October 2023

Private Forestry Guidance Materials

Farm forestry

Forest & Wood Products Australia

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Farm Forestry

Important information

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GREENWOOD STRATEGY

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Introduction

Background

To meet Australia's, and the world's, increasing demand for wood fibre requires a policy approach that maximises the role of small-scale, privately owned forests in fibre supply.

There are barriers to participation of private landholders and Indigenous groups in commercial forestry. One of the most significant obstacles is limited knowledge about how plantations and native forests can be managed as a legitimate and profitable land use that contributes meaningfully to Australia's future wood fibre needs.

Forest & Wood Products Australia (FWPA), with funding from the Australian Department of Agriculture, Fisheries and Forestry (DAFF), engaged Greenwood Strategy Solutions Pty Ltd to undertake a comprehensive project to collect, collate, analyse and make available the large volume of historic trials and publications related to the topic and to prepare detailed Guidance Materials that will help break down these knowledge barriers.

This document provides guidance on management of farm forestry plantations for commercial timber production. It can be read as a standalone reference or together with the other guidance materials in this series.

Purpose

This document provides a generic overview to the business of small-scale private forestry in Australia. It is supported by a suite of more-specific documents that address each of the three types of forest management as well as providing detail on topics of particular interest.

It is intended to inform people and organisations interested in developing private forestry as an enterprise. It aims to provide sufficient detail to assist individuals and businesses to make well -considered decisions about forestry as a serious and viable land-use option that can provide commercial, social and environmental outcomes. This is one of several Guidance Materials publications prepared as part of the Australian Government's commitment to delivering the National Forest Industries Plan.

The Private Forestry Guidance Materials are not intended to provide operational instruction about how to grow forests or manage them as a business. Rather they are an introduction to the range of considerations that landowners and businesses should take into account when managing forests for commercial outcomes.

Who should use the Private Forestry Guidance Materials?

Audiences that could benefit from this guidance document include:

- landowners
- advisers
- regulators
- non-government organisations
- timber processors and manufacturers.

Structure of the guidance materials

There are four guidance documents in this series, covering the following topics:

1. An introduction to the business of small-scale farm forestry, private native forestry and Indigenous managed forest lands.
2. Farm forestry
3. Indigenous owned and managed forests.
4. Private native forestry.

References to relevant publications are provided within the guidance documents and can be accessed via the FWPA online database of relevant publications. The database includes actual publications and links to a vast catalogue of material that has been produced by government departments, programs and regional plantation groups over many years.

The Guidance Materials also include a series of information sheets and case studies that provide more detail on specific topics of interest.

Professional advice

Forestry is a specialist discipline and wood products markets are quite different to markets for other commodities. Many land owners utilise the advice of professional agronomists when looking to get the most out of their cropping or grazing activities. Forestry is no different. It is strongly recommended that farm foresters seek the advice of professional forestry service providers to understand how commercial forestry can best be integrated into their specific agricultural enterprise and obtain detailed site-specific guidance on how to go about this.

Farm forestry in context

What is farm forestry?

The benefits of trees in agriculture

It has long been recognised that trees integrated with agricultural systems can offer a wide range of benefits for farms and in supporting sustainable landscapes.

For individual farm enterprises, trees can provide a profitable alternative income stream through generation of forest products while improving farm productivity and providing ecosystem services. Forest products may include timber products for commercial sale or on farm use and non-timber products such as honey. Productivity benefits include shade and shelter for stock and crops, erosion prevention, improved water quality and management of salinity. More recently, the role of trees in capturing carbon has emerged as a potential benefit, either to offset farming emissions or to generate carbon units for participation in Australia's Emissions Reduction Fund. In many cases, trees integrated into agriculture can provide multiple benefits at any point in time.

At a landscape scale, farm forestry generates regional employment and economic activity. It also offers environmental and ecosystem benefits for biodiversity, water quality and yield, soil health, and carbon accumulation and storage.

Forestry as a farming practice

It is important to recognise that landowners typically perceive farm forestry as part of the overall farming system – farmers don't usually want to be foresters, they want to be farmers who use forestry as a form of agriculture. Farm forestry "*…incorporates commercial tree growing into farming systems. It takes many forms, including timber belts, plantations, woodlots, wide-spaced tree plantings and the sustainable management of existing stands of native vegetation*" (DAFF, 2003). What a farm forestry regime "*…looks like and how it performs will depend on interests, resources and opportunities facing landholders involved and their ability to design and manage their forests effectively*" (DAFF, 2003).

Definition of farm forestry

The concept of incorporating trees into agricultural systems and enterprises covers a wide range of land-owner objectives. Agroforestry is the broad term which best describes tree growing on farms for multiple benefits. Farm forestry is the term most often applied at the commercial end of the agroforestry spectrum. It refers to the integration of commercial tree growing – either as plantations or native forest – into farming systems and enterprises. Although native forestry is included in this broad definition, this document is focused on plantations. Accordingly, the ABARES (2022) definition of farm forestry that has been adopted is: "*Establishment or management of planted trees, usually in rows and which meet the definition of forest, with timber production as a primary management intent, on individual private landholdings with a total area of plantings usually less than 1,000 hectares*."

Farm forestry in Australia today

Governments, industry and farmers have promoted farm trees and invested in the sector since the early 20th century, in recognition of the potential benefits of farm forestry. Many farms have established shelterbelts and woodlots, with more significant farm forestry expansion occurring in some regions during the 1990s and 2000s. Obtaining an accurate description of the farm forestry sector is challenging. It is also not possible to accurately report timber production figures. However, several studies provide a useful overview of the extent and nature of farm forests growing in Australia.

Extent of the farm forestry

Farm forestry is estimated to represent at least 4% and possibly up to 9% of Australia's commercial plantation estate. Australia's total plantation estate is about 1.74 million hectares, mostly made up of large (greater than 1,000 ha) ownership categories that are well understood and routinely reported through the National Plantation Inventory (NPI) (Daian *et al*, 2022).

Farm forestry is one of five ownership categories recognised in the NPI. Figure 1 presents total plantation area by ownership category in five-year intervals from 2000/01. It shows that the relative proportion and absolute area for each category has changed over the past 20 years. The area identified as farm forestry has ranged from 161,000 ha (8% of area) to 409,000 ha (21% of area).

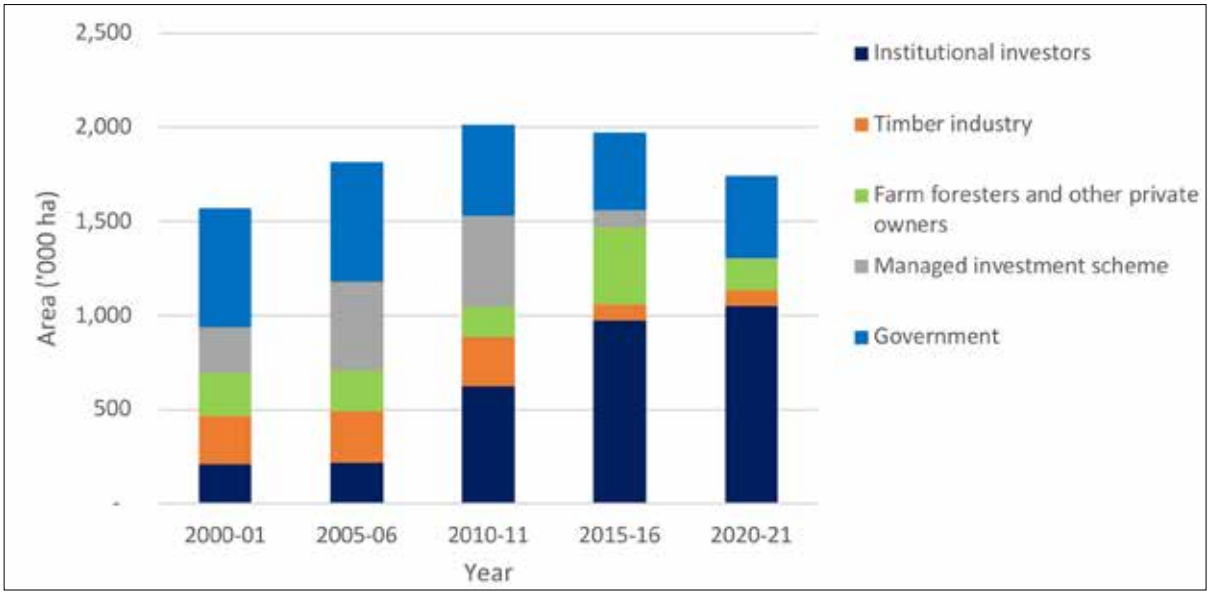

Figure 1: *Ownership of Australia's plantations (2000/01 to 2020/21). (Source: ABARES, 2022)*

Since 2001, three discrete studies have been undertaken to attempt to estimate the area of farm forestry in Australia. The most recent study, undertaken by ABARES, was focused on farm forestry plantations for which verifiable data is available and identified 73,400 ha (Daian *et al*, 2022). Previous estimates range from 66,983 ha (Woods *et al*, 2001) to 155,431 ha, including 55,100 ha of on-farm managed investment scheme plantings (URS Forestry, 2008). The three studies also present significantly different areas for some jurisdictions (see Table 1).

Jurisdiction	Estimated farm forestry area by jurisdiction (hectares)				
	Woods *et al* (2001)	URS Forestry (2008) Non-MIS	URS Forestry (2008) MIS	URS (2008) Total	Daian *et al* (2022)
Australian Capital Territory	0	27,950	0	27,950	0
New South Wales	7,862				9,000
Northern Territory	44	44	0	44	0
Queensland	3,292	4,759	0	4,759	3,800
South Australia	6,106	2,516	6,700	9,216	1,000
Tasmania	16,100	14,805	6,200	21,005	45,600
Victoria	21,086	11,577	20,200	31,777	10,700
Western Australia	12,496	38,680	22,000	60,680	3,200
Total	**66,983**	**100,331**	**55,100**	**155,431**	**73,400**

Table 1: *Estimated area of farm forestry from three studies (Source: Daian et al, 2022)*

There are several potential reasons for the variation in estimates. First, it is difficult to gather information on small-scale, privately owned plantations. Second, over the two decades in question, areas have come into and gone out of plantation production on farms due to a range of factors, including agricultural land use change and the collapse of the managed investment scheme (MIS) sector. Finally, each of the studies relied on different input data quality.

Farm forestry plantation species

A wide range of tree species are used in farm forestry. However, Daian *et al*, (2022) indicate that small-scale plantations are dominated by just three commercial species. Of the 52,000 ha with species verified in the ABARES study, *Pinus radiata* (radiata pine – 13,800 ha), *Eucalyptus nitens* (shining gum – 32,900 ha) and *Eucalyptus globulus* (Tasmanian blue gum 1,700 ha) make up 93% of the area. The selection of appropriate species is addressed later in this document.

Knowledge needs in farm forestry

Gaps in landholder knowledge about farm forestry are recognised as a significant barrier to realising the role of this sector in Australia's wood fibre supply. There is a wealth of published information regarding farm forestry. However, much of this information is regionally specific, out of date and focused on niche concepts such as high-value sawlogs and species that have not proven to be widely successful.

In a recent study, Greenwood Strategy (2021) consulted with a range of forestry and agriculture organisations in Tasmania, as well as individual small forest owners. The study identified that smaller forest owners and farm foresters wanted to understand more about forest management, forestry markets and log prices and that lack of knowledge about these topics is a reason for not doing forestry or for exiting forestry.
Schirmer (2004) undertook a survey and subsequent consultation with farm forestry professionals, researchers and practitioners to develop an understanding of what farmers wanted to know about the role of forestry on farms. While there are limitations to the findings and differences exist between regions, the results provide a guide to the basic information needs, which include:

Species: *trials of tree species*

Integrating trees into farming systems: covering issues such as:

- economic analysis on integrating trees into the farm enterprise and on markets for farm forestry products
- studies on interactions between trees and crops or pasture
- studies examining particular forms of planting such as shelterbelts, alley farming and inter-cropping.

Processing: *Studies about on-farm processing and small-scale harvesting.*

Extension: *Studies on adoption of and extension for agroforestry and farm forestry.*

Policy: *Studies on policy relating to agroforestry and farm forestry.*

This document specifically focuses on negotiating the business and commercial practicalities of establishing, growing, managing and selling plantation timber products from farm forests.

Sustainability and farm forestry

Definition

Traditionally, sustainable forest management referred to maintenance of the productive capacity of forests or sustained yield. However, the concept has evolved with expanding recognition of the roles that forests play for communities, the environment and the economy. Now, sustainable forest management, in the broadest sense, means management of forests to sustain the full range of environmental, social and economic benefits they offer. However, there are widely differing views about what factors are important in the three sustainability categories and which of those should carry more weight. There are also different expectations about what sustainability means for natural forests compared to plantations, and for forests where people have a strong cultural connection.

Australia's sustainable forest management framework

Australia's sustainability framework for forests is well established. It includes national and state level policies, regional forest agreements, a framework for criteria and indicators to measure sustainability and independent third-party forest management and chain of custody certification.

Framework element	Specific actions	What does it mean
National policy	National Forest Policy Statement (1992)	Promotes the conservation and sustainable management of forests
	National Forest Industries Plan: Growing a better Australia – a billion trees for jobs and growth (2018)	Promotes the expansion of forestry and forest industries with the right trees in the right place at the right time.
	Regional Forestry Hubs	Eleven Regional Forestry Hubs in strategic locations funded by the Australian Government to support the 'Growing a better Australia' policy.
	National Institute for Forest Products Innovation	Establishment of research centres in partnership with states and industry to drive smarter use of forest resources.
	Regional Forest Agreements	20-year agreements between the federal and state government to support regional approaches to balancing conservation and timber production needs from native forests.
	Australia's Sustainable Forest Management Framework of Criteria and Indicators (2008)	An internationally recognised framework for monitoring, measuring and reporting on Australia's sustainable forest management.
State and Territory frameworks	Policy, legislation, regulation	Each state and territory has policies, legislation and regulation (such as Codes of Practice) in place to ensure sustainable forest management practices.
Certification	Independent, standards-based verification of sustainable management of forests and supply chains	Independent, third-party certification of sustainable forest management and timber manufacturing to internationally recognised standards, which applies to the majority of Australia's production forests.

Table 2: *Australia's sustainable forest management framework.*

Measuring sustainability

There are many accepted approaches to the measurement of forest management sustainability. Some apply at a national or state scale; others are suitable at an enterprise or farm scale. Some examples of commonly used and accepted frameworks are discussed below.

Montreal Process criteria and indicators

Australian governments have adopted the Montreal Process Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (the Montreal Process). The Montreal Process emerged as an initiative of the 1992 Earth Summit in Rio de Janeiro, focused on sustainable management of forests. Sustainable forest management aims to maintain a wide range of forest values into the future. The Montreal Process provides a framework for categorising and measuring these values in an agreed and consistent format. In Australia, the criteria and indicators form the basis of five-yearly State of the Forests reporting which is undertaken at the national level.

Forests and the circular economy

The core concepts of the circular economy include[1] :

1. Designing waste and pollution out of systems of manufacture and production that would be otherwise lost during disposal and recycling.
2. Making the most of both consumable and durable components of products through processes like composting and anerobic digestion (consumables) and maintaining product life spans (durables) through repairing, repurposing and upgrading.

Forests and wood products have a critical role to play in moving towards a circular economy. The core principles align well with the goals of sustainable forest management and products manufactured from wood and wood fibre are well suited to both biodegradation and repair and repurposing. Importantly, forests are a renewable source of raw materials, particularly for the construction sector, and especially when compared to alternatives such as steel, concrete and bricks.

Triple bottom line accounting

Triple bottom line accounting seeks to quantify and balance the financial, social and environmental costs and benefits of an enterprise or activity. By measuring the social and environmental and economic impacts (both positive and negative), triple bottom line accounting aims to drive sustainable behaviour.

Natural capital accounting

Natural capital accounting is based on the concept that every part of the natural environment has a capital value that contributes to the overall value of an enterprise or activity. It is particularly suitable for application to land management scenarios, where soils, water, pastures, livestock, crops, trees and native flora and fauna all have an important role in contributing to the sustainable operation of a primary industry enterprise. This approach aims to measure, record and manage the natural capital balances across a land management unit in both physical (e.g. soil health) and monetary (revenue and profit) terms. Natural capital accounting is increasingly being seen as a useful tool for agricultural production, including forestry.

Sustainability at the farm scale

Increasingly, individual farm owners are expected to demonstrate their sustainability credentials so that they can maintain access to markets for the food and fibre they produce. Companies that control supply chains for agricultural commodities, such as large grocery chains, have an expectation that the goods they sell are sourced from sustainably and responsibly managed enterprises in order to meet customer requirements. There are many ways that farming enterprises can demonstrate their sustainability credentials. Incorporation of sustainable forest management is one important tool available to landowners to achieve this.

[1] United Nations Economic Commission for Europe (UNECE) https://unece.org/forests/circularity

Forests and climate change

Carbon sequestration by forests

As forests grow they accumulate and store carbon. When forests are harvested, the products that are manufactured (e.g. building timber, furniture, packaging and paper) continue to store that carbon for years, decades and even centuries. Commercial management of forests is one of the most effective tools available to assist in tackling climate change. Appropriate silvicultural management increases forest productivity, allowing the accumulation of more carbon in growing trees that will later be stored for the long term in manufactured wood products.

Carbon markets

Some active forest management strategies are eligible to participate in Australia's Emissions Reduction Fund (ERF), which can provide additional revenue to the forest owner. For eligible forestry activities, forestry practitioners can register a carbon forestry project with the ERF and generate Australian Carbon Credit Units (ACCUs). ACCUs can be retained by the owner to offset their own emissions from other on-farm activities, can be sold through reverse auctions run by the Clean Energy Regulator, or can be sold into the secondary market.

Carbon market eligibility

There are strict rules that determine whether commercial forests are eligible to participate in the ERF. For plantation forests, these rules include geographic zone limits (depending on the size of the proposed plantation), annual rainfall limits (depending on the location of the plantation) and assessing whether the establishment of plantations will have a negative impact on the surrounding agricultural landscape. Practitioners of commercial native forest management are not able to participate in the ERF, although there are other native vegetation management strategies that are eligible. Australia's Clean Energy Regulator publishes detailed methodologies that explain whether particular types of forest management are eligible and under what conditions.

Policy, regulation and planning for forestry activities

In Australia, responsibility for land management belongs to the states and territories and each has a unique approach to the way in which private forestry is regulated. It is important to understand and comply with the requirements for your location and circumstances.

In some jurisdictions, the requirements for plantation establishment and management are clearly documented so that landholders can quickly and easily determine how to go about incorporating forestry into their enterprise. In other jurisdictions, the regulatory framework is less well articulated and sometimes not specific to forestry as a land use. There are also differences in relation to what level of government (state or local) is responsible for approving and regulating forestry activities. Australia's State of the Forests Report (2018, Indicator 7.1a) provides a schedule of key legislation relating to the conservation and sustainable management of Australia's forests, for each state and territory[2]. Local government planning schemes should also be consulted for relevant local overlays. The longevity of a forestry project means that there are likely to be multiple changes to policy during the crop cycle. Appropriate authorities or expert advice should always be sought.

Forest Industry Hubs

Eleven Regional Forestry Hubs have been established as part of the Australian Government's *National Forest Industries Plan – Growing a Better Australia – A Billion Trees for Jobs and Growth*. his policy framework is intended to support industry in its establishment of new forestry plantations to meet Australia's future needs for wood and fibre..

The Hubs are located in regions where existing concentrations of timber resources are combined with significant processing and manufacturing operations and export facilities. The Hubs provide strategic planning, technical assessments and analyses to support growth of the forest industry in their regions.

[2] https://www.agriculture.gov.au/sites/default/files/abares/forestsaustralia/documents/sofr_2018/web%20accessible%20pdfs/SOFR_2018_Criterion7_web.pdf accessed on 01/07/22.

Farm forestry as a business

Forestry as part of a farming enterprise

Why, what and where

If you are considering establishing a farm forestry enterprise or looking to get more commercial output from an existing farm forestry plantation, it is critical to get the why, what and where right before you start. *Why* do you want to establish a plantation? *What* do you want to plant? *Where* do you want to plant it (Borland, 1995).

There are several distinct but interrelated aspects of planning for farm forestry. It is important to know how farm forestry will integrate into your farm business – the topic of this section. Once you have established your why, what and where, specific forestry plans can be developed to guide how the farm forest is established and managed. This is discussed later in the document.

Farm forestry and farm planning

The motivation for establishing a plantation will vary considerably, whether purely for timber production or as part of a broader integrated agricultural system. For most farm forestry practitioners, the integration of plantations will be a complementary or supplementary activity to other agricultural strategies on the property. Even if farm forestry is the primary agricultural activity, that is a farm planning decision. At the farm enterprise level, integration of farm forestry will involve assessing the role of forestry as part of the overall business plan including its influence on farm cash flows, medium term land availability and its effect on the overall productivity of the farm. Andrews *et al* (2004) identify a series of considerations to aid planning farm forestry as an agricultural endeavour, and assist in determining your why, what and where.

1. Set objectives for the whole farm and the plantation.
2. Consider the farm family's long-term goals, succession plan and willingness to invest.
3. What are the potential market and product opportunities?
4. Review the types of farm forestry production systems that could suit the property.
5. How will farm forestry complement and be integrated into existing farming systems?
6. Identify specific land degradation issues or problem areas that farm forestry could solve.
7. What labour and capital resources does the landowner have that can be committed at various stages of plantation development?
8. Consider the natural (climate, soil and land) and infrastructure resources of the property and their suitability to farm forestry.
9. Consider existing farm infrastructure, particularly roads and tracks that may need relocating or upgrading to support forestry machinery.
11. Identify the most suitable locations and planting configurations for the farm.
12. Understand requirements for approvals and legislative and regulatory compliance.

These steps are explored in more detail in the following pages.

Setting farm forestry objectives

The first step in aligning farm forestry intent with the overall farm business plan is to clearly identify the objectives for establishing a plantation and understand the potential outcomes (see Table 2). While a farm forest can have single or multiple objectives, they are not always complementary, so understanding your priorities is key. Your objectives will drive decisions about what you plant, where you plant, and how you manage your plantation.

Objective	Outcomes	Description
Financial	Revenue	Generation of farm income
	Superannuation	Generation of income for specific financial needs
	'Green-back'	Asset creation through investment of surplus funds into a biological asset in the form of a plantation.
On-farm co-benefits	Animal welfare	Providing a safe and comfortable environment for animals.
	On-farm timber needs	Providing physical timber products for on-farm use such as fencing.
	Environmental services	To manage environmental site quality or ameliorate environmental damage.
	Aesthetics	Improving the visual appeal of a farm.

Table 3: *Some potential farm forestry objectives and outcomes.*

Long term goals

The long-term intention for your farm forest is an important factor to account for at this level of planning. Are you looking to create a permanent farm forest for an ongoing income stream? Or is the inclusion of a farm forest in your enterprise a more dynamic venture intended to serve as a green bank for particular purpose such as funding education, retirement or new enterprises? Long-term goals inform many forest management decisions and in particular what happens after final harvest. Table 3 provides some examples of long-term options and how these influence management decisions.

Objective	Outcomes	Description
Long term forestry	Replant	The plantation is managed as a long-term, multi-rotation farm forestry business activity.
Partial involvement	Full or partial tree crop sale	Owner sells all or part of the plantation to another party and retains partial involvement, either through the retention of some ownership, the provision of plantation management services or both.
Forestry exit	Manage to harvest	Owner manages the plantation from establishment to harvest and then reverts the land for other agricultural use
	Full tree crop sale	Owner establishes the plantation and later sells the trees to another party prior to harvest, usually with a lease over the land.
	Land and tree sale	Owner establishes the plantation and later sells the trees and land to another party prior to harvest.

Table 4: *Examples of end-of-rotation options for farm forestry plantations.*

Human resources and capital

Establishing and maintaining plantations requires significant labour and capital investment. Farm enterprises may have labour and equipment suitable to undertake some forest management activities. However, depending on the scale of the plantation the resource demand of these activities can be significant. Understanding what resources and finance you are willing to make available and what you will outsource will help you determine the scale and type of plantation enterprise suitable to your situation.

Markets

The availability of processing or export facilities within economic transport distance is a significant factor in the success of a farm forestry venture and influences all aspects of plantation management. Plantations in established timber-growing regions are more likely to have a well-defined path to market as well as ready access to specialist contractors and professional advice. The proximity of markets to the forest also determines haulage costs and likely rate of return. Obtaining local professional advice is strongly recommended.

Farm forestry production systems and complementary plantings

Farm forestry production systems refer to how farm forests are configured within the agricultural landscape. Often these systems are complementary to agriculture. They can offer benefits such as shelter for stock, pastures and crops that enhance overall farm productivity while delivering an additional commercial return through timber sales. Options include woodlots, shelterbelts, break of slope plantings, alley farming and wide spaced designs. Figure 2 illustrates a complementary planting around the boundary of a centre pivot irrigation system to improve water efficiency by reducing evaporation and water loss from wind exposure. Farm forestry can also address land degradation problems by lowering water tables and maintain soil quality in areas at risk of salinisation (Figure 3) and stabilising erosion prone slopes. These systems have been comprehensively addressed within existing agroforestry literature over a long period of time, including Brown *et al* (1968), Reid & Bird (1990) and Abel *et al* (1997). Farm forestry practitioners are encouraged to use these references.

Figure 2: *An aerial view of a centre pivot with Tasmanian blue gum plantation located immediately adjacent the irrigation boundary (Sylva Systems, 2022).*

Figure 3: *Strategically planted hardwoods in south west Western Australia, located to maximise remediation of salinity impacts. (Sylva Systems, 2018)*

However, if commercial timber production is one of the purposes for this type of planting, care is needed to ensure the dimensions and size of the plantings are suitable to commercial timber properties relevant to available markets. For example, plantations often exhibit an edge effect where the trees on the edge of the planting develop heavy branching or other tree form issues that reduce log quality. These problems are potentially exacerbated in windrows and alley plantings, where a greater proportion of the trees are close to the edge of a small plantation. If the intent is to grow sawlog as the primary product, the proportion of trees impacted by edge effect is an important consideration.

It is also worth considering that forest management operations are more efficient in larger more consolidated farm forests. Economies of scale influence the willingness of specialist contractors to accept work in plantations, as well as the cost of operations. When forests are too small, the cost of transporting specialist equipment can outweigh returns, which severely constrains the production and marketing options available to a smaller plantation enterprise.

Natural environment

Your farm's natural environment will dictate to a large degree whether a commercial farm forestry venture is possible, what species to plant and what management is required to optimise productivity and returns.
There are a range of site-specific factors to consider, including:

- soil type, structure and nutrient status
- topography
- distribution and location of land productivity categories
- climate (seasonality, rainfall and temperature)
- water availability
- previous land use
- degraded areas.

Climate and soil conditions are particularly important to understand as this will strongly influence what species can be grown on your property, and where they will grow best and most profitably. As with crops, pastures and livestock, each species has a tolerance range of climatic conditions

such as rainfall, humidity, maximum and minimum temperature, and light conditions. As a simple example, the differences between Australia's temperate, sub-tropical and tropical climatic zones mean that radiata pine is not suited to the northern states and African mahogany is not suited to the southern states. Most commercial plantation species grow best on sites with low to moderate slopes, deep soils and sheltered aspects, but can grow commercially on less optimal sites at slower growth rates or with more intensive management interventions.

It is common for farm forestry plantations to be in areas of the property that are less suitable for other agricultural activity. This can be an effective design consideration for maximising available land use. However, it is important to recognise that some of the issues that cause challenges for crops and pastures may also be limiting for tree growth. For example, low-lying areas that are swampy, subject to regular inundation, frost prone or have shallow or problematic (saline or highly acidic) soils are unlikely to support good tree growth, regardless of management intervention. Similarly, areas that are excessively rocky, steep or isolated by water features might grow healthy trees but will have limited accessibility when it comes time to harvest.

Site conditions also influence the management requirements of plantations. Previous land use can be particularly important to understand as it strongly influences nutrient availability, soil condition and weed competition as well as site establishment requirements.

Infrastructure

Farm and third-party infrastructure are important considerations when determining the location of a new plantation. Farm infrastructure includes roads and laneways, fences, irrigation infrastructure, yards and sheds. Expenses for construction of new roads, crossings and fences for farm forests can be reduced by using existing farm infrastructure. However, plantation design and location should not interfere with operational access for machinery and livestock as this will negatively affect the profitability of other agricultural activities.

Access for forestry equipment and haulage is a key consideration. Equipment used for commercial forestry activities, such as excavators, harvesting machines, forwarders and skidders, is generally large, requiring wide access gates to move between paddocks. Larger trucks are preferred for haulage, as this reduces the cost of moving wood to market. Potential access routes within your property should be considered at the planning stage to minimise truck configuration limitations at harvest resulting from other property planning decisions. Understanding local road access options for heavy truck traffic may also influence where you situate a farm forest within your property, as municipal mass limits and permit requirements may present more haulage constraints on some roads than others.

Third party infrastructure includes powerlines, underground cabling, and high-pressure gas pipes. Great care needs to be taken when locating plantations close to or adjacent third-party infrastructure. In addition to easements, planning regulations may specify setbacks from powerlines and neighbouring houses for fire protection purposes. Working around these features can add operational complexity and cost to plantation operations.

Social considerations

It is important to consider the impact of a plantation on your neighbours and others in the community. Plantations pose different fire risks to other types of farm enterprises, due to the volume, size and arrangement of fuels. Planning schemes often require plantations to be set back from dwellings and other infrastructure to reduce this risk. Forestry activities generally involve use of heavy machinery and large trucks, which are noisy and in dry conditions can create dust.

Safety for contractors and others is a key consideration, in particular for harvesting and haulage operations. Forestry can also impact sensitive adjacent or nearby land uses such as recreational areas or organic farms. Operational constraints and social impacts can be reduced if these factors are taken into consideration during initial planning.

Integration with the farm plan

Armed with a good understanding of your farm forestry objectives and goals and the specific characteristics of your property and location, you will be well placed to determine the farm forestry configurations with greatest potential for sympathetic integration into your agricultural enterprise. This will take account of the property's natural and infrastructure characteristics, available resources, markets, applicable regulations and potential plantation production systems and integrated agricultural benefits. Ultimately, the aim is to complement or enhance farm profitability and productivity through the integration of farm forestry. It is therefore important to consider theeconomic impact of planted trees, in terms of potential returns, on agricultural production and property values (Schirmer, 2004). However, to analyse options well, it is necessary to understand more about plantation management practices, growth forecasting and forest products. These topics are addressed in the next sections.

Plantation management practices

To support successful planning and management of farm forests it is important to understand the practices underpinning commercial plantation timber production.

Plantation silviculture

What is silviculture?

Silviculture is the art and science of forest management. It is about managing the establishment (or regeneration), growth, structure and health of forests to achieve defined objectives. Silviculture for planted forests is very different to natural forests. Commercial plantations usually comprise trees that are the same age, species and size. By contrast, natural forests often include trees that are a mix of ages and species, as well as growth habits and sizes. Another key difference is that plantations typically involve much greater levels of intervention, from site preparation through to final harvest. However, the basic principles of silviculture apply to both. To put it most simply, trees in stands compete for the available resources (nutrients, light and water) that support growth. Stands can be manipulated by designing and applying silvicultural strategies to maximise production of the desired characteristics and to achieve the forest owner's objectives.

In many respects, plantation silviculture has similarities with other agricultural systems: the crop is planted, tended and harvested. What differs most is the length of the growing period (usually 15 to 35 years), and the progressive removal of biomass through thinning and pruning over the growing period (called a rotation). The removal of biomass allows retained trees to grow further before a final harvest.

Types of silvicultural regimes and strategies

There is not a one-size-fits-all approach to silviculture. The design of a silvicultural regime needs to reflect the biological needs of the target species, along with site-specific attributes (soil nutrition, past land-use, rainfall and topography) and market requirements for the timber (e.g. logs for structural timber manufacture or woodchips for paper, panels and packaging). It may also be adjusted to reflect the financial resources available to the landowner. Figure 4 presents the elements of a generic plantation silvicultural regime. In designing the silvicultural regime, each individual element needs to be tailored to address the site, species and market specific variables relevant to the plantation. It is important to consider what has worked for similar situations historically. If a silvicultural approach can be seen to have worked for the same species in the same region, then it can be relied on. If it has not previously been applied, more information is required to confirm its potential suitability. This applies to silvicultural activities across the entire plantation cycle, from site preparation through to harvest.

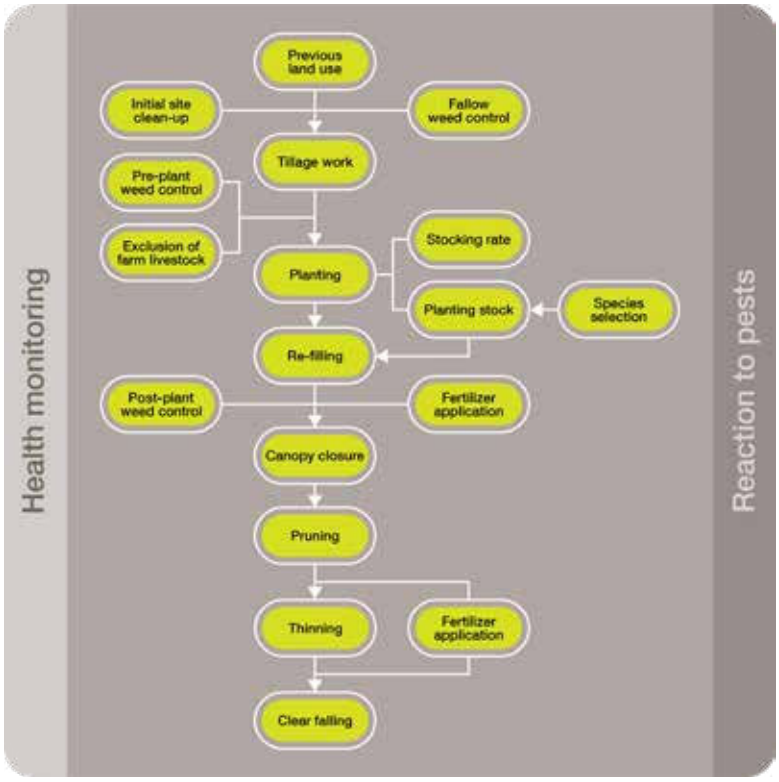

Figure 4: *The elements of a generic silvicultural regime. (Sylva Systems)*

Figure 5: *An ex-pasture site prepared for sandalwood planting. (Sylva Systems, 2006)*

Overview of silvicultural concepts and operations

This section introduces some important silvicultural concepts and operations. It is a generic overview and landowners are encouraged to seek advice specific to their farm forestry requirements.

Plantation rotation

The total duration of a tree cropping cycle from plant to harvest is termed the rotation length. This is an important concept, both scientifically and financially. Understanding it is important for matching tree growing outcomes with farmers' needs. The rotation length will vary according to the intended outcome for the plantation, the species being grown, growing conditions and the available markets. In Australia, short-rotation plantations are usually grown for up to 15 years, typically to produce smaller logs that will be chipped and converted to pulpwood for making paper, panels and packaging. These plantations are usually not subject to further silvicultural activity between establishment and final harvest. Most of Australia's hardwood (eucalyptus and acacia) plantations have been established specifically to produce pulpwood over shorter rotations and there are also examples of short-rotation softwood (pine) plantations. Long-rotation plantations are usually grown for up to 35 years to produce logs that can be processed into solid wood products such as sawn timber for house frames. Most of Australia's long-rotation plantations are softwood, although there is an increasing area of hardwood plantations being established as or converted to longer rotation length for solid wood production.

Site preparation

Site preparation covers a variety of activities designed to give the plantation the best chance to establish and grow and provide safe conditions onsite. Activities include site clean-up, tillage, weed control and fertiliser. Site preparation requirements vary depending on the environmental conditions and previous land use.
It is most likely that plantations will be established on cleared agricultural land (usually pasture sites, see Figure 5) or following harvest of a previous plantation (see Figure 6). Plantations grown on sites previously used for tree growing need different site preparation and weed control regimes to pasture sites because there are harvest residues and often woody weeds to be managed. Ex-pasture sites may have highly compacted soils, requiring greater tillage to ensure trees are stable and growing optimally, although they generally have lower supplementary nutrition needs.

Figure 6: *A Tasmanian blue gum plantation after harvest at age 22 years. (Sylva Systems, 2022)*

Site clean-up

Site clean-up prior to planting involves activities including removal of large harvest residues if the previous land use was a timber plantation (see Figure 7), or removal of redundant fences and farming infrastructure if it was another form of agriculture.

Retention of organic matter is an important strategy for maintaining optimal tree growth rates in the long term. Higher levels of organic matter improve soil moisture retention and availability of nutrients. On ex-plantation or sites with woody weeds, small residues are ideally retained and distributed to provide uniform benefits across the site. On sites where harvesting residues (slash) are distributed in a way that impedes establishment activities, this can be achieved with a chopper roller towed behind heavy machinery or by heaping. A chopper roller is a large heavy drum with longitudinally mounted blades that knock down and chop up woody material up to 10 cm in diameter. Heaping is usually conducted with a root rake mounted on heavy machinery. The root rake moves slash while leaving soil in place.

Tillage

The growth and stability of a tree is promoted when its roots can penetrate soil deeply to anchor it and facilitate access to moisture and nutrients. Deep soil disturbance is necessary to promote growth when soil profiles have compacted layers. This is generally achieved by deep ripping with a long tine behind heavy machinery. On less-accessible sites ripping can be achieved by spot preparation (digging a hole) using a tine mounted on an excavator. Most sites will require ripping for optimal growth conditions. This may not be necessary for deep mountain soils, loamy and sandy sites, which have enough depth and friability to grow trees without deep ripping.

Seedling survival and good health is critical to the success of a plantation. Seedlings of most commercial species are vulnerable to extremes in moisture and temperature, which can stunt growth and, in some instances, kill young trees. In lower-lying or very cold sites, conditions can be improved by changing the soil profile to create mounds to raise seedlings above the level of the water table or cold air drainage layer.

Figure 7: *Heavy post-harvest debris levels in a radiata pine plantation. (Greenwood Strategy, 2021)*

Less commonly, furrows are formed to provide a more sheltered and wetter environment for drought-prone sites. Sometimes, heavily compacted topsoils are cultivated to break up clods and air pockets without mounding. Mounds, furrows and cultivation zones are formed over the rip line, usually simultaneously using a plough or a heaping tool.

Fallow and pre-plant weed control

Initial weed control is important to provide planted seedlings the opportunity to thrive and utilise the available site resources. It is best undertaken prior to planting to avoid damaging or killing young trees. Pre-plant weed control usually involves broadcast or strip chemical application, depending on the weed spectrum and environmental and neighbourhood factors. The type of chemical used should be appropriate to the weed spectrum and situation and ideally provide some residual effect to reduce the need for post-plant weed control. If a site is left fallow for a longer period prior to planting, it may be necessary to conduct fallow weed control to prevent weeds from seeding and proliferating prior to planting.

Chemical use may not be appropriate in some sensitive situations. In this case, weeds can be controlled after planting using more labour-intensive mechanical weed control methods such as slashing and brush cutting.

Fertilising

Planting on former agricultural sites with a history of fertiliser application generally reduces supplementary nutritional needs of plantations in comparison to ex-tree growing sites. However, there is considerable research and evidence about poor tree form and growth for radiata pine plantations grown on ex-pasture sites due to depletion of trace elements (such as boron) or accumulation of elements from previous fertiliser application (such as nitrogen) (Greenwood Strategy, 2021). This phenomenon, termed Toorour syndrome

(Turvey et al, 1993), can potentially be overcome with higher stocking rates or improved genetics to control tree form.

Former plantations or degraded sites may need fertilising to improve tree growth or to address specific nutrient deficiencies on the site. Often a fertiliser regime is developed in response to soil or foliar nutrient testing. Fertiliser can be applied immediately prior to planting (broadscale application), at the time of planting (spot application with a slow-release tablet or hand spraying) or soon after planting. Care is required for fertiliser application at or following planting, particularly if there is a risk that the fertiliser will come into contact with the tree. Fertiliser may also be applied later within the rotation as deficiencies are detected or to promote growth.

Establishment

Selection and management of planting stock

Planting stocks (seedlings) will usually be purchased and transported to the plantation site from a specialist tree nursery. They may be bare-rooted or potted. It is essential to survival that planting stocks are well cared for in the nursery, during transport and on-site prior to planting, including protecting them from drying out and from heat or cold stress.

Another consideration that may be important is the provenance of the genetic material. Some seedlings of commercial species are bred for improved growth rates, timber qualities, disease risk resistance or to suit specific site conditions. These are generally more expensive and difficult to source than open pollinated stock. For many farm forestry plantations this may not be a concern, although it could be worth considering for some sites.

Planting and tree spacing

There is a range of literature available about the process of planting trees that should be consulted for the landowner's specific requirements. An important factor to consider is the initial spacing of trees, which defines the stocking rate (trees planted per hectare). Initial tree stocking influences the way in which trees grow (e.g. lower stocking rates will result in shorter, branchier trees with larger diameters, and higher stocking rates will result in taller trees with smaller limbs and diameters). Higher initial tree stockings will obviously be more expensive and may require more non-commercial interventions to achieve a final stocking for clearfell harvest. Whether or not it is intended to thin a stand can also be a consideration. The challenge is to determine the optimal number of trees to plant to meet the combined growth and financial objectives, as well as the expectations of log markets, species characteristics and integration with farming enterprises such as grazing. Like other elements of silviculture, there is no single answer. There are a number of useful references including Borough *et al* (1984) for eucalypts and Lewis *et al* (1976), and Lewis and Ferguson (1993) for radiata pine. It is also recommended that landowners seek local advice, relevant to the species and the silvicultural system proposed.

Animal control

Damage by insects, feral animals, native wildlife and stock can be problematic for plantations during establishment. Browsing levels are highly situational and dynamic, and can result in total crop failure. Monitoring is crucial during the establishment phase to ensure control is timely and effective. Insect pests are a particular issue for eucalypts. In some areas, it is usual to undertake insect control at the point of establishment, either with a slow-release insecticide in tablet form, soil injection or spray application, or using protective guards.

Monitoring and maintenance

It is critical to continue to monitor for pests, diseases and nutrition issues through the life of the plantation in order to maximise plantation productivity and manage forest health (see de Little, 2002). The design of the monitoring regime (intensity and methods) should reflect the local plantation risk (pests, diseases and soil quality) profile for the species being grown. Monitoring, identification and reaction to issues is a continuous cycle (see Figure 8). Monitoring techniques can include physical and aerial inspections (pests and diseases) and sampling (e.g. foliar analysis for nutrient status).

Pruning

Pruning for timber quality

Pruning to remove the lower branches at a relatively young age enables the growth of wood which is clear of knots (clearwood). Clearwood (see Figure 9) is valued for appearance grades of timber (e.g. decorative face veneers and furniture wood). In some cases, wood that is free of knot holes (not necessarily free of branch wood) is also more valued for structural applications due to its better strength. Pruning is usually undertaken in lifts as the tree gains height. A first lift is typically between two and three metres to produce a clearwood butt log. Another one or two pruning lifts may be undertaken, up to six metres (high pruning). However, pruning is an expensive, labour-intensive and potentially dangerous activity, particularly for high pruning (see Figure 10). If there are no local markets that value the production of clearwood through a premium price offer, consideration should be given to whether any pruning is of financial value and, if it is, to what height.

Figure 8: *A forest health management cycle based on de Little (2002 & 2004).*

Figure 9: *A freshly sawn pruned woodlot eucalypt log; note the knotty core surrounded by clearwood. (Sylva Systems, 2022)*

Pruning for asset protection

Pruning is also often undertaken around the perimeter of a plantation and along roads and access points in order to provide enhanced fire protection from potential ignition sources. It may also be undertaken for forest health reasons (to prevent transmission of diseases and pests and improve air flow), although thinning is a better approach to achieve this outcome.

Thinning

Why thin?

As plantation trees grow they begin to compete for the available site resources (water, nutrients and light). Early in the life of a plantation, this competition is an advantage as it forces trees to grow taller. However, after a point the competition will impact tree growth and increase stress on individual trees, sometimes resulting in tree deaths. The application
of a thinning regime aims to remove trees to reduce this stress and improve the availability of resources for retained trees, promoting growth of future commercial timber.

Designing a thinning regime

Thinning regimes vary considerably based on the target product, the species being grown, the rotation length and the availability of markets for smaller diameter logs. For example, eucalypt plantations grown on short rotations for pulpwood production are typically not subject to thinning operations. Pine plantations grown for structural timber production on long rotations will usually be subject to be between one and three thinning events, sometimes including a non-commercial (or thin to waste) operation at a relatively young age. Where markets exist for smaller logs, such as pulpwood, preservation and landscape timber, there are typically more thinning events scheduled. In some circumstances, long-rotation plantations may remain unthinned.

Figure 10: *Pruning at heights can be dangerous and operators should not take short cuts such as shown here. (Sylva Systems, 2018)*

Figure 11*: Unthinned radiata pine plantation at risk of windthrow. (Greenwood Strategy, 2021)*

Thinning risks

The timing of thinning events can introduce broader risks to plantation viability. Late thinning has been observed to increase the risk of windthrow damage to retained trees (Greenwood Strategy, 2021). Legg et al (2021) has compiled generic thinning regimes for various species and species groups and different log product regimes for each of the National Plantation Inventory regions (see Table 6 for radiata pine example). These provide a useful starting point for designing a suitable thinning regime. However, as with other aspects of these guidance materials, it is recommended that you seek professional advice which is specific to your circumstances

Singling

Singling is a thinning practice unique to plantations that have regenerated from coppice. In Australia it is typically employed in the management of second rotation Tasmanian blue gum plantations that have been allowed to regenerate from the harvested tree stump. Singling aims to remove one or more of the multiple stems that can regenerate on a single stump, with the aim of enhancing the growth prospects of the retained coppice stems.

Species selection

What is the best species to plant?

The choice of which species to plant has important implications on the amount of timber grown, the log products that can be harvested, the markets which can be sold to, the potential returns and return period, and non-timber benefits. The decision will be influenced initially by the landowner's objectives for a farm forestry program. The best species to plant will be the one that can deliver to the landowner's specific requirements and desired outcomes. *Andrews et al* (2004) identify six preferred characteristics for species selected:

1 . Adapted to grow vigorously under the conditions present on the site.
2. Able to deliver the landowner's objectives.
3. Produces the desired timber products efficiently (acceptable growth rates and tree form).
4. Produces commercially acceptable wood products for the available market.
5. Is genetically suitable to the location and the farm environment.
6. Has a track record in the region in terms of timber production from planting through to final harvest and marketing.

Plantation species in Australia

If the aim is to grow plantations for maximum profit, the species selection will be limited to those that are preferred by the local timber industry. These species have reliable and desirable characteristics that meet the requirements for the processed timber products and for which processing technologies are well established. The situation for plantation forestry is no different than grain markets, which are dominated by a small number of preferred species such as wheat or rice, or livestock markets, which are dominated by sheep and cattle. Wood fibre is a commercial commodity, like most other agricultural products, and at scale there are limited market preferences.

Australia's plantation estate is dominated by four species[3]. Of the 1.744 million hectares of plantations in Australia, 1.414 million hectares (81%) are either radiata pine, Tasmanian blue gum, shining gum or southern pines. The remaining 19% are a range of hardwood and softwood species, some of which have been proven as commercial plantation prospects and some are best described as speculative, from a commercial timber production perspective. The plantation estate is heavily concentrated in the southern states. However, as noted previously, there are important differences in species suitability between the southern (temperate) and northern (sub-tropical and tropical) zones, with species suitability aligned with specific regions.

The National Plantation Inventory (NPI) has been reporting plantation area by region since 1997 (NFI, 1997), including by species and region. The NPI data demonstrate both the strong focus on a limited number of species (see Figure 12 and Figure 13) and the strong geographic concentration of preferred species (see Figure 14 and Figure 15) (Legg et al, 2021).

Softwood or hardwood?

There are biological differences between the two types of trees – softwoods (such as pines) and hardwoods (such as eucalypts and acacias), which mean that they are preferred by different markets for different reasons. Table 4 shows a comparison of key plantation and wood property attributes for two common plantation species grown in Australian plantations – radiata pine (softwood) and Tasmanian blue gum (hardwood). Tasmanian blue gum is also harvested from natural forests, and in this context it is important to understand that the properties of tree species growing in natural forests are often quite different to when they are grown in plantations.

[3] Southern pines refers to a number of species and hybrids, including Pinus caribbea, P. hondurensis and P caribbea X hondurensis.

Plantation species occurrence in Australia

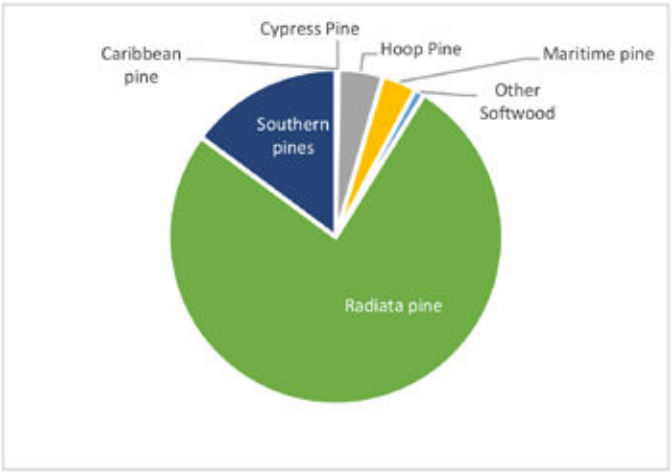

Figure 12: *Proportion of softwood plantation species by area (Legg et al, 2021)*

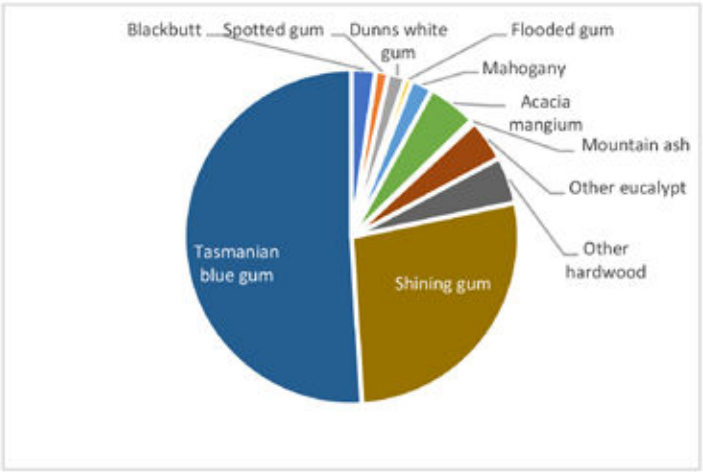

Figure 13: *Proportion of hardwood plantation species by area (Legg et al, 2021)*

Plantation species distribution by state and territory

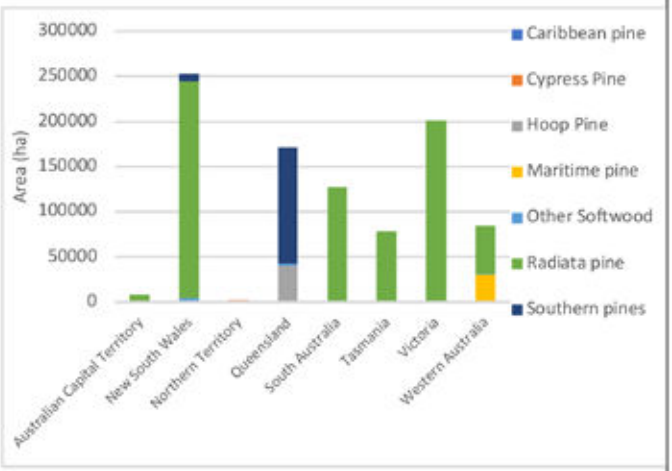

Figure 14: *Softwood plantation species distribution by state and territory (Legg et al, 2021)*

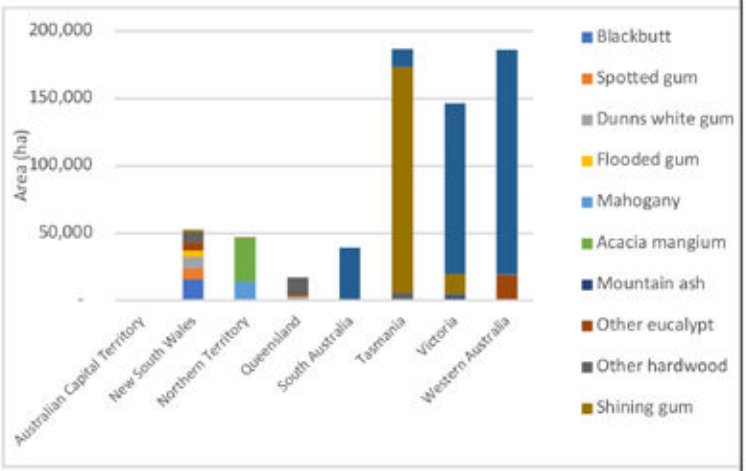

Figure 15: *Hardwood plantation species distribution by state and territory (Legg et al, 2021)*

	Softwood	Hardwood
Reproduction	Plants producing cones e.g. Radiata pine.	Plants producing flowers e.g. Tasmanian blue gum.
Wood density	Radiata pine basic density of 404 kg/m^3 (age 10 yrs) to 485 kg/m3 (age 30- 40 yrs).	Plantation grown Tasmanian blue gum basic density of 482 to 547 kg/m^3.
Carbon storage	For Victorian and NSW radiata pine 0.84 t/ m3 CO2-e (at age 30 yrs).	For Western Australian Tasmanian blue gums 1.05 t/m3 CO2-e (at age 10 yrs).
Saw and veneer logs	Roundwood harvested for timber framing materials through to furniture.	Natural forest sourced roundwood harvested for framing materials through to furniture. Emerging use of plantation grown resources.
Paper making	Long fibres give paper strength (e.g. cardboard, tissue paper and newspaper).	Short fibres give paper a smooth surface (e.g. photocopy paper).
Reconstituted products	Wood-based panels made from thinnings and clearfall logs.	Wood-based panels.
Engineered wood products (EWP)	Established applications in products such as cross laminated timber beams (CLT), laminated veneer lumber (LVL).	Emerging use of plantation resources for EWPs.
Bio-energy (by combustion)	A calorific value of 21 MJ/kg for oven-dry softwood.	A calorific value of 19 MJ/kg for oven-dry eucalypt wood.

Table 5: *Comparison of key attributes for common softwood and hardwood plantation species*

Species domestication and commercialisation

Domestication of plant and animal species for agriculture has been occurring for thousands of years. It occurs when a species is continually and selectively bred for specific characteristics. It is an important concept for agricultural commodities – it implies a process of gradual improvement, through breeding, of a particular species to favour desirable qualities, including productivity, consistency, resilience and ability to be produced at scale on a reliable basis. That is as important for timber as it is for fine wool producing merino sheep or long grain rice. For forestry, domestication is a relatively new development. In Australia radiata pine has been subject to tree breeding for particular traits since the 1950s. Mature breeding programs also apply for hoop pine, Tasmanian blue gum, shining gum and Caribbean pine and hybrids (Lott and Read, 2021).

If plantations are to be established and managed purely for profit, then selection of a domesticated species that is preferred by the available market is the most sensible path to take. Where a new or alternative species is being considered, it makes sense to understand whether it has been proven as a commercial option. The most obvious way to do that is to observe it having been grown, harvested and processed in the region of interest. If that evidence is not available, then the species has not yet reached commercial status and it is therefore a greater risk as a choice of plantation species.

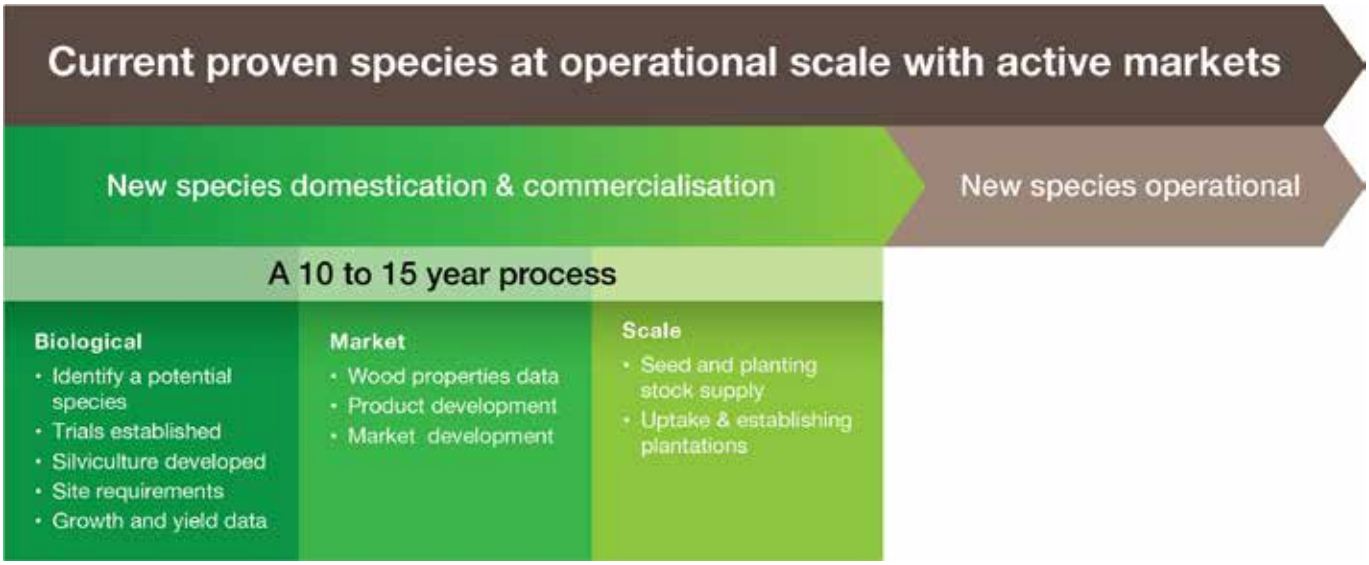

Figure 16: *The process of species domestication and commercialisation (Sylva Systems)*

As an example of this, Duncan et al (2000) assessed 17 potential eucalypt species for plantation potential in Gippsland. Subsequent research resulted in the development of growth models for six species (Wong et al, 2000) but at this stage, only two species have been demonstrated to be commercial because they have been grown, harvested and processed by the local timber industry.

Figure 16 shows the process of species domestication and commercialisation.

Plantation growth, yield and productivity

The main product from a farm forestry plantation is usually logs, measured in volume (cubic metres) or weight (tonnes). Understanding how trees and plantations grow and what units are measured is important throughout the rotation but particularly at harvest time. That includes understanding the merchantable (what can be sold) and non-merchantable elements of the tree. Measurement and estimation to predict future growth and yield from plantations is essential to effective forest management planning (Davis & Johnson, 1987).

Biomass to merchantable volume – what are we measuring?

Not every part of a tree will end up being turned into a log and sold to a customer. There is a difference between the total biomass grown in a plantation and the amount of wood that is finally loaded onto a truck as a merchantable log. This is no different to a cereal crop, where the primary product is the grain, or livestock for meat production. Figure 17 describes the relationship between biomass and merchantable volume. When foresters measure and estimate growth, yield and productivity for commercial plantations, it is usually expressed in terms of the quantity of log products that will be sold from the plantation.

Figure 17 describes the standing biomass components of a tree. While it may be possible, in theory, to harvest and sell all these tree components, it is unlikely in practice and may also be undesirable, particularly if it is intended to re-establish the site to plantation following harvest, because it depletes nutrients on the site. The merchantable tree stem (logs) is usually the primary product. In most cases it will be limited by a small

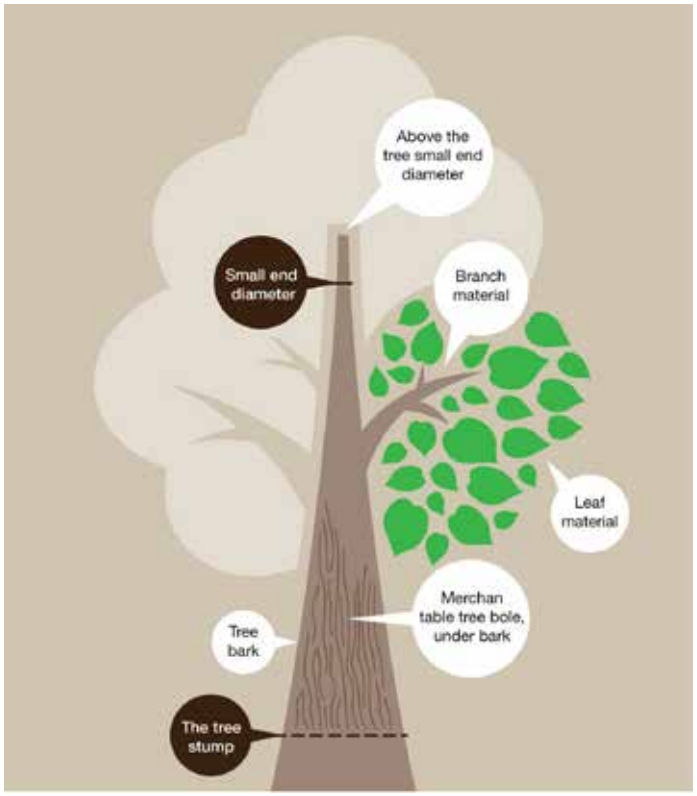

Figure 17: *A depiction of the aboveground standing biomass components of a tree (Sylva Systems).*

end diameter, which is usually set by the customer or harvesting contractor as the smallest practical diameter to handle or process.

Total recoverable wood in log form will usually comprise between 70% and 80% of the above-ground biomass in Australian plantations (Jenkin, 2013). The remaining biomass usually remains on site in the form of harvest residues, comprising branches, leaves and docked stem lengths. Table 5 describes the steps from above-ground biomass to merchantable volume.

Tree component	Description
Biomass	The total quantity of biological material in the tree above ground
Biological volume	The total volume of stem-wood (less branches and leaves) from the ground surface to the tip of the tree.
Gross merchantable volume	The total volume of stem wood from the stump to the small end diameter (measured over bark or under bark)
Net merchantable volume	Volume of stem wood loaded onto a truck (as either log or woodchip) for delivery to a customer, after log defects have been physically removed.

Table 6: *Explaining the steps from biomass to merchandise volume*

Understanding tree growth

To understand how trees grow it is important to understand the concept of increment and how that is measured and expressed. There are two important measures, both of which are measured as m^3/ha/year:

- Current Annual Increment (CAI) is the amount of growth that a tree exhibits in a specific growing year.
- Mean Annual Increment (MAI) is the average annual growth of the plantation at a specific age.

Figure 18 shows the CAI and MAI curves and relationships for an *Acacia mangium* plantation. In theory, the optimal time to harvest a plantation, based on volume increment, is when these two curves intersect. However, there are a range of other factors that might influence harvest timing, including wood properties, availability of harvest services, market demand and price, or other operational factors such as weather.

MAI can only be accurately measured once the harvest is completed. Until that point it can only be estimated. Jenkin & Pitt (2004) note this as a fundamental difference between grazing systems and plantation forestry when comparing land productivity.

Estimating growth, yield and productivity of stands

The most accurate system for estimating growth, yield and productivity is to physically measure the forest (termed a forest inventory)[4] at particular ages and then apply yield models (to estimate the available log products at the time of measurement) and growth models (statistical models which estimate future growth and future log products).

A key factor in the reliability of a forest inventory is how well the species and silvicultural regime has been studied. Reliable estimates can be made for long-rotation radiata pine plantations grown for sawlog in southern Australia and short-rotation Tasmanian blue gum and shining gum plantations producing pulpwood. Estimates for long-rotation Tasmanian blue gum and shining gum plantations producing sawlog are much less reliable because there is not as much known about growth, yield and productivity of these regimes.

Yield is usually expressed as volume (m^3/ha) of commercial log products and is presented in yield tables. ABARES has developed yield tables for a range of common species, silvicultural regimes and regions, which are used to model future potential wood supply at the national level for the National Plantation Inventory (see Table 6 Legg et al, 2021). Yield tables are used as input to financial analysis for a farm forestry venture, to compare the potential productivity with other sites and to analyse actual production.

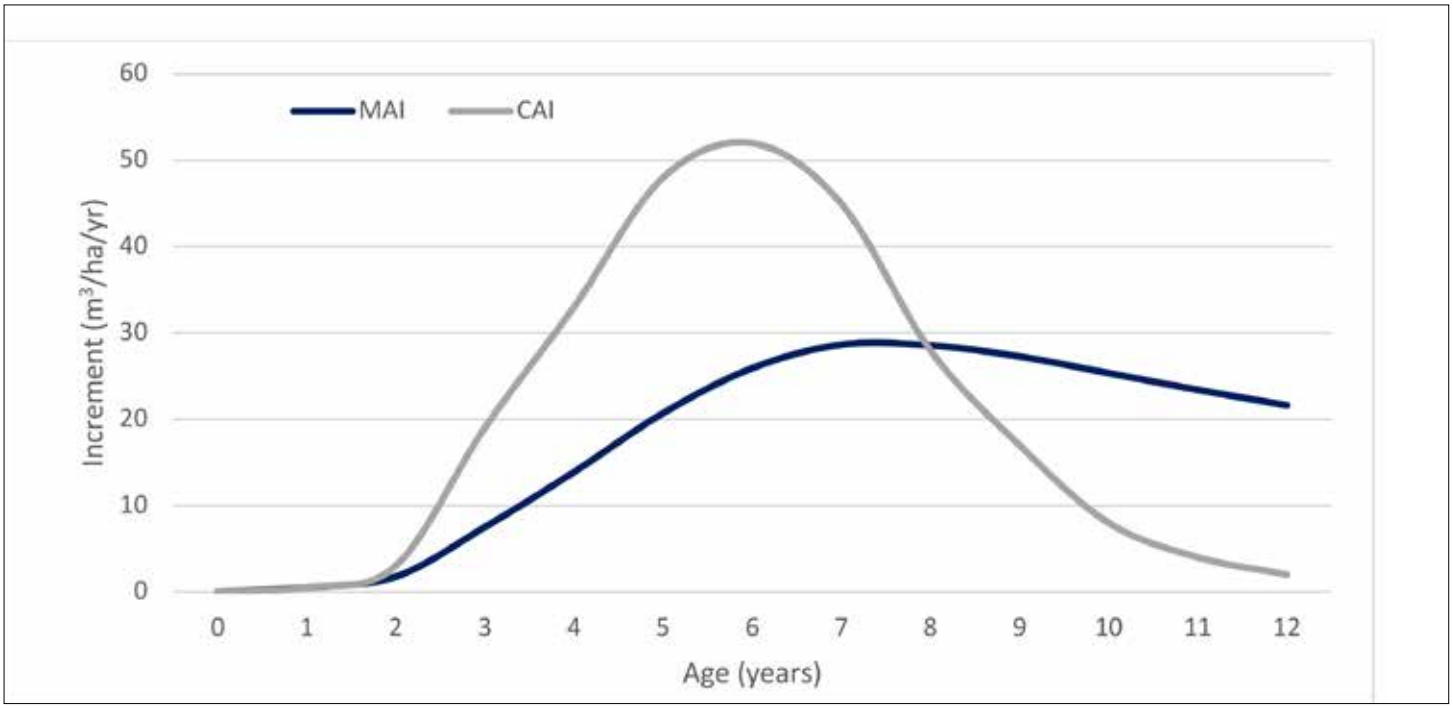

Figure 18: *Example of MAI and CAI curves for a theoretical short rotation hardwood plantation. (Sylva Systems)*

[4] The Agroforestry in Australia website has several guides available for forest inventory, see Measuring trees and forests by Rowan Reid.

Region	Plantation productivity at thinning and harvest (m3/ha)											MAI (at harvest)
	1st thinning		2nd thining		3rd thinning		Clearfall		Total			
	Pulp	Sawlog	Pulp	Sawlog	Pulp	Sawlog	Pulp	Sawlog	Pulp	Sawlog	Total	(m^3/ha/yr)
Western Australia	80		40	60	60	40	50	270	230	370	600	20
Green Triangle	110		50	15	25	55	20	350	205	420	625	21
Murray Valley	100		60	60			30	380	190	440	630	21
							220	180	220	180	500	13
Central Victoria	100		60	50			30	300	190	350	540	18
Tasmania	100		80	40			40	320	220	360	580	19

Table 7: *Generic yield tables for P. radiata in different regions for different silvicultural regimes. (Legg et al, 2021)*

Plantation area

Plantation area is a key input to estimating log yields. There are three measures of area used in forestry: net planted area, gross area and title area. Net planted area is the area planted to trees that will be available for harvest, excluding failed areas. Gross area includes the net planted area, roads, firebreaks, failed areas, dams and waterways as well as physical features which cannot be planted (e.g. rocks, natural vegetation and steep areas). Title area is the legal description of a section of land.

The yield of a plantation is calculated by multiplying the net planted area by the applicable volume estimate. Plantation productivity and volume estimates vary according to site conditions. To improve the accuracy of yield predictions, net planted area can be split into smaller plantation stands of similar site quality and attributed to a specific productivity class.

Plantation description

A range of specific terms, concepts and measurements are used to describe a plantation and are useful to understand (see Table 7 for a summary).

Element	Acronym	Description	Units
Area statements		Area statements for a specific stand of trees	
Title areas		Legal description of a section of land	Hectares (ha)
Gross area		Total area developed as a plantation.	Hectares (ha)
Net planted area	NPA	Area actually planted to trees.	Hectares (ha)
Diameter at breast height	DBH	Diameter at breast height = 1.3 m (breast height) above the ground	Millimetres (mm) or centimetres (cm)
Diameter at breast height under bark	DBHUB	Diameter at breast height under bark.	Millimetres (mm) or centimetres (cm)
Diameter at breast height over bark	DBHOB	Diameter at breast height over bark.	Millimetres (mm) or centimetres (cm)
Basal area	BA	Basal area is the cross-sectional area of a tree stem at 1.3 m height. BA assumes a circular stem (which in reality may not be the case; BA is estimated based on DBH.	Square metres (m^2); usually square metres per hectare (m^2/ha).
Basal area under bark	BAUB	Basal area under bark.	Square metres (m^2); usually square metres per hectare (m^2/ha).
Basal area over bark	BAOB	Basal area over bark.	Square metres (m^2); usually square metres per hectare (m^2/ha).
Predominant height		A number of techniques are used to estimate predominant height; e.g. height of largest DBHOB tree in each row of a 4-row permanent sample plot (PSP) used for growth assessment.	Usually in metres (m).
Growth rates / increment		Measures of plantation growth and productivity.	
Mean annual increment	MAI	Mean annual increment is the total volume at a point in time divided by age (number of years) at that time. It is an estimated average annual volume growth at that age.	Expressed as cubic metres per hectare per year (m^3/ha/yr)
Current annual increment	CAI	Current annual increment is actual increment for each year calculated as difference in volume between year n and year n + 1	Expressed as cubic metres per hectare per year (m^3/ha/yr).

Table 8: *Plantation description – terms, concepts and measurements.*

Forestry planning framework

There are two important levels of planning for forest management. First is the plantation management plan, which documents the overarching and long-term intent of the forest owner. The second level is the operational plan, which provides detailed prescriptions and directions for conducting specific forestry activities at a point in time. In many Australian states and territories, an operational plan is legally required before significant activities, such as harvesting occur. Development plans are required prior to establishment in some jurisdictions. A forest management plan is likely to be optional but is highly recommended.

Why plan?

Successful management of farm forests, like any agribusiness activity, requires long-term planning to ensure that the forest owner's objectives and requirements can be achieved, and any legal and regulatory requirements are met. The depth of planning requirements will vary depending on the size and complexity of the enterprise or forest, the owner's management objectives and any external regulatory or investment requirements that need to be addressed. In its simplest form, a farm forest management plan will likely include a map and description of the forest area and documentation about intended activities and how they will be conducted.

These forestry planning processes and factors for consideration are described in general commercial terms as a business model that explains how an enterprise creates, delivers and captures value in economic, social, cultural or other contexts. This typically involves a cycle of plan-execute-measure-adjust to support successful ongoing development of an enterprise. In a forestry context these phases can be described as:

1. Current conditions (or the 'environment of the enterprise') – measure/quantify.
2. Future potential – analyse, model options and decide.
3. How to get there – planning, design, actionable strategy, testing, resources.

Given the diverse and often complex nature of forest conditions, management requirements and options, specialist advisory services may be required through each of these phases to investigate, quantify and recommend management strategies and options that best fit the objectives of a forest owner.

Important components of a plantation management plan

There is no fixed format for a forest management plan. However, a good plan typically incorporates the following elements:

1. Definition of the forest owner's objectives for management of the forest.
2. A detailed description of the forest.
3. Identification and documentation of the management strategy.
4. Scheduling of forest management activities.
5. A process for evaluation, review and refinement.

Management objectives

Documenting your farm forestry management objectives provides the basis for determining what will be grown and where, how the plantation will be managed to integrate with other agricultural activities, and what measurement and monitoring regimes to apply.

Forest description

The forest description in a plantation management plan addresses the context and current conditions of the farm forest, drawing on information gathered in the planning section. This description could be discrete for the forest area itself or could more generally apply to the forest in the context of a whole property and related agricultural and land management activities. The description would include a map of the proposed plantation location and cover topics that affect its management including:

- definition of the plantation boundaries and relevant property and other legal boundaries
- natural environment
- adjacent land use (neighbours, public activities, farming activities)
- regulatory requirements
- infrastructure
- markets.

Management strategy

By defining management objectives, or the preferred future state, and describing current conditions, the forest owner is well placed to develop options for management of the forest. Analysis and modelling of various management options will identify their relative strengths and weaknesses, and the costs and benefits to the owner of potential scenarios. This may also include identifying where there are gaps in important information that need to be resolved to better inform decision-making.

Once the range of management options has been considered and a preferred approach identified, management strategies can be further developed to achieve forest owner objectives. An effective forest management plan is tailored to the current conditions and targeted at future potential outcomes. The potential of a forest is assessed with an understanding of current and future supply and demand, and what is realistically achievable with the resources available. The forest management plan is used as the foundation for operational management plans, which describe and specify how to manage the forest to achieve the preferred outcomes. Silvicultural practices are then customised to encourage various product outputs and values from the forest over time. These practices apply through the full cycle of forest growth including forest maintenance and protection, stand improvement activity, which may include commercial or non-commercial thinning, harvesting at a prescribed intensity, and regeneration via different methods.

Activity scheduling

Once the preferred management options are confirmed and management interventions defined, a schedule for implementation can be developed. This will ideally include establishment activities, and routine annual activities, such as forest health monitoring, fire prevention works, road and fence maintenance, and pest and weed control. It may also address issues such as preferred seasonality for grazing. Scheduling should also consider preferred timing for harvesting (recognising that this will be influenced by other factors, such as the availability of markets and contractor services).

Evaluation and refinement

The forest management plan is not a static document. As information gaps are filled, market requirements change and the forest responds to management interventions, it is important to routinely evaluate and refine the plan.

Operational plans

Forestry operational plans document how activities are to be done on the ground. They are an important tool for instructing contractors and other parties about the standards, conditions and specifications (or prescriptions) for all activity within the operational area. The level of detail, accuracy and quality of communication within these plans will largely determine the level of operational success. Operational plans should be developed for all major activities in the plantation cycle, such as establishment, tending, maintenance, roading, harvesting and, if necessary, site rehabilitation. The detail of these plans varies according to the operation, but topics usually included are:

- a general description of the operation
- location of operations including property boundaries and any areas with exclusions or special management requirements (including a map)
- timing of operations
- who will conduct the operation
- detailed operational specification
- management prescriptions for specific features and hazards
- weather restrictions
- safety considerations
- neighbour / stakeholder considerations
- hygiene considerations
- emergency plan
- contact details
- monitoring and supervision
- record keeping.

As described in the policy and regulation section, most states and territories have formal or informal codes of practice in place that provide direction or guidance about how plantation operations, particularly harvesting, are to be planned and undertaken. It is important that farm forestry practitioners understand any obligations that must be met in their relevant jurisdiction. Although not exhaustive, Table 8 presents a summary of some of the typical items required in harvesting plans.

Topic / activity	Issues addressed
Design and planning	Operational harvesting plans
Licensing and control	Relevant legal, policy and forest certification requirements
Safety	Workplace Health and Safety (WHS) Codes of Practice, legal requirements, emergency communication and evacuation
Fire precautions	Thresholds for specialist conditions and minimum standards
Site values and protected features	Flora and fauna habitat, ecology, landscape, cultural heritage, archaeology, geomorphology
Marking of harvest area items	Marking system for boundaries, access, water courses, trees (removal/ retention), hazards
Wet weather	Minimum operating prescriptions to avoid soil disturbance and water pollution
Roads and crossings	Design, use and maintenance of roads, bridges, crossings
Tree felling, processing and extraction	Standard operating procedures and specifications
Snig tracks	Design, use and maintenance
Loading, landings / log dumps	Design, use and maintenance
Water quality	Minimum standards and specifications
Soil and drainage	Minimum standards and specifications
Steep country	Thresholds for specialist conditions and minimum standards
Designated locations	First aid, fuel storage, waste collection, vehicle parking, emergency and evacuation points.
Site productivity, rehabilitation and regeneration	Minimum standards and specifications
Declarations and acknowledgements	Forest owner, contractors, site visitors, regulators

Table 9: *Typical forestry code of practice contents and requirements.*

Workplace Health and Safety

Forestry operations are rightly recognised as presenting a heightened safety risk. That is even more the case if manual chainsaw felling of trees is proposed and where there are steep or difficult conditions. In some Australian jurisdictions, there are specific workplace health and safety rules in place regarding forestry activities. In all states and territories there are obligations on forest owners, contractors and other parties to ensure that the workplace and any operations are undertaken safely and that any risks of injury or death are identified and managed by those parties.

Safety is a critical consideration for each phase of planning and management of your farm forest. Growers can design out risks from the outset through the location and configuration of the plantation, reducing overall impacts to both workers and the bottom line. Safe Work Australia provides a suite of guidance material to assist in identifying, assessing and controlling risks associated with forestry operations.

Forest products and markets

Farm forestry timber products

A wide variety of products are manufactured from forest-based products. Timber products range from traditional firewood, fencing timbers and rough building materials, to sawn timber, engineered and reconstituted wood products, paper, packaging, fabric and biofuels. Global markets are increasingly turning to the bioeconomy to provide alternatives to non-renewable or fossil fuel-based resources. Expanding markets include fabrics, pellets and liquid biofuels, and new products are constantly emerging.

While growers focused on meeting on-farm or local needs might do some rudimentary processing, most farm forestry products are sold in log form or as woodchip inputs for manufacturing. Figure 19 provides a general overview of supply chains for a typical range of wood-based products manufactured from Australian forests.

Harvesting operations are usually managed to produce sawlog and/or pulplog specifications. Sawlogs are of higher quality and value, and must meet strict specifications for species, log diameter and length, straightness, knots and defects. Straightness, size and defect is less important for pulplog. However, some markets take limited species and have zero tolerance for charcoal. Raw forest products may also include woodchips processed on-site and residues.

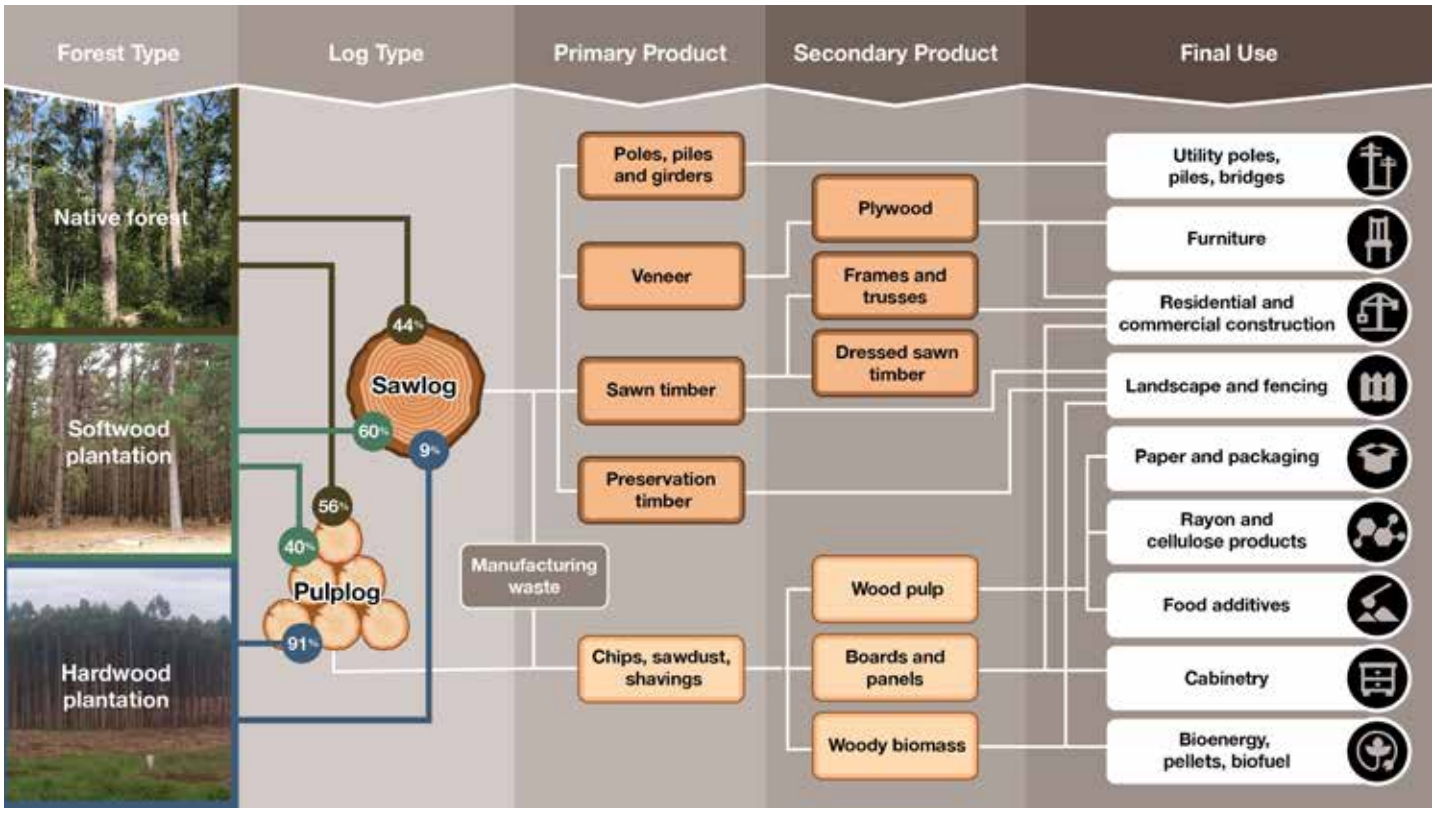

Figure 19: *How logs are used in Australia.*

Alternative farm forestry products and values

Products from farm forests may include non-timber and cultural products, such as honey, foliage, seeds and oils. As these products may have specific growing requirements, specifications for them are quite specialist and unlikely to be produced concurrently with timber products.

The high-value myth

Growing trees for high-value specialty timbers has been a particular focus of the farm forestry sector. This approach to encouraging farm forestry adoption suggests that there are significantly greater returns to be had by farm foresters if they plant species with particular xwood qualities or if they undertake specific management interventions, such as pruning and thinning to grow logs with more valuable characteristics (e.g. Keenan, 2007; Brown & Beadle eds, 2008). In reality, available markets set the value of timber products in terms of the price the market is willing to pay. If a landowner has spent a lot of money pruning their stand and the available market does not distinguish between pruned and unpruned sawlogs, what has been created is a high-cost tree from which it will be difficult to make a positive return. There are many examples of this kind of poor advice, where a willing buyer is not available for the supposedly high-value timber grown (e.g. North, 2010). The promotion of these flawed concepts and subsequent operational failures has done much to adversely affect the perceptions of forestry as a viable complementary or alternative land use among the farming community.

Product mix is determined by market demand at the time of harvest. Species, size and management history will determine which markets are appropriate for the operation. For example, a first thinning operation in a softwood plantation may produce logs suitable for preservation timber and pulplogs, whereas later age harvests may produce an integrated mix of sawlog of varying grades, poles and pulplogs. The hardwood plantation woodchip market operates differently, with plantations grown specifically to produce high-quality pulplog product only.

There are numerous resources schematics depicting forest and wood products supply chains in general terms. For the purpose these guidance materials, the forest and wood products industry comprises three main sectors (see Figure 20). Each of these is supported by input and output transport networks for goods and services. Advanced manufacturing is separated out from primary manufacturing because of its importance to facilitate understanding of how logs and timber products move into and out of different regions.

Figure 20: *Three sectors in the native forest and wood products industry*

Farm forestry operations

Pricing and value determination

How much money you earn from harvesting your trees will depend on a number of factors. These might include:

- what species is being harvested
- how old the trees are
- how much volume of logs is present
- what log products are being sold
- the cost and complexity of harvest
- the distance from your forest to the customer
- what point along the supply chain you will be selling the logs.

Price points

The net price you receive for your trees at harvest is usually referred to as the stumpage price. This is the value you receive for your logs once the costs of planning, road works, harvesting, hauling and any other professional advisory services are accounted for. The price paid by a customer receiving the harvested products is usually referred to as a delivered price. Usually, the delivered price will be calculated at the mill door (for domestic processing) or at wharf gate (for exported products).

In most cases, smaller private growers will sell their logs on the stump. That means that the purchaser of the logs is paying for (and taking the risk on) all costs associated with harvesting and delivering the wood and paying the forest owner for the unharvested value of the trees. This is usually a low-risk option for most growers. However, some growers may feel they have the capability and confidence to engage contractors themselves. Alternatively, there may be professional service providers that you can engage for a fee to manage the sale, harvest and delivery of your logs to a customer. Typically, these agents will work for a set fee calculated on a value per cubic metre, or for an agreed percentage of the delivered price.

Whatever approach you choose to take, it is worthwhile testing the market to understand what options are available to maximise your net returns within the levels of risk you are comfortable to accept.

Estimating what will be harvested

It is important that you are provided with a reliable estimate of what volume of logs will be harvested and what log products will be produced, along with a calculation of the estimated value you receive. This estimate is usually made based on a pre-harvest inventory – that is, an estimate made from measuring the trees and harvest area and calculation of volume and value of logs to be harvested. You should then be provided with an ongoing record of what is harvested and sold that you can use to reconcile actual volume and value against the estimate that was provided and what you observe.

Calculating log value

Small-scale farm forest growers are often concerned whether they are receiving a fair value for their logs at harvest. When you are considering harvesting and selling your forest it is useful to understand how log value is calculated.

Prices

The delivered value of a log will vary depending on the species being harvested, the nature of the local market and the level of demand. As a simple comparison, if you have a blue gum plantation, the delivered value of the product (whether logs or chips) will be the same for every unit of product sold but there may be an opportunity to improve the value if there is more than one buyer. However, if you are harvesting a mature pine plantation, there will be a range of log types produced that are suitable for a mix of uses including, for example, structural sawlog, non-structural sawlog, preservation and woodchip, depending on the availability of local markets for each of those products.

Costs

The typical costs associated with harvesting and selling logs include:

Activity	Cost units
Harvest and planning approvals	Fixed
Road and landing construction and maintenance	Unit ($/km) or by quote
Harvesting supervision	Unit ($/hour or $/m3)
Harvesting	Unit ($/m3)
Loading	Unit ($/m3)
Haulage	Unit (cents/m3/km)
Sales marketing and administration	Unit ($/hour or $/m3)

Calculating the stumpage

An important principle to address when calculating stumpage values is to adjust for the units in use, as well as variations for different forest products. For example, woodchips are usually sold in bone dry metric tonnes. Therefore, it is necessary to make a conversion to determine what that value means for a log that is sold in cubic metres or green tonnes. If multiple products are being sold from the same operation, they will probably be sold to different destinations and for different delivered prices. Adjustments need to be made for cost of haulage over different distances and for different price points.

An example of a radiata pine clearfell operation is presented in Table 9. In the example, it is assumed that the forest area is 50 hectares and that pulp logs and a range of sawlog sizes and quality will be harvested from the site and transported to different locations. Results are presented for stumpage value by area, by volume and in total.

Harvest Variables					
Harvest area (ha)	50	Harvest cost ($/m³)	25	Haulage cost ($/m³/km)	0.15
Planning and levies ($)	10,000	Roads and landings ($/m³)	1	Marketing & Supervision ($/m³)	6

Product	Standing volume (m³/ha)	Haul distance (km)
Large sawlog	80	49
Medium sawlog	100	49
Small sawlog	20	73
Perservation and posts	30	15
Pulplog	70	49
Total	**300**	

Item	$/m³	$/ha	$ total
Planning, levies and advice	0.67	200	10,000
Marketing & supervision	6.00	1,800	90,000
Roads and landings	1.00	300	15,000
Harvest	25.00	7,500	375,000
Haulage pulplog	7.35	515	25,725
Haulage pres and posts	2.25	68	3,375
Haulage small sawlog	10.95	219	10,950
Haulage medium sawlog	7.35	735	36,750
Haulage large sawlog	7.35	588	29,400
Total cost	**39.75**	**11,924**	**596,200**

Revenue			
Item	**$/m³**	**$/ha**	**$ total**
Large sawlog	150	12,000	600,000
Medium sawlog	125	12,500	625,000
Small sawlog	90	1,800	90,000
Perservation and posts	115	3,450	172,500
Pulplog	60	4,200	210,000
Total Revenue	113	33,950	1,697,500
Net stumpage (profit)	**73**	**22,026**	**1,101,300**

Table 10: *Calculation of stumpage for a radiata pine clearfell operation in New South Wales.*

Engagement of service providers

Depending on the complexity of the forest and the owner's objectives, forest planning and operational activities can be improved with input from specialist service providers. This may include professional advisers to measure, analyse and recommend management strategies, manage planning applications, support negotiations with customers and contractors, and with the harvest and delivery of products. Other specialists are usually involved in a shared capacity with local government, neighbours and community groups in risk and emergency response such as control of pests, disease and fire. Contractors are commonly engaged to undertake forest management and maintenance work, as well as harvesting and haulage utilising specialist equipment.

Professional service providers

Professional service providers, such as experienced forestry consultants and third party property managers can provide a suite of support and advisory services, which can range from preliminary forest assessment through to preparation of harvesting plans and even management of harvest, haulage and marketing operations. Forest owners are encouraged to consider what professional services are available and how they can help ensure forest management objectives are achieved. Local and state government agencies and industry and professional associations can assist in locating appropriate providers.

Operational service providers

It is usual practice to engage contractors to undertake a range of operational activities such as road construction and maintenance, harvesting and haulage. The relationship between the forest owner and contractors is important because it can mean the difference between achieving a good or a poor outcome. An important fundamental in the relationship is the contract for services, covered in more detail below, which should clearly stipulate the expectations of all parties with respect to costs, operational activities to be undertaken, required outcomes and responsibilities.

Operations and sales arrangements

Some business arrangements can be very straightforward, such as a fixed volume spot sale of sawlogs from a well-managed forest to a local mill. This is a simple supply chain involving one product harvested and delivered to one customer and is likely to have advantages of minimal preparation, management and administration. A successful outcome from this scenario would be where the harvest and deliver process maintained full compliance to all operational codes and standards, as well as achieving the forest owners financial and non-financial objectives.
Other more complex arrangements can also be rewarding when they are well designed and managed. For example, there may be objectives to not only harvest and sell sawlogs but also to improve the stand quality for future crops of multiple products, address environmental sensitivities such as erosion gullies or restore threatened wildlife habitat, and at the same time improve grazing potential with adjoining paddocks. With accurate resource and site information, and a clear understanding of how to achieve commercial, environmental and community values while maintaining compliance with best practice, a well-planned and managed harvesting operation may be capable of delivering significantly more and ongoing value than a simple one-off spot sale.

Stumpage sales

If you are undertaking a stumpage sale, your only direct contractual relationship will be with the log buyer. The log buyer could be the harvesting contractor, an independent log buyer or a timber processor. It is essential that you have a written contract with the log buyer which stipulates conditions such as:

- Responsibility for planning and approvals.
- Responsibility for safety management and specification of liability.
- Harvest and haul contractor details and expectations of performance and behaviour.
- Insurance requirements for all parties.
- How the harvested wood will be measured and the measurement communicated to you (e.g. with log dockets or a similar system).
- How and when you will be paid for your logs.
- Whether payment is on a lump sum unconditional basis, or based on logs harvested – usually calculated by weight (tonnes) or volume (cubic metres).
- Clear contractual responsibility for all costs.
- What condition the site is to be left in following the harvesting event.

Agency sales

It may be possible to engage the services of a third-party agent that can manage some or more of the aspects of planning and supervising the harvesting process, engaging the contractors and establishing sales arrangements with customers on your behalf. It is still essential to have in place a written contract that stipulates the conditions of the arrangements, including how the agent will be paid (e.g. set unit fee or percentage of net stumpage).

On-truck and delivered sales

Dealing directly with a timber processing company for log sales and direct engagement of harvest and haulage contractors is generally only undertaken by growers with considerable experience. In this instance, the forest owner takes on the majority of risk and responsibility, including for regulatory compliance. It is very important that the forest owner has a clear understanding of their legal and contractual requirements.

Operational risk management

Contractual arrangements

Contractual agreements are the most important tool for managing risk in forestry operations. As outlined above, contracts should provide absolute clarity about which parties are engaged and responsible for which activities. In many cases, a log purchaser or agent will provide a template contract for the activity. It is essential that you take legal advice on the contract to ensure that your interests are clearly addressed. Under delivered sales arrangements, forest owners are responsible for contracts and this should also be undertaken with legal advice.

Insurances

Contracts must clearly specify which parties must hold insurance, what insurances need to be held and what value should be insured. It is usual for all parties to hold public liability insurance to an agreed level. Any party that uses employees to undertake activities must also hold workers compensation insurance. Where a party is involved in providing professional or expert advice, it is normal for them to hold professional indemnity insurance. A certificate of currency must be provided that specifies what the insurance is for, what value is insured, what entities are insured and when the insurance expires. Your own insurer may require to be notified about the insurance details of other parties.

Financial analysis for farm forestry

This section introduces the principles and options for financial analysis for private forestry enterprises. It is important to note that for many private forestry practitioners, forestry is one of a number of integrated land uses on a property. Therefore, financial analysis may need to include assessment of all farming activities. The discussion in this section addresses only the forestry component. There are also variations between different types of and different approaches to forest management which have implications for financial analysis.

Financial analysis models

Discounted cash flow and net present value

The most common approach adopted for financial analysis in forestry is the application of a discounted cash flow (DCF) analysis to calculate net present value (NPV) and internal rate of return (IRR). Using this approach, a cash flow is developed for the operation or enterprise for a predetermined time period. Future cash flows are discounted to adjust for the fact that a dollar value earned or expended today is worth more than the same dollar in the future, because of inflation. The discount rate is usually developed based on a range of factors including estimated inflation and risk.

Simple discounted cash flows

In the most basic example, a cashflow will recognise operational cost inputs and sales revenues for a forestry activity from now until an agreed point in the future, typically the point of harvest. The NPV and IRR can be calculated for a single hectare and extrapolated across the whole forest.

Complex discounted cash flows

However, farm management is multi-faceted. Costs may include the opportunity cost of choosing forestry over an alternative land use, in addition to operational costs. Benefits may include environmental services or enhanced productivity for integrated land uses in silvo-pastoral systems, in addition to revenue from log sales. Simple cashflows will address only the operational aspects of preparing for and undertaking forest management for log production and some enterprises will want to actively consider the broader range of costs and returns. In some cases, the returns may be intangible (e.g. ecological health improvements) and so an approach to valuing those must be developed.

Cost-benefit analysis

Cost-benefit analysis (CBA) is a specific technique which is used to capture direct and indirect, as well as intangible or difficult to quantify costs and benefits to determine the overall value of processing with a project. It is particularly useful in assessing projects and activities that involve complex natural systems or enterprises where there is a complex interface between various integrated or alternative actions.

Operational cash flows

Farm forestry generally requires an up-front capital investment to prepare the land and establish a plantation. This needs to be considered in the context of whole farm cashflows and in consideration of the other benefits the farm forestry will provide to the farming enterprise.

Information requirements

Reliable financial analysis and forecasting for farm forestry operations requires good quality information inputs about the forest resource, proposed operations and likely sales.

Markets

A key element of financial analysis is to understand the available markets for log products. Important questions to answer include:

- Where are customers located (distance to market influences the net price received for logs)?
- What products can be sold (e.g. in some regions there is no market for pulp logs)?
- What are the typical prices for those products (stumpage or delivered prices)?
- What is the current and future level of demand for log products?

It may not be possible to answer these questions accurately ahead of entering a sales arrangement, but it is a good idea to develop an appreciation of these factors through enquiry to log purchasers, other forest owners or professional service providers.

Harvest and haul costs

As with questions about markets, it may not be possible to accurately determine standard harvest and haul costs for your operation before entering a contract. However, it is important to get a feel for what they are likely to be based on similar enquiries.

Forest management costs

There are also a range of ongoing forest management costs which should be accounted for. These may include:

- road construction and maintenance
- fire prevention and management
- fencing
- weed and pest animal control
- professional forest management and planning advice
- insurances.

Financial analysis examples for different farm forestry management models

Landowners are often faced with land use and land management decisions that have important ramifications. Often these decisions will inform a choice about whether or not to establish or re-establish a plantation rather than an alternative agricultural activity such as grazing. In other situations it may be a decision about what species to plant or what re-establishment technique to use. The examples below demonstrate the value of financial competent and well-informed financial analysis in assisting land use and forest management decision-making. In these examples, the cost of land has not been included; it is assumed the land is owned outright. It is also important to note that the analyses presented below, while based on expected costs and returns for the relevant regions, are simplified for illustrative purposes and cannot be relied on to make investment decisions. It is recommended that growers seek expert advice whenever undertaking financial analysis.

Blue gum re-establishment: replant or coppice?

In this example, the forest owner in south-west Victoria has harvested an existing Tasmanian blue gum plantation and has decided to continue with forestry on the site. The grower is faced with the choice of two scenarios, either:

1 Clearing the previous plantation crop and re-establishing with new seedlings with better genetics; or
2. Allowing the stumps to regenerate as coppice.

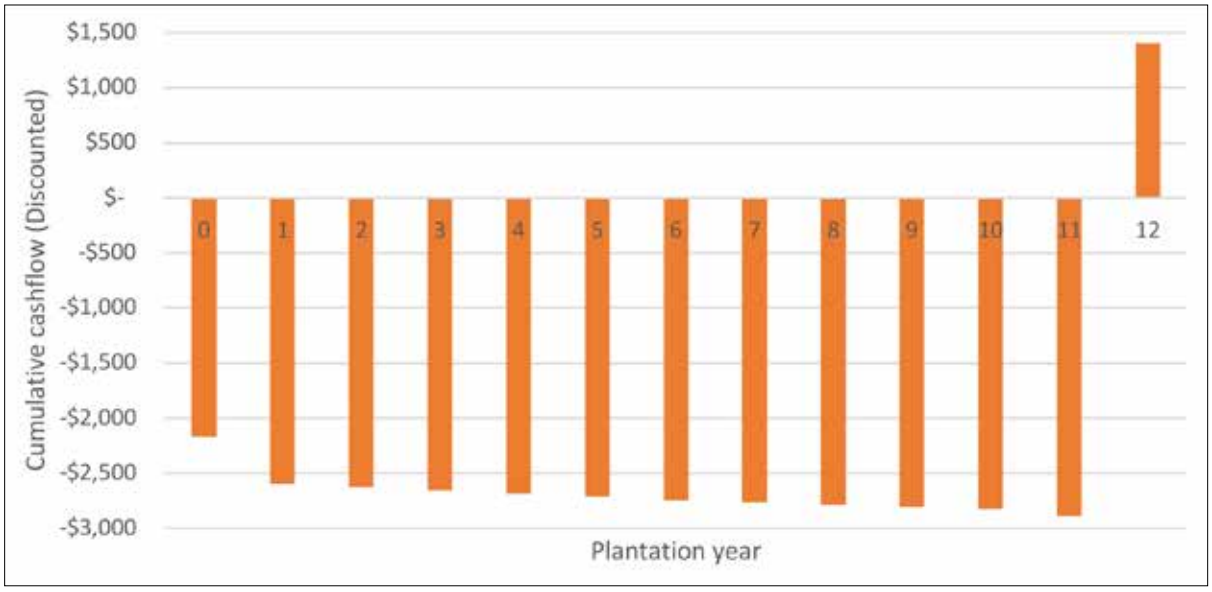

Figure 21: *Sample discounted cashflow profile for a second rotation blue gum plantation re-established with seedlings.*

In Scenario 1, the high-quality genetics of the new seedlings mean that the plantation is expected grow at a MAI of 17.8 m^3/ha/yr meaning that it can be harvested at age 12 to yield 225 green metric tonnes per hectare. However, there are very high upfront costs for land preparation and establishment. The discounted cash flow analysis indicates a NPV of $1,404/ha (see Figure 21).

In Scenario 2, the poorer genetics and slower overall growth as a result of relying on coppice regeneration mean that the plantation grows more slowly with a MAI of 10 m^3/ha/yr, yielding 180 green metric tonnes per hectare at harvest. Consequently, the rotation length is pushed out to 18 years. However, the very low early rotation costs mean that the discounted cash flow analysis indicates a NPV of $1,702/ha (see Figure 22).

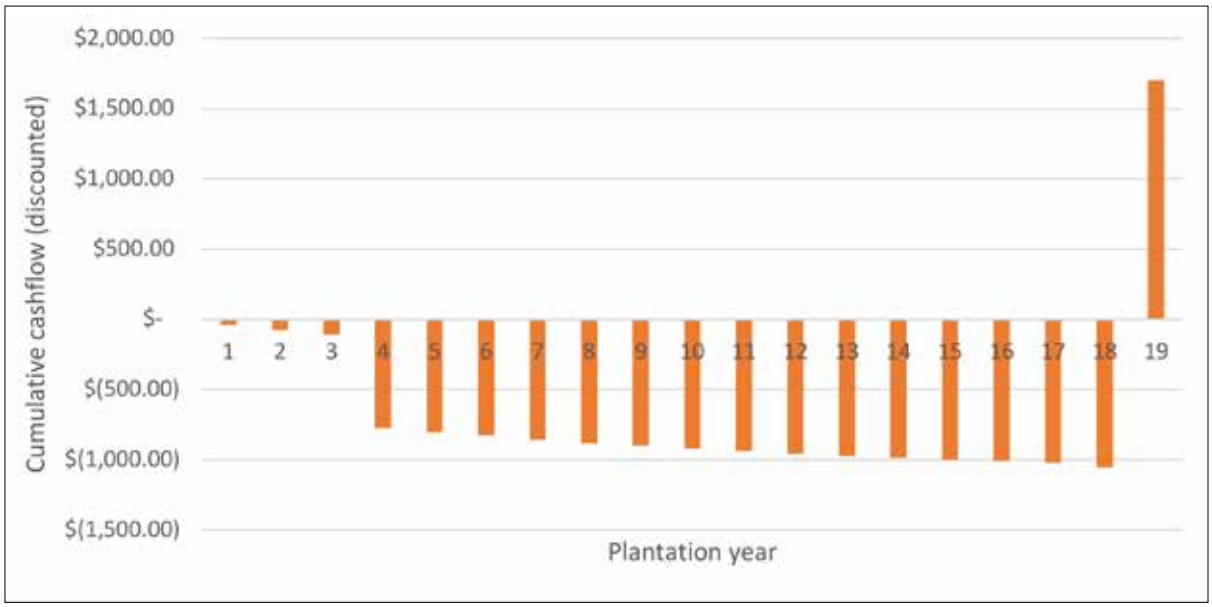

Figure 22: *Sample discounted cashflow profile for a second rotation blue gum plantation re-established with coppice.*

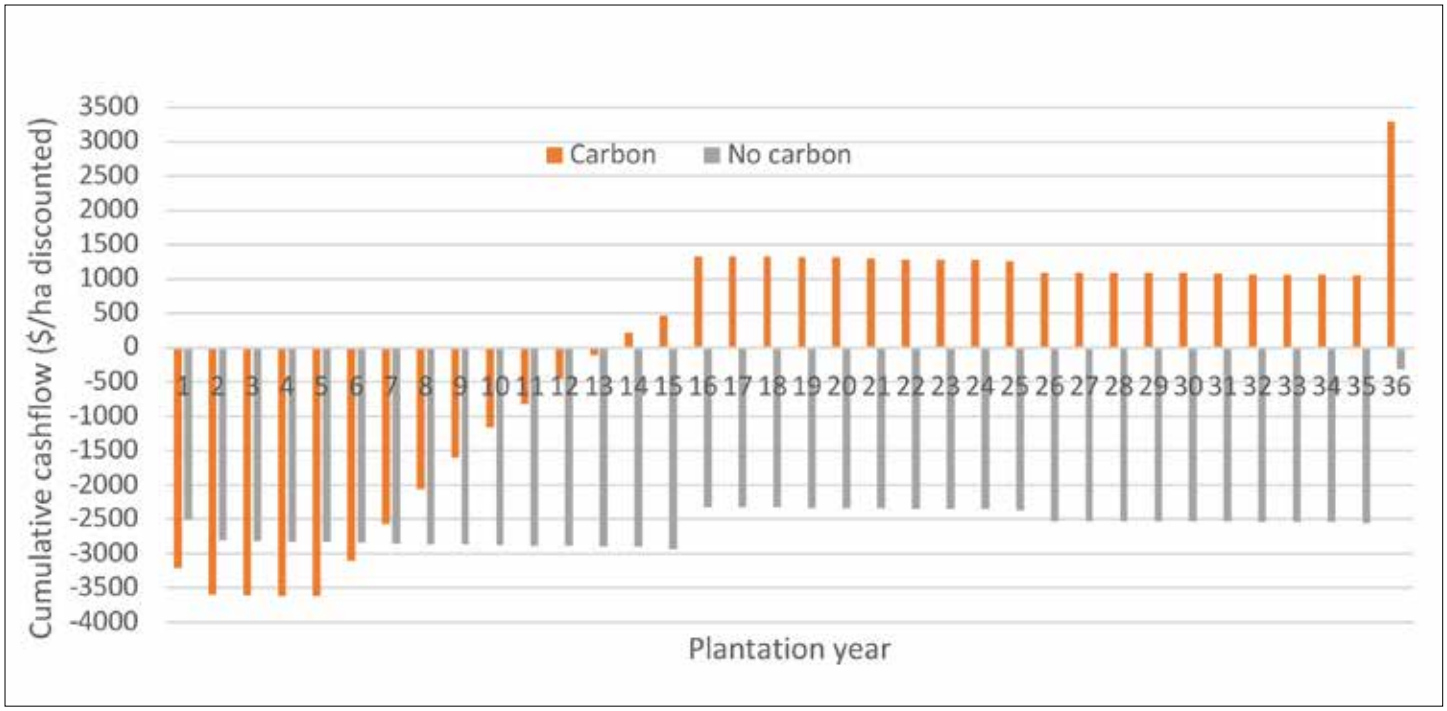

Figure 23: *Comparison of new pine plantation establishment with and without a carbon price.*

In this example, assuming there were no other risk factors involved, it would make sense for the landowner to pursue the lower cost option of re-establishing from coppice, even though the alternative would deliver higher volumes and higher gross revenue at harvest. This also assumes the landowner is willing to wait an additional 6 years for the income.

Influence of a carbon price on decision to establish a new pine plantation

Plantation costs are heavily weighted towards the early years of the rotation, meaning there is a long time between incurring the costs of establishment and realising benefits from harvest. If a plantation can be established as an Emissions Reduction Fund (ERF) registered project, it can generate Australian Carbon Credit Units that can be sold earlier in the rotation to generate additional cashflow and offset establishment costs. In the example below, a farm owner near Oberon in the central tablelands of New South Wales is considering establishing a new pine plantation. In the absence of a carbon price, the project would generate a negative NPV of -$360. With a carbon price[5] in place, the project is positive, generating a NPV of $3,290. In this instance, the farmer would likely only progress with the project if it was eligible to participate in the ERF (see Figure 23). That is because of the impact of the early rotation carbon revenue offsetting the early rotation costs.

[5] The carbon analysis and pricing used in this analysis is simplified for illustrative purposes and cannot be relied on for investment purposes.

Next steps – getting started

The Private Forestry Guidance Material series provides a large amount of information that aims to improve the knowledge base of rural landowners and encourage those who are interested to consider small-scale forestry as a viable on-farm enterprise. It is intended to break down knowledge barriers that may prevent some landowners from seriously considering forestry. If the Guidance Material has created enough interest for you to seriously consider establishing plantations or actively managing your native forests, the question is what next?

> Define your objectives

The first step is to understand and clearly document your reasons for getting into forestry and what you hope to get out of it – your objectives. This will be different for every landowner and every situation. It could be that you want to establish a standalone plantation forestry enterprise or include plantations as a commercial element of an integrated farming operation. You may be focused on environmental and on-farm benefits, with the aim of also generating future revenue as a secondary benefit. For some landowners, the objective may be to generate carbon credits to offset on-farm emissions, or you may be looking to diversify farm income sources. Whatever your objectives and motivations are, it is important to articulate and document them clearly as your starting point.

> Work out your information needs

With what you know about your own property and the local wood products industry, and with the help of these Guidance Materials, you will probably already be equipped with a lot of information to assist in working out how to progress. But you will probably require more information. Work out and document what you know already and what other information you require to make an informed and financially sensible decision.

> Undertake your own research

There is a large body of information available about small-scale private forestry that will be relevant to your specific situation. It is useful to consult Forest & Wood Products Australia's online database, talk to local contractors and timber processors, look at what other private forestry practitioners are doing in your area and attend field days. There are also organisations such as the regional forestry hubs, industry organisations and government agencies with dedicated staff and useful online resources which are available.

> Consult an expert

Even if you are an experienced private forestry practitioner, there is value in consulting expert professional forestry advisers about any aspects of the proposed forestry venture that you have concerns or questions about. A small investment in professional advice could be the difference between failure and success. It is also important that you consult your lawyer and your accountant to determine any business or personal implications of starting a forestry business.

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