, good in rocky areas, takes time to establish. Tubestock do better if 'grown on' for a year.
Longleaf box	*Eucalyptus gonyocalyx*	Fast grower.
White box	*Eucalyptus albens*	Fast grower, prefers deeper, well drained and not shallow and sandy soils.
Red box	*Eucalyptus polyanthemos*	Susceptible to mistletoe, so better in treelots than as isolated paddock trees.
Ironbark	*Eucalyptus sideroxylon*	Grows ok, but a slow grower. Not local, but Frogmore area.
Tumbledown gum	*Eucalyptus dealbata*	Fast grower. Not local but endemic to wider Boorowa/Cowra area.
Yellow box	*Eucalyptus melliodora*	Medium grower. Grows in less well drained areas than white box but not in poorly drained.
Apple box	*Eucalyptus bridgesiana*	Handles damp situations and specially suits drainage lines on slopes. Tolerates more waterlogging than yellow box.
Blakely's red gum	*Eucalyptus blakelyi*	Ideal for the more poorly drained areas.
Grey box	*Eucalyptus microcarpa*	
White cedar	*Melia azedarach*	Grow well but not available locally. Small tree good for birds & stock shade. Usually planted as bare-rooted whip in winter.
River red gum	*Eucalyptus camaldulensis*	Can be very fast grower. Grows well in gullies on lower slopes.
River oak/sheoak	*Casuarina cunninghamia*	Prefers sandier rather than clay soils.

Fig 3.1: List of trees used by HCLG in its paddock tree planting work, grouped by relief and soil situation. It provides an example of some of the considerations relevant when choosing species for planting. All trees listed in this table were found to be 'good goers' in the Hovells Creek area.

	Local species	Suitable location in the landscape			
		Ridges, steeper slopes, rocky knolls (sandy soils)	Gentler slopes & plateaux, often lower in landscape (soils with clay layer below sand)	Creek flats and floodplains	River banks / riparian areas
	✓	✓			
	✓	✓			
	✓	✓	✓		
	✓	✓	✓		
	✓	✓	✓	✓	
	✓	✓	✓		
	✓	✓	✓		
		✓	✓		
		✓	✓	✓	
	✓		✓	✓	
	✓		✓	✓	
	✓		✓	✓	
	✓		✓		
			✓		
	✓		✓	✓	✓
	✓				✓

Notes: Based on suggestions from McDonalds Farm Trees, Keith Hyde, Gordon Refshauge, Rosemary Hook, John & Liz Baker, Boorowa Regional Catchment Committee map and NSW Flora Online.

There are other considerations that are particular to different locations and situations. For example, red box (*Eucalyptus polyanthemos*) is currently proving particularly susceptible to heavy box mistletoe (*Amyema miquelii*) infestations in the Hovells Creek area, with many semi-mature and mature trees suffering dieback or even dying (Fig 3.2 and 3.3). While mistletoe growth on eucalyptus species is quite normal, the reasons for the current particularly heavy growth of mistletoe on red box is not understood. Various methods of mistletoe control, ranging from glyphosphate injections in the host tree, physical removal with the assistance of a cherrypicker, and shooting mistletoe growths out of the trees with a rifle (Fig 3.2), have all been tried with only limited success. Consequently planting red box as isolated paddock trees may result in significant losses in the longer term.

Availability of local tubestock tree species

Most tree nurseries have local tubestock tree species available for purchase. If you wish to plant widely distributed trees such as the white box, yellow box and Blakely's red gum, then you will likely be able to purchase them readily. However, it should be noted that they are unlikely to have been grown from locally sourced seed.

Most local nurseries buy their seed from commercial seed collectors, who in turn use contractors to collect and supply them with seed. This seed may have been collected from anywhere in the natural range of the tree, potentially far distant from your location, meaning there is an absence of any adaptation to the specific local environment. Very few local nurseries collect their own seed from their local area. Where they do so in a professional manner they will ensure they are collecting from large healthy tree specimens that stand by themselves so as to avoid their seed being crossed with nearby less healthy trees.

The focus of this guide is *Eucalyptus* species, primarily because they are the dominant and most widespread tree species in the area. They are also particularly affected by the J-rooting issue discussed in Chapter 4.

There is also a handful of tree species from other families local to the area which are planted as paddock trees and in tree corridors, namely kurrajongs, casuarinas and the black and white cypress pines. These are readily available from nurseries. Cypress pines are slow to germinate and, as is noted in Chapter 4, kurrajongs benefit from being planted after having been 'grown on' for a further year.

Fig 3.2: Using a rifle to shoot box mistletoe growths from a badly infested red box paddock tree (note the old dead mistletoe clumps lying on the ground).

Fig 3.3: An otherwise healthy red box paddock tree that died recently from a heavy box mistletoe infestation.

Case study: regeneration of black cypress at Pine Hill

Fig 3.4 and 3.5 show Pine Hill, a rocky knoll at Old Graham, which was fenced off in 1993 when there were only four senescent black cypress pines (*Callitris endlicheri*) growing on it. Then in 1994 about 15 tubestock *Eucalyptus* species and kurrajongs were planted within the fenced off area.

By 1996 self-set black cypress trees were coming up through the long grass throughout the fenced-off area. Sheep had previously eaten the tops off newly-grown self-sets and thus prevented any natural regeneration, but fencing and excluding sheep from the area allowed the self-sets to grow prolifically. Rabbits had, until their virtual elimination by calicivirus in the late-1990s and early-2000s, also been very active grazers in the area.

Since the early-2000s it has been necessary to go in with a pair of loppers almost every year and thin the black cypress by cutting many of them off at ground level (they don't sprout again from a cut stem). This thinning is necessary to avoid the phenomenon of 'lock-up', whereby patches of young cypress trees grow so closely together that they are unable to grow beyond 4–5 m in height, rather than their usual height of 10–15 m.

This 'lock-up' phenomenon has been a key issue for silvicultural management of areas of white cypress pine (*Callitris glaucophylla*)[3] in Western NSW, especially in the Pilliga Scrub (Pilliga Management Area of State Forests of NSW). The removal of sheep and the death of rabbits, first from myxomatosis and later from calicivirus, allowed white cypress to regenerate so prolifically and thickly that 'lock-up' occurred, requiring programs of manual thinning to ensure the continued and future availability of such a key source of sawlogs.[4]

Early land surveys of the Hovells Creek area from the 1850s show that there were patches of white cypress on the valley slopes and hills, but these have all been cut out for timber, leaving only the less commercially attractive black cypress pine.[5]

When Pine Hill was first fenced off, there were very few remnant shrubs and forbs to be seen. There was only one specimen of western silver wattle (*Acacia decora*), a few *Hardenbergia violacea*, one patch of *Dianella longifolia* and several green hop bush (*Dodonea viscosa*). But after 10–15 years the Acacia in particular had spread, plus many of the local forbs began to appear (presumably from seed or from bulbs that had previously been grazed) and by 2020 they covered the whole area. They included small vanilla lily (*Arthropodium minus*), pale vanilla lily (*Arthropodum milleflorum*), chocolate lily (*Dichopogon fimbriatus*), bulbine (*Bulbine bulbosa*), yellow rush lily (*Tricoryne elatior*), rock isotome (*Isotoma axillaris*), small St John's wort (*Hypericum gramineum*) and pale sundew (*Drosera peltata*), plus many others too numerous to mention. The hill also became a favourite place for local eastern grey kangaroo (*Micropus giganteus*) mothers to live with their joey at foot.

Fig 3.4: Pine Hill, a rocky knoll on Old Graham, shortly after being fenced off in 1993. At the time there were only four senescent black cypress (Callitris endlicheri) growing on the knoll.

Fig 3.5: Pine Hill in 2018. About 15 tubestock Eucalyptus species and kurrajongs were planted in 1994. The black cypress pines which now dominate the area are all self-sets from the seed of the four original old trees, two of which have since died.

Tree planting and climate change

Climate change is now an accepted reality and has long term implications for the nature and composition of our natural vegetation. As areas become drier or wetter, or hotter or colder, so the tree cover will gradually change in composition, reflecting the differing natural range of individual tree species. This means that some local species will be under more stress than others, while some species from elsewhere may grow better in the area in the future.

The Hovells Creek area sits near the junction of four BOM weather forecast areas – the South West Slopes, Central West Slopes and Plains, and the Central and Southern Tablelands. In an attempt to take stock of what future long term changes might occur in the climate of the area, a workshop was organised by HCLG and held in 2019 at Frogmore, with the keynote presentation by Professor Mark Howden of The Australian National University Climate Change Institute.[6]

Professor Howden made the following points regarding the expected impact of climate change on the Central West and Central and Southern Tablelands areas:

- Global warming relative to 1850–1900 was forecast by the IPCC in 2018 as likely to reach 1.5° by 2040 and perhaps as early as 2026, resulting in higher mean temperatures in the area. (This 2026 date now seems likely to be achieved based on press reporting of more recent research and IPCC announcements.)
- Temperature variability is increasing.
- Heatwaves are likely to have increased duration and intensity.
- Drought will have increased frequency and intensity.
- Heavy precipitation events will increase.
- Autumn rainfall may decrease and summer rainfall increase as Australia's seasonal rainfall zones move southwards – though this could result in increased total annual rainfall for the area.
- Rainfall run-off is likely to fall by about 15 per cent for each °C of warming.

A consequence of all these trends is that crop yields in the area, other things being equal, are already being reduced and will be reduced further.

The Australian Bureau of Agricultural and Resource Economics and Science (ABARES) has commissioned research on the impact of climate change on commercial forestry, which concluded that there would be an overall decline in wood yields in all areas of commercial forestry as a result of predicted climate change.[7] It can be reasonably assumed that there will be a corresponding reduction in the health and growth of paddock trees in the Central West and Central and Tablelands area. ABARES conclusions are consistent with the assumptions made in a Macquarie University 2016 report by Hancock, Harris, Broadhurst and Hughes on 'Climate-ready Revegetation: A Guide for Natural Resource Managers'.

The problem is that while various long-term changes can clearly be expected in the health and composition of paddock trees in the area covered by this guide, there appears as yet to be no practical research on which specific species might be affected by climate change in the area, or which other species might be better suited. So for the present there is little alternative but to continue planting existing local tree species, perhaps with some careful small-scale experimentation with other species (see box below).

Clearly an applied and practical study covering which specific species might be affected by climate change in the area, and which other species might be better suited for the area, would be a useful exercise to be commissioned at some point by the relevant Local Land Services regions or by a consortium of Landcare groups.

Planting native species outside their natural range

One of the challenges posed by global warming is predicting which tree species might be better suited to an area in future. Although extensive local studies have not been conducted, one local tree enthusiast has undertaken some trials.

Some years ago he collected seed from grey gum (*Eucalyptus punctata*). The natural range of the grey gum extends through the ranges and near coastal areas from Gympie in Queensland to Nowra in NSW, but it is not found in the Hovells Creek area. Young grey gum trees, grown from seed, grew very well in the Hovells Creek area and over a number of years their performance has generally been better than that of such key local species as *Eucalyptus blakleyii*, red box and yellow box. The grey gum trees also performed well through recent drought periods and the wet periods of 2021 and 2022.

Another tree trialled in the area on a lower lying well-watered slope is black gum (*Eucalyptus aggregata*), which to date has grown very well. Black gum typically grows in the Central and Southern Tablelands in lower parts of the landscape on alluvial soils and adjacent to creeks, and is classified as vulnerable.

Non-local but high-performing species suitable for changing conditions could play a role in future paddock tree planting programs, but clearly the results from a number of trials would be required before any judgements could be made. The impacts of introducing new species into areas where they have not previously found may also have unintended consequences on assemblages of plants and animals local to the area.

Key takeaways from Chapter 3

1. Aim to plant local species that are well suited to the chosen location (such as river flats, slopes or hills) within the landscape.
2. Be aware that some species may be particularly vulnerable to disease, insect attack or mistletoe infestation.
3. Climate change is real and will increasingly have an impact on the range of our tree species. As yet there is no clear evidence to guide species selection, including the possible planting of non-local species that might be better adapted to changing conditions.

Fig 3.6: Scattered paddock trees and occasional woodland on the hills, slopes and flats of the Hovells Creek valley, with Old Graham in the centre.

NOTES AND REFERENCES

1 'Local species' are those whose natural range includes the local area of interest. This is as distinct from 'endemic species'. The concept of 'endemism' refers to whether a species is found somewhere else, or not – so a species which is 'endemic' to the Cowra region is found only in and around Cowra. A species can also be endemic to a much larger area – for example eastern Australia. There can be value in planting species which are endemic to your local area or region, because in being found in a more restricted area, they are unique.

2 See surveyor's notebooks for V B Riley, 1871, and also survey plans for portions in the four parishes of Kember, Newham, Kenyu and Graham, Department of Lands Archives, Sydney.

3 White cypress pine (*Callitris glaucophylla*) and black cypress pine (*Callitris endlicheri*) are similar in appearance, with a height of up to about 15–20 m, and their distribution overlaps widely. White cypress is distinguishable by its blue-grey foliage and is highly prized as a termite-resistant building timber. By comparison black cypress pine is not termite resistant and weathers less well in the open.

4 For an excellent overview of white cypress pine and its distribution and management, including the risk of 'lock-up', see Thompson WA and Eldridge DJ, 2005, 'White cypress pine (*Callitris glaucophylla*): a review of its role in landscape and ecological processes in eastern Australia', *Australian Journal of Botany*, 53: 555-570.

5 Some white cypress are now regenerating naturally along the roadside on the Cowra side of Darbys Falls.

6 The workshop, 'Managing the Dry Times', was organised by Hovell's Creek Landcare Group with funding from the Foundation for Rural and Regional Renewal (FRRR). Professor Mark Howden is also Vice Chair of the Intergovernmental Panel on Climate Change (IPCC) Working Group II. A copy of Professor Howden's Powerpoint presentation is available at: hovellscreeklandcare.org.au/past-projects/152-workshops-set-to-help-farmers-doing-it-tough

7 ABARES, 2011, Potential Effects of Climate Change on Forests and Forestry in Australia, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Chapter 4

Sourcing Suitable Tubestock

This chapter looks at why we plant tubestock trees rather than larger ones and highlights the importance of using good quality tubestock. It considers how J-rooting seriously compromises the quality of tubestock and of paddock tree planting outcomes. The incidence of J-rooting across a range of tree suppliers is examined, highlighting the importance of sourcing good quality tubestock. The special case of kurrajongs, and the benefits of 'growing them on', is also considered.

Using poor quality tubestock severely compromises the success of a paddock tree planting. The cost of tubestock is only a small part of the overall cost of planting such a tree, so it is a bad investment decision to use poor tubestock.

Tubestock vary significantly in quality. Healthy trees grow from good tubestock. Poor quality trees result from the use of poor seed, poor potting mix, unsuitable growing conditions and the use of propagation and pricking out techniques that result in J-rooted, kinked or circled roots.

Individual landowners, Landcare groups, NRM funding bodies and local councils need to pay attention to these issues if they want to get good results from their investments in tree planting.

To have the best chance of sourcing tubestock of a high quality, buy from a nursery with an established tree-growing reputation, seek feedback from customers, and make sure you personally examine the quality of the tubestock in the light of the criteria listed at right.

Tubestock specifications[1]

Good tubestock should meet the following criteria:

1. Tree foliage should be healthy, firm-textured and free from insect, fungal or physical damage.
2. Tubestock should be properly hardened, which may result in them losing their bright green colour. Hardening requires plants being out of a shade house or polyhouse for at least 4–5 weeks.
3. Trees should have vigorous, actively growing roots with fresh white growing tips (Fig 4.1).
4. When removed from the forestry tube or Hiko pot the potting mix should be held within the root structure and not fall away (Fig 4.1).
5. Plant containers must have effective root trainer ridges to prevent root circling.
6. Tree roots should not be J-rooted or kinked (Fig 4.2 and 4.4).
7. Air pruning should have caused minimal root protrusion through the bottom of the container (Fig 4.1).
8. It should be possible (after watering the tubestock well) to remove the plant from the container without damaging the foliage or roots.
9. A seedling height of between 150 mm and 250 mm is optimal and below 100 mm is a concern.
10. Tubestock should not have been in their forestry pot for more than 6–9 months. Stock older than this gets tall, leggy and completely pot bound, and don't transplant successfully.

Fig 4.1: *Eucalyptus* tubestock showing potting mix well contained by roots with fresh white root growing tips. The results of air pruning are evident at the bottom of the soil balls.

Propagation

Native seed propagation is a specialised field best left to professionals. It is not covered in this booklet. Unless one has spare time and is interested in propagating eucalypt seedlings as a recreational activity, propagating your own trees is not worthwhile.

Key success factors for propagating tubestock eucalypt trees include using:

- good quality seed
- well-draining propagation soil mix of appropriate ph value
- appropriate low phosphate fertiliser designed for native trees
- a suitable greenhouse or polyhouse to house the seedlings while germinating
- professional propagation practices including watering, and
- propagation techniques which avoid J-rooting.

Why use tubestock instead of more advanced trees?

There are three principal reasons for purchasing tubestock, either in the 120 mm high forestry tubes used by most growers, or in 85 mm high Hiko pots, rather than as more advanced trees:

1. The cost difference is significant – tubestock cost between $3 and $8 each, while young trees in 100–200 mm pots cost between $15 and $25.
2. The work involved in planting trees from larger pots is very much greater than with tubestock.
3. Experience has shown that young tubestock eucalypt trees settle in more quickly and grow much better than those that have been grown on in larger pots. Within a few years tubestock overtake older trees that were in larger pots. Trees in larger pots are also more susceptible to drying out and dying when planted out in the paddock.

Trees in pots larger than 200 mm are unlikely to transplant successfully unless they are given ongoing watering and are planted very carefully into well prepared ground. This is in contrast to most exotic European deciduous trees which can be transplanted quite successfully, often bare-rooted, during their dormant winter period.

J-rooting, circling and kinking of tubestock roots

A problem that seems to be particular to *Eucalyptus* species trees is that the tap root – an important part of the *Eucalyptus* root system – is too often J-rooted, kinked or circled. This adversely affects the growth of the young tree by impeding the flow of nutrients and water up the tap root to the tree, as well as reducing the stability of the young tree in the ground. The challenge when purchasing *Eucalyptus* tubestock is that for their first year J-rooted or kinked trees are indistinguishable from other good tubestock. It is only after a couple of years that their deficiencies start to become apparent – they can then become stunted, struggle to thrive or blow over more easily.

The significance of this problem is highlighted in 'Tree Stock for Landscape Use', an Australian Standards document which provides criteria for those who grow, specify or purchase tree stock for landscape use with the objective of ensuring that a tree is 'free of faults that would be likely to cause the tree to fail at some point in the future'.[2]

Fig 4.2 below shows an image reproduced from page 15 of the Australian Standards document which illustrates J-rooted, kinked, circling and girdled roots, which the standard states, 'shall not be present in the root ball'. When such faults are present then supply of that tree is in breach of the relevant Australian standard and is actionable under Australian consumer law, which requires that goods be of 'merchantable quality' and be 'free from defects that were not obvious at the time of purchase'.[3]

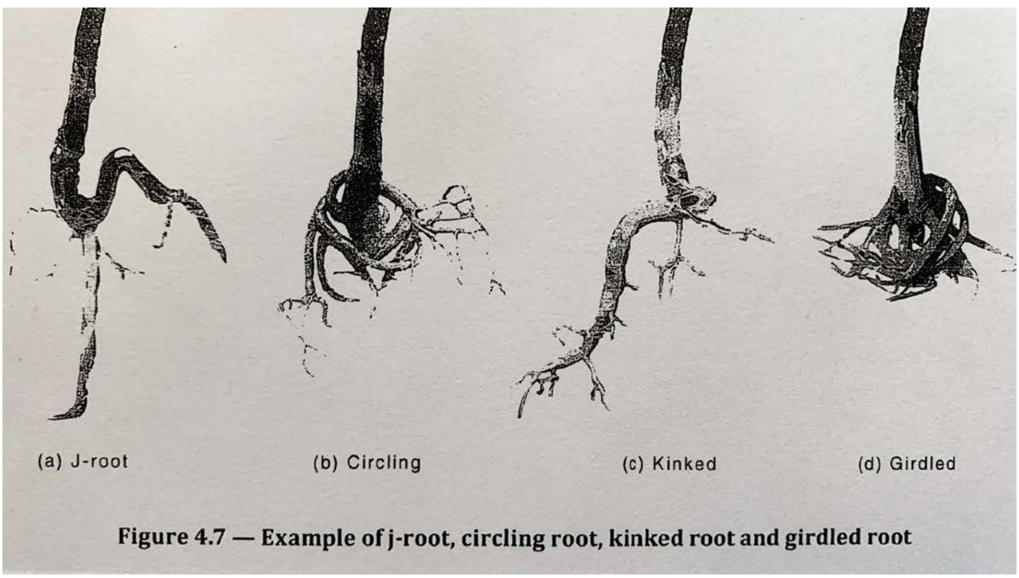

Fig 4.2: Image from Australian Standard 2303:2018 showing various root problems.

The impact of J-rooting in the field

Derek Moore, of the School of Agriculture at Charles Sturt University, has provided a succinct account of the need to pay attention to J-rooting/kinking:[4]

'Unfortunately because trees are very long lived it can take years for problems of poor quality root systems to become apparent and often it isn't realised that the problem was poor nursery production practices which crippled the root system and doomed the tree at planting . . .

'It is currently beyond question that poor root system quality at planting can result in trees subject to poor growth, windthrow, trunk breakage at ground level and the premature failure of plantings . . . Kinked roots (known in SE Australia as J-rooting) usually occur when the seedling is pushed into a dibbled hole in the container growing medium . . . In extreme cases J-roots can lead to the trunk of the tree lying in the soil a bit like a ball in a socket and the stem can simply snap off at this point a number of years after planting . . .

'There are two potential solutions to the problems of root kinking (or J-roots). The first is to eliminate dibbling (where a hole is formed in the container medium and the germinated seedling is removed from its propagation environment and placed in the hole).

'An alternative is the direct seeding of the tree either into the final production container or into a small intermediate one.'

Incidence of J-rooting and related problems in sample trees purchased in the Central West

To assess the incidence of J-rooting and related problems in *Eucalyptus* tubestock being sold to individual land owners and Landcare groups in the Central West, a 'mystery shopper' exercise was undertaken, with sets of six yellow box tubestock trees obtained from each of six different nursery suppliers:

- a specialist native plant nursery in Canberra, Oct 2019
- a general plant nursery in Central West NSW, Sept 2019
- a large nursery specialising in native plants in South East NSW, Oct 2019
- a small general nursery in South East NSW, Oct 2019
- a specialist tree nursery in Central West NSW, Oct 2019
- a Landcare group on the South West Slopes, NSW, Oct 2019.

After washing all of the soil from the root ball (essential if J-rooting and other allied problems are to be seen and identified) the bare roots of the 36 young trees were assessed, with the identity of the suppliers hidden from the assessors.

Condition of roots	Supplier						Total trees	%
	A	B	C	D	E	F		
Good	1	6	1	1	6	4	**19**	**53**
J-rooted	5	0	2	2	0	0	**9**	**25**
Circled	0	0	0	0	0	1	**1**	**3**
Kinked	0	0	3	3	0	1	**7**	**19**
Girdled	0	0	0	0	0	0	**0**	**0**
Total trees	6	6	6	6	6	6	**36**	**100**

Fig 4.3: Incidence of J-rooting and other problems in 36 tubestock trees sourced from six suppliers.

The results of the root assessment, shown in Fig 4.3, are very disturbing. Half of the suppliers had only one tubestock out of six that met the Australian standard. On the other hand, two suppliers had no problems with any of their trees.

Viewed overall, only half (53%) of the 36 tubestock trees sampled met the requisite Australian Standard. From a statistical standpoint, and based on Fisher's Exact Test, the results in the table are judged to be statistically highly significant.[5] In plain English, there is significant variation shown between the incidence of J-rooting amongst the sample of trees from the six suppliers that is highly unlikely to be a random result.

Fig 4.4: Six tubestock trees from Supplier D, showing two with J-rooting, three J-rooted/kinked, and only one straight-rooted (second from left).

Fig 4.5: Six trees from Supplier E showing six good straight-rooted trees (slight kinks are evident in some of the trees, but not to a degree judged to be an issue for future tree growth).

The causes of J-rooting and of allied root problems

Most local nurseries germinate their eucalypt seedlings in trays of seed raising mix, which are then pricked out, desirably before the first true leaf stage when only the two cotyledon leaves are showing.

According to Wrigley and Fagg's classic *Australian Native Plants*, the best method of pricking out and planting seedlings is to only partly fill a forestry tube container with potting mix and then hold the seedling in position while the remaining mix is filled into the container.[6] The plant is then gently firmed down with the fingers. This ensures a straight, natural root system.[7]

Eucalyptus seedlings typically have a fine hair-like tap root which needs to be kept straight and pointing downwards. Unfortunately some growers plant their seedlings into forestry tubes that have already been completely filled with potting mix. They then use a dibber, or a piece of pointed wooden rod, to make a hole in the mix, with the seedling's roots then inserted into the hole and the mix firmed down around it.

The problem with this method, and what causes J-rooting, is that when the root is inserted into the hole the very fine hair-like lower end of the taproot may not go straight down, but instead often catches on the side of the hole and is bent back upwards. This is particularly a problem if the seedling is at or past the true leaf stage when the tap root is quite long, as it more easily catches on the side of the hole.

Then, as the bent tap root grows, it senses that it is pointing upwards and so turns and grows downwards, thus creating the distinctive J-shaped root. As the tree grows and the root thickens, this J-shaped bend in the taproot becomes a significant constriction, which not only prevents the free flow of sap between the taproot and the above ground stem and leaves, but also weakens the capacity of the taproot to anchor the tree into the ground by providing a point of mechanical weakness.

The problem with pricking out is that to do it successfully staff need to be very careful and real discipline is required to do it right. The managers of several Landcare and other non-profit community nurseries have commented that pricking out seedlings properly when relying on volunteer labour is not easy because of the difficulty of imposing the necessary quality control on occasional volunteers. In commercial nurseries, where paid employees can be required and expected to follow specific procedures, the process is, or should be easier. However, as this chapter describes, some commercial nurseries also have real difficulty pricking out seedlings successfully and in producing quality tubestock.

How to avoid J-rooting and related root problems

One large nursery avoids J-rooting and allied problems by direct sowing tree seeds into small plastic pots, such as those in 'Hiko' trays (Fig 4.6), which comprise 40 connected small plastic pots, each 40 mm diameter x 85 mm deep. The seedlings are then thinned, so that only the healthiest one remains in each pot. There is thus no need for pricking out and the young trees are then planted into the field direct from the Hiko pot. However, it is important that tubestock are not left for too long in these Hiko pots, as they have less depth for root growth than do forestry pots.

A few nurseries direct sow seed directly into black plastic forestry tubes (50 x 50 x 120 mm deep) of potting mix, and these again require thinning to ensure that only the one best seedling is left in each pot. The problems with this approach are: potting mix is less suitable for seed germination than the finer mix typically used in seed trays; it is difficult to provide the best conditions for seed germination in forestry pots; and forestry pots require a lot of greenhouse space when germination is underway.

Other nurseries, including some interstate and overseas, direct sow their seed into 30 mm deep plastic plug trays (Fig 4.7) filled with seed raising mix.[8] A similar approach involves sowing seed into small peat-like pellets. Once the seedlings have germinated then each plug or pellet is removed from the plug tray and inserted in its entirety into a hollow made in the top of the potting mix in a forestry tube. With this approach there is no transplant shock and no disturbance of the taproot, which at this very early stage is little developed and is air pruned in the soil plug, which is contained within a relatively open-bottomed cell in the plug tray. This method produces well-rooted tubestock trees with no incidence of J-rooting, girdling, kinking, circling or other tap root damage, and is clearly the preferred approach. This technology originated in the USA and Europe for hydroponics and vegetable growing, but is now being used in Australia and other countries for tree growing.

It is important to flag here that even perfectly rooted tubestock trees face problems if they are left in their tubes for too long and if their roots are allowed to become too pot bound. This is a further argument for planting out tubestock trees in autumn rather than in spring (see Chapter 5).

Fig 4.6: Six 85 mm high Hiko pots cut from a larger Hiko tray of 40 pots and a 120 mm high forestry pot.

Fig 4.7: Plastic plug tray containing 288 growing cells 27 mm deep. Cells have a relatively open bottom to ensure air pruning of the roots, and are filled with potting mix and used to germinate a seedling in. Once the seedlings are the right size they are moved with their soil plug and inserted in the top of a forestry tube of potting mix. Since the seedling remains in its soil plug there is no possibility of the tap root being bent, as often occurs when seedlings are pricked out of a seed tray. Photo from The Climbing Fig Garden Store website.

Raising awareness of J-rooting

Awareness of J-rooting among landowners, Landcare groups and local councils is generally very low. Indeed in a recent case, an NRM professional argued quite incorrectly that J-rooting was not a problem for the growth of *Eucalyptus* tubestock, despite extensive evidence to the contrary. Worse still, many of those who are aware of the importance of the issue then ignore it, perhaps because they don't know how to handle it.

The problem is that even established nurseries, which may otherwise produce high quality shrubs and plants, sometimes provide *Eucalyptus* tubestock which fail to meet the basic J-rooting specifications. Against this backdrop we spoke in late 2019 with several nurseries in the Central West who admitted to producing J-rooted tubestock. In one case the nursery showed no interest in addressing the matter and as recently as autumn 2023 was still selling J-rooted tubestock. We have also encountered retailers happily selling what they knew were J-rooted trees, and some local councils and LLS offices have bought trees from local nurseries knowing that they are J-rooted. Clearly this situation reflects some of the mysteries of sub-optimal human behaviour.

Despite this, there are other nurseries which are very sensitive to the risks of J-rooting and successfully avoid it. Such root problems are treated very seriously by some large and professional organisations. One example is Melbourne Water, which manages 33,000 hectares of land across Greater Melbourne. Melbourne Water's 'Plant Supply Standard' states that 'J rooted stock will not be accepted. Nurseries must develop quality control protocols so that only the best quality material free from J rooting is supplied. Where orders have greater than 2% J rooting . . . Melbourne Water reserves the right to reject the order.'[9]

All of this raises the question of how damaging to *Eucalyptus* tree growth is J-rooting of the tap root? While the tree-growing literature unanimously condemns kinking or J-rooting, we have been unable to find published research on practical controlled trials of the long-term consequences of planting J-rooted or kinked tubestock. However, it is widely accepted that during the early stages of a *Eucalyptus* tree's life the tap root is particularly important, both as a means of the tree absorbing water and nutrients, and also for anchoring it into the ground. It is at this stage in the tree's life that J-rooting can be so limiting to the establishment, growth and physical stability of the tree.

After 5–10 years *Eucalyptus* trees start to put out many more lateral roots. Examination of trees that have blown over in wet weather, or whose roots have been exposed by river or stream erosion, highlights the importance of these lateral roots and the relative unimportance of the tap root in many mature established trees. A healthy tap root is, however, fairly necessary to the tree's ability to reach this age in the first place.

Other basic tubestock quality problems

Established nurseries sometimes provide tree tubestock which, aside from any J-rooting issues, fail to meet the basic specifications outlined at the beginning of this chapter. For example, on a recent planting project one nursery supplied hundreds of trees which were all well under the recommended 150 mm in height, with half being under 100 mm. Furthermore, for many of the tubestock the root structure was not well established through the potting mix, such that when some of the young trees were removed from the pots much of the potting mix fell off. This meant that some of the young trees were planted almost bare-rooted. The survival rate in such situations will likely be low, the more so if the young trees were either not watered in or did not receive rain reasonably soon.

Another thing to avoid is tubestock that have been in their forestry pots for more than 9 months or so. Tubestock trees older than that are typically tall, leggy and usually completely pot bound, such that the roots cannot get out into the surrounding soil if they are planted out. Reputable nurseries throw out such stock.

The dilemma for many people arises where unsuitable trees are either picked up or delivered without being checked against the specifications, making it difficult to remedy the situation once problems are discovered. Planting then usually goes ahead either against people's better judgement or in ignorance of the problem. This can especially be the case where a group of friends or volunteers have been arranged to help with a planting project on a specific date, and there is no time to organise better quality tubestock.

Kurrajongs — a special case

Kurrajongs (*Brachychiton populneus*), which grow widely across the granite hills and slopes at Hovells Creek and are a key component of the local tree cover, are very different from the *Eucalyptus* species that dominate the area. They typically have a swollen taproot which has a water storage role and thrive in rocky areas, often growing out of the fissures between large rocks. They are one of about 30 Brachychiton species that are often characterised by swollen trunks that store water. They are not known to suffer from the J-rooting problem that affects *Eucalyptus* species.

However, experience has shown that when kurrajong tubestock, especially small ones with small tubers (Fig 4.8), are planted in the paddock they can stall and grow very slowly, as they find it difficult to prosper in areas of thick grass and ground cover.

A solution to this problem, adopted by HCLG member Keith Hyde, was to 'grow on' tubestock kurrajongs for a year in potting mix in a one litre milk carton with holes in the bottom (Fig 4.9 and 4.10). The cartons need regular watering, which is easily done by placing them next to, for example, a garden vegetable bed which is watered regularly with a computerised sprinkler.

The additional year's growth helps the kurrajong's underground tuber grow quite large (Fig 4.11) and such young trees do much better when planted out in the paddock. They also transplant very successfully. (For fuller details see the YouTube video on kurrajong paddock trees detailed in Appendix 2.)

Fig 4.8

Fig 4.9

Fig 4.10

Fig 4.11

Fig 4.8: Young kurrajong trees grown in a tray of 40 Hiko pots from one supplier. They are really too small to plant out (most are only 75–150 mm in height and have small tubers), whereas the young kurrajong in the forestry pot from a second supplier (200 mm in height) has a bigger tuber and better root ball, and could be planted out. Photo by Keith Hyde.

Fig 4.9: The smaller of the young kurrajongs from the tray of Hiko pots in Fig 4.8 have been transplanted into 1 litre milk cartons to be grown on for a year. Photo by Keith Hyde.

Fig 4.10: Kurrajong grown on in a milk carton to avoid it 'stalling' when planted out Into the paddock. A milk crate of kurrajongs grown on for a year in 1 litre milk cartons is on the right of photo. Most of the 'grown on' kurrajongs were 400–600 mm in height and had developed large tubers as per the example in the right of Fig 4.11

Fig 4.11: A tubestock kurrajong tuber on the left and, on the right, a much larger tuber of a 400–600 mm high kurrajong after being grown on for a year in a 1 litre milk carton.

Key takeaways from Chapter 4

When undertaking tree plantings on any scale, success rates will be greatly improved if the following points are observed:

1. Be conscious of the tubestock specifications detailed in section 4.1 above and accept that not all tubestock trees are equal. Some are simply 'not fit for purpose' and are a waste of time to plant, while others are of high quality and will give good growing outcomes.
2. Choose tree suppliers carefully and ensure that their tubestock meet the specifications on page 57 by examining/testing a sample of their trees (Fig 4.3 suggests that a sample of six, or even four, trees is more than sufficient for this). Ensuring that you only purchase trees that were planted by direct seeding into Hiko pots or forestry tubes, or into soil plugs and thence into forestry tubes, is a reliable way of ensuring that you get straight-rooted tubestock trees.
3. Don't assume that a general plant nursery, which propagates and produces high quality shrubs and garden plants, will also produce high quality tubestock trees suitable for paddock tree planting. Two of the nurseries surveyed and included in Fig 4.3 above produce really excellent shrubs and garden plants, but failed to produce good tubestock.
4. When ordering any quantity of tubestock, place your order in early spring for the following autumn to ensure that the supplier can plan ahead to fill your order with good tubestock. Make clear to the supplier what you expect to receive.

NOTES AND REFERENCES

1 This section draws heavily on pages 5–10 of 'Ephemeral & Terrestrial Plant Supply Standard', Melbourne Water, nd.

2 'Tree Stock for Landscape Use', AS2303:2018, Standards Australia, 2018.

3 Australian Competition and Consumer Commission (ACCC), 2009, 'Warranties and Refunds: A Guide for Consumers and Business'.

4 Moore D, 2001, 'Nursery Practices and the Effectiveness of Different Containers on Root Development', Treenet Proceedings of the 2nd National Street Tree Symposium: 6 & 7 September 2001.

5 Fisher's exact test is a widely used statistical significance test used especially with small sample sizes to determine if there are, and the extent of, non-random associations between two or more categorical variables.

[6] Wrigley JW and Fagg M, 2003, *Australian Native Plants: Cultivation, Use in Landscaping and Propagation*, 5th edition, New Holland Publishers, Sydney.

[7] For an account with photographs of how to successfully prick out *Eucalyptus* seedlings see p58 in Stewart A, 2012, *Let's Propagate: A Plant Propagation Manual for Australia*, revised edition, Allen & Unwin, Sydney.

[8] Murray Ralph describes the use of cell or plug trays for growing native trees and plants in Ralph M, 2003, *Growing Australian Native Plants from Seed*, 2nd edition, Bloomings Books, pp22–23 and Fig 4.1.

[9] Melbourne Water, nd, 'Ephemeral & Terrestial Plant Supply Standard'.

Chapter 5

When to Plant Paddock Trees: The Case for Autumn Planting

This chapter considers the benefits of planting tubestock in autumn. Two field trials were undertaken to compare autumn and spring planted tubestock in terms of:

- differing survival rates
- varying degrees of root growth
- differences in above ground biomass growth
- the benefits of using water crystals or native fertiliser.

Planting a series of individual tubestock paddock trees in steel mesh guards, each with a weed mat and a plastic/cardboard guard, is expensive, both in terms of materials and labour. A tree which dies is a significant expense and loss, and for various reasons may not be replaced.

Experience from the HCLG paddock tree project, and advice from HCLG's local tree nursery, is that autumn planting gives significantly better results than spring planting – better survival rates *and* superior tree growth.

Yet, while many people plant trees in autumn, there are others who continue to plant in spring, and some tree planting guides and projects still recommend or accept the suitability of spring planting.[1]

Why autumn planting is superior to spring planting

A dry spell in spring, or a particularly hot dry summer – or worse still a combination of the two – can be very hard on recently planted tubestock. Quite a number may either die completely or die back down to their lignotuber[2] (see Fig 7.8), from which hopefully young shoots will later appear, but this may set the tree back by a year or two. Watering can greatly reduce tubestock loss, but for many landowners it simply is not practical to water tubestock out in the paddock.

One of our early experiences of large-scale tree lane planting (Fig 7.2), undertaken in early-spring 2002, was followed by a long dry spell and a hot dry summer. Consequently we lost more than 50 per cent of the 550 tubestock we had planted – a dispiriting loss. The work involved in replanting the dead trees the following year was quite significant. It was these losses that prompted an investigation into and subsequent commitment to autumn planting.

Planting in autumn, after the 'season break' when the first good autumn rains have fallen, and when there is good soil moisture and the ground is still warm, enables tubestock to put their roots out into the surrounding soil. By the time spring comes those roots are well established and able to tap into and actively draw moisture from the much larger body of soil surrounding the original root ball. This makes the young tree much more resilient to dry spells in spring or to a hot dry summer, compared to spring-planted tubestock. The problem that spring planted tubestock face is that they are limited to moisture drawn from the tubestock root ball itself, including any moisture that can move into the root ball from the surrounding soil.

While autumn-planted tubestock may or may not have put on much above-ground growth by the time spring arrives, the key point is that significant root growth will have occurred between autumn and spring.

La Niña and El Niño

Dry spring periods and hot dry summers often occur in the Central West and Central and Southern Tablelands, so that is what we need to plan for and is part of the basis for preferring planting in autumn as against spring. An El Niño event, which is typically characterised by drought-inducing drier springs and hotter and drier summers, makes this autumn planting preference even more important.

This scenario is reversed during La Niña years, which can occur every 3–7 years, and are sometimes characterised by particularly wet winters and spring and relatively wet summers. During the La Niña of 2022 and early 2023, spring-planted tubestock did not face problems from drying out. On the contrary, some autumn-planted tubestock died from being waterlogged, or flooded, during the winter and spring of 2022! This scenario is, however, much less common and less devastating for tubestock than a dry spring or hot dry summer.

Research project to test the benefits of autumn vs spring planting

To test the benefits of autumn vs spring planting, two related field trials were set up in 2020 on a fenced off area of open gravelly soil on a granite hill slope at Hovells Creek (Fig 5.1). The detail of the trials and the methodology adopted are outlined in Appendix 3.

Fig 5.1: Fenced trial plot with initial autumn tubestock tree plantings, April 2020.

The trials used 45 tubestock yellow box trees (*Eucalyptus melliodora*), planted in groups of 5, varying between autumn and spring plantings and with differing treatments involving using native fertiliser or water crystals, and control groups with no treatment.

The results, assessed in October 2022, some 30 months after the autumn plantings and 25 months after the spring plantings, showed striking differences between the outcomes for the two plantings.

All 15 trees planted in autumn 2020 survived, whereas only 11 of 15 trees planted in spring 2020 survived. One of those had died back to the lignotuber but was sprouting young shoots from it. So only 10 trees, or two-thirds of the 15 spring plantings, maintained or increased their original stem growth.

The 15 autumn-planted trees had, on average, almost double the biomass when compared to the 11 surviving spring-planted trees – an average weight of 243g per autumn-planted tree compared to an average weight of 123g per surviving spring-planted tree. The biomass, calculated by weighing green stems and leaves, was used as an indicator for growth over the time period. Although the autumn trees had spent an additional five months in the ground, both groups of trees were propagated at the same time as part of the same batch of seedlings and both had the opportunity of two full growing seasons to develop their above-ground biomass.

From a statistical standpoint, based on Fisher's Exact Test, the results of the trials are judged to be highly significant and valid – that is, there was a significant variation in biomass between the autumn and spring-planted tubestock trees that was highly unlikely to be a chance result.

Fig 5.2: Trial plot with fencing and plastic guards removed showing comparative growth of trees planted in autumn (the left hand trees in each of the three rows) and spring (the right hand trees in each of the three rows).

Visual evidence of the striking difference between the amount of growth put on by autumn 2020 planted trees, as compared with spring 2020 planted trees, is provided in Fig 5.2. The autumn planted trees on the left of the pairs of tree rows are noticeably taller and more branched than the spring planted trees planted immediately to their right (see Appendix 3 for full details of the methodology and controls used).

Climate and frost avoidance

Some people suggest that spring planting is necessary to avoid winter frost damage to tubestock. However, we have found no evidence of frost damage to healthy tubestock planted out in autumn in the Central West and Central and Southern Tablelands area – provided that the tubestock had been previously hardened off properly. Hardening off is done by first moving tubestock from the greenhouse to a sheltered position under shadecloth, before they are put out in the open. Suitably hardened tubestock trees are regularly over-wintered in commercial nurseries in Canberra, Cowra, Grenfell and Darbys Falls, without being protected from the frost.

The reason why some people still prefer to risk planting tubestock trees in spring rather than autumn is something of a mystery. One thought is that it is a hangover from European conventions about climate, which generally favour spring planting and assume spring growth after harsh winters.

In other climate zones, such as the high plains of the Monaro and higher parts of the Great Divide, where winter can be much more harsh, many people sensibly recommend planting tubestock in spring, so as 'to avoid killer frosts and drier winters'.[3]

Benefit-cost analysis of autumn vs spring planting

There are some significant benefit-cost considerations behind the recommendation of autumn planting over spring planting.

For the committed smallholder/landholder who is only planting 10–20 trees, a failed spring planting of tubestock trees is not the end of the world. They will probably simply replant the following year.

However, for a Landcare group or larger landholder arranging a large tubestock planting, a failed spring planting is far more serious. Reports from several Landcare groups in the Central West suggest that when landowners lose 5–20% of their plantings they often don't replant them in successive years. For large plantings this can represent the loss of a significant financial investment, as well as a greatly reduced planting outcome.

That Landcare and other similar groups now largely accept the significant benefits of autumn over spring planting was illustrated by the recent decision of Boorowa Community Landcare Group (BCLG) to move their annual tree planting project from September to May 2023. Since the year 2000 BCLG and North Sydney Council Bushcare have had a cooperative project called 'Building Bridges to Boorowa', whereby a group of North Sydney volunteers spends a weekend in Boorowa helping plant trees on farms in the district. The project has always been run in September, but from 2023 onwards the project has been moved to May because of the unacceptably high losses suffered in recent years from September tubestock plantings.

Other results from the trials

The two field trials also tested the comparative benefits of using water crystals or native fertiliser to support the early growth of the tubestock. Early root growth was shown to be best where water crystals were used, with survival rates also being enhanced by the use of water crystals. Root growth with native fertiliser was somewhat better than for the control group, but not to a significant degree. It is thus not possible to be definitive from the trial about the benefits of adding slow release native fertiliser.

Research conclusions

Anecdotal reports from people planting tubestock in the Central West and Central and Southern Tablelands are that better results are achieved from autumn planting than from spring planting. Notwithstanding this, some sources still advise people that spring planting is ok.

This chapter has reported on two trials undertaken to test the benefits of autumn planting as compared with spring planting.

Trial 1 highlighted the significant root growth put on by autumn-planted trees during autumn and winter. Comparing the roots of tubestock of the same age wintered in the nursery, and then planted in spring, it was clear that autumn-planted trees had developed a greater physical root capacity which is likely to enhance their ability to tap into soil moisture in dry spells during the following spring and summer.

Trial 2 produced the striking result that after two growing seasons, autumn-planted trees had double the biomass of spring-planted trees and much better survival rates (100% for autumn plantings vs 73% for spring plantings).

Key takeaways from Chapter 5

1. Aim to plant tubestock paddock trees in autumn once the first good rains have occurred, and when there is good soil moisture. Try to avoid spring planting unless a wet spring and summer are forecast (noting that forecasting is an uncertain business).
2. Use water crystals when planting trees as they lead to both significantly increased tree growth and higher survival rates.

NOTES AND REFERENCES

1 'Planting Your Patch: A Guide to Revegetation on Your Property', issued in 2016 by Central West LLS, recommends on page 26 that tubestock trees be planted into a good soil moisture profile anytime between April and August. It is unfortunate that the guide makes no reference to the very significant benefits of planting in autumn (April/May), or to the comparative risks of planting in August.

2 The lignotuber is a woody swelling at the root crown where the trunk or stem meets the root system, usually at soil level (see photo in Fig 7.8).

3 See discussion summary in 'Summit on Large Scale Tree Planting in the Snowy Monaro', Upper Snowy Network, 2019, available at uppersnowylandcare.org.au/2019/10/large-scale-tree-planting-on-the-monaro-summit-report

Chapter 6

Steps for Planting Tubestock Paddock Trees

This chapter sets out a step-by-step approach to planting tubestock paddock trees. The process described involves planting the individual tubestock tree into a prepared hole, and providing suitable protection for the young tree.

At the end of the chapter is a useful checklist of all the tools and supplies required for planting tubestock.

1. Planning for planting

Before you start planting you need to plan a tree layout (Chapter 2); decide what species of tree to plant where (Chapter 3); order and buy your tubestock trees (Chapter 4), mesh guards, weed mats and other materials (Chapter 7); and possibly pre-position the guards and posts where you are going to plant your trees.

Fig 6.1: 20 good young tubestock ready for planting. From left to right, red box, yellow box, stringybark and apple box.

2. Get your gear together

Load your ute, vehicle or wheelbarrow with all the necessary gear (see checklist at end of this chapter). There is nothing worse than having to go back for something you forgot. Water the tubestock trees well shortly before you set out, so that they will come out of their forestry tubes easily.

3. Cut and remove turf from above hole

Using a sharp shovel cut out a 300–400 mm square of turf from where you intend to plant the tree. This helps create a dish for watering after planting and reduces subsequent weed or grass competition. Put any pieces of turf aside, as you can use them later to help hold the weed mat down. This is especially important in exposed areas where the wind can get under the weed mat.

If you are in good country, with heavy grass cover, you might have sprayed the spot with glyphosate previously. However, be careful not to use residual herbicides. There have been cases of high failure rates among tubestock trees planted in areas previously sprayed with residual herbicide.

4. Dig a hole for the tree

With either a shovel, mattock or, better still, an auger in a battery-powered drill, dig down and loosen the soil to about a shovel's width and depth, leaving the loosened soil in the hole. The tree will be planted into this loose soil, making it easy for the young tree to send its roots out from its potting mix root ball.

When using an auger in a battery-powered drill, one approach is to drill three holes in a triangle. Then use the auger to collapse the holes into each other to make a larger hole of loose soil. Use a drill with a metal rather than a plastic chuck to stop the auger working loose in the chuck, and with a handle on the side of the drill so you can hold it firmly. Don't push down too hard, or the auger will really bite into the ground, turn the drill and twist your arm off! Just let it drill slowly, lifting the drill upwards somewhat as it bites in. Drilling in soil full of roots can be dangerous, as the auger can jam in the roots and twist the drill very strongly.

Augers of 75 mm diameter work well to drill holes for tubestock. A longer 600 mm auger allows you to drill a somewhat deeper hole than a 300 mm auger and also requires less bending down.

Fig 6.2: Battery-powered drill with metal chuck, handle and 300 mm auger of 75 mm diameter.

Fig 6.3: Using a drill and 600 mm long auger of 75 mm diameter to drill 3 holes for planting.

A tractor or bobcat with a 200 mm or 300 mm diameter post hole auger can be used to make larger holes for tree planting. If the auger polishes or glazes the sides of the hole then use a bar to break the sides of the hole. A one or two-person portable auger/post hole digger with a 200 mm diameter auger is another option.

Alternatively, a tractor fitted with a deep ripping tyne can be used earlier in the season to rip a cross where each tree is due to be planted.

Note that it is important not to try to plant tubestock into the ground without first digging a hole and loosening the soil in it. In 1992, when I first started planting trees at Hovells Creek, I planted 6–7 eucalypt trees simply by pushing a Hamilton tree planter into moist undug ground and then pushing the tubestock into the resulting hole. It was a wet season so the trees took and grew, but they grew very slowly for 3–4 years and compared very poorly with trees planted in subsequent years into properly prepared holes.

5. Mix water crystals into the soil

After digging your hole with a shovel or auger, add about one teaspoon (5 mL) of water crystals. Using a trowel, shovel or your auger ensure that the water crystals are well mixed into the loose soil and aren't just sprinkled on the surface or dropped as a heap in the hole (see Chapter 7).

6. Add native fertiliser (optional)

Using a trowel or shovel place a native fertiliser tablet near the bottom of the hole or add a good pinch of loose native fertiliser into the hole, mixing it well into the soil. (Native fertiliser is specially formulated for Australian native plants and typically has a phosphorus content of 3% or less.)

7. Make a hole in the loose soil, plant the tree and water in well

Make a fairly deep hole in the centre of the loose soil with a Hamilton tree planter. If you are only planting a few trees a narrow trowel can also be used to do this. Water the hole so that the soil in the hole is wet when you put the tubestock into it.

Remove the tree from the forestry pot (you may have to squeeze the pot and tap the edge of it on a firm surface when upside down, to help loosen the tree and its root ball from the pot).

Plant the tree well down in the hole so that the soil comes part way up the stem, push the loose soil in round it, making sure you have created a soil dish round the tree and then water in well. Do not heel the soil in too firmly, but let the watering settle the soil.

Fig 6.4: Hamilton tree planter.

Fig 6.5: Newly-planted tubestock, only lightly heeled in, but before a dish has been formed and watered.

8. Weed mat, canes and plastic guard

Put a weed mat over the tree and push or hammer two canes into the ground through the pre-cut holes in the weed mat. Put the plastic round the canes and then push in the third cane so as to hold the plastic open fairly tightly. If you are using cardboard or corflute plastic guards they may only need 1–2 wooden stakes to hold them.

If the ground is dry, hard or gravelly you can make a pilot hole for the cane or wooden stake by first hammering in a sharpened metal spike. A piece of 10 mm steel rod about 0.8m long works well. Sharpen it at one end and bend an elbow at the other end to hammer onto and to help pull it out of the ground.

Fig 6.6: Securing weed mat and hammering in third cane for the plastic guard. An assistant is not only good for companionship and moral support, but can assist greatly by passing relevant items to you, so that you can get the job done quicker!

9. Fasten weed mat down

To be effective, weed mats need to smother the weeds under them and protect the surface of the soil from drying out. But in exposed areas wind often causes the corners of the weed mat to blow up. One fix is to lay the pieces of turf, removed when the hole was first being dug, upside down onto the corners of the weed matt as in Fig 6.7. The same pieces of turf can also help form the dish round the young tree for watering. Stones or small rocks can also help hold down the corners of the weed mat. Alternatively wire pins can be hammered into the ground through the weed mat.

Fig 6.7: Plastic guard with weed mat held down by turf laid upside down.

10. Install a steel mesh guard

Stand the mesh guard over the newly-planted tree and hammer in star pickets to hold the mesh in place (post drivers can tend to catch on the mesh). Alternatively, work out the correct location of the star pickets and then use a post driver to drive them in, before sliding the mesh inside or over the posts once they are in the ground.

Use galvanized tie wire (1.57 mm in diameter is a good size in terms of strength and flexibility) to attach the posts to the steel mesh – two tie wires on each post are usually sufficient. Use two star pickets for 1200 mm high mesh guards for sheep and three star pickets for 1650 mm high guards where cattle may be grazing. Use longer pieces of tie wire twisted on by hand, with their tails left on, for easy removal later (short wires twisted tight with pliers can be difficult to remove). Bend the tails of the wire inwards so that they can't poke stock in the eye.

11. Water immediately

Finally, water the tree in well, so that the dish is left full of water and as much water as possible has soaked into the soil around the tree.

Follow-up watering is very labour intensive and not normally done unless you planted in a hot dry spell or are in drought, in which case several waterings may be necessary.

The tree in Fig 6.8 below was one of 21 planted in a staggered corridor across a gently sloping hill paddock in early July 2016 (planting was delayed until after good rains, as autumn was very dry) with no post-planting watering. All 21 trees were established and growing well during dry summer weather in February 2017.

Fig 6.8: Tree planted in autumn 2016 looking healthy in Feb 2017 after a long dry hot spell.

12. Post-planting weed control

In productive 'heavy' lower-lying country with thick grass and heavy weed growth (or after a very wet season) it may be necessary in spring to carefully spray with glyphosate around the outside of the plastic guard to reduce grass and weed competition. This isn't normally necessary in lighter country. (Avoid using residual herbicide, as per note at step 3.)

13. Leave steel mesh guards in place until trees are above browsing range and trunks are sturdy

Steel guards often need to be left in place for five or more years, depending on the size of the tree. This is to protect the young tree until its trunk is thick enough to bear the rubbing weight of livestock and until most of its branches and leaves are above sheep or cattle browsing range.

Fig 6.9: Young black cypress pine tree with bark and lower branches badly damaged by sheep when mesh guard was removed prematurely, October 2020. Twelve trees in total were similarly damaged, but all survived (see Fig 7.12).

Galvanised steel mesh guards can be recycled repeatedly for 20–30 or more years for new tree plantings. This significantly reduces the cost of future plantings and they can also be used to protect tubestock being planted to fill in gaps in earlier plantings or to spread tree connectivity further, or to protect self sets. At Old Graham some old ungalvanized mesh guards cut out of 'bin' mesh purchased at a clearing sale in 1992 were used three times and are still going strong.

14. That said… remove steel mesh guards before it's too late!

Depending on location, climate and seasons, many trees will have grown well above their guards after 5–7 years and will be able to handle the pressure of stock rubbing. Certainly by that stage rabbits, hares and kangaroos will have long since lost interest in them. It is possible at this point, after removing the tie wires, to use a long-handled rake or the like to push the intact steel mesh guard up and over the top of the growing tree. Alternatively you can stand in the back of a ute tray and lift the mesh guard up over the tree.

Removal of some guards can be particularly challenging, especially in a flood zone where they collect soil and other debris, or are surrounded by tussock grasses. Fig 6.10 shows a mesh guard in such a situation being removed by being lifted with hay bale prongs – a method that requires a tractor and can also be used more generally.

Once removed the intact guards are then ready for immediate re-use.

Do not 'forget' to remove the guards before the trees get too tall or wide, because then you will have to undo the guards to remove them. Often soil and grass may have covered the bottom wires, making the task harder. If left for a few years longer, the trees' branches grow through the wire mesh; a few more years and the mesh becomes a permanent fixture.

Fig 6.10: Hay bale prongs attached to a tractor lifting a mesh guard for removal. Photo by Keith Hyde.

Key takeaways from Chapter 6

1. Start by planning your layout and ordering your trees.
2. Get all your gear together for the job (see checklist below).
3. Cut and remove turf for the hole.
4. Dig the hole for the tree with loose soil in it.
5. Mix some water crystals into the soil in the hole.
6. Add native fertiliser and mix into the soil (optional).
7. Plant the tree in the hole, remembering to water in well.
8. Position the weed mat, canes and plastic/cardboard guard.
9. Fasten the weed mat down securely.
10. Install the steel mesh guard wired onto its star pickets.
11. Give the tree a final good watering.
12. If necessary spray weeds around the tree over the growing season.
13. Leave the mesh in place to protect the tree until it can handle the rubbing of stock.
14. But don’t forget to remove the steel guards before it is too late and they start to become part of the tree.

Checklist for tools and supplies to take when planting trees

There is nothing worse than driving for 15 minutes to a distant paddock to plant trees and then remembering that you have forgotten something important and having to drive back. The following checklist may help you avoid such a situation.

1.	Mesh guards (1200 mm high for sheep or 1650 mm for cattle or sheep) each with 2 or 3 star pickets respectively – unless these have been put out on site earlier	☐
2.	Long-handled shovel with a sharp cutting edge (sharpen it on the inside edge with a file if necessary, to make cutting into turf easier)	☐
3.	Battery-powered drill with augur to drill planting holes (recommended)	☐
4.	Digging bar – in case the ground is hard or there is a smallish rock in the way or in the hole itself	☐
5.	Water crystals with a teaspoon measure (and native fertiliser/tablets if being used)	☐
6.	Tubestock trees that have previously been well watered	☐
7.	Hamilton tree planter, or a small narrow trowel if you are only planting a few trees	☐
8.	Canes or stakes (plus a few spares to replace dodgy ones)	☐
9.	Metal spike in case the ground is too hard to push the canes/stakes in	☐
10.	Hammer to put the canes/stakes in (a brickie's hammer is very good)	☐
11.	Plastic or other type of guards	☐
12.	Weed mats	☐
13.	Large plastic carryall (in a bright colour – so it is easy to see!) for carrying weed mats, canes, stakes, guards and small tools and tie wire between adjoining trees – particularly relevant in hilly country where a ute can't be driven to each planting site	☐
14.	Roll of tie wire (possibly pre-cut) and pliers	☐
15.	Heavy sledge hammer and/or post driver to hammer in star pickets	☐
16.	Watering-can or bucket for watering in tubestock	☐
17.	Drums of water	☐

Chapter 7

Further Notes on Planting and Protecting Tubestock Paddock Trees

This chapter covers many specific aspects of tree planting, including:

- how much work is involved in planting them
- using water crystals to achieve high survival rates
- various ways of protecting tubestock trees, including making steel mesh guards
- protecting self-sets, or even transplanting self-sets as an alternative to planting tubestock, and
- some suggestions on sourcing the right inputs at the right price.

1. Time taken to plant tubestock paddock trees

Our experience at Old Graham, as two relatively fit 70-year olds, was that over a day the average time taken to plant tubestock trees was:

- 15 minutes to plant a new tubestock tree with a mesh guard, provided the mesh guards and star pickets had been pre-located (4 per hour, enabling 24–28 per day).
- 12 minutes to plant a replacement tubestock tree within a mesh guard (includes undoing the existing guard and then reinstating it).
- 10 minutes to plant tubestock trees within plastic guards with weed mat and crystals, but with no steel guard (6 per hour, enabling 36–42 per day).

The timings assume that you have all the gear with you and that you haven't forgotten anything! It also helps not to be too ambitious on the first day until you have got into the swing of things and are really well organised.

2. Using water crystals when planting tubestock

As noted in Chapter 6, water crystals should be well mixed into the soil, and the tubestock tree well-watered after planting – thus allowing the crystals to absorb water straight away.

Water crystals work by swelling to many times their normal size as they absorb water, rather than allowing it to drain through and down into the subsoil. The crystals then hold the water which they later release to any tree roots that are in contact with them. This is particularly important in free draining soils where rainfall can percolate rapidly down through the soil and very quickly end up out of reach of the tubestock's roots.

In the event of unexpected dry spells, especially soon after planting, the moisture in the water crystals is available to the young tree and helps reduce any shock from the dry conditions. During the planting trials described in Chapter 5 it was particularly noticeable that those tubestock which were planted with water crystals, and were dug up after 12 months, not only had grown more than had other tubestock in the trials, but they still had intact water crystals among their roots that were holding water.

It is essential to mix the water crystals in with the soil. If you use more than a teaspoon of water crystals or simply dump them in a heap in the hole then when watered they are likely to expand and may even push the tubestock tree up out of the hole! A couple of HCLG members had this experience when first using water crystals. Fig 7.1 shows what a teaspoon (5 mL) of water crystals looks like when added to 0.75 L of water.

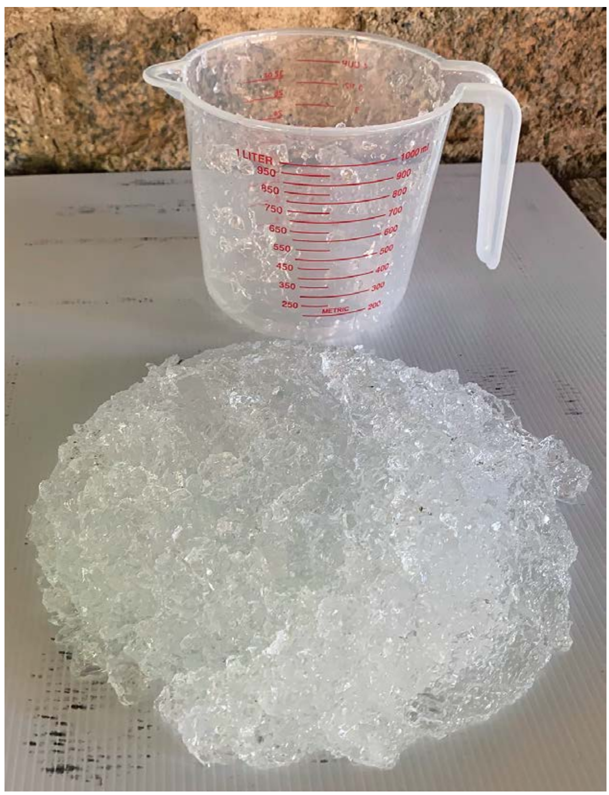

Fig 7.1: One teaspoon (5 mL) of water crystals in 0.75 L of water.

Some people (including the landscaping and revegetation contractor described in the box below) pre-mix their water crystals with water and then carry a bucket of expanded water crystals with them, tipping some into each hole for mixing with the soil. We found that in hilly country, where everything has to be carried by hand to the planting site, this was much harder work than simply sprinkling some dry crystals into the hole. Our experience was that if the dry crystals were well mixed in with the soil and the tree was then well watered, the crystals absorbed the necessary water and performed their task well.

Unfortunately, some sources of advice still do not accept the potential contribution that water crystals can make to successful tubestock planting. The 2023 online publication *Riparian Management Tubestock Guide* states, 'Water crystals, while prolonging soil moisture around the roots, won't guard against drought as they eventually dry out. They can also suck moisture away from roots when it rains (depending on how they are applied).'[1] This comment surely misses the point about how water crystals work.

Cost-benefit of using water crystals

The cost of water crystals per tree is very modest. In 2023, a 1 kg container of water crystals cost $21, and contained 238 teaspoons (weighing 4.2 g each) at a cost of 8.8 cents per teaspoon or per tree. (By comparison a smaller 100 g container of water crystals cost $4.10, equating to a cost of 17 cents per tree.)

The compelling case for using water crystals is illustrated by a successful landscaping and revegetation contractor who estimates that over a 40-year career he planted more than 500,000 trees on new roads projects for government bodies. He explained that his contract payment was based not on how many trees he planted, but on them all still being alive and growing at the end of a specified time period, which was typically between 13 and 26 weeks. This meant that he was responsible for replacing any dead tubestock trees and maintaining them until they were clearly established and could be handed over. He used water crystals in all of his contracts as he had found they were a key tool for keeping young trees alive through any initial dry spells, significantly cutting his costs by reducing the number of trees that he had to replant.

3. What protection do your tubestock need?

The general practice is to plant individual tubestock trees within an outer steel mesh guard that provides protection from stock and kangaroos, within which an inner smaller plastic or cardboard guard is positioned over the weed mat to protect the young tree from rabbits, hares and adverse weather conditions. If installed correctly, the steel mesh guard can also protect the young tree from rabbits and hares, meaning that the inner guard is not always necessary for this purpose.

Where large numbers of tubestock are being planted within a fence that excludes stock, then steel mesh guards are not needed and would also be prohibitively expensive for a large number of trees, with the loss of a few trees to kangaroos being manageable.

Fig 7.2: Trees and shrubs, protected by a mixture of cardboard milk cartons and plastic guards, planted in six rows in an L-shaped, fenced, stock-free lane/shelterbelt. Revegetating around an existing paddock tree such as shown in this picture will help protect that tree in the long run as well.

4. Plastic, cardboard or similar small protective guards

Inner guards are variously made of flexible plastic (Fig 7.4), corrugated plastic (corflute) or cardboard (Fig 7.18). The HCLG paddock tree project used plastic guards because they were readily available, cheaper and could be easily collected, folded and re-used, but plastic guards can linger over time and create litter. Collecting plastic guards after trees outgrow them helps reduce this but involves quite a lot of work.

Biodegradable plastic guards are now widely available which reduces this problem, although they leave residual microplastics in the environment. It is, however, a moot point as to how significant a problem a limited number of such biodegradeable plastic guards can cause in rural areas. A recent UK study has also highlighted the carbon emissions produced in manufacturing plastic guards.[2] Thus, from a broader environmental perspective, using recycled cardboard guards is probably preferable, though you need to check that they will last long enough to serve their purpose.

There is some debate about the practical value and importance of using small protective guards. Fig 7.3 briefly summarises the arguments for and against the use of small protective guards.

Reasons for using small protective guards	Reasons against using small protective guards
Protection from adverse weather conditions, wind and excessive transpiration	No published research has been found to support the use of guards and they may not be necessary in areas without extreme weather conditions
Discourage kangaroos from grazing newly-planted areas	Small protective guards are not a deterrent to kangaroos in situations where there is no alternative feed for them
Prevent rabbits and hares from nipping off young tree shoots	Where steel mesh guards are being used, more effective protection is provided by ensuring rabbits and hares cannot get under the mesh
Help mark plantings in large-scale fenced areas	Additional environmental pollution; additional expense and time

Fig 7.3: A summary of some reasons for and against the use of small plastic or cardboard protective guards.

In many cases small protective guards seem to be used almost as a customary activity, without much thought given as to whether they are really necessary. Some of their apparent benefits are disputed, as outlined below.

A key argument used in support of guards is that they provide protection for tubestock from **adverse weather conditions**. In the Snowy Mountains and the Monaro, this may indeed be the case. But in the Central West and Central and Southern Tablelands, areas that are not subject to extreme weather conditions, tubestock appear to cope quite well without protective guards.

A local tree nursery has described to us a research project undertaken by CSIRO in the late 2000s, for which their nursery supplied a batch of single species tubestock that were planted out both with and without small plastic/cardboard tree guards. Their recollection is that the tubestock without guards grew the same or better than those with guards. Ever since then the nursery has avoided using plastic or cardboard tree guards in tree plantings on their own property. Their experience is that the trees have grown well and have never suffered any adverse effects from not being protected by such guards. This experience has been supported by a number of others involved in paddock tree planting, and although various tree planting guides and books support the use of plastic or cardboard guards to reduce transpiration or wind damage, no published control-based practical research has been found which supports this.

Small plastic or cardboard guards provide very limited **protection from kangaroos**, which can easily rip the guards off or put their heads down inside the plastics to nip off the young trees. The key issue here is the availability of alternative feed for kangaroos when the trees are planted. In one HCLG project 30–40 trees were planted in plastic guards along a ridgetop in autumn within a fenced enclosure, shortly after rain but when there was very little grass feed available, and the kangaroos ate the tops off all of them (Fig 7.4).

Fig 7.4: Tubestock tree that has had most of its leaves nibbled off by kangaroos.

Protection from rabbits and hares is an important consideration and protective guards may be necessary for this purpose. Most areas in the Central West have rabbits and to a lesser extent hares, both of which will promptly nibble or nip the top off newly planted tubestock trees. One afternoon at Old Graham, with darkness coming on and after planting about 25 paddock trees, it was decided to leave installing the plastic guards and steel mesh until the following day. By the next morning rabbits had nipped the tops off more than half the tubestock, as evidenced by ground scratchings and rabbit droppings round the newly planted trees.

Plastic or cardboard guards can provide effective protection against rabbits and hares, but so will steel mesh guards that are firmly anchored at ground level, as outlined in the next section.

Protecting against rabbits and hares

The problem is that rabbits and hares are particularly attracted to newly dug ground. This was the basis of the old poison carts used to control rabbits on rural properties. The carts had a single steel tyne which ploughed a groove in the ground that was attractive to rabbits, with a funnel on the cart feeding rabbit poison into the groove. The act of digging a hole to plant a paddock tree creates a similarly attractive spot of newly dug ground. Consistent with this, where there are young or newly grown self-set eucalyptus trees with no disturbed soil around them, rabbits don't touch them.

This is why a guard will be necessary around newly planted trees in rabbit country. This purpose can be served with a plastic or similar protective guard, or by installing the steel mesh guard flush with the ground.

5. Why use steel mesh guards?

Steel guards, made of 75 mm mesh of 4 or 5 mm gauge, are essential to stop sheep, cattle or kangaroos either eating or physically destroying tubestock planted in an open paddock. Good galvanized steel guards of 4 mm gauge are expensive (see below), but can be used repeatedly for 20–30 years.

Steel guards made from the standard 75 mm mesh are rabbit proof provided they are placed on level ground, in which case inner guards are not needed to protect the tubestock from rabbits. This doesn't work on a slope, where rabbits can get under the lower side of the mesh guard - unless the guard is dug into the ground on the higher side to ensure there is no gap on the lower side. Alternatively the guard can be installed at an angle to the vertical, with its base flat to the sloping ground (see Fig 7.5). Some people are uncomfortable doing this, just as some people don't like fence posts that are not installed on the vertical!

Fig 7.5: Tree guard installed at an angle with its bottom parallel to sloping ground to stop rabbits getting underneath.

6. Cutting and fabricating steel mesh guards

Australian-made rolls of galvanized steel mesh, manufactured by ARC and used on the HCLG project, are of 4mm gauge galvanized wire. They come in either a 1200 mm width (for protection against sheep and kangaroos) or a 1650 mm width (for cattle/sheep/kangaroos) and are 28.5 m long. The rolls of mesh are usually cut into 12 lengths, each 2.38 m long, which are then fastened into a circular tree guard with a diameter of 0.7 m. Some people cut 13 guards of a slightly smaller diameter rather than 12 guards from a roll of mesh (Fig A1.5).

One approach to cutting up the rolls of mesh is to find a sloping location and stake down the open end at the higher point, before then unrolling the mesh downhill. While the unrolling is still hard work, especially near the end of the roll, the weight of the roll of mesh rolling down the slope helps overcome the tensioned tightness of the roll. Once unrolled the lower end is staked down.

The unrolled length of mesh can be marked ready for cutting into 2.38 m lengths by using a measuring stick of that length or a tape measure and putting marks along the roll at:

2.4 m, 4.8 m, 7.1 m, 9.5 m, 11.9 m, 14.3 m, 16.6 m, 19.0 m, 21.4 m, 23.8 m, 26.1 m.

One approach to cutting the mesh into lengths is initially to cut across all but the middle two or three wires. Then with the whole roll partially cut, go back and progressively cut the last couple of wires. Do this either with somebody to help you stop the lengths of mesh springing up as you cut them, or by standing with your feet astride the cut to stop the cut mesh springing up.

Cutting the mesh is best done with long-handled bolt cutters. Slide a length of timber under the mesh to help lift it off the ground, giving the end of the bolt cutters some clearance. Bolt cutters should be well-oiled and, if overly stiff, can have their bolts loosened very slightly to make them easier to use. Angle grinders can also be used but – apart from safety concerns about their use and it being rather back-breaking work – their sparks can be a real bushfire risk.

When forming the 2.38 m lengths of mesh into a tree guard, allow an overlap of one row of mesh squares to help maintain the roundness of the guard. A pair of vice grip locking pliers are very useful to hold the wire mesh squares together while you are fastening the tie wire (Fig 7.6).

Tie the overlapping mesh with 3 pieces of galvanized tie wire (middle first and then top and bottom). Using long pieces of tie wire twisted on by hand, with their tails left on, makes them much easier to remove later, rather than using shorter wires twisted on with a pair of pliers, which can be difficult to remove later. The ends of the wires must be turned in to avoid injury to livestock.

Some people cut the mesh close to the next vertical wire so that the free pieces of horizontal mesh wire can be twisted round the verticals on the other side of the guard and then back on themselves. This makes a very secure guard in case of cattle pressure. However, such guards are much harder to undo when removing them as compared with those fastened with tie wire, and you can always use additional pieces of tie wire if you are concerned about pressure from cattle.

Fig 7.6: Using vice grip locking pliers to hold mesh together on a steel guard so tie wire can be fastened.

7. Preparing and positioning mesh guards prior to planting

Carting formed 700 mm diameter mesh guards to a paddock location can be time consuming, as only 5–7 round guards will fit onto most ute trays.

An alternative approach is to nest the unformed lengths of cut bent mesh inside one another, drive them to the paddock and then form and tie them into tree guards at the planting site. A front end loader or fork lift can also be used to load bundles of cut bent mesh.

Things often get busy when it comes to planting time. So one approach in sheep country (less suitable for cattle, which may walk over them and move them round) is to cart and assemble the mesh in the paddock in late summer, and then stand them with the star pickets laid across their bases on the sites where you intend to plant. This allows you to work out your planting layout, see how it looks with the guards in place, and adjust it before planting.

Prepositioning the guards and star pickets also allows you to spray your chosen planting sites with glyphosate (e.g. Roundup) if there is a thick cover of grass and weeds.

Prepositioning steel mesh guards and pickets means that once planting rains come from late-March onwards, and you are ready to plant your trees, you can simply load all your gear (see checklist at the end of Chapter 6) and start planting your trees straightaway. With this approach, one fit person can easily plant 18–24 trees in steel guards in a day.

8. Paddock trees within steel mesh guards and clusters as contributors to weed infestations

One problem with steel mesh guards that protect paddock trees is that they can contribute to weed infestations. Fig 7.7 below shows a mesh guard full of St John's wort that has gone to seed. The surrounding paddock was deliberately heavily grazed by merino wethers in spring to eat down and help control St John's wort. Unfortunately the guard has provided a safe harbour for the weed, which will now seed into the surrounding area and can also send vegetative runners out into the area around the guard. The only possible solution is to spray with herbicide round a plastic guard which prevents spray drift getting onto the young tree, but this is a risky proposition unless done carefully.

Similar weed infestation problems occur when tree lanes or clusters are fenced off, such that grazing or spraying can't readily be used to control weeds within the fenced off areas. Between 2013 and 2015 we fenced off 5–6 clusters on Old Graham and planted them with trees and shrubs. At the time there were only isolated patches of St John's wort in the area, and none present in the paddocks that the clusters were fenced off from. However, an inspection in 2023 showed that with the rapid spread of St John's wort across the Hovells Creek area most of the clusters either had some wort present or had heavy infestations. Without some form of weed control, which is very difficult between the trees and shrubs, those clusters will now provide an active seeding source for the surrounding paddocks. This is a very worrying development, the solution for which is not easy to see. Certainly this development will discourage some landowners in the district from creating such clusters.

Fig 7.7: St John's wort plants growing and seeding within a steel mesh guard.

9. Mulching and weed mats

Using mulch or a weed mat helps limit competitive weed growth around newly planted tubestock trees and reduces moisture loss from the ground surface round the tree by protecting it from the sun and wind.

Mulch is not practical for use in distant paddocks or hilly areas. For that reason mulch isn't recommended other than in urban or peri-urban settings, or where vehicular access is good and only a small number of plantings are involved.

In contrast weed mats are very easy to use in most settings. Weed mats are typically square and 450 x 450 mm in size. Most have a slit in the centre to go over the young tree and 3 slits to accommodate the canes or hardwood sticks that support the tree guard. Some jute mats break up fairly easily, whereas mats made from recycled fabric, while still being biodegradable, do seem to last much longer.

10. Replanting dead tubestock

A hot dry summer can cause young tubestock to die off, so that they show dry dead leaves and a crackly stem (Fig 7.8).

But don't rush to dig them out and replace them without checking carefully first. After autumn rains, many of them may shoot from the lignotuber, a bulbous swelling at the junction of the root and stem that occurs in most eucalypt species and is sometimes buried under the ground (Fig 7.9).

Fig 7.8: An apparently dead tubestock, which after the April rains sprouted from its lignotuber and then later grew into a multi-stemmed paddock tree.

Fig 7.9: Two tubestock (left) with soil washed from roots to show the lignotuber where the roots join the stem. A lignotuber is also visible on the tubestock tree (right) that is in a 200mm pot.

11. Protecting self-set seedlings

Some years, typically after good winter and spring rains, a flush of young self-set tree seedlings (also known as 'volunteer' seedlings) can appear in spring/summer in grassland near trees or on the floor of open woodland. Their appearance may follow a number of years when few, if any, seedlings have germinated due to previous dry periods.

Opportunistic protection or fencing off of such self-sets can be a very effective way of increasing the number of paddock trees on a property without any planting work and without a failure rate. It is therefore a particularly cost-effective approach. The secret is to spot the young self-sets when they first appear and protect them before stock can eat the tops off them.

Fig 7.10: A small group of seven trees photographed in 2022, which had steel guards put round them when they first appeared as self-sets in 2004.

Fig 7.10 shows seven 18-year old trees which grew from self-set tree seedlings that germinated in late 2003 and were spotted in early 2004 as 100 mm high seedlings. As soon as they were spotted, some spare steel mesh guards (removed only months earlier from a small paddock tree planting) were put round them before the sheep could graze the tops off them. The self-sets had grown from seed downwind of a large paddock tree, just visible at the right of the photo.

A striking feature of self-set *Eucalyptus* seedlings is how well and quickly they grow. Experience has shown that their growth rate often far exceeds that of quality tubestock trees properly planted into a well-prepared hole. This again reinforces the cost effectiveness of taking advantage of and protecting such self-sets.

Fig 7.11: A large number of self-sets growing downwind of an old paddock tree in a lightly grazed paddock.

Similarly, Fig 7.11 shows a lightly grazed paddock where a large number of self-sets have sprung up downwind of an old paddock tree following the wet weather of 2021 and 2022. Given that the old paddock tree looks fairly senescent and there are very few other paddock trees in the paddock, an obvious option is to fence in the old tree along with some of the self-sets so as to exclude stock.

One way of doing this would be to fence a triangular area, with the tree trunk within the apex of the triangle and the base of the triangle incorporating some of the self-sets downwind of the tree. It would be necessary to thin the self-sets as they are too densely packed to be able to grow into mature paddock trees.

Any self-sets that are not fenced will probably be grazed down to their lignotuber when feed in the paddock becomes tight. Experience has shown that once young self-set trees have been grazed down to their lignotubers once or twice they rarely grow into the sort of trees seen in Fig 7.10, even if they are protected after the initial grazing.

12. Transplanting self-set seedlings

A flush of young self-set seedlings, as described in the previous section, provides the opportunity to transplant some of them.

Figures 3.4 and 3.5, and their accompanying text in Chapter 3, described how exclusion of sheep and rabbits from Pine Hill on Old Graham enabled black cypress pine self-sets to grow prolifically. In autumn 2015, we took advantage of this to transplant some of the pines. Inverted pyramid shaped pieces of turf about 100 mm deep, each containing a pine seedling of 100–150 mm in height and held together by the grass roots, were cut from Pine Hill and planted in a neighbouring paddock. The pieces of turf were placed into a matching inverted pyramid-shaped hollow cut into the ground and after watering were heeled-in well. All 12 trees transplanted very successfully and, as Fig 7.12, shows, they were 2–3m in height some seven years later.

This transplanting exercise was prompted by the local unavailability at the time of black cypress tubestock, explained by the fact that they can be hard to propagate and that the seedlings grow slowly.

Fig 7.12: Twelve black cypress pines transplanted from Pine Hill in autumn 2015 as 100 mm high seedlings and standing 2–3 m in height as of late 2022. These are the same trees that were damaged by sheep after their mesh guards were removed prematurely in October 2020 (see Fig 6.9) but had recovered well by the time of this photo.

Eucalypt self-sets such as those in Fig 7.13 are not as easy to transplant, although it is worth trying if only a few trees are required. Most eucalypt seedlings have long tap roots, so can only be dug up and moved when the seedling is 100–150 mm or so high and sufficient soil is taken along with the seedling to maintain the integrity of the root ball. Several Hovells Creek neighbours have reported considerable success in transplanting limited numbers of small eucalypt seedlings, provided they moved them with a sufficiently large ball of soil. The approach they described was essentially the same as that described above for transplanting black cypress pines.

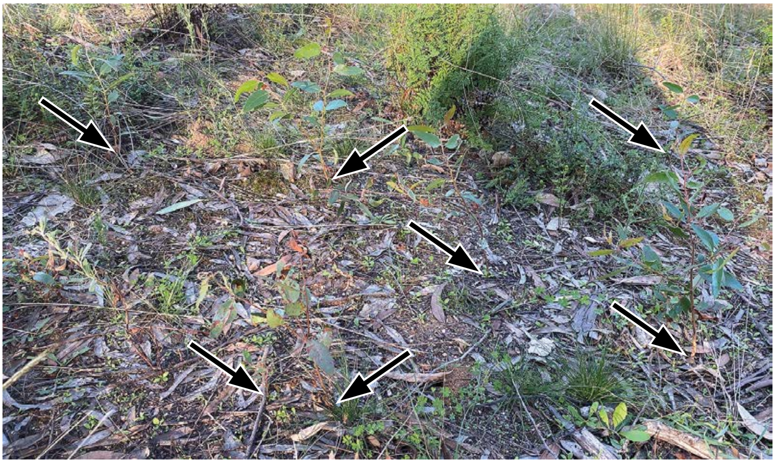

Fig 7.13: Floor of open woodland in the Grasmere Woodland at Hovells Creek in April 2021, showing seven eucalypt self-sets of between 100 and 200 mm in height growing in an area of less than 1 m x 2 m. Black arrows indicate where the seven young tree stems emerge from the ground.

13. Larger scale tubestock plantings in fenced-off areas without using steel guards

While this book focuses on how to plant individual paddock trees, it is useful to offer a few comments on large-scale tubestock plantings within fenced-off tree lanes, tree clusters, gullies and the like. Key considerations to have in mind include:

- Order your tubestock trees well ahead of time, as it may not be possible to source several thousand quality tubestock at short notice. Ordering in early spring for autumn planting is the best approach.
- If you are planting yourself, perhaps with the assistance of other Landcare group members or friends, avoid being too ambitious as to how many you can plant in a day (see Section 1 in Chapter 7 for estimates of the time taken to plant paddock trees).
- If you are planting with the assistance of volunteers and/or friends make sure you have sufficient suitable planting tools on hand for them, as well as someone who can provide guidance to inexperienced volunteers before and during planting. Be conscious that it is much harder to maintain planting quality control using volunteers than it is for a tree planting contractor who is using experienced staff.
- Typically on larger scale projects the best approach is to lay out the canes, mats and small guards to mark the correct spacing for planting, before going along and planting the trees.

See the case study in chapter 2 for more on large-scale tree plantings.

Buying and sourcing the right inputs at the right price (with 2023 prices)

Planting paddock trees can be expensive and significant savings can be made by buying right. Following are details of some product options with 2023 prices.

Steel mesh guards and star pickets

On its paddock tree planting project, HCLG used galvanized steel mesh in 28.5 m rolls, either 1200 mm or 1650 mm wide, made in Australia by ARC Manufacturing. Experience shows that rolls of mesh are generally more expensive from rural suppliers than from discount steel suppliers. Significant savings can be made by Landcare groups buying in bulk for their members, and still further savings can result from having a large consignment of rolls of mesh delivered to a central location direct from the factory.

Unfortunately steel prices have risen significantly in recent years. HCLG's supplier of mesh charged $275 and $375 per roll respectively for 1200 mm and 1650 mm wide mesh in 2017, but in 2023 the price was $590 and $675. This equates to $50–60 per guard, plus the work involved in cutting the roll into lengths. The guards can be used a number of times, reducing their effective lifetime cost.

Star pickets/steel posts cost upwards of $6 each. Experience is that the more expensive top-quality heavier duty star pickets are overkill. The cheaper and somewhat more lightweight ones seem to do the job equally well given their role is merely to anchor the steel mesh guards tie-wired onto them.

In HCLG's case a truckload of mesh was delivered direct from the factory to a centrally located property at Hovells Creek (Fig 7.14). Several weeks later members picked up their mesh, with a tractor loading their trailers and utes.

Fig 7.14: Unloading rolls of steel mesh shipped direct from the manufacturer to a central location.

It is also possible to buy pre-cut galvanised round steel mesh guards that are supplied in bundles of 25, but which some rural suppliers also sell individually (Fig 7.15).

Fig 7.15 (right): Pre-cut lengths of galvanized steel guard.

Another available product is the Mallee mesh cattle guard, which is supplied as two pre-formed L-shaped panels 1.95 m high and 750 mm wide, together with 2 x 1.8 m star pickets and 15 m of barb wire. Early 2023 pricing for these guard packages was $127 each or $97 each for 25 or more (Fig 7.16).

Fig 7.16: Mallee mesh cattle guard. Photo from commercial website.

It is false economy to buy cheap 3 mm lightweight imported mesh with poor welds for your guards. They are easily damaged by cattle, or by sheep penned into a tight area. The damaged galvanized steel mesh in Fig 7.17 was bought from a large hardware chain.

Fig 7.17 (right): Cheap 3 mm lightweight imported mesh which has been badly damaged by cattle reaching in to eat the top off a young paddock tree. Photo by Keith Hyde.

Tubestock trees in 120 mm high forestry pots

These can vary in unit price from between $7.50 or more from a retail nursery, to $3 when purchased in bulk from a wholesale tree nursery.

It is essential to buy good quality tubestock, which you may need to pre-order. They are key to the success of the whole venture. It is crucial when purchasing tubestock to follow the specifications detailed in Chapter 4.

Canes, plastics and weed mats

These can all be purchased online, from tree nurseries or from large hardware suppliers. There is a wide range of products (Fig 7.18) and prices and quality can vary significantly.

Canes are generally cheaper than hardwood stakes. Flexible plastic guards require 3 canes, whereas some stiffer corrugated plastic (corflute) or cardboard guards may only require one or two hardwood stakes or canes. Using a steel spike (see Chapter 6, step 8) to make a hole for the canes or hardwood stake can ease the difficulty of hammering them into harder ground.

Fig 7.18: Selection of small guards for protecting tubestock trees.
Photos from commercial websites.

Key takeaways from Chapter 7

1. Using water crystals can significantly increase tubestock survival rates at little cost.
2. Tubestock may not always need the protection of smaller plastic or cardboard guards.
3. Tubestock that appear dead may resprout from the lignotuber, so don't replace them too hurriedly.
4. Protecting self-set seedlings can be a great way of gaining extra paddock trees as they usually thrive better than planted trees.
5. Steel mesh bought from discount steel suppliers is often cheaper than from rural suppliers, and even more so if purchased in bulk.
6. It can be false economy to use cheap lightweight steel mesh guards.

NOTES AND REFERENCES

[1] Bender I, Gould L and Lovett S, 2023, *Riparian Management Tubestock Guide: A guide for landholders planting tubestock as part of their riparian restoration projects*, Rivers of Carbon, available at riversofcarbon.org.au. Quotation is from Step 7 of 'How do I plant tubestock'.

[2] Chau C *et al.*, 2021, 'The Environmental Performance of Protecting Seedlings with Plastic Tree Shelters for Afforestation in Temperate Oceanic Regions: A UK Case Study', *Science of the Total Environment*, 791: 148239.

Appendix 1

Note on HCLG's linking paddock trees project, 2016–2019, funded by the NSW Environmental Trust

Grant funding

In May 2016 HCLG was awarded $89,990 ex GST by the NSW Environmental Trust for Project 2015/RR/0037 'Habitat Restoration at the Grassy Box Gum-K2W Flyways Interface'. The grant covered the materials and tubestock required to plant and protect (within individual stock proof guards) 1,500 paddock trees in the Hovells Creek area over three years from 1 Sept 2016 to 30 August 2019.

The approach

The trees were to be planted as linking trees to provide connectivity between existing patches of trees and shrubs. Guidance for the planting layouts was based on a series of Habitat Connectivity Plans prepared in 2016 and 2017 by a consultant, Ms Susie Jackson, for 13 individual properties. The objective was to plant paddock trees at 30–50 m intervals within a 50–100 m wide corridor, so that birds, insects and small animals could use them as a movement corridor between existing patches of trees and shrubs. It was accepted that actual on-farm planting layouts would be modified as necessary from Ms Jackson's original plans to take account of specific land use requirements. Where a property had not had a Habitat Connectivity Plan prepared, then the landholder was required to follow the general principles and logic behind the planting of trees for habitat connectivity.

2017 plantings

A bulk order for rolls of galvanized steel tree mesh and star pickets was placed in late 2016 and was distributed to members in early 2017. Significant savings were achieved by shipping a truckload of mesh and star pickets direct from the factory in Victoria to a farm in the Hovells Creek area, for subsequent pickup by members. A bulk order for tubestock trees and weed mats, canes and plastic protectors was placed with a local nursery, with them being distributed to members in late March 2017 ready for autumn planting. The original grant commitment was for 500 trees to be planted per annum across 10 properties. However, with bulk buying of materials (especially of the steel mesh and star pickets), and some redesign of the project, it proved possible to plant 670 trees across 21 properties in 2017.

Advice to members on tree planting saw the provision of notes on planting and on recommended tree species for the different types of land where the trees were being planted, e.g. valley flats, lower slopes and granite hills. These notes were placed on the HCLG website.

In the event the autumn rains were late in 2017, causing much of the planting to be delayed until late autumn. This meant that newly planted tubestock had only limited time to establish themselves before the dry and hot weather of summer. Nonetheless, survival rates exceeded 95 per cent.

Monitoring of the results of the 2017 plantings was undertaken by HCLG's Landcare Support Officer (LSO), with a copy of her report being submitted to the NSW Environment Trust in late 2017 as part of the group's required annual report to the Trust.

Feedback from the Trust on its review of HCLG's first annual report was very positive, including the comment that, 'The Grantee should be highly commended for their level of commitment to both the on-ground activities implemented by landholder members, and the detailed information contained in the monitoring and financial reports.'

Fig A1.1: View looking south east from above Old Graham (on the west side of Hovells Creek) across towards the east side of the valley, with farmland of the Willow Glen property seen in the valley.

Fig A1.2: View looking north over Hovells Creek Valley from Jerringomar (formerly Kooringle) property. Photo courtesy Doug Dockery.

2018 plantings

Materials were supplied to HCLG members to cover the planting of 678 trees across 22 properties in 2018, as compared with the grant commitment of 500 trees. Those who took part had all either completed their 2017 plantings, or had been obliged to delay their 2017 plantings for personal or weather-related reasons.

Two changes in emphasis occurred in 2018. First, participating members were encouraged, where it was consistent with their linking tree layout, to plant their trees along drainage lines or in gullies. This was done because the damper ground in such areas both makes for easier planting conditions and provides more soil moisture to support newly planted tubestock. Birds, insects and small animals also have a preference for trees planted along drainage lines.

Fig A1.3: Row of *Eucalyptus* species planted as part of the project in 2018 in steel guards inside a roadside boundary fence. Photographed in mid-2023.

The second change was that members were encouraged to space their linking trees more closely to allow for some tree mortality over the next 100 years. This was an important lesson which emerged from a talk given to HCLG in early 2018 by Dr Mason Crane of Sustainable Farms at the Australian National University.

In June 2018 a field day was held for HCLG project participants and for members of neighbouring Landcare groups, led by the Yass Area Network Landcare group. Following the field day the Yass Network decided to start their own paddock tree project.

In early 2018 a YouTube video was produced, 'Hints for Paddock Tree Planting', which summarised lessons learned from the first year of the project and provided guidance for future plantings.

In autumn 2019 a further four YouTube videos were produced on: making steel guards; using a Power Planter augur when planting tubestock; growing on kurrajong tubestock; and the case for autumn planting of tubestock.

Following investigation of the problem of J-rooting in tubestock, a note on root kinking and J-rooting was loaded onto the HCLG website.

Fig A1.4: Project paddock trees planted in 2017 on the lower slopes of the Hovells Creek valley and photographed in mid-2023. Photo by Keith Hyde.

2019 plantings and 2020 carryover

Ongoing dry conditions in 2019 prompted the project to adopt the use of water crystals for all tubestock plantings. This followed advice from a landscaping and tree planting contractor working for NSW Department of Main Roads who made a very strong case for their use in all tubestock planting as an insurance against dry spells. See Chapter 7 for details.

In the final year of the project an estimated 700 trees with guards were distributed for planting. However, dry conditions over the three years had delayed some plantings and some members sensibly decided to carry over their tubestock entitlement to 2020, when more favourable conditions were expected and did eventuate.

In total 2,048 trees were planted across 23 member properties over the four years 2016 to 2020.

The final feedback received from the NSW Environmental Trust on the three-year project was 'excellent'.

Fig A1.5: Healthy paddock tree planted in 2017 as part of the project and photographed in mid-2023. The 1650 mm high steel guard has a smaller diameter because 13 guards instead of the usual 12 have been cut from a 28.5 m roll of mesh. Photo by Keith Hyde.

Other HCLG projects involving tubestock tree planting

Other recent HCLG projects which have involved tubestock tree planting to date and which built on the above NSW Environmental Trust funded project are:

1. **'Saving Our Superb Parrot', 2018– continuing.**

   This project involves protecting mature paddock trees and supports the planting of new paddock trees with stock proof guards. The aims include habitat restoration, on ground protection and improving connectivity in the landscape. The project covers HCLG and neighbouring Landcare areas and is funded by the NSW Department of Planning and Environment's 'Saving Our Species (SoS)' program.

   To date the HCLG arm of the project has received grants totalling $65,000 and has planted 250 tubestock paddock trees in cattle-proof steel mesh guards, has planted 2,500 trees and shrubs within fenced off areas, and fenced and protected 35 mature paddock trees.

2. **'Erosion control works on properties to address threatened species and sedimentation issues in Hovells Creek and the Lachlan River', 2020– continuing.**

   This project involves a range of dam works, fencing and protecting areas, with trees and shrubs being planted in the protected areas. The project is funded by the NSW Environmental Trust and South East LLS.

3. **'Streambank and Gully Erosion Mitigation Project', 2019–2021.**

   This project involved undertaking earthworks to remedy erosion, protection of affected areas, and planting of trees and shrubs in the affected areas. The project was funded by Central Tablelands LLS with a grant of $10,000.

Appendix 2

YouTube videos on tubestock paddock tree planting

These videos on paddock tree planting were prepared as a source of advice and guidance for HCLG members who were new to paddock tree planting.

The videos also shared the experience of different members, so contain some useful hints even for experienced paddock tree planters. They are also relevant for projects outside the Hovells Creek area.

Hints for paddock tree planting (9:20 mins – July 2018)
Provides an overview of how to plant tubestock paddock trees, covering all of the key stages.
https://youtu.be/Y4YTbHfFBRk

Hints for making steel mesh tree guards (8:25 mins – March 2019)
How to cut up 28.5m rolls of steel mesh to make tree guards for use with paddock trees.
https://youtu.be/L8OFSadcRRA

Hints on using a power planter to plant paddock trees (4:42 mins – April 2019)
Using a Power Planter augur to drill holes for tubestock tree planting, especially in dry or hard ground.
https://youtu.be/Hrav1sVMeDE

Hints for successful kurrajong paddock trees (2:24 mins – April 2019)
'Growing on' tubestock kurrajongs for a year prior to planting out as paddock trees, so as to give them a head start.
https://youtu.be/hGB1isMG4Sk

Why we should plant paddock trees in early autumn (4:46 mins – April 2019)
An early video examining the benefits of planting tubestock paddock trees in autumn (April/May) instead of in spring, produced before the research project detailed in Chapter 5 and Appendix 3.
https://youtu.be/tBnLMOIoTTg

Scan the QR code
to view all videos.

Appendix 3

Field trials to test the benefits of autumn vs spring planting

To test the benefits of autumn vs spring planting, two related field trials were established in 2020.

An area of open gravelly soil on a granite hill slope at Old Graham, Hovells Creek, was fenced off and planted, in several stages, with 45 tubestock trees in plastic guards with weed mats (Fig A3.1). The trees were yellow box (*Eucalyptus melliodora*) of a uniformly high standard (Fig A3.2), with no J-rooting because of the propagation techniques used.

Fig A3.1: Fenced trial plot with initial autumn tubestock tree plantings, April 2020.

Fig A3.2: Tray of yellow box (*Eucalyptus melliodora*) tubestock used in the trial plantings, April 2020. They were chosen to be all of the same size (approx. 150–200mm in height).

Field Trial 1: Assessment of root growth occurring between autumn and spring 2020 in autumn-planted tubestock

In autumn 2020 (on 12 April) three rows of five yellow box tubestock trees were planted and watered in well:

- **Row 1** – five trees were planted as controls without any special treatment.
- **Row 2** – five trees were planted, with a teaspoon of water crystals mixed into the soil in the hole they were planted into to help hold water.
- **Row 3** – five trees were planted with the addition of a slow-release low phosphorus native fertiliser mixed into the soil in the hole they were planted into.

Five months later, in spring 2020 (on 13 September), all 15 young trees were dug up. Fig A3.3 shows them in red plastic trays, with row 1 on the left, row 2 in the centre and row 3 on the right of the photo.

Fig A3.3: Trees dug up in Sept 2020 after 5 months in the ground, with row 1 on the left, row 2 in the centre and row 3 on the right. These root balls compared very favourably with the small tubestock root balls shown in Fig A3.4 for trees just removed from their tubes.

The trees were difficult to dig up without damaging their roots, as they had all rooted out into the soil surrounding their original tubestock potting mix root ball. This is a significant difference from trees of the same age overwintered in a nursery (Fig A3.4), which when planted in spring have much smaller root balls (limited as they are to the size of their forestry tube).

It was noticeable that the trees from row 1 (planted without any special treatment) had rooted out into the surrounding soil less, and had developed significantly smaller root soil balls, than had those in rows 2 and 3. The largest root soil balls were definitely in row 2 (which had had water crystals added) followed by row 3 (with the slow-release native fertiliser added). Root growth with native fertiliser was somewhat better than for the control group, but the improvement was not as significant as for the water crystals.

It was also noticeable that the water crystals in the row 2 trees were intact and full of water and there was no evidence of them having broken down or degraded.

The height of most of the 15 young trees was much the same as when they were planted 5 months earlier, although a few showed signs of branching and some limited new leaf and stem growth. This limited leaf and stem growth may reflect the fact that the trees used in the trial were yellow box, which tend to be a relatively slower growing *Eucalyptus* species, whereas some other species can put on quite a bit of leaf and stem growth between autumn and spring.

Field Trial 2: Differences in stem and leaf growth between tubestock planted in autumn and spring

In conjunction with Trial 1, in autumn 2020 (on 12 April) a further three rows, each of five yellow box tubestock trees, were planted. Each row of five trees was watered in well and given the same treatment as in Trial 1:

- **Row 4** – five trees were planted as controls without any special treatment.
- **Row 6** – five trees were planted, with a teaspoon of water crystals mixed into the soil in the hole they were planted into to help hold water.
- **Row 8** – five trees were planted with the addition of a slow-release low phosphorus native fertiliser mixed into the soil in the hole they were planted into.

Fig A3.4: Tubestock trees that were wintered in the nursery and are about to be spring planted in September 2020.

Then in spring 2020 (on 13 September) a further three rows of five yellow box tubestock trees, were planted. They were part of the original tray from which the autumn trees had been planted (Fig A3.2) and had been overwintered in the nursery (Fig A3.4) along with other tubestock trees being overwintered by the nursery for spring sale. Again each row of 5 trees was given the same treatment:

- **Row 5** – five trees were planted as controls without any special treatment.
- **Row 7** – five trees were planted, with a teaspoon of water crystals mixed into the soil in the hole they were planted into to help hold water.
- **Row 9** – five trees were planted with the addition of a slow-release low phosphorus native fertiliser mixed into the soil in the hole they were planted into.

In October 2022, 30 months after the original autumn plantings and 25 months after the spring plantings, the stems of the trees in all six rows were cut off at ground level. All the above-ground stems and leaves were then weighed immediately while still green, providing a biomass figure that was treated as a proxy for tree growth. The results are summarised in the table in Fig A3.5 below:

	Autumn Planting 12 April 2020				Spring Planting 13 September 2020			
Row number	4	6	8	Total autumn	5	7	9	Total spring
Planting treatment	(a) control	(b) water crystals	(c) native fertiliser		(a) control	(b) water crystals	(c) native fertiliser	
Number of trees planted	5	5	5	15	5	5	5	15
Number of trees surviving in Oct 2022	5	5	5	15	3	5	3	11
Number of dead trees in Oct 2022	0	0	0	0	2	0	2	4
Above-ground biomass (g)	1088	1388	1180	3656	331	390	628	1349
Average above-ground biomass (g)	218	278	236	243	110*	78	209*	123*

* Green tree weight is averaged here among surviving trees only. If averaged across the total number of trees planted for each group, the average weight of stem/leaf growth in these cells would be significantly lower.

Fig A3.5: Comparison of tree survival rates and green stem and leaf growth weights (biomass) in October 2022, for trees planted in autumn and spring 2020 with one of the following treatments: (a) control – no additional treatment; (b) water crystals used; (c) native fertiliser used.

The results, and the differences between the outcomes for the autumn and spring plantings, are striking.

All 15 trees planted in autumn 2020 survived, whereas only 11 trees planted in spring 2020 survived. There was above average rainfall between autumn 2020 when the first trees were planted and spring 2022 when the tree biomass was recorded. Both 2021 and 2022 were relatively wet winters, although the trial site was very well drained .

Of the 11 surviving spring-planted trees, one had died back down to the lignotuber but was sprouting young shoots from it. So only 10 trees, or two-thirds of the spring plantings, actually maintained or increased their original stem growth.

In comparison, the 15 autumn-planted trees had, on average, almost double the biomass when compared to the 11 surviving spring-planted trees – an average weight of 243 g per autumn-planted tree compared to an average weight of 123 g per surviving spring-planted tree. The biomass, calculated by weighing green stems and leaves, indicates growth over the 30 and 25 month time periods. Although the autumn trees did spend an additional five months in the ground, both groups of trees were propagated at the same time and were part of the same batch of seedlings and had had the opportunity of two full growing seasons to develop their above-ground biomass.

From a statistical standpoint, based on Fisher's Exact Test, the results in the table are judged to be highly significant – that is, there is significant variation in biomass between the autumn and spring-planted tubestock trees that is highly unlikely to be a chance result.

Fig A3.6: Trial plot with fencing and plastic guards removed. Comparative growth of trees planted in autumn and spring 2020 (see Figure A3.1), as at October 2022. The rows are numbered 4, 5, 6, 7, 8, 9 from left to right. That is from left to right the trees are autumn, spring, autumn, spring and autumn, spring plantings.

Visual evidence of the striking difference between the amount of growth put on by autumn 2020 planted trees, as compared with spring 2020 planted trees, is provided in Fig A3.6. The autumn planted trees on the left of the pairs of tree rows are noticeably taller and more branched than the spring planted trees planted immediately to their right.

The role of water crystals in supporting the survival and growth of trees was also evident in the on-site inspection, with the best growth and survival rate for spring-planted trees being observed among those planted with water crystals – though this is not visible in Fig A3.6.

In summary, autumn planted trees had significantly higher tree survival rates and double the above ground tree growth as compared with spring plantings.

Glossary

air pruning	The drying out of root tips so that they stop growing once they reach openings in the base of the tube or pot.
allelopathy	The biological phenomenon by which a chemical in the leaves of *Eucalyptus* trees negatively affects plant growth and seed germination in the area under the tree's dripline.
BCLG	Boorowa Community Landcare Group.
BOM	Bureau of Meteorology.
canopy	Foliage of a tree.
corflute	A twin walled corrugated polypropylene plastic sheet which can be used to make small tree guards, usually black or green in colour.
CTLLS	See LLS.
CWLLS	See LLS.
endemic	Confined to a given area.
eucalypt	plants of the *Eucalyptus, Corymbia* and *Angophora* genera.
exotic	Introduced from another location.
fencing off	The practice of building a fence along one side of a paddock, or in a corner, to create a stock free area, thus protecting trees or shrubs growing in the fenced off area.
forestry tube	A tapering black plastic tube used for growing tree seedlings, 5 cm wide at the top, 120 cm deep and with a square profile. Good forestry pots have internal vertical 'training' ridges, which discourage roots from circling round inside the pot.
FRRR	Foundation for Rural and Regional Renewal.
germination	Initial growth of a plant from a seed.
grown on	The practice of growing seedlings for a longer period of time, often by repotting them into larger pots, so that they attain a larger size before being planted in the ground.
habitat	Environment in which a plant grows.
hardening off	Process of adapting seedlings to field conditions before planting out. Typically this involves moving tubestock outside after their initial growth in a greenhouse or shadehouse.
HCLG	Hovells Creek Landcare Group.
HCV	High conservation value.
heavy country	Colloquial farming term for what are typically clay soils in valley bottoms, which tend to hold water and don't warm up quickly in spring. By comparison light soils are typically more open, sandy or gravelly soils on slopes or ridges which tend not to hold water because they are free draining, and which warm up quickly in spring.
indigenous	Belonging naturally to a specific area.
lignotuber	Modified underground stem typical of most eucalypts, often with multiple stems growing from it.
light country	See heavy country.
LLS	Local Land Services, an arm of the NSW Government which has a number of regions, including SELLS (South East LLS) and CWLLS (Central West LLS) and CTLLS (Central Tablelands LLS).

lock up	A term used to describe the dense growth of white and black cypress species which occurs when a mass of self-sets grow closely together, with slender trunks and only reaching a height of 3–4 m. Thinning of the 'locked up' trees is required for them to grow into mature trees.
LSO	Landcare Support Officer.
native fertiliser	Fertiliser specially formulated for Australian native plants, typically with a phosphorus content of 3% or less.
pricking out	Transplanting young seedlings from a seedling tray of potting mix, in which they were germinated with other seedlings, into individual forestry pots or other small pots.
residual herbicide	A herbicide that can persist in the soil for a long period of time.
root trainer ridges	Vertical internal ridges inside plastic pots that are designed to guide roots down rather than allowing them to circle and grow round inside the pot.
sapling	A young tree with a slender trunk, typically of between 1 and 3 m in height.
seed	Propagating organ of a plant, comprising a protective coating covering the embryo and food reserves.
seedling	Small plant raised from a seed.
self-set	A tree seedling which has grown naturally from seed out in an open paddock or woodland. They are typically found near mature trees that have seeded and they often only germinate after suitable rains. Also known as 'volunteer' seedings.
senescent	A tree that is over-mature and is in a state of decline due to age .
shrub	Woody plant less than 3 m in height without a single main stem, or where branches occur down to the base of the main stem.
species	Group of plants possessing the same constant and distinctive character. Abbreviated to sp. (singular) and spp. (plural). Species are grouped in genera, such as *Eucalyptus*.
star picket	Colloquial bush term for the standard 1650 mm long steel bitumen coated fencing post (though some are also galvanized), which is pointed at one end, has three vertical edges (hence the word 'star') and has holes for fencing wire to run through.
sucker	Shoot growing from a root or an underground stem.
tree	Woody plant more than 3 m high. Trees usually have a single main stem, although many *Eucalyptus* species have lignotubers and can have multiple stems growing out of the lignotuber.
tubestock	Seedlings, usually 100–250 mm in height, growing in a plastic tube, typically a forestry tube.

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Note: **Bold** page numbers refer to illustrations and captions.

About the author

Dr John Baker grew up in England and moved to Australia in 1970. After completing a PhD degree at The Australian National University he worked in the overseas development assistance field for ten years, including three years as Australian ambassador to a number of African and Indian Ocean countries. He subsequently held a number of senior federal public service positions, before resigning to establish a management consulting firm, which he ran until his retirement.

In 1991 he and his wife Liz purchased a dilapidated stone former coaching inn on a former sheep property at Hovells Creek, between Boorowa and Cowra, as a second home. After restoring the building they undertook extensive tree planting across their property and became heavily involved in the Hovells Creek Landcare Group. John's 30 years of practical experience in tree planting and his management of HCLG's paddock tree planting project over a number of years have contributed to the writing of this guide.

Paddock trees are an iconic and important element of the cropping and grazing lands of regional NSW, providing habitat for native wildlife as well as supporting farm productivity. They are in decline, and there is a real risk that these large, stately old trees will become a thing of the past.

Planting tubestock trees today, that will become the large old trees of tomorrow, is an achievable and rewarding act of stewardship that all landholders can undertake.

A Practical Guide to Planting Tubestock Paddock Trees is an essential resource for anyone planning tubestock paddock tree planting on farms or properties in central NSW. Failed plantings are an expensive loss that can be avoided with some forethought and planning.

The guide draws on many years of planting experience and practical field trials. It explores planting considerations including choice of species, location in the landscape, when to plant and how to choose quality tubestock that will survive and thrive.

‘A Practical Guide to Planting Tubestock Paddock *Trees is an excellent contribution towards improved knowledge and better management of natural assets on farms and rural properties. This is because it is underpinned by years of practical experience in restoration. For example, it has highlighted key issues in tree restoration and management of which few people would be aware – the advantages of planting in autumn rather than spring and the problems caused by J-rooting in tubestock. These and many other important findings are why all farmers and rural property owners interested in better managing their land should read this terrific book.’*

David Lindenmayer

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