Foreword

In many countries, small-scale forestry operations provide a major component of the industrial wood-supply. Native forests in Australia can provide both wood and non-wood values. These assets can benefit individuals (owners), as well as local, regional and State economics and assist with national conservation targets.

Much of the private native forest resource might be suited to timber production forestry for a range of products and quantities. Sustainable timber production, according to the principles of Ecologically Sustainable Forest Management is both possible and desired. The opportunity to manage private native forest for biodiversity conservation or specific biodiversity outcomes is central to the recovery of degraded forest landscapes and the preservation of remnant vegetation particularly on private property. In particular small scale forestry operations with specific management purposes can be integrated into the farm or property activities, providing either economic, social or environmental outcomes – or some components of all.

This publication considers the planning, implementation and marketing decisions – recommended and required – to sustainably manage private native forests either at property level or as part of the regional network of timber production and conservation. Specific case studies for (a) foothill mixed species forests of the south east of Victoria and New South Wales, and (b) for dry eucalypt forest of South East Queensland are presented as examples of more intensively managed forests and the biological, economic and legislative factors which affect their successful and sustainable utilization for wood products.

While most of the information in this document is relevant to many areas of both private and public native forest nationally it is stressed that management of particular landscapes, forest types, species and products throughout Australia differ significantly and planning and management should give due regard to the relevant legislation, Codes of Practice, and local biophysical factors.

The report aims to provide small-scale farm forestry enterprises with the general principles and decision strategies to successfully investigate options, source relevant resource information data and assist in planning, implementing and marketing their private resource. Giving guidance when to involve extension officers and or local government agencies. The management guidelines provide step by step assistance for inexperienced forest managers in evaluating and achieving timber production and conservation objectives.

This project was funded from a co-operation of CSIRO Forestry and Forest Products (CFFP) and the Forest Technology Program (ftp). The revenue was matched by funds provided by the Australian Government through the RIRDC / Land & Water Australia / FWPRDC, together with the Murray Darling Basin Commission, as part of the Joint Venture Agroforestry Program.

This report is an addition to RIRDC’s diverse range of over 1800 research publications. It forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems. The JVAP, under this program, is managed by RIRDC.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- purchases at www.rirdc.gov.au/eshop

Peter O’Brien
Managing Director
Rural Industries Research and Development Corporation
Acknowledgments

Following the departure from CSIRO Forestry and Forest Products of the main authors – Peter Clinnick & Bob McCormack – Mike Connell (Ex-CFFP) of Eumoyni Options Pty Ltd was requested by RIRDC to review and revise this document.

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## Contents

**Foreword** iii  
**Acknowledgments** iv  
**Contents** v  
**Executive summary** vii  

### Chapter 1. Introduction
- The need for a management guide for private native forests ................................................. 1  
- Background to native forests in Australia .............................................................................. 3  
- Sustainable forest management .............................................................................................. 6

### Chapter 2. Property management planning
- Principles of property management planning ......................................................................... 8  
- Planning and management cycle for private native forests .................................................. 10  
- Developing the forest management plan .............................................................................. 12

### Chapter 3. Silviculture to improve forest condition and value
- What is silviculture?............................................................................................................. 22  
- Silviculture to improve condition, growth and value........................................................... 24  
- Management of forest stands and stand components ........................................................... 28  
- Fire in the native forest......................................................................................................... 48  
- Grazing in native forest........................................................................................................ 51  
- Silviculture enhancing or maintaining biodiversity ............................................................. 51  
- Maximising growth of wood products ................................................................................. 54

### Chapter 4. Case studies - illustrating the use of silvicultural strategies to increase wood production – particularly of sawlogs
- Restoring productivity in uneven-aged ‘high-graded’ dry Spotted Gum-Ironbark in SE Queensland - Case Study 1 ................................................................................................... 57  
- Sustainable sawlog production in even-aged regrowth forests of Silvertop Ash in SE Australia - Case Study 2 ................................................................................................... 62

### Chapter 5. Protecting soil and water, biodiversity and aesthetics
- Soil and water protection...................................................................................................... 75  
- Protecting water from industrial pollutants ........................................................................ 81  
- Protecting biodiversity ......................................................................................................... 81  
- Minimising the visual effect of harvesting........................................................................... 84

### Chapter 6. Product recognition
- Understanding potential non-wood values ........................................................................... 87  
- Understanding potential wood products .............................................................................. 88

### Chapter 7. Forest inventory – collecting the appropriate forest information
- The need for assessment and measurement ........................................................................... 93  
- Understanding the resource components ........................................................................... 94  
- Plot measurements and calculations ................................................................................... 98  
- Making the harvesting decision .......................................................................................... 106  
- Decision without objective data ......................................................................................... 109  
- Other help and tools ........................................................................................................... 109
Executive summary

The need for a guide to management of private native forest

Native forests in Australia can provide both wood and non-wood products and values. These assets can benefit individuals (owners), as well as assist local, regional and State economic and conservation targets.

The current Regional Forest Assessment and resource management processes will lead to further reduction in both the area and quality of public native forest available for wood production. Australia’s needs for forest products will increasingly be met from lower quality, mature regrowth forests (and an expanding plantation estate). The private owned native forest can and will supply some of the future timber products.

Active silvicultural (forest) management of the private forest resource has been rare in the past in Australia. Most historical harvesting has been exploitive, carried out by the landowners, millers (or their contractors) and has been conducted on the basis of selecting the very best trees.

Using “high grading” strategies removes the best trees (over about 35 cm in diameter) over one, or a number of cutting cycles. Much of the remaining resource now consists of damaged trees, or trees with poor form and vigour. In many instances on farms, the sawlog quality of many of the remaining trees has been further compromised by the frequent use of fire to promote grass growth for grazing.

Indiscriminate and repeated forest harvesting, grazing and fire can also affect essential habitat for some flora and fauna (particularly insectivorous mammals and birds). Where these processes are not managed carefully they can cause permanent damage to soils, water quality and forests. Continued ‘high grading’ and poorly planned and managed harvesting operations - without regard to the sustainable health and productivity of the forest will lead to further and more drastic decline.

Uncontrolled regeneration in gaps (large or small) or cleared areas, without judicious removal of excess damaged and poor quality trees will adversely affect the productivity and health of the regeneration – continuing the cycle of decline. As forests decline they continue to lose productivity and to re-juvenate them requires often drastic silvicultural regimes to ensure the long-term return to health and productivity – there are no short-term fixes.

If the private forest resource is to achieve its sustainable productive potential, then pro-active and appropriate silvicultural regimes benefiting wood production, or biodiversity, or both are needed.

Objective

To provide Guidelines to owners and managers of private native forest which consider and describe the major steps in planning, assessing and implementing native forest management. Providing, in one ‘Guidelines’, the basis for understanding what is involved in the decision process for successful and sustainable management; and an indication of where to seek further information and advice.

This project was funded from a co-operation of CSIRO Forestry and Forest Products (CFFP), the Forest Technology Program (ftp) and the Australian Government through the Rural Industries Research and Development Corporation (RIRDC).

Structure of the Guidelines

While the guide concentrates on commercial and conventional native forest timber production, recognition and guidance is also provided in relation to maintaining and improving biodiversity.

The scope of the guide deals with forest operations up to the point where the log arrives at the mill or the processing plant. It is structured and presented in a sequence that follows the understanding and planning of activities in sustainable forest production, forest assessment, marketing and harvesting processes and outlines the data and analysis required to reach informed decisions about managing wood and non-wood values in smaller to medium sized private forest areas.
Forest management planning

Long-term Property Management Planning is essential where forestry production or biodiversity management enterprises are to be undertaken. In particular small scale forestry operations with specific management purposes can be integrated into the farm or property activities, providing either economic, social or environmental outcomes – or some components of all.

Sustainable timber production, according to the principles of Ecologically Sustainable Forest Management is both possible and desired. Active management is needed to maintain the forest in a productive state. The opportunity to manage private native forest for biodiversity conservation or specific biodiversity outcomes is also central to the recovery of degraded forest landscapes.

There are no hard and fast rules to forestry planning. The common approach (followed by most larger forestry management agencies) is to recognise three main type of plan based on their time horizon. This leads to:

- **Strategic Forest Management Planning**: detailing the assessment of the forest, land assets and condition, and taking the long-term view (beyond the forest rotation, usually 100 years or more) set out the broad silvicultural and management strategy. The scope of the planning horizon exceeds the tenure of any individual planner or manager.

- **Medium Term Business Planning**: setting out the business strategy for the forest enterprise focusing on the nearer to medium term (2-10 years) and usually considering timing and sequence of possible marketing, sales and investment decisions.

- **Short Term Operational Planning**: specifying plans (often months to a year in time frame) to control and guide management operations (eg. harvesting an individual compartment or coupe) and having a strong focus on work instruction.

Silviculture for native forests

Silviculture is the management of the forest trees or stands to achieve changes in forest health and condition; growth of forest wood or non-wood products; maintenance and alteration in habitat or biodiversity; or regeneration of the stands. Silviculture employs techniques which can alter the density and structure of stands by:

- removing trees to reduce competition and so accelerate the growth of those retained,
- removing damaged or undesirable trees or other vegetation components,
- altering canopy and understorey structure to promote timber or biodiversity values, and
- promoting germination and regeneration of desirable species or forest structures.

The way in which forest stands are managed is determined largely by the current forest condition and by consideration of the growth stages of the trees making up the stand.

Managing forest health condition and structure using silvicultural techniques

Forest managers use silvicultural techniques to maximise the growth of potentially valuable trees and improve financial returns. Treatment of the forest should also plan for its regeneration as a productive forest. The main native forest silvicultural principles include control of regeneration stocking, spacing or fertilizing of young forest, and thinning and/or fertilisation of older regrowth eucalypt forest, appropriate intensities of selective harvesting in mature forest. These are all options for achieving increased productivity of forest stands and improved efficiency of forest operations. They each have positive and negative effects on biodiversity management and potential.

Wood Products

Timber products are harvested and sold either as a selective harvesting of specific products or as secondary or by-products to harvesting operations (culls, downgraded harvested logs or as short
lengths bucked from log grading operations). In mixed species and/or multi-age forests, a harvesting operation may specifically target a number of products.

Major products in the forests are derived from sawlog products found in the main stem which are either:

a) sold whole as specialty logs such as poles, piers and veneer logs; or

b) sold as potential sawn timber products for structural and furniture use.

Recognition of these products and management of the forest to maximize their growth and value is central to silvicultural management for high value wood production. Residual wood, either as poorer quality logs, or as short stem lengths and large branches, are often sold as pulpwood products or firewood products (logs, splits, branches, woodchips).

Where log lengths are very specific, or available stems do not reach merchantable log size, there can be considerable market opportunities for fencing materials (posts, rails and strainers). Other timber products for specialty timber such as burls and small lots of furniture pieces are utilised as the opportunity arises, but are generally not part of particular management strategies.

Durability and wood density characteristics are major determinants of the end use of timber products and local requirements and Australian standards specify durability classes and product specifications in the market place. This includes limitations on the amount and position of various wood defects.

**Case studies in silviculture as examples**

Throughout the Guidelines, a number of case studies detailing the use of silvicultural practices for increasing wood production and value in native forests are discussed.

It is imperative that users of these Guidelines understand that the case studies are examples only of specific management strategies applied to a forest type and structure. Management strategies detailed are designed specifically to achieve product or biodiversity outcomes and were determined after thorough investigation and assessment of the physiographical characteristics of the landscape and the unique structure and species composition of the forest area to be managed.

In any forest area, thorough assessment, inventory and evaluation is required to provide the basic information to enable planning and implementation of the most appropriate management systems.

**Forestry operations that affect habitat affect biodiversity**

Ecological sustainable forest management is the imperative for management of most native forest landscapes at least at the regional scale. Forestry activities - particularly forest harvesting - undoubtedly affect habitat in different ways to natural processes (primarily fire, wind and competition). The importance of the effect depends on the size of the area treated and on the nature and intensity of the changes. The effects may not be substantial for an individual private forest manager.

Food, shelter and refuge are the key constituents of habitat. Changes to the forest as a result of harvesting are either:

- direct, in the removal of selected trees that that might have been providing any or all of these key components, and

- indirect, as a result of changes in sunlight, moisture, temperature, shading etc. that influences the way the forest changes and grows after a harvesting operation.

Individual farm lots or forest areas are not required to achieve all biodiversity values however, particularly sensitive or susceptible environments may need to be managed specifically - even if that excludes some forest operations and/or harvesting.

Across Australia, State agencies and many private landowners are required to adhere to Codes of Forest Practice designed to protect soil, water and biodiversity values. Limiting the deleterious affects of human intervention in the landscape, particularly by forest operations, harvesting and transport.
Adherence to Codes of Practice minimises the long-term effects, but does not exclude wood production management of native forest areas.

Managing larger private native forest areas for wood production will require some compromise between maximising timber production and perhaps increasing or at least maintaining local biodiversity values.

**The need for assessment and measurement**

Appropriate planning, management, harvesting and protection of forest resource can only be carried out with an understanding of biological, sustainability, product and marketing principles. The unique arrangement of the components of landscape, vegetation, timber and habitat structure determine what is possible and indicates the management required.

Forest inventory is a specialised assessment of the condition and potential values of the forest, not only its wood product values, but also those values which are important to the management of biodiversity or other non-wood factors.

The Guide details a range of essential measurements and assessments that allow the forest manager to recognise products and potentials (wood and non-wood) and to determine the best strategies for management (silviculture and biodiversity) to meet the objectives of the forest management plans.

The most important decision when beginning an inventory assessment is the accurate delineation and stratification of the management unit boundaries – as measurements taken will generally be multiplied by calculated areas to estimate product volumes, values and costs and the relative importance of some habitat values.

Knowledge about tree sizes and of potentially harvestable volumes is essential for good forest management and business planning. These Guidelines provide sampling techniques and strategies (with example calculations which are easy follow and understand).

**Marketing**

When the inventory of the forest resource is complete, standing and potential value can be assessed. The marketing of timber (or even biodiversity) values requires some specialist knowledge. Marketing is much more than selling. It involves understanding the products available from the forest, the likely customers and the strategies and processing to maximise the value returned from the forest resource. Successful marketing is an interactive process matching existing and potential customers and markets.

Prices will fluctuate with demand and constant evaluation of the market place will provide stability, opportunities and development. Farm foresters however with small product parcels and infrequent sales can find it difficult to achieve sales when demand is low. Understanding all of the potential products and the long-term management of the forest is essential to making the right decisions.

Log-grading of sawlogs and quality grading of the timber products is an essential process in maximising value and returns. Log-grading is a specialist activity and certified log graders with a complete understanding of local and regional markets are worth employing.

There are 3 main approaches to selling timber products:

1. delivery to the mill door where the saleable product only is delivered and the owner is responsible for all activities;
2. selling on an area or woodlot basis where the ‘products’ from the area are sold for a fixed price whatever is removed. The successful bidder is responsible for most of the activities; and
3. stumpage sale where the buyer arranges and undertakes harvesting and transport under contract to the owner.

Stumpage sale is the most common from of sale in Australia.

Stumpage paid to the landowner is the price ‘left over’ after all of the costs have been taken into account (i.e. the price paid at the mill gate minus administrative, all harvesting and transport costs).
The variable that has the greatest effect on market access is the distance to the prospective purchaser. Stumpage is drastically reduced at greater haulage distances, but also with poor property access and long snigging distances during the harvesting operation.

Wood sales contracts are the legal documents which define the terms of sale, allowable harvesting systems specified by harvesting and operational plans, prices to be paid for each product range and the point of sale. It is very important that all points that are negotiated are detailed in the contract.

Sales can be arranged by landowners or by the use of intermediaries such as agents or co-operatives. When selling for himself, a landowner can negotiate price and customer for himself, although until experienced, the services of a consulting forester would be an advantage. Alternatively, woodlots could be sold as private bids or auctions.

**Harvesting systems**

Native forest harvesting in Australia commonly involves 3 stages:

1. falling and the initial preparation of the timber product (falling, heading and crosscutting) at the stump; and
2. extraction from the stump area to the roadside (snigging, skidding and forwarding); and
3. preparing particular products (grading, sorting, bucking and processing) for transport.

Harvesting systems are usually described by the length of the wood as it is transported from the stump to the landing, either as long lengths (> 6 m), short lengths (converted to smaller lengths usually < 6m) or whole tree systems with no crosscutting (stem and crown is transported whole).

The planning of harvesting operations is linked to the results of forest inventory and the management objectives decided upon. Harvesting is a difficult and potentially very dangerous aspect of forestry and a wide range of speciality equipment and developed systems are available to carry out the harvesting and conversion of timber products both in the forest and at the roadside. The Guidelines provide information on many of the most common harvesting systems and equipment which are needed to plan, harvest, process and transport wood products from the forest to the mill.

Specialist mechanical systems used for large scale forestry operations are described as well as systems specifically designed for on farm management of smaller scale operations using farm tractor based equipment.

**Conducting the forest operations**

Harvesting and transport operations are a major cost component in the sales price of logs at mill. Where farm-foresters have the capability, harvesting using farm resources can make good economic sense. However, newcomers should make a detailed assessment of the labour and equipment requirements and expertise that will be needed to undertake harvesting, roading, loading, or other activities.

For farm foresters with access to both equipment and skills, conducting the forestry operations can be financially rewarding and satisfying. Owner-managers may be able to ‘Do it Yourself’ and therefore lower production costs and increase cash income by conducting all or part of their own harvesting and transport operations. However, these activities are hazardous, require higher skill levels and may require specialist equipment.

Contracting out all or part of the operations can reduce the inputs needed from the farm forester. There will be less return in employing contractors and it does not eliminate the need for owner/manager input or even expert input entirely.

Professional advice can avoid unforseen problems and save money in the long-term. A range of forestry, business and legal advisors are available in the market place to assist in aspects of forest management, harvesting and sales.
Detailed forest management planning

The preparation of the detailed harvesting plan aims to ensure the effective communication and common understanding of the proposed operations to all involved (governing bodies, contractors, owners). During implementation the plan provides for the monitoring of compliance to Codes of Forest Practice and documentation of alterations as circumstances dictate (within the established codes and agreements).

Plans assist communication and provide a valuable record for the future. They are more effectively produced in 3 steps:

1. assembling the supporting information, including permits, constraints, protective measures and harvesting systems;
2. mapping the area resources, detailing operational plans and operational maps for specific sections; and
3. detailing safety measures (including management of personnel, traffic, fuel and fire risk).

These plans function as the work instructions to the team carrying out the operations. Its main contents are the specific operational plans, information and maps of the harvest areas, exclusion zones and infrastructure.

Glossary and Bibliography

The Guidelines have brought together a detailed glossary of terms; and a comprehensive bibliography of relevant publications and websites which can assist the private native forest owner, manager or extension officer to evaluate the native forest resource under his care.
Chapter 1. Introduction

This introductory chapter is divided into two sections. The first section explains the reasons for the existence of the guide and the intended target audience, with subsequent information describing the objectives, scope and direction of the guidelines. The second section provides background information on the nature of the private forest resource and explains fundamental issues, including the nature of sustainable forestry, as well as the values and products that are important for forest owners.

The need for a management guide for private native forests

Native forest, managed carefully, can supply both select and high volume products. Native forest also generates spiritual, physical and socially beneficial products, far different from the values generated in other, less diverse environments. Biodiversity, for example, is an important attribute of natural forest, and is an asset to any property and its surrounding community. Protection and even enhancement of biodiversity is a prospect if sustainable forest management principles are applied.

There has been a steady expansion in the amount of degraded land across Australia, increasing the imperative for sustainable management of remaining areas. Achieving multiple objectives requires caring and skilled management which in turn needs knowledgeable and skilled people.

The national action plan for salinity and water quality, and the legislation banning or highly restricting clearing in many states, has applied greater pressure to the public native forest resource and the existing plantation resource. Sawlog quotas from public native forests have undergone serious and continual reductions. There has never been a greater argument for the retention and management of private native forests for timber production. Sustainable and profitable forest management is the logical choice, encouraging retention for the sake of the land earning its keep. For the rural sector struggling to maintain some form of viability this option as opposed to clearing or full chemical treatment is yet to be fully realised.

This guide aims to provide forest management and marketing information to the private native forestry sector. The guide takes a wide view and presumes that the manager is concerned with all the aspects needed for sustainable forestry, not just the focus on the harvesting phase. Higher standards of private forestry practice can better protect our natural heritage, while achieving other more commercial goals, including the economic survival of the rural sector.

Well-planned forest management is necessary for many reasons. The state of the forest after the harvesting event has a large bearing on its future growth and value. In this context, planning the best management, harvest and regeneration program is of utmost importance.

Finally, when taken in aggregate, the small successes or failures of the many farm-foresters in practicing their forestry has a regional- or even State-level effect. There is a public and government interest in ensuring ongoing improvement in private forestry knowledge and practice, and thus a need for accessible and easily understood guidelines.

The guide is also intended for use by extension officers who are often called upon to provide advice to landholders on issues associated with native forest management. Farm tree and Landcare groups will also find some of the material useful in managing their existing or renewed forests and vegetation corridors.

Information is also needed because of both, an increased interest in private forestry, and importantly, an increased interest in improving forestry standards while seeking to achieve sustainable forestry. Some landholders are new to private forestry. These guidelines are for them. Other landholders have been involved before, but since many conduct a timber harvest of their forest only rarely skills and knowledge need refreshing.

Finally, the forest is often a place where escape from the world’s stresses can occur and wherein the human spirit can be renewed. The motivation for private
native forest management is not always an economic one. Forest farmers generally consider themselves as land stewards and custodians of the resource - which we all trust future generations will utilize judiciously.

**Objectives**

The objective of the guide is therefore:

To provide information to owners and managers of private native forest describing and considering the major components of native forest management. Providing in one place the basis for a good understanding of what is involved in the decision process and an indication of where to seek further information.

**Scope and direction**

While the guide concentrates on commercial native forest timber production, recognition and guidance is also provided in relation to maintaining and improving biodiversity. In a few instances reference is made to plantations and while some of the information is transferable, plantations are not the consideration in these guidelines.

This guide aims to provide a general background level of information relevant to Australian native forests. The guide is organised around the key topic areas of planning, silvicultural management, marketing and harvesting. This leads the reader into what alternatives are available for wood production management and the harvesting and transporting wood from the private and often smaller forest resource.

**Case studies as examples**

It is not possible in a general guide such as this to provide detailed information on regions or at a site-specific level for individual farms - Australia’s forests are simply too diverse. A number of case studies are discussed in the guidelines to provide examples of planning, management and utilization strategies in particular forest types.

Similarly the size of the subject material is too large to provide a textbook level of treatment. Interested readers are urged to follow the links and references, to ask questions of fellow farm-foresters or experts; and to interpret what they hear and learn for their own forest types and farm situation.

The guide is focussed on the conventional timber industry rather than specific requirements or techniques for the management of speciality products. The scope of the guide deals with forest operations up to the point where the log arrives at the mill or the processing plant. On-farm “portable” sawmills are an interesting option for native forest managers, but these are not treated here (this topic is well addressed in Hanson and Stewart 1998).

**Structure of the “Guidelines”**

The guide is structured and presented in a sequence that follows the implementation of the forest management, marketing and harvest processes (see Figure 1.1). The following sections in this introduction and in subsequent chapters (1 to 6) outline:

- What it means to be sustainable and how sustainability might be measured; and what forest values might be important to the landholder (Chapter 1),
- The basis is set down for preparing Property Management Plans and which include areas of forest resource to be managed particularly for wood products (Chapter 2);
Private native forests make a substantial contribution to Australian forestry: 1.5 M ha of closed forest and 13 M ha of open forest.

Aspects of silviculture including, regeneration systems and thinning are addressed in (Chapter 3); with specific case studies as examples from south-east New South Wales and south-east Queensland forests: (Chapter 4),

Information about protecting and managing biodiversity values during management for wood production is provided (Chapter 5);

Guidance on potential commercial products (Chapter 6) and forest inventory techniques (Chapter 7) for assessing and evaluating the forest resource,

Understanding the market place (Chapter 8) and its effect on the value of existing and potential products. Examples from case studies for sellers and buyers is presented,

Harvesting and transport are costly and integral components of the wood production operations and descriptions of available equipment and common systems are provided in (Chapter 9),

With Chapters 1 thru 9 providing resource, background and explanatory information the decisions and outline regarding the production and implementation of the detailed Forest Management Plan (Chapter 10) are presented, and finally

A Glossary and Bibliography are presented for the benefit of Private Native Forest owners and extension officers.

Background to native forests in Australia

Native forests are comprised of a wide diversity of plants that provide habitat and food for wildlife, as well as timber resources ranging from firewood to highly valued veneer timbers. On the farm, forests can provide shelter for stock, material for fence posts and rails, firewood, as well as logs. The farm-forest can be a ‘value-store’ - providing saleable logs and sawn products when agricultural commodity prices are depressed (Parsons 1999). Some forest owners place a high value on the forests’ intrinsic characteristics, while others take it for granted.

Area

Statistics on the areas classified as suited to ‘commercial’ timber production on the eastern mainland states under private ownership /leasehold control indicate that there is 1,479,000 ha of closed forest with a further 12,730,000 ha of open forest. In the west there is about 24,000 ha of closed forest and 397,000 ha of open forest privately owned. Closed forest is generally of significantly higher productivity.

Queensland and the Northern Territory, between them, have about 54% of all native forests in the country and 67% of all native forests on leased land. It should however be noted that these are not usually the forests with high timber productivity.

Western Australia has 22% of the native forest estate, of which less than 4% is owned privately. 91% of these private native forest blocks are less than 15 ha in area (Parsons 1999). Western Australia figures indicate a harvest of 68 500 m$^3$ yr$^{-1}$ (BRS 1998) however it is uncertain how much of this was from clearing activity.

Volume

The annual volume of logs removed from private land in NSW has been approximately 200 000 m$^3$ yr$^{-1}$, Queensland 276 000 m$^3$ yr$^{-1}$ (Parsons 1999) and for Victoria between 25,000 and 40,000 m$^3$ yr$^{-1}$ (Penny pers. comm.). Together, this amounts to just over 0.5 million m$^3$ yr$^{-1}$ of timber leaving private land on the eastern mainland. Tasmania is actually the major producer, with 2,000,000 m$^3$ of logs from private forests across 800,000 ha of private land in 1999-2000 (P. Taylor, pers comm.), about four
times the total for the rest of Australia. Table 1.1 provides detailed information on the relative areas of private and leasehold forest in each State.

Estimating the sustainable level of wood production from private forests in Australia is not readily achieved. Private forest owners are under no pressure to sell regularly or to supply statistical details about areas cut and yields. There is no government sponsored system of systematic measurement such as those found in some other countries where private forestry is an important wood supply source. Little is known about private forest productivity levels.

It is believed that there is little active silvicultural management of Australia’s private native forests. Alexandra and Hall studied private forestry in the late 1990’s and noted that there were numerous industry, structural and bureaucratic impediments (Alexandra and Hall 1998). In the absence of active management, productivity levels are probably low.

Table 1.1. Forest area by crown and tenure category, for each state and territory

<table>
<thead>
<tr>
<th>Crown cover and Tenure class</th>
<th>ACT</th>
<th>NSW</th>
<th>NT</th>
<th>QLD</th>
<th>SA</th>
<th>TAS</th>
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<td>1. Closed forest</td>
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<td>17</td>
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<td>477</td>
<td>1396</td>
<td>15</td>
<td>17</td>
<td>1</td>
<td>24</td>
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<td></td>
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<td></td>
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<td>323</td>
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<td>127</td>
<td>4218</td>
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<tr>
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<td>4729</td>
<td>4524</td>
<td>1336</td>
<td>783</td>
<td>665</td>
<td>270</td>
<td>16124</td>
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<td>5937</td>
<td>6795</td>
<td>1659</td>
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<td>665</td>
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<td>3. Woodland</td>
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<td>1543</td>
<td>0</td>
<td>0</td>
<td>13877</td>
<td>61351</td>
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<tr>
<td>Total</td>
<td>3</td>
<td>9881</td>
<td>25007</td>
<td>32917</td>
<td>2520</td>
<td>0</td>
<td>372</td>
<td>15105</td>
<td>85805</td>
</tr>
<tr>
<td>All forest</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leasehold</td>
<td>13</td>
<td>5966</td>
<td>20236</td>
<td>23996</td>
<td>1866</td>
<td>0</td>
<td>0</td>
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<td>2327</td>
<td>801</td>
<td>1038</td>
<td>1502</td>
<td>42019</td>
</tr>
<tr>
<td>TOTAL</td>
<td>20</td>
<td>14012</td>
<td>31423</td>
<td>41107</td>
<td>4193</td>
<td>801</td>
<td>1038</td>
<td>15527</td>
<td>108121</td>
</tr>
</tbody>
</table>

Figure 1.1. Information roadmap for managing private native forest.

- **Property Management Plan**
  - **Agricultural Management**
  - **Forestry Management**
  - **Other Activities** (e.g. Mining, Tourism)

- **Scale of Operation**
  - Limited or one-off on farm use

- **Forest Management Planning**
  - **Level of detail**
    - Simplified
    - Detailed
    - Sustainability issues
    - Site and resource information

- **Resource Assessment & Evaluation**
  - **Chapter 1 & 2**
  - **Chapter 3 & 4**
  - **Chapter 5**
  - **Chapter 6**
  - **Chapter 7**
    - Silvicultural management
    - Biodiversity management
    - Product recognition
    - Inventory and evaluation

- **Product & Habitat Management**
  - **Chapter 8**
    - Markets possibilities / limitations
    - Legislative limitations
    - Silvicultural systems

- **Operational Planning**
  - **Chapter 9**
    - Harvesting / utilisation Systems
  - **Chapter 10**
    - Detailed operational plans

- **Profits**
- **Product Sales**

- **Whole of property** Planning phase
- **Review of product and sustainability Outcomes**
Sustainable forest management

Native forest types have many distinct attributes, which in combination generate different values for different people. The timber grower focuses on the quality and volume of the trees and how quickly they grow. In a wider context, the naturalist looks at the range of flora and fauna species, their interactions and the intrinsic qualities of the habitat. Often situated outside the forest, the catchment manager takes a different view again and may see the forest as a dynamic mix of soils and vegetation, generating high quality water on a perennial basis. Residents of the region, or passers by can gain enjoyment by simply seeing the forest. Sustainable forestry, taken broadly tries to manage to meet the widest possible range of interests such as these across regions, and to do so reliably through time. The detailed management of smaller areas (such as private property adheres to similar principles but cannot expect to meet every requirement.

Sustainability considerations have been applied to many activities in recent years, stimulated in part the Sustainable Development and more recently the Ecologically Sustainable Development discussions fostered by the United Nations, among others. Modern sustainability analyses recognise three major groups of interests: economic productivity, environmental values and wider social benefits. Sustainability recognizes that all three factors, economic, environmental and social are important.

In the early days of European settlement, bush resources were viewed as never ending. Economic resources were exploited to meet the timber needs of a growing country. Today, we know that forests are limited. All governments in Australia have moved to adopt principles of sustainability, not just in forestry, but also as a broad principle. Recognition of the need to jointly consider environmental, economic and social factors is now generally referred to as Sustainable Forest Management (SFM).

SFM analyses have led to re-definition of sustainable cutting levels for harvesting in many public forests and major changes to the balances between production and protection forest.

Sustainability is also recognised as important for private forestry. Nowadays there is an expectation that landholders will exercise good “stewardship” of their lands. This means working within sustainable production limits and recognizing the need to preserve functioning environmental systems.

Sustainable forestry concerns extend beyond the farm gate. The way in which you manage your forest has off-site as well as on-site effects that may have consequences for outsiders. These may be hunters, relying on the critical area of forest to support a population of deer; tourists appreciating the visual tranquillity of tree covered slopes; or distant irrigators and industry reliant on good quality water to grow and process food products.

It also matters what your neighbours do (and even their neighbours). Some important aspects of forest environmental systems (eg water yield, populations of some of the larger animals) operate at broad landscape scales and sustainability can only be looked at regionally. As yet, Australia has few systems to support the necessary level of interaction and planning BETWEEN forest owners and the broader environmental issues, but these are emerging.

The need for sustainable practices

The new broadly-defined sustainability approaches are important from the environmental perspective. Extensive land uses, such as timber harvesting need to be balanced in size and overall effect through time. It is critically important that successful forest regeneration occur, in such a way that populations of animals, trees and other plants are able to regionally maintain the biodiversity and sustain the health and vitality of the forest.

Active management is needed to maintain the forest in a productive state. Maintenance of high growth rates is important to those involved in timber production. Adopting the correct schedules of silviculture and using the appropriate equipment at harvest, followed by good practices during
regeneration and restoration phase, are all critical elements in ensuring long-term productivity, the protection of biodiversity as well as maintenance of soil and water values.

Farm-forestry activities have an effect in the district economy. Timber processing has local economic consequences. For example, increased local employment opportunities may arise from the farm forester’s efforts at value-adding.

There can even be international consequences. The acceptance of a range of agricultural and forestry products into overseas markets is now frequently dependent upon formal certification under an internationally accepted environmental standard. Certification may give the seller a marketing edge.

Most recognise that acceptance of the principles of sustainable forest management is now expected of forest managers. The important questions are “How to do it?” and “How to demonstrate that you are doing it”, not “Whether or not to do it?”. These guidelines are intended to help with the “How?”.
Chapter 2. Property management planning

Private native forest management planning is infrequently undertaken in Australia. When forest management plans are prepared they are of widely differing standards, content and coverage. Legislative requirements provide a major stimulus, but requirements are often fragmented and do not result in useful plans from the managers point of view.

In many instances the time frame being considered only extends to the immediate harvest and regeneration, whereas for the operation to show it is sustainable the plan needs to be long-term and interactive with other farm enterprise planning.

In order to properly manage and sustain their income, landholders generally undertake some form of planning. However planning on the farm is, in general, different to planning for public native forest. Farmers usually operate on marginal resources and because they tend to be ‘doers’ rather than planners they will generally establish a direction or goal and proceed stepwise, based often on intuition and experience. Frequently, planning information remains in their head.

A written plan, albeit simple, will help overcome many problems. This is because writing it down forces you to acknowledge and think through potential constraints as well as opportunities for action. The current view is that planning is necessary for effective management, but the effort needs to be in accordance with the scale of the operation.

This chapter sets out a desirable basic framework of forest planning in the context of farm-forestry. It identifies the hierarchy of plans, from the most general long-term strategic plans down to those covering forest management.

Principles of property management planning

The starting point in planning any new enterprise should be the ‘Big Picture’. The Property Management Plan (Figure 2.1) provides an overarching coverage of all the issues and their interaction. This is particularly likely in farm-forestry situations where forestry is likely to be only a part of the farming enterprise. The “new” enterprise must ‘fit-in’ and changes might need to be made in other areas so that it can be accommodated.

Figure 2.1 Relationship between the PMP and other farm management plans.
Whole property planning records the fundamental decisions about land allocation within the farm. Property maps (or annotated photos – Figure 2.2) form the basis for the more detailed individual enterprise plans. The hierarchical nature of an overarching property management plan allows decisions to be placed in context and the prioritisation of the various on-farm enterprises.

Figure 2.2. Example of a property plan layout – the map is but a small part of the Property Management Plan (Plan courtesy of North Forest Products).

Forestry planning hierarchy

There are no hard and fast rules to forestry planning. The common approach (followed by most larger forestry management agencies) is to recognise three main type of plan based on their time horizon. This leads to a long-term strategic perspective, a medium term tactical perspective and the immediate operations view (Figure 2.3). The functions of these plans are:

Strategic Forest Management Plan

These are the very important foundation plans for the forestry enterprise. They detail the assessment of the forest and land assets and condition, and taking the long term view (beyond the forest rotation, usually 100 years or more) set out the broad silvicultural and management strategy. The scope of the planning horizon exceeds the tenure of any individual planner or manager.
Medium Term Business Plans

These plans set out the business strategy for the forest enterprise. They typically focus on the nearer to medium term (2-10 years) and usually consider timing and sequence of possible sales and investment decisions and relate these to expected market conditions. These usually represent the active strategy of an individual manager, and an expectation that they will personally implement them.

Short Term Operational Plans

These are the task specific plans, often months to a year in time frame. They are drawn up to guide specific operations (eg. harvesting an individual compartment or coupe). They have a strong content of work instruction.

Figure 2.3. Forestry planning hierarchy.

Planning and management cycle for private native forests

Planning is an important component of the management cycle or system which is frequently presented as Plan, Implement, Monitor, and Review. (Figure 2.4). In the diagram the three types of plan are presented in the one box to highlight that they all contribute to the planning framework for the farm-forestry enterprise. The three layers of plans support each other. It is a good idea to develop at least the main parts of all three layers.

The circular nature of the diagram is also intended to emphasise that plans are never “finished”, they are always subject to review and revision in the next cycle, or when new data comes in.

A quick desktop analysis for newly managed forests

In the situation where farm-forest managers considering the potential of bringing their forest under management for the first time we suggest they approach planning and evaluation in two phases. In the first phase, conduct a paper or desktop “First Pass” analysis to assess feasibility. If this provides a promising indication, then proceed to a full plan development. Sound planning provides opportunities to:

- Make the best use of assets (e.g. soils, timber, finances);
- Help an enterprise to operate efficiently over the long term without undue effect on the community or the environment;
- Identify and resolve problems that constrain productivity;
• Optimise financial returns;
• Provide a basis for product certification;
• Meet legal and local planning requirements;
• Provide an information framework to next manager (there usually will be one given the long term nature of native forestry)

Here are some questions which should be considered in the ‘first pass’ analysis:

**Question 1. “Is it feasible and can it be profitable?”**

Generally what follows on from a conceptual idea is a quick assessment of the legalities (Can the area be harvested?), extent, quantity and potential of the resource and perhaps, local market opportunities.

Are there practical barriers making harvesting and transport particularly expensive? A detailed evaluation can follow later if it is decided that the overall proposition sounds feasible.

**Question 2. “If there is no resource to market now, what needs to happen to have a marketable resource at some point in the future?”**

For example, “Is there an appropriate thinning or fertilizer management strategy that could improve wood production?”

**Question 3. “Does forestry fit with the other farm enterprises?”**

Forestry might be a good “fill-in” job, but if the operation is substantial other factors need to be considered. Conflicts in time allocation and overstretching resources may add to the risk of failure. Identify, or be aware of your strengths and limitations as well as the expectations of other partners that will be involved in the enterprise.

**Figure 2.4. The management cycle.**
Guideline 2.1. Identify the outstanding and potential features of your forest

<table>
<thead>
<tr>
<th>Forest attributes</th>
<th>Land use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great timber trees</td>
<td>Timber production and education</td>
</tr>
<tr>
<td>Excellent wildlife</td>
<td>Tourism and education</td>
</tr>
<tr>
<td>Unusual vegetation</td>
<td>Conservation for biodiversity</td>
</tr>
<tr>
<td>Plentiful fish / feral animals</td>
<td>Fishing and hunting</td>
</tr>
<tr>
<td>Creates a good feeling</td>
<td>Recreation and conservation</td>
</tr>
<tr>
<td>Deep, stable soils</td>
<td>Water production</td>
</tr>
<tr>
<td>Looks good from afar</td>
<td>Landscape (enhanced property value)</td>
</tr>
</tbody>
</table>

…and then plan the strategies and actions that will make the goals happen.

Developing the forest management plan

The Native Forest Management Plan must go well beyond wood production and cover your management intentions for all major aspects such as protection of water quality and maintenance of biodiversity. The level of detail that needs to be applied will vary with different properties and circumstances. In some states this type of plan is becoming important in a legal context.

The following section is set out as a checklist for factors that might be considered. Assembling the information may take some time, but it provides a valuable reference that will assist future planning and prevent retracing steps at a future date. Six major steps will be followed sequentially:

1. Setting objectives
2. Property and forest management history descriptions
3. Specify the broad management
4. Inventory and evaluation
5. Specify the proposed forest management prescriptions
6. Fire management
7. Mapping forest management
8. Developing the native forest business plan

Setting Objectives

(Step 1)

The first step is to work out what you want to achieve. Questions you might ask yourself are:

- What do you want your financial situation to be in twenty years?
- What do you want the enterprise to look like (what business structure)?
- What is a sustainable level of output?
- What do you want your forest to look like?
Examples of some specific objectives could be:

“To establish an economically sound and environmentally sustainable forestry venture which will have the capacity to provide short and long term income.” or,

“To provide a means of involving and supporting the family in the future and to maximize after-tax profits”.

Property and forest management history descriptions

(Step 2)

This section can be completed in parallel with the mapping information and diagrams that are obtained or (see also Step 3).

Property details

- Owner and contact information;
- Property location (Name, road, locality; Local government area);
- Title description and tenure – lease or freehold
- (Lot numbers, Deposited plan, Parish and County and areas of each type of tenure).

Disturbance and management history

- Previous harvesting, thinning, regeneration;
- Previous fire–regeneration, fuel reduction, wildfire;
- Grazing, weed and feral pest management.

Specify broad management

(Step 3)

Depending on the forest’s size and composition, there is frequently an advantage to dividing the forest up into discrete management units. Sometimes this is based on differences in soils or vegetation. More commonly it is based on current forest condition e.g. tree size and growth stage. It is desirable that compartments have similar management requirements although it is also usual to divide larger areas, even where all other factors are similar, to provide for flexibility in the timing of management.

Determining management units

The most important aspect of management unit design is consistency in vegetative cover/composition.

Often management unit boundaries are set to run along important natural features such as drainage and ridge lines. The boundaries can also recognise any known limits or requirements of efficient harvesting or roading. However, in reality unless the area to be managed is large, farm boundaries, existing fences, tracks and roads often override natural limits in favour of cost and convenience.
As stratification/delineation of management units has direct consequence in relation to inventory accuracy - roads, fences and any other features have little to do with managing a stand according to its capabilities. In the process of stratification, timber production units may be identified that currently have insufficient access. In seeking defined and manageable units a ‘walk thru’ or ‘drive thru’ of the forested area will allow sketching (estimates) of the logical management unit boundaries onto the forest planning maps or photos and overlays. Areas with consistent forest structure and similar visual character (soils, understorey patterns, species etc) should be delineated. The following patterns are usually easily identified and will assist further decision making:

- Differences in past management intensity/practices,
- Units of different species composition,
- Areas that exhibit superior growth potential,
- Areas that could be managed for specific products (poles/piles),
- Non productive areas suitable for other uses,
- Special feature areas, recreation areas, specific habitat, etc,
- Areas where there is a significant difference in regeneration or trees per hectare, or,
- Areas that have a significant difference in forest type, predominant height or even average bole length (Pole unit, Sawlog unit or there may be a unit that has a species composition and bole length only suitable for fencing material).

The further break down of these units based on providing flexibility for timing and scale of operations is easily achieved after inventory has determined average harvestable volume (per hectare per unit). These management areas form the basis of the Forest Management Plan. Knowing the extent of the areas with commonalities may influence habitat management, the choice of machinery, or the most economic long-term method of harvesting.

**Inventory and evaluation**

*(Step 4)*

Assess what you have in terms that allow comparisons between properties, blocks, management units. At any stage discuss with local agencies who can advise on information source ands local knowledge.

**Landscape and climate**

- Geological instability (affects roading, intensity and extent of harvest);
- Soil type and erosion risk (affects productivity, water and aquatic values);
- Rainfall – pattern, amount and intensity;
- Flood /drought frequency;
- Fire and frost frequency;

**Fauna and vegetation**

Note the forest type, species (overstorey and ground vegetation, wildlife), rarity, habitat features, and diversity rating (Consult with Department of Conservation / National Parks and Wildlife).

- Identify forest types;
- Structure –age classes, height, stage of development;
- Condition – crown health factors, understorey health,
- Habitat factors – structural complexity, diversity; cover, tree hollows
- Presence of mammals, reptiles, birds, bats etc
- Unusual and uncommon patches of vegetation

**Potential forest management (wood and non-wood utilization)**

For each forest type and uniform area identify:

- The size of the area;
- Proposed management use (timber production, conservation, multiple use, water protection)
- Connectivity (proximity to other forested areas, continuous with other forest areas, access)
- Landscape “values” (skyline, visible from roads, visible from dwelling, aesthetic value)
- Fire management (fuel characteristics, access for self and emergency services, water availability)

**Products, markets and transport**

- Timber – Veneer, sawlog, posts, poles, chips;
- General – Honey, seed, cut flowers, water.
- Markets – Export, interstate, local or niche.
- Transport-Carriers and costs for different products;

**Specify the proposed forest management prescriptions**

(Step 5)

The next steps are to decide the proposed management activities and detail their objectives and the operational plans to achieve the outcomes: This can only be carried out after a detailed analysis of the resources, potential utilization, products and evaluation of economic factors. The following chapters (3 to 9) provide detail on silviculture, policy, planning requirements and decision based information which can instruct and inform the forest owner of the techniques, considerations and potential outcomes of forest management decisions.

With that background in the basic principles and factors affecting sound practices and economics, the more detailed forest management and operational plans can be formulated. Chapter 9 provides information on preparing and implementing the more detailed forest management plans. The property management plan can then continue to its logical conclusion as follows:
Forest management plans

- Silvicultural systems to improve wood and non-wood values
- Environmental management (relating to Codes of Practice)
- Harvesting systems where required
- Program of cutting operations where required
- Detailed harvesting and operational plans

Fire management

(Step 6)

The control of fire in native forests on farms is important for the protection of rural residents, property, timber and biodiversity assets. The need for exclusion of all fire or the management of controlled burning on farms depends on many factors such as forest type and age; climate; the wood and non-wood products present; and the proximity of buildings and other assets.

The compromise is always whether or not the benefits of controlled fire (protection, fuel reduction, silvicultural management) will outweigh the costs, disadvantages or the risks. If there are serious doubts about the risks – don’t burn. More details of the use of fire as a silvicultural tool are given in Chapter 3 but points to consider in developing the broad management plans include:

Fire as a management tool

- Necessity for hazard reduction burning
- Requirement for burning to achieve regeneration of forest type
- Assessment of structure and diameter classes of desired species
- Timing of burning regimes to reduce risks
- Applications for permits and assistance
- Purchase and maintenance of proper equipment
Fire protection and suppression

- Education and training
- Safety equipment and maintenance
- Emergency procedures and plans
- Safety zones for residents, fire crews and livestock
- Communication equipment and plans
- Water resources and accessibility (designated water points)
- Access to resource (roads and gates and signage)

In managing fire on the property fire risk, fire management and fire suppression strategies should be discussed with the relevant fire authorities and agencies in your area.

Mapping forest management
(Step 7)

Local government or land agencies can often provide resource and tenure maps which provide a starting point for large scale mapping, access and market appraisal. They will be aware of other useful maps at finer detail. A useful website for maps and aerial photograph information sources in each State is: [http://www.maptrax.org/](http://www.maptrax.org/). Further information on how to prepare a forest management plan from base resources such as photos or contour maps is provided in Chapter 10. Figure 2.5 illustrates a forest management map providing anecdotal and planning information.

Maps and Sketches

- Property plan or aerial photograph with boundaries of land uses.
- Roads and major tracks,
- Forest Management Areas including timber stands (on large properties);
- Biodiversity and critical flora and habitat areas (threatened species);
- Landslip and soil erosion hazard,
- Aboriginal and European heritage and archaeological sites.

Developing the native forest business plan
(Step 8)

Business planning is particularly important when significant investment or revenue decisions are being considered. The plan should cover the foreseeable future, for example the next five years. Key sections of a business plan include:
Roads and major tracks,

Objectives and business profile (What and who you are, where you are going);

Marketing (Trends, products, customers, strategies);

Production (Objectives, capacity, output, system and method, quality control);

Personnel (Objectives, labour, advisers, productivity, available time and skill);

Financial (Objectives, set-up cost and financing, forecasts, cash flow, records, insurance).

A detailed outline of business planning is not provided here because fortunately information provided for the general business planning framework is well documented. The reader is referred to publications such as "Writing your Plan for Small Business Success" (Brit 2000). The website http://www.sba.gov/starting/ is also a source of valuable advice in planning a successful business venture. Both references provide a solid framework on which to develop your individual business plan.

Note that. Marketing is addressed in Chapter 8. Harvesting (production in the list above) is addressed in Chapter 9.

Maintain Records

These are valuable for many reasons – taxation, occupational health and safety, business efficiency and succession, to name just a few. Records can include:

- Timber inventory;
- Information and assistance sources;
- Sources of labour and contractors;
- Suppliers of equipment and materials,
- Contracts, insurance.
**Guideline 2.2. Maps, photo scales and distance**

Map scale is often expressed on maps as a ratio and/or as a linear scale. A transparent ruler is a useful tool in measuring map distances.

**Ratio**

By way of example, **1:100,000 means** one unit (say 1cm) on the map represents 100,000 of the same units on the ground, or **1cm on the map = 100 000cm =1km on the ground**.

Large scale maps are often **1:5,000** Small scale may be **1:1,000,000**

**Linear scale**

Most maps have a linear or bar scale (and a North point for orientation). This is a visual means of representing the map scale ratio.

When drawing a map it is useful to **use a linear scale**, and show it on the map so that if the map is expanded or reduced during photocopying, the relative distances remain the same.

Linear or bar scale

```
0   1   2km
```

**Finding the scale of a photograph**

**Step 1.** On your plan of the proper locate the distance between two known points; for instance, two corners or two roads. Alternatively, measure the distance between the two selected points on the ground using a tape or survey chain (note: distances on plans are measured on a level plane).

**Step 2.** Measure the distance between the same nominated two points on your photo.

e.g. **Actual distance between roads is 1.6km**

  **Measured distance on the photo is 8.0cm.**

  **1cm on the photo is then = 1.6 / 8 = 0.2km or 200m or 20,000cm**

  The scale is **1cm (on the photo) = 20,000cm (on the ground) or 1:20,000**

**TIPS**

Regardless of scale, if you remove the last two zero’s the corresponding figure will represent 1 cm = x metres. E.g. **1:20,000 = (1cm = 200m)**

Aerial photos (unless ‘corrected’) will often have large distortions near their outer edges; so be aware that the scale may alter across different parts of the photograph.
Figure 2.5. Forest management maps and plans - for the long term.
Guideline 2.3. Complete a comprehensive forest management plan

- Specify the management objectives
- Describe (map) land and forest including management history (where known)
- Specify the broad management plans and possible management units
- Conduct detailed inventory of forest condition and values
- Describe the detailed management plan for each discrete management unit
- Carefully consider fire management strategies – including suppression
- Support the whole process with detailed mapping
- Develop the business plan
- Maintain good records
Chapter 3. Silviculture to improve forest condition and value

Active silvicultural (forest management) of the private forest resource has been rare in the past in Australia. Broadly, much of the forest estate is considered to be in a poor state. Descriptions have gone as far as “the wood of neglect” (Dargavel 2000).

Most harvesting has been exploitive, carried out by the landowners, millers (or their contractors) and has been conducted on the basis of selecting the very best trees. Much of the remaining resource now consists of damaged trees, or trees with poor form and vigour. Furthermore, in many instances on farms, the sawlog quality of many of the remaining trees has been compromised by the frequent use of fire to promote grass growth for grazing. Where grazing has been conducted, compaction by stock has often further reduced the potential for soil water storage and root growth and subsequently trees become more prone to disease and insect attack. Grazing also affects the composition of the understorey, which is essential habitat for some insectivorous mammals and birds. Reptile, mammal and bird have been affected by the collection of firewood from the forest floor which has directly affected habitat.

If the private forest resource is to ever achieve its sustainable productive potential, then pro-active and appropriate silvicultural regimes benefiting wood products or biodiversity (or both) are needed.

What is silviculture?

Silviculture is the management of forest stands and the trees they contain. Silviculture employs techniques which can alter the structure of stands by:

- removing trees to reduce competition and so accelerate the growth of those retained,
- removing damaged or undesirable trees or other vegetation components,
- altering canopy and understorey structure to promote timber or biodiversity values, and
- promoting germination and regeneration of desirable species or forest structures.

Techniques such as mowing, burning, fertilising, spacing, thinning, culling, various harvesting strategies and various regeneration techniques are used to achieve the desired objectives of management. The sequence and intensity of silvicultural operations needed to meet the objectives of different forest owners can vary widely, as can the purpose. Silvicultural strategies can be used to increase wood production and to encourage the development or increase in habitat components for biodiversity.

The choice of silvicultural approach is constrained by the requirements and capabilities of the tree species, and in some states by legislation, particularly those to ensure effective regeneration. Opportunity for change then depends on the current state of the forest.

Silvicultural objectives therefore reflect the owner’s objective, for example high quality sawlog production, or perhaps the maintenance of a suitable understorey for birds. Tree density and forest structure are manipulated to encourage the growth and development of selected parts of the forest. Decisions are based on the relative arrangement of trees, their height, crown condition, health, whether they shade or are shaded by other trees. Silviculture is practiced at scales from the tree-by-tree level up to the whole-forest (thousands of hectare scale) where it is frequently undertaken by a mechanical application of broad silvicultural policies and prescriptions.
In maximising tree growth (usually for wood production) the “tree-by-tree” approach offers the opportunity to prescribe the best solution and possibly maximise response for the site but at the cost of the silviculturist’s time. The latter, “broad scale” approach offers economy in application, but runs the risk of ignoring local variation with lower averaged stand responses. The farm-forester has the potential advantage of being able to focus on the small scale, site-specific approach and maximise stand response.

It is important to note that the vast majority of forests on private land are highly modified and often severely degraded with regard to productivity and health. As forests decline they continue to lose productivity and to rejuvenate them requires often drastic silvicultural regimes to ensure the long-term return to health and productivity – there are no short-term fixes. The continued selective harvesting of the best trees - called ‘high grading’ - without regard to the sustainable health and productivity of the forest will lead to further and more drastic decline. Uncontrolled regeneration in gaps (large or small) or cleared areas, without judicious removal of selected damaged and poor quality trees will adversely affect the productivity and health of the regeneration – continuing the cycle of decline.

**When do we apply silvicultural treatments?**

To manage a forest of a desired structure which already reflects its management objectives (production, biodiversity and sustainability objectives) attention needs to be paid to the health and condition of the various components (tree crowns, understorey development, species interactions, tree growth/vigour and the expression of competition). Increases in competition factors, changes in crown conditions or localised disturbance require monitoring AND management to maintain the overall objectives within the forest’s capability.

To improve and then maintain the productivity and health of a stand of trees which is in poor condition (due to previous harvesting strategies or natural catastrophic disturbances), most poor quality and damaged trees should be harvested during the initial cutting cycles leaving suitably spaced healthy trees with crown and stem characteristics which indicate the potential for more vigorous growth and development. This is achieved by culling, selective harvesting, or thinning, and can alter the structure and the species mix with consequent changes on the various ‘values’ of the forest. Depending on the forest type, the stage of maturity of the forest and the requirement to provide habitat trees – some damaged or poorer quality trees would be retained either as habitat trees, seed sources or ‘shelter’ for developing regeneration.

The numbers and spacing of the retained trees for whatever purpose (sawlogs, habitat trees, potential sawlogs, potential habitat trees, poles, posts, regeneration) will be determined after consideration of the potential productivity of the site (e.g. soil type, rainfall) and the physiological and silvicultural requirements of the species.

Species vary greatly in their susceptibility to suppression, and in their ability to respond to release from suppression. Some species will respond to release by thinning or spacing even after many years of almost no growth. Response can also vary within species between regrowth of seedlings, coppice or lignotuberous origin.

Tree diameter distribution also has direct implications for stocking densities i.e. the larger a tree gets the more growing space is required. There are significant differences in the appropriate distribution (trees per hectare) of diameter classes e.g. under 10 cm dbhob (diameter at breast height over bark), 10 - 20 cm dbhob, 20 - 30 cm dbhob, etc depending upon species susceptibility to suppression, site quality and the regime that is being applied. In addition, the harvest systems which are allowed in your State may determine that a pseudo-plantation style of management i.e. cyclic clearfall coupe is appropriate. As such, forests with even diameter class may be produced which will drastically alter the appropriate stocking at certain stages of forest development. Again, site quality and species will
... whatever the scale of management some knowledge of the complexities of forest habitat, health and silviculture is essential ...

Tree diameter distribution is a highly complex aspect of forest management due to a wide range of variables. In other ways it can be extremely simple as a landholder develops a gut feel for tree spacing based on crown health and placement. Assessing the appropriate diameter distribution of any forest is like a snapshot in time where we basically pre-empt natural selection.

It is important to note that change in silvicultural or biodiversity objectives would require some alteration of the silvicultural strategy applied to these and any other forest. Subtle changes in forest condition across the site may require adjustment in tree selection, retained tree spacing and product potentials.

Whatever the intensity or scale of management some knowledge of the complexities of forest habitat, health and silviculture is essential to making the most appropriate decisions on-farm. Manipulation of forest structure and even individual tree crowns and boles requires knowledge of the growth and health consequences to both trees and stand. Individual species have differing responses to competition from other vegetation. Not all species are regarded as potentially profitable or suitable for management of potential wood products.

This is the art and science of silviculture

**Silviculture to improve condition, growth and value**

**Understanding forest structure, health and potential for wood production**

Silvicultural planning is one of the major components of Forest Management Planning (refer to Chapter 2). Commonly, in native forest management, the forest is divided up into zones (termed forest management units) based on forest condition and past silvicultural management. This is an area where the smaller scale private native forest management might have an advantage. The private forest owner often develops an intimate knowledge of their forest and can adapt forest practices to suit their circumstances and objectives. The options for the future management of the forest to achieve any or all of timber production, flora and fauna protection or water yield, are determined by the condition of the forest, forest type, commercial potential, markets, biodiversity and an array of personal preferences.

**Forest structural attributes and their manipulation**

The age of the tree, understorey and groundcover components (juvenile, immature, mature and over-mature), their physiological origin and development (seedling, coppice, lignotuber, rhizome) and habit (single stem, multi stem, creeper etc) combine to determine the structural character of the forest. Two main management divisions are recognised for forest in Australia - the uneven-aged forests where regeneration occurs principally through gaps in the forest canopy and the even-aged forests, even if they are in distinct patches within larger forest areas, have stands that originate from the same regeneration event, often-severe fire. The uneven aged forests effectively have no definable age. They are frequently described by the growth stage of the oldest of major component.

Eucalypts, especially the ash species, can regenerate with up to 250,000 trees per hectare surviving the first year. Over the subsequent decades the dominant trees assert themselves and suppressed trees die to leave a well-spaced forest with as few as 150 trees per hectare by the time the trees left reach maturity. The carrying capacity of a stand (number of healthy vigorous trees which could be
supported varies with species characteristics and with site quality factors. Regeneration in denuded areas (clearfalls) and suitable gaps (selective logging) will vary in density depending on light, soil and climatic conditions following the creation of the growing space.

Eucalypts can regenerate and grow rapidly to take advantage of openings in the forest but growth can also quickly slow or cease when the developing trees begin to compete with established overstorey and other vegetation. Even following release from competition by silvicultural intervention (spacing, thinning or selective logging) trees can quickly begin to suffer from competition effects. The length of time that released trees can maximise their growth patterns depends on site quality and species characteristics.

**Forest health and condition**

When assessing the health and condition of a forest, or selecting trees for retention, it is important to evaluate factors which indicate health and vigour of the trees in the forest type. This applies equally to mature, developing and regeneration forests.

Since the tree crown (viz. also ‘crown’ structure of understorey plants) is the machinery which collects energy (light), converts this energy (photosynthesis) into products and builds the support systems (stems, branches, roots) of the tree it is of prime importance in forest health. The health of the crowns reflects forest condition, growth and vigour and potential response to changing conditions. Ultimately the crown determines the development of the chosen products.

Without appearing too whimsical, a forest is very like a manufacturing plant. The crowns of the trees are the various engine rooms that make the products. The engines produce stems (products) that support the engine rooms (in their quest for light to facilitate more production). Engines (individual crowns) that are not performing at their peak become inefficient, produce less product and without proper maintenance will fail prematurely. Engines (crowns) that have served faithfully for many years will eventually wear out (this is unavoidable) and therefore eventually fail. Good product (wood or non-wood) management encourages peak performance, manages all levels of products and objectives and is prepared to evaluate and replace components to maintain overall factory (forest) performance objectives.

Crown management then is the key to successful management of any silvicultural treatment and nearly all wood production management objectives.

Grimes (1987) has developed a crown assessment system which is capable of identifying slow and fast growing trees of Spotted Gum - Ironbark forests and relating various aspects of each of the characteristics with their growth rate. Research over a long period of time concluded that mean annual diameter breast height increment was reflected in weighted totals of five recognisable crown factors. These factors are good indicators of health, vigour and potential in many species other than Spotted - Gum Ironbark forests, even without the established relationship between the crown factors and breast height increment.

In Grimes’ system the five crown factors are:

1. **Crown position**
   The position of the tree crown relative to adjacent crowns. The entire crown may be open with no competition from above or the side. In total contrast the crown may have no direct access to light either from above or the side and in a completely suppressed position. Rating is scored from 5 (open) to 1 (fully blocked) in five classes.

2. **Crown size**
   Considers the depth, width and shape of the crown (this normally varies with stem diameter and with the species). Many regrowth species for example in the sapling and pole sizes have conical
shaped crowns which round off as the tree matures. Assessment varies from recognition of wide, deep and roughly circular plan without obvious faults to an unproductive crown which is very small and ungainly. Rating score from 5 (no faults) to 1 (small ungainly) in five classes.

3. **Crown density**

A ‘measure’ of the trees’ photosynthetic area which is assessed by the distribution and density of the foliage clumps in the crown. This can vary dramatically with species. Assessment varies from very dense even clumps with even distribution throughout the crown, to very few leaves anywhere in the crown. Rating score from 9 (dense, even) to 1 (very few leaves) in five even-spaced classes.

4. **Dead branches**

When assessing dead branches - thinned dead branches found just inside the leaf zone are ignored as commercial eucalypt species generally shed their lower branches to form clean boles. Dead branches within and on the upper extremities of the crown are assessed. Crowns are assessed from those which have no visible dead branchlets or branches in the crown apart from thin twigs and lower shedding branches to larger and small branches obviously dead or dying over most of the crown (rating score from 5 (none) to 1 (many) in five classes.

5. **Crown epicormic growth**

Epicormic growth usually occurs after some causal agent has instigated branch death or die-back, causing a consequential slowing of growth. Or it may occur in over-mature crowns where branches are dying. A normally healthy crown has the foliage concentrated at the branch extremities and so epicormic growth along branches suggests ill health. Assessment ranges from no epicormic growth to epicormic growth being present over most of the crown and stem. Rating score from 5 (none) to 1 (everywhere) in five classes.

Each crown characteristic is given a score and an end tally ranks the growth potential from poor to excellent. Scores are weighted in the order of crown density > crown position, crown size, dead branches > epicormic shoots. This is a relatively easy system to use and is invaluable in choosing the best trees for selection. Even looking at the five factors of crown health, often it will be immediately obvious which crown is best and therefore deserves highest consideration for retention. It is essential to look at the 5 factors of crown health, as these together determine health, vigour and likely response.

A tree with a crown showing deterioration, damage or senescence is unable to give maximum stem response (product) even if retained in a suitable growing space. Thinning and selective harvesting operations should retain trees with the greatest potential to achieve the objectives – those trees with product potential AND with healthy, responsive crowns.

The factors described above give indications of crown health and vigour and therefore trees with higher scores (healthier crowns) are preferred. Naturally there will be often some areas of a stand where there is not much choice and poorer quality stems and crowns (with less potential) may need to be included. Not forgetting of course, that poor quality, damaged stems and crowns might also be chosen as they can increase biodiversity potential within the stand.

Comparison and evaluation of crown condition is done within age and structure classes to compare trees (i.e. poles vs. poles, saplings vs. saplings, old trees vs. old trees) for selecting within components. The general condition of a component such as ‘advanced growth’ will provide information on the health and condition of those trees which are affected by older trees, disturbance factors (fire, insect attack etc) and give insight into the level of stand competition (suppression by older and larger trees), competition between advanced growth (affects of stocking density) and nutrition (poor growth and vigour). All of course, affected by, site quality and stocking capacity.

**Vigour**
This description is difficult to quantify and really reflects a ‘healthy’ tree which is exhibiting a good response to its environs. A vigorous tree is usually obviously well developed, healthy, as tall as or taller than its surrounding similar age cohorts and not exhibiting any defects which may reduce future growth. A damaged tree may be ‘vigorous’ immediately after the damage but this damage may effect its future competitiveness in the stand – i.e. (a) branch damage to the top or one side of the crown may affects its later development. (b) stem damage may allow pathogen entry and degradation of wood, sap wood flow etc which could reduce growth, competitiveness and product potential.

Form

Form characteristics vary between species but are generally critical to the evaluation of potential products. Eucalypts grow towards the light and when stocking density forces competition (even small amounts) the apical dominance of trees will force growth mostly upwards and ‘away’ from the surrounding crown competition. Without competition from close neighbours most eucalypts will grow upward but also outwards (to many times the diameter of the stem). Where surrounding trees are not evenly distributed trees may grow irregular crowns (towards the most light) and developing stems will ‘bend’ towards the most light.

Most eucalypts are shade-intolerant to a large degree although species that are more shade tolerant may grow with reasonable form (but less vigour) in low light conditions.

The preferred ‘form’ characteristics of most timber products are straightness and as long a length as possible to allow efficient handling. Form and length generally provides:

- Maximum structural wood content in the tree
- Easy and efficient harvesting and handling
- Maximum product choices (types and lengths)
- Efficient sawmilling processes.

Trees of good form and height have often been the most vigorous of competitors in the developing forest and are likely to further response to release from competition. They may also contain the most wood product. However the form of a tree does not need to associated with tree height per se but matched to the products. Shorter trees of ground durable species make valuable fence posts – and other desirable product lengths are quite variable.

Bole length and quality

The bole describes that portion of the tree which is most valuable and usable for timber products and in most trees can develop into a long length of straight, clear (branch free), sound wood – especially on higher quality sites. Eucalypts growing in close proximity to other trees and understorey are generally efficient at branch shedding and develop clear boles as they progress through sapling and pole stages of growth. If the growing space is irregular or there is too much open space around an individual then bole shapes may change, tree stems may bend or crowns may spread their crowns into the space and forego height growth (which will reduce future bole length). Insufficient regeneration stocking, damage during development and poor crown growth on poor sites can all affect bole development and therefore potential value.

Trees are most often graded and selected on the basis of bole length, straightness, shape, branch characteristics and absence of visible defects or damage. ‘Product length’ is used to partition the bole into different types of products were that is appropriate i.e. sawlog length + pulpwood length; or post length + firewood length.
Habitat values

In nature it is often the most complex systems that create the greatest diversity of habitat. This variation in habitat and food sources is created in the forest through combinations of soil and water availability; groundcover and ground structures (old logs, rocks, etc); differing layers of vegetation; and climatic and seasonal conditions.

Often the most favourable conditions for a diverse range of species (including a range of trees, shrubs and ground plants) are a eucalypt type overstorey with a dense and healthy understorey. Therefore silvicultural practices which maintain or develop these components in a healthy condition need not reduce habitat ‘value’ – especially when there is a mosaic pattern of silvicultural management and untouched forest. Evaluating a forest for biodiversity requires an understanding of species, habitat requirements and biological patterns (feeding, breeding) and a quick assessment of habitat value is often restricted to recording the number and type of components that provide complexity (i.e. characteristics of logs, litter layers, understorey species, overstorey species, heights and density of vegetation layers, tree hollows, dead trees, old trees etc.)

Other value characteristics

Healthy forest can provide many other aesthetic and product values (recreation, food, energy, medicines, water quality, and erosion control) to a landowner or community (local and regional). The scale is usually the limiting factor for providing community values and hence the other values realised on farms are more along the lines of potential for bee-keeping, cut-flowers, ornamental wood products (burls and wood turning pieces).

Evaluation of some of these factors is often difficult but when considered in addition to other management strategies can provide the landowner with value adding alternatives or activities complementing silvicultural practices.

Management of forest stands and stand components

The way in which forest stands are managed is determined by the growth stages of the trees making up the stand and on current forest condition. The health and condition of the crowns, tree form and vigour - especially in trees undergoing competition and suppression - affect the productivity and potential of the stand and needs to be evaluated in determining management strategies. Easily recognisable forest stand conditions are:

1. Mature to over-mature stands of mostly old trees, possibly ready to be harvested and requiring regeneration strategies, or with patches of regrowth and advanced growth
2. Regeneration forest after gross disturbance (e.g. wildfire, cessation of agriculture or grazing)
3. Young trees (saplings), often in dense clumps of even-aged trees, many of which may be suppressed and therefore not provide commercial products if harvested;
4. Mid-aged stands with competing trees of even- or uneven-aged classes that could provide commercial products if harvested;

Uneven – aged forest will generally be more complex due to the presence of more than one age class. Understanding some of the complexities and relationships will promote the development of sound management decisions based on appropriate forest inventory and manipulation of density and structure to meet wood and non-wood objectives.
Figure 3.1. Strategies in the life cycle that can increase health, productivity and condition of the forest.

Over Mature
Or
Poor Quality
Conservation, Selective harvesting, Seed trees, Clearfall
Regeneration control, Habitat manipulation
Utilisation, Culling, Burning, Disturbance, Gap creation

MANAGING
NATIVE FORESTS
FOR
WOOD and/or NON-WOOD
VALUES

Mature stand
Selective harvesting
Habitat manipulation
Manual Culling, Gap creation

Regeneration
Early spacing, Stocking control, Species control
Mowing, Poisoning, Manual culling, Fertilisation

Mid-aged
Immature or Pole stand
Selective harvesting, Commercial thinning
Product manipulation, Habitat manipulation
Poisoning, Manual Culling, Fertilisation

Young trees
(saplings)
Early spacing, Stocking control, Species mixes
Habitat manipulation, Product manipulation
Slashing, Poisoning, Manual culling, Fertilisation
Mature and over-mature stands and stands of very poor health and quality

Much of our existing mature forest consists of tree of older age classes exhibiting poor quality and damage. Depending on the site quality these stands may have a range of size classes or dominant and co-dominant trees with a well developed understorey structure. Individual tree health may be poor in quality as many of these trees will have senescent crowns or will have been trees left behind after high grading silviculture. Depending on site quality, there could be as few as 100 stems per hectare. On higher quality sites there could be many more trees. These forests are often in an unproductive state, productivity usually declines with age in eucalypt forest. However, regeneration may be suppressed or non-existent as a result of the previous history of the stand. To re-invigorate the stand and to produce a change in stand condition in the longer term, regeneration practices will need to be managed. The removal of most or all of the poor quality and unproductive trees will allow management of regeneration strategies to rejuvenate the forest. Habitat management of these types of forests may indicate that, for biodiversity, these forests should remain untouched. To do nothing in these forests will lead to further decline and could in fact bring about a change in forest type altogether. Careful management of any harvesting strategy and careful management of the regeneration developed as a result of harvesting can lead to enhanced productivity and sustainability of long-term biodiversity values.

The presence of mature and over-mature trees could suppress regeneration to such an extent that productivity could be lost and forest structure cannot be maintained.

Depending on State Policies a number of silvicultural choices can be made at the time of final crop harvesting. These general strategies and the main factors that influence their choice are discussed below:

- Single tree selection
- Group selection
- Patch cutting
- Shelter wood
- Seed tree
- Clearfelling

The choice of silvicultural practice is strongly influenced by three factors (i) What silviculture is allowed within your State (ii) What does the tree species need for regeneration and good growth? and, (iii) What is the current condition of your stands? (Where are you starting from?).

The main variable is the tree species’ tolerance to shade during regeneration and early growth.

**Single tree selection**

This system is based on the selection and felling of individual trees. Regeneration and or recruitment of replacement trees needs to be achieved in the gap made by the removal of just one canopy. The approach is successful with species that have a high tolerance of shade, for example, Coachwood (Ceratopetalum apetalum) and White Cypress Pine (Callitris glauca). Tolerance for shading means that seedlings can survive and grow in lower light conditions. Many eucalypts do not possess a tolerance for shade and do not regenerate well under the canopy of larger trees.

A frequent practice in the earlier days of Australian forestry, when logging was controlled by millers, was to take out only the best species and largest trees. This is termed ‘high grading’. This generally
resulted in forests stocked with the remaining low value trees with poor growth rates and a low regeneration of desired species.

Correctly conducted, in appropriate forest types, single-tree selection over a range of size classes and species should result in an overall improvement in the quality of the timber on the block. Improvement in the value of the retained growing stock can be achieved by removal of other trees on the basis of them being over mature, reaching their full economic potential, slow growing, of poor form or degraded and damaged.

**Group, gap or patch selection**

This form of harvesting involves harvesting small areas (groups or patches) of trees at any one time. Gap sizes range from a few trees up to a hectare. This technique is more applicable to tree species that are intermediate in their shade tolerance; examples are Blackwood (*Acacia melanoxylon*) Turpentine (*Syncarpia glomulifera*), Brushbox (*Lophostemon confertus*), and Grey Ironbark (*E. paniculata*). It is also applied to eucalypts, (Australian Group Selection) with gaps toward the larger size. With light demanding species, regeneration is frequently best in the centre of the gap. Both regeneration and tree growth near the edge suffer shading and competition for resources from edge trees.

![Diagrammatic representation of (a) Single tree and (b) Group selection](image)

**Shelterwood**

The system can be used where species are able to regenerate in some shade and remaining shelterwood trees are not likely to suffer windthrow. Typically, this system is applied in higher elevation, mixed-species forests (for example, Mountain Gum *E. dalrympleana*, and Alpine Ash *E. delegatensis*). Shelterwood systems offer protection (principally from frost) for the development of a young forest. Older shelterwood trees are harvested when the young crop is safely established. Scattered old-growth trees can be left for habitat, but as was the case for group selection, the effect of shading and competition on regeneration should be considered.

**Seed tree**

The seed tree system relies on seed-fall from retained trees for regeneration. Care must be taken to select trees that have an adequate crop of seed. The system is often used in low-elevation mixed-species and also River Red Gum forests. Care is required in the selection of seed trees as this has a major influence on the species mix of the regenerated forest.
Guideline 1.1. Shelterwood selection

Shelterwood management can proceed in 2 or 3 steps. The first thinning may or may not provide enough light for regeneration, but a heavier second thinning, maintaining uniform canopy with well spaced crowns, will not inhibit light, but still protect young seedlings from frost. A basal area of 12-14 m²/ha is recommended for wetter sites (>800 mm) and 9-12m²/ha for drier sites.

Clearfelling

Clearfelling is currently not allowed in Queensland and is often a special circumstance in other States where it is judged against the requirements for habitat trees and seed trees to facilitate regeneration. It is imperative to check your local regulations with Government agencies.
This method of silvicultural management is used where seedlings of a species are shade intolerant and need the substantial exposure of sunlight to germinate and grow, for example, Alpine Ash (*E. delegatensis*), Mountain Ash (*E. regnans*) and Silvertop Ash (*E. sieberi*) or where a stand of trees is uniformly poor and total renewal of the stand is appropriate. The major concern with clearfelling is to ensure adequate supply of seed or advanced regeneration. Seed sources for many eucalypt forests are predominantly in the heads of the felled trees. If seed supply is determined to be inadequate, then artificial seeding might be necessary.

Clear falling (and patch cutting) can generate a large quantity of low-grade logs. The economics of the operation are greatly enhanced if these products find their way into the pulpwood or firewood markets.

While clearfelling can create larger areas of even-aged forest on regeneration, when repeated in smaller patch sizes a mosaic of age groups can be created. The progressive approach has advantages for wildlife as compared to one-time treatment of the whole area. Of course, the initial change in habitat in the smaller patches is dramatic and can be long lasting. More and more clearfell is considered to be a drastic last resort used for highly degraded stands suffering from severe suppression and a lack of potential healthy and developing trees.

Timing of the harvest must be well planned to maximise regeneration (potential seed crops must be present or natural regeneration strategies will fail due to lack of seedlings. Insufficient tree seedling numbers can lead to a dominance of weed species and/or a change in forest composition. Inadequate moisture for germination and survival because of poor seasons could also cause failure of regeneration. If fire is used to promote seed bed development, then timing also plays a major role.

**Guideline 3.2. Clearfelling - A few tips**

Clearfelling – IF IT IS ALLOWED IN YOUR STATE OR CIRCUMSTANCES - can be conducted in strips; but some important things to note are; firstly the strips should be wide enough to expose a significant area to direct sunlight. They can be aligned north-south to minimise the shading effects on the regenerating forest.

If clearfelling is to be conducted in large patches, seed trees might need to be left to provide for regeneration (rule of thumb - tree height approximates seed fall distance). The best seed trees are not always the best habitat trees and consideration must be given to how the situation will be managed for the long-term beneficial outcome.

**Figure 3.5. Diagrammatic examples of (a) open clear-fall with seed tree and (b) strip clearfell system**

![Diagram (a)](image1)

![Diagram (b)](image2)

Harvesting techniques used in different forest types are generally designed around the specific requirements for regeneration. Natural regeneration of even-aged forest more frequently occurs as a
result of large scale events such as fire. Figure 3.6 provides an example of typical decision sequences for silvicultural choice in dry mountain forests.

**Figure 3.6. Choosing a dry eucalypt forest silviculture system (Adapted from Orr 1991).**

- **Ensure that wood production is appropriate**
  - **Is there a buyer for pulpwood/residues?**
    - **YES**
      - **Are there sufficient potential sawlogs to retain for later harvest?**
        - **YES**
          - **Potential sawlog retention**
        - **NO**
          - **Are there areas of regrowth or**
            - **YES**
              - **Regrowth retention**
            - **NO**
              - **Is additional regeneration required or regrowth and potential sawlog content low?**
                - **YES**
                  - **Altitude greater than 600m**
                    - **YES**
                      - **Shelterwood retention**
                    - **NO**
                      - **Grassy understorey or low potential for productivity (poor soil/low rainfall/stony)**
                        - **YES**
                          - **Seed tree retention**
                        - **NO**
                          - **Clearfell for wood production or use alternative system if other values are higher priority. Seek advice**
                - **NO**
      - **(If sufficient) Selectively cut for sawlogs**
Post harvest management

Once the harvesting operation has been carried out, then its adherence to its objectives needs to be monitored. The proposed spacing given to retained stems should be close to the specifications given to the operators (or the ‘do it yourselfer’).

Attention paid to directional felling and the location of temporary and perhaps permanent landing areas will mean efficiencies in further silvicultural activities. Debris which is spread higgledy piggledy will create access and efficiency problems in later harvest, may affect successive regeneration and will certainly increase fire risk for individual trees and within the stand.

Too much distance between trees, or damage or stress on retained trees may encourage epicormic growth and branch development to the detriment of future value.

As a general rule, older trees require more space than younger trees and crowns require sufficient space for a growing tree to maintain a healthy and growing crown and to allow it to grow into the space.

Regeneration forest after gross disturbance

Following major disturbance such as severe wildfire all of the previous vegetation may be defoliated, burnt or killed; even the mature trees. If sufficient seed was available or remains following the event then a carpet of regenerating vegetation can occur (including trees, shrubs and ground cover species). Forests may be manipulated (seedling removal, density control to favour one or more group of species for the preferred development of a particular products or products or for a particular forest structure. Management in this way can alter long term productivity, profit or biodiversity.

Regeneration may be seedling, coppice (from previously cut stumps) or lignotuberous (from basal swellings common to most Eucalyptus sp. Any or all of these are capable of producing vigorous regrowth and can grow on to become healthy, large and valuable trees.

Soil disturbance and/or poisoning can be used to manipulate the species mixes, especially between tree seedlings and other vegetation. Mowing, combined with a selective poisoning, is a convenient method of managing tree density and species at this younger age. Strips can be mowed in one or two directions to reduce numbers while maintaining the species diversity. Selective poisoning to favour particular species could be carried out in the remaining un-mowed patches. In some States, Acts governing vegetation management may require the maintenance of species composition as per the ecosystem type – check the local legislation.

Young trees in sapling stages

Spacing is a natural process which occurs during the development of the stand. Competition causes the eventual death of many trees - leaving more room for the remainder. Spacing (or non-commercial or pre-commercial thinning) can accelerate this process by pre-emptively removing a proportion of the stand. This results in higher production and faster returns from the forest by reducing the usually long period of competition and allowing the selected trees to utilise all the light, nutrient and water resources of the site from an earlier age.

Early spacing is an expense with no immediate income and is generally conducted when the forest is between 5 and 20 years of age. The operation is implemented on the basis that financial benefits will be achieved by significantly reducing the time to grow the sawlog trees or significantly increasing their value. Work by CSIRO on pre-commercial thinning has demonstrated a 30-90 % increase in the growth of retained trees tapering off over 10-15 years as the forest canopy and root systems fully re-
occupy the site. Younger regrowth respond more strongly to thinning compared to a older stands. Even greater responses are achieved on some sites with the addition of fertiliser.

By accelerating growth, early spacing can provide an option for an early thinning yield of timber products. Thinning experiments in Silvertop Ash (*E. sieberi*) at age 10-15 years, for example, allowed later commercial thinning at 35-40 years (Raison et al 1995), with the retained trees expected to achieve sawlog size at a much earlier age, say 65 years instead of 80 - 100 years.

Competing young saplings in even-aged forest generally have more conical crowns (with small branches) as they grow upwards towards the light and away from their neighbours (which are usually close). Open spaced saplings may have more rounded crowns. Crown shape, health and density are easy to judge and trees already suffering suppression may exhibit ungainly and irregular shaped crowns or stems which bend towards gaps or away from more dominant trees.

The spacing requirements for species and product development vary and some detailed silviculture will be covered in case studies and further sections. As an indication - a forest managed for maximum bole growth from a young age requires enough trees to maintain form and promote height growth and for a forest where commercial products may be cut a number of times (thinning or selective logging) throughout the rotation this would be around 1500 -3000 stems ha⁻¹ or 2-3 m apart (Table 3.1).

This allows for more selection options and re-assessment of product in later cuts to maximise retained tree value and health.

### Table 3.1. Table of nominal tree spacings and approximate stems per hectare achieved.

<table>
<thead>
<tr>
<th>Nominal Spacing</th>
<th>~Stems per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 X 1</td>
<td>10000</td>
</tr>
<tr>
<td>2 X 2</td>
<td>2500</td>
</tr>
<tr>
<td>3 X 3</td>
<td>1111</td>
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<tr>
<td>4 X 4</td>
<td>625</td>
</tr>
<tr>
<td>5 X 5</td>
<td>400</td>
</tr>
<tr>
<td>6 X 6</td>
<td>278</td>
</tr>
<tr>
<td>7 X 7</td>
<td>204</td>
</tr>
<tr>
<td>8 X 8</td>
<td>156</td>
</tr>
<tr>
<td>9 X 9</td>
<td>123</td>
</tr>
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<td>10 X 10</td>
<td>100</td>
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<tr>
<td>11 X 11</td>
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<td>12 X 12</td>
<td>69</td>
</tr>
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<td>13 X 13</td>
<td>59</td>
</tr>
<tr>
<td>14 X 14</td>
<td>51</td>
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<tr>
<td>15 X 15</td>
<td>44</td>
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<tr>
<td>16 X 16</td>
<td>39</td>
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<td>28</td>
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<td>23 X 23</td>
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</tr>
<tr>
<td>24 X 24</td>
<td>17</td>
</tr>
<tr>
<td>25 X 25</td>
<td>16</td>
</tr>
</tbody>
</table>
Early spacing - Which equipment can be used?

The axe or tree girdler (ringbarking) is laborious and time consuming and impractical if used to treat large numbers of trees. On large trees ringbarking can also be achieved using a chainsaw to girdle the trees making girdle cuts about 20-30 cm apart into the solid wood of the tree.

Brushcutters or clearing saws while less labour intensive than ringbarking, allow coppice regrowth to occur in some species and these continue to compete for site resources. (Coppice refers to the ability of cut stumps to re-sprout). A brush cutter is useful in very dense stands of small diameter trees (<5-10 cm) that are too small to strike with a stem injector.

Small chainsaws with cutting bar capacities between 30 and 40 cm³ have also been used for thinning, but need to be fitted with a chain brake and be capable of continuous running at all angles. Chainsaws, when used for clearing regrowth thickets are a slow, dangerous and laborious operation. Most application has been in stands with larger stems (10-15cm). The problem with using both the brushcutter and the chainsaw is the build up of slash in the work area, compromising safety and increasing the post-operation fire hazard. A chainsaw buyer’s guide is published annually in the New Zealand Forest Industries Magazine and details suitability for different tasks.

Tractor-driven slashers can be used to cut a swathe through regrowth vegetation (e.g. http://www.quadco.com). Purpose-built machines mount the cutter unit in front of the base machine. While these have proven effective in reducing stem numbers in dense stands, such as those resulting from fire regeneration, they are restricted in effectiveness if there are stumps, logs or other obstructions hidden from the operators view.

Figure 3.7. Brushcutter early spacing in silvertop ash (E. sieberi) forest.

Stem injection is the most widely practised method of eucalypt spacing. It has several advantages over other methods of thinning. The activity is faster and easier work than slashing or brush cutting. In addition, slash is not placed immediately on the ground, therefore avoiding work area risk and reducing the risk of later fire damaging remaining trees. Coppice competition is also eliminated when
stem injection is used. Stem injection allows large trees (>10 cm) in close competition to be eliminated. These larger trees are usually too large to be removed by clearing saws.

Figure 3.8. (a) and (b) “Woody Weeder” operating in dense forest stand.

(a) (b)

Mid-aged stands with competing trees

Thinning removes competition for water and light; and improves the growth rate of the remaining trees. Selection of trees for removal or retention requires forestry knowledge and expertise acquired from experience, through instruction (e.g. Master Tree Growers courses), or contracted through the services of a consultant.

Commercial thinning

Commercial thinning of native forests is increasing in Australia. The intensity of thinning depends on the species, the density of the stand and its age. Stand density is usually described by forest inventory in terms of trees per hectare. Another useful measure is the basal area in units of square metres per hectare. (Basal area is the summed cross-sectional area of trees at their notional base measuring point, 1.3 metres above ground level - see Inventory section, Chapter 7). Species vary with age in terms of the appropriate numbers of trees left to grow. Recommendations on thinning prescriptions for local species might be sought from local forestry agencies or forestry consultants. As with pre-commercial thinning, evening out the spacing between remaining trees is important to allow for even growth of retained crowns and subsequent growth of released trees.

Crown shapes of competing trees in the larger sapling, or pole stages, can be conical or rounded as natural spacing has dictated. Health and vigour are important to the trees ability to respond to release. Using a system such as Grimes (1987) crowns with high scores are preferred. The first decision needs to be what product are we managing for – this will determine the tree characteristics required.

A nominal spacing for a thinned vigorous regrowth stand (or poles or advanced growth) which will be subject to selective logging or a second thinning at a later age would be around 200 -400 stems ha\(^{-1}\) or 5-7m apart (see Table 3.1). A stand which is thinned to leave only the future sawlog crop in one major cut (to suit clearfell with seedtree and habitat retention as the final cut) may retain only 100-200 stems ha\(^{-1}\) or 8-12 m between trees.
Guideline 3.3. A special note on herbicide use.

Choosing an herbicide for stem injection – must do items:
- Choose a chemical registered for the purpose and tree species;
- Confirm that it is effective, suited to the equipment being used and that costs are acceptable;
- Ensure minimal risk to the operator’s health and safety and to the care of the wider environment.

Read the label

The information required to handle and apply the herbicide is given on the ‘label’ or a small leaflet attached to the container. You have a legal responsibility to read, understand and implement the instructions on the label. If in doubt, seek professional advice. Material Data Safety Sheets are available from the chemical companies on request.

Glyphosate

With Glyphosate-based herbicides the risks to human health are low compared with most other herbicides registered for stem injection. The single heading (hazard) rating for Glyphosate herbicides is “Caution”; most alternatives are rated as “Poison”. Personal protective equipment for using Glyphosate-based herbicides in forests includes hard hat, eye protection, combination overalls, rubber / cloth gloves and good work boots that have been silicon coated.

Features that minimize risk to operator health and the wider environment include its non-residual characteristics and limited movement through the soil combined with the fact that application is by direct injection into the tree, rather than by spraying. However, care should be taken to select a surfactant that does not affect aquatic life when using Glyphosate to poison willows.

Glyphosate has proven to be very effective for thinning regrowth forest of 5 years and upward over a wide range of Eucalyptus and Acacia species.

The dosages to be used are specified on the label. Note that it can vary widely. For example, for young regrowth eucalypts 1 ml of 360 g/l active constituent formulation, injected every 15 cm of circumference may be recommended. For large, old trees it can be as high a two ml every 5 cm of circumference.

Alternatives to Glyphosate

Alternatives to Glyphosate may be required for Blue-Gum (E. globulus) plantations where the vigour of the tree appears to overcome the effect of the chemical. Picloram (TORDON 1040 - User Hazard moderate to high) formulations have been widely used over many years for killing large, older trees. It may be possible (regulations vary between States) to obtain a permit to use an unregistered herbicide ‘off-label’ for a specific operation.

Operational considerations

Choosing the correct herbicide and dosage does not always ensure the optimum result; there are operational factors to consider such as:
- Climate, health and vigour of the plant. Stress, whether from drought, excessive heat, moisture, cold or disease can reduce effectiveness.
- Seasons. Experience with young regrowth eucalypts suggests that a similar result is obtained during all seasons, the time required to get a resulting kill will, however, differ. For other species and in particular deciduous species such as willows, the season may be more important.
- Operator skills. Users need to ensure that the sapwood is penetrated adequately and the proper dosage applied.
**Thinning and fertilization**

The decision to thin (and the attractiveness to a thinning contractor) depends on having a minimum amount of material per hectare. As an example, in SE NSW stands of 18-35 year old Silvertop Ash (*E. sieberi*) or Messmate Stringybark (*E. obliqua*) are routinely thinned from 2000 stems/ha to 230-320 stems/ha. The common systems in use in industrial forestry are the grapple harvester/delimber followed by a forwarder (*harvesting equipment is covered in Chapter 9*). The system uses a regular pattern of access corridors (outrows) and bays with a width of about 10m. These systems are sensitive to slope with performance declining and damage to residual trees and operating costs increasing with increased slope. Systems based on chainsaw felling and skidder extraction (*Chapter 9*) are feasible, but skills and care is needed to avoid excessive damage levels to the buttlogs of remaining trees.

*Figure 3.9. Commercial thinning silvertop ash (Photo M. Connell).*

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**Guideline 3.4. Commercial thinning - Seek advice**

The economics and logistics of commercial thinning are sometimes complex and situations will vary with contractor, machinery and market availability as well as product price. If a first-time commercial operation is planned, then it is worth seeking professional support.

**Pruning retained trees**

Trees retained for future sawlog products can be value-added by encouraging development of a longer clear bole of wood below the crown.

Pruning can add value to future wood by eliminating side branches that would otherwise show up as knots in timber products. Most eucalypt species grown for sawlog production “self-prune”, that is branches die and fall off the tree as the trees grow in height. Close spacing at young ages occurs naturally in many regenerating stands, and this assists in keeping branch size small and ensuring early branch shed. Pruning can play a role where young stems are more widely spaced, or the species does not shed branches readily.
Pruning also opens up the canopy, allowing more light to reach grass or other herbage useful for grazing. Cattle grazing can assist in accelerating the decomposition process following pruning. Another advantage of pruning is that it reduces the ability of fire to spread to the crown, at least once the slash has decomposed.

A considerable amount of pruning is done in softwood plantation forestry and to a lesser degree in eucalypt plantation forestry. Most pruning is conducted with shears or hand-saws. It is important to trim the branch flush with the tree stem, but to take care not to cut into any stem collar surrounding the branch. Small lightweight ladders are used for high pruning. Mechanised pruning equipment based on powered shears and small chainsaws has been developed (Figure 3.3). Such machines can be used in both plantation and native forest applications. However, saw based equipment can leave a rough cut surface at the branch stub.

Figure 3.10.  Stihl telescopic pruner with 5m reach (photo courtesy of Stihl).

Pruning can have risks. Any pruning that causes a wounds exposing sapwood creates a site for fungal and insect invasion. Timing of the operation and wound treatment are important matters when considering pruning and prevention of decay in hardwoods.
**Guideline 3.5 Some general rules about pruning young stands**

Stems larger than 10 cm diameter are candidates for pruning, but some, such as spotted gum and flooded gum, can be left to self-prune;

Prune before branches develop to be more than 3 cm diameter;

Fast growing trees such as Southern Blue Gum (*E. globulus*) can have up to 50% of their green crown length pruned off, but with slow growing or open-grown trees, it is usually recommended that trees should have no more than the lower one third of the total foliage removed;

Only prune trees when their product value can be increased by the investment (usually dominants and co-dominant trees).

Pruning in the growth season can take advantage of rapid stem growth and faster occlusion over the stubs, wound treatment is an option. Species susceptible to pathological attack may be better pruned during winter. Silvicultural operations should be timed according to the region, season and species being managed.

Do not damage the branch collar and when using a saw, do an undercut first;

Form pruning may be required in some species (such as Blackwood and Ironbark) to prevent the development of multiple leaders.

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**Ensuring regeneration in native forest**

*Natural regeneration*

Native forest will often naturally regenerate from seed shed from parent trees and some seed stored in the ground or carried by insects, birds and other animals. When planning a regeneration or harvest/regeneration operation assess the potential seed crop that is present on the mature trees. When attempting to naturally renew a eucalypt forest, on most farms there are four possible sources of natural regeneration:

1. Seed present in heads of fallen trees from harvesting operation;
2. Trees left standing after harvesting an existing forest;
3. Trees in woodland or isolated in pasture paddocks;
4. Trees in nearby forest edges.

Seed trees in a harvested area can often be used as a supply of seed sources (in addition to felled heads) to distribute seed and can protect new shoots from frost. Remember that most seed is shed on warm days on the lee side of the seed tree. Generally about 5-7 tall trees per hectare are sufficient. To promote an adequate seed bed, reduce debris and stimulate drying and opening of seed capsules, the slash and debris left from a harvesting operation is often burnt in Autumn. This promotes a favourable environment for seed germination, establishment and initial growth of the eucalypt crop.

In situations where trees are isolated in a paddock, or there is a need to extend the existing forest margins, proper site preparation and/or soil disturbance is often required to achieve good regeneration. Climatic conditions and seed production varies from year to year and regeneration may not always happen in the first year. Where poor seed crops exist it may be necessary to delay operations.

*Artificial seeding*
If insufficient natural seed sources are available, then artificial seeding can be carried out. Manual, mechanical or aerial methods of seed distribution and sowing are suitable and vary greatly in cost depending on the species, availability of seed and the area to be treated.

**Seed sources**

Seed is not always shed in sufficient quantities from nearby trees, or they may not be representative of the original forest composition or a species that is suited to timber production, or habitat for endangered or desirable native species. Don’t collect seed from the single paddock tree because these tend to be self-pollinating and therefore of limited genetic potential. Collect seeds from as many local sources and species as possible. Diversity creates a better environment for fauna, a healthy forest and more options for management as the forest matures. The seed source needs to be adequate to counteract seed predation which in some environments can be quite substantial.

Direct seeding can be suitable for some species but different environments will have specific requirements.

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**Guideline 3.6. Sowing seed**

A couple of basic rules are; not to bury the seed deeper than its diameter or alternatively cover it lightly with a mulch or sealant. Excellent results have been obtained in loamy soils and dry environments by using a surface sealant such as a light cover of bitumen. If a program of direct seeding is planned then it is useful to consult with some of the specialist texts listed in the bibliography.

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**Site preparation and management**

For many species the regeneration area needs to be largely disturbed bare earth prior to the seed being shed in summer. This can be achieved by slash burning, scarifying or using herbicide. Deep ripping close to the contour in drier areas, followed by cultivation prior to seed shed will allow new seedlings a good start, especially the growth achieved in the second year, because of moisture stored in the rip lines.

Seeded areas need to have stock excluded for most of the time, at least until the trees are well above browsing level. Sheep are usually less damaging than cattle, but sheep will ringbark young trees if feed is in short supply. Cattle will rub and browse low branches and this can create an entry point for fungal disease. Fire hazards can be reduced by crash grazing the area (very high stocking rate for short periods of time). Always monitor the regeneration closely while grazing so that damage to the emerging crop is minimal. In young stands stock often cause more damage than the grazing value is worth. Other problems are nutrient concentration, and compaction of soils, particularly around stock camping places.

Another management consideration is vermin - such as rabbits. Shooting or a 1080 poisoning program is common procedure for most newly planted or regenerated areas on farms, but targeting the right species is important. Expert advice is important since 1080 is also deadly to humans and can cause harm to wildlife.

Weeds and unwanted grasses can be a problem for regeneration and can be killed by spraying. Spraying is preferred because cultivation brings up a new crop of weeds from the seed bank in the soil. There are suitable sprays to spray over the top of eucalypts and wattles, but it is vital to seek professional advice from the local supplier or extension officer as to which ones are appropriate for your situation. Spraying should be avoided when the trees are under moisture stress, even with the correct chemicals. Regenerating trees and understorey species will benefit enormously from the extra water availability when weed and grass competition is removed.
‘Trees for Rural Australia’ (Cremer 1990) is a useful general text for landholders engaging in natural regeneration, direct seeding or seedling establishment while ‘From seeds to leaves’ (Stewart and Stewart 1995), provides a comprehensive guide to growing and planting trees and shrubs. It is especially valuable since it includes prescriptions on the use of smoke for some difficult to germinate seed.

Regeneration is susceptible to fire damage for some time after establishment and steps need to be taken to protect the new forest from fire. Depending on species this may be for up to 20 years.

**Coppice**

Coppice shoots arise from cut or damaged stumps of many eucalypts (and other species). Coppice production has been commonly used for regenerating firewood in some native forest while in some eucalypt plantations; it is used to grow a second (and sometimes third) pulp crop. Solid wood products can be cut from coppice stems.

Not all species will produce coppice shots and the ability to do so varies with age. Some of the species that coppice well include the plains and foothill forest eucalypt species such as boxes, ironbarks, stringy barks, Silvertop Ash and Messmate and many of the gums, particularly Spotted Gum, Sugar Gum and River Red Gum. Many ash-type high-elevation species exhibit poor coppicing abilities.

**Advantages**

- Suits a range of plantation and native forest types (Coppice is a major regeneration tool for many species.);
- Allows for selection of best form;
- Looks natural; and post harvest “green-up” is rapid.
- Frequency of harvest is flexible;
- Minimal live stock exclusion required;
- Rapid regrowth rate;

**Disadvantages**

- Callous (the point from which new growth emerges) may be a point of weakness as the primary leader gets taller and heavier-stems can fall off the stump.
- Not all coppice species are suited to large sawlog production;
- Loss of numbers in stand over time;
- High labour input in reducing coppice stems;
- Limited range of species;
- Delays replacement with genetically superior seedlings over time, if desired;

Coppice regeneration is often vigorous and prolific. Since competition for resources is important for expression of dominance and proportional wood production reducing stocking (and shoot density) needs to be carried out at appropriate times. Too many coppice stems will create excessive and detrimental competition upon and between stumps or standards. Thinning of coppice stems is usually undertaken at an early age before co-dominant stems develop and before the possibility of weakening the stump/shoot interface. Thinning to 2 to 3 stems per stump is usually carried out manually and selection criteria should adhere to the principals of good form and a solid attachment to the stump.
Figure 3.11. Multi-stemmed coppice regeneration from a cut stump.

Guideline 3.7. ‘Do and Don’ts’ with coppice systems

Cut stumps between 10 -30 cm high with a slight angle and smooth top, don’t step the cut.

“Coppice with standards” is a system where selected trees are harvested creating a two stage crop.

Often stumps 10 -15 cm diameter produce good coppice shoots leaving the best (straight and bigger, minimal defect standing trees) till later.

Aim for about 200 live stumps/ha, cutting half at 15-20 years and the rest at age 60-80 depending on growth rates.

Pruning to 6 m (at a dry time of the year) may be necessary.

Don’t fell in summer or impending frosty periods.

Lignotubers

Lignotuberous regeneration can be very important in the regeneration of eucalypt forest particularly in the drier sclerophyll forests such as Spotted Gum and Snow Gum forests (Florence 2004). In some forests regeneration is entirely by lignotuber. Many species of lignotubers can withstand a range of fire intensities (severe wildfire or hot spots may kill them), drought, extreme temperatures and severe grazing.

It is speculated that established lignotuberous seedlings slowly produce a root system which can quickly take advantage of improved conditions (removal of overstorey competition, increased light, water and nutrients) and produce a vigorous and rapid development through sapling and pole stages.

Jacobs (1955) suggested that continued regeneration and destruction of shoots actually makes each subsequent new shoot stronger until finally a shoot gets a chance to develop into a sapling and beyond.
Not all lignotubers develop quickly on release – some species and individual plants can take many years. Overstorey trees can exert a competitive influence for some distance past their crown extremities and reduced regeneration growth is often evident as is the case for seedling regeneration. Generally there is less long-lived lignotubers as moisture gradients increase and understorey is more dense and vigorous.

Many lignotuberous species develop more slowly in the seedling phase and are more susceptible to competition which can reduce seedling numbers dramatically even after a dense regeneration phase. Without high levels of competition from vigorous understorey a well stocked and vigorous regrowth can maintain its advantage over other species and understorey and produce an excellent regrowth forest.

**Planting**

Planting in native forest sites in Australia is generally only undertaken where there has been a failure of the forest to regenerate adequately with the desired species mix. It is sometimes referred to as ‘enrichment planting’. The cost of such plantings is usually high and prohibitive because small numbers are planted in various locations. Protection of the new plants may be necessary. New seedlings are planted in amongst other regenerating species or in bare areas which did not regenerate, they are often targeted by browsing animals.

Planting stock varies depending on the species and region (visualise climate and soils) and can be grown in specially designed pots and tubes; or as open-rooted seedlings for cuttings (Figure 3.12). Manual planting equipment has been designed to assist the planter with ergonomic friendly devices which reduce operator-bending; planting guides designed for particular pot types; and the ability to open and close the soil matrix for efficiency when planting (Figure 3.13).

**Figure 3.12. Tube, Speedling, Hyco cell and open rooted planting stock.**
Figure 3.13. Ergonomically designed tree planters (a) Pottiputki and (b) Hamilton Tree Planter.

Guideline 3.8. More help on silviculture and species

Forestry Tasmania has produced a valuable set of booklets that provide excellent information on managing native forests in southern Australia. (http://www.forestrytas.com.au/forestrytas/pages/publications.html)

- Eucalypt seed and sowing (1991)
- High altitude *E. delegatensis* forest (1990)
- Lowland dry eucalypt forests (1991)
- High altitude *E. dalrympleana* and *E. pauciflora* forests (1990)
- Silvicultural systems (1994)
- Regeneration surveys and stocking standards (1996)
- Remedial treatments (1992)
- Lowland wet eucalypt forest (1998)
- Rainforest silviculture (1998)
- Blackwood (1991)
- Silvicultural use and effects of fire (1993)
- Monitoring and protecting eucalypt regeneration (1999)
- Thinning regrowth eucalypts (1998)

Another Tasmanian document specifically targeted toward private forest owners is “Managing your dry forests” (Orr 1991). The guide clearly lays out practical recommendations on silviculture. Major species considered include:

**The Ash group** - Messmate Stringybark (*E. obliqua*), Gum Topped or Alpine Ash (*E. delegatensis*) and Silvertop Ironbark (*E. sieberi*).


**Gums** - Southern Blue Gum (*E. globulus*), Manna or White Gum (*E. viminalis*) and other associated foothill species such as Mountain Grey Gum (*E. dalrympleana*) and Swamp Gum (*E. ovata*).
Fire in the native forest

Fire is a natural phenomenon of many forests and is sometimes required in the natural systems for periodic regeneration and renewal of species mixes. There is considerable variation in intensity, frequency and effect within vegetation types, however many species in more fire prone areas have a particular fire regime that favours their regeneration and competitive survival.

Four main types of vegetation are recognised in most discussions of fire history and the use of fire as a silvicultural tool:

- Forest
- Woodland
- Shrubland
- Grassland

The use of fire in Australian forests dates back to aboriginal culture with the use of fire to facilitate hunting (to kill and herd animals) and the promotion of growth of particular food plants. Early Australian settlers used fire extensively for land clearing and reduction of forest debris and understorey. It is still one of the cheapest forms of land clearing. Light, frequent burns to promote stock palatable grasses was also a feature of early fire history and this practice continues today.

More recently the burning of tree heads (crowns cut off logs on the ground) and debris left over from harvesting operations has been used promote seed beds, facilitate seedfall from seed trees and reduce future fire risk. Each contributing to vigorous and healthy regeneration in suitable forest types.

The careful use of fire for reducing fire risk to people and property (including areas of value-added forest) is an important management tool at farm, local and regional levels.

Fire effects

Fire history has had considerable effect on determining boundaries and species mixes in forests in the natural environment. Four major forest types, each exhibiting particular fire proneness and adaptions, are recognised:

- rainforests,
- wet sclerophyll forests,
- dry sclerophyll forests and,
- woodlands

Rainforest

Rainforests are more immune to fire than most forests except in particular conditions - such as after strong winds or cyclones - where debris builds up and may be elevated and drier. The ecotones areas (edges) of rainforest and other vegetation types may see some fire effects which can alter boundaries over time.

Eucalypt dominated forests

Fire is one of the most powerful influences in eucalypt forest and has been part of their evolutionary development. Generally eucalypts are well adapted to fire and there are two main types with contrasting strategies in the forest life cycle which reflect those adaptions (Jacobs 1955):
Wet sclerophyll eucalypt forests
Generally highly productive forests which show little development of lignotubers and coppice (Blackbutt, Flooded Gum, Mountain Ash, Alpine Ash, Karri) are often killed or very easily damaged by fire of even low intensities. In most seasons, in most years, these forests are at little risk from fire but in extreme seasons they can be highly flammable and completely destroyed by wildfire. After such intense fires regeneration by seed released from dead and dying trees, immediately following the fire, can create exceedingly dense “wheatfield” regeneration all of the same age (even-aged forest). This is the common factor in many of the high productivity forests in Tasmania, Western Australia and Victoria. If however there is a second fire before these new forests reach maturity and seed-set then the eucalypt forest may be lost and replaced by shrublands and/or forests of other species (Acacia sp may become more prevalent and dominant for instance).

Dry sclerophyll eucalypt forests
Generally less productive forest in which the trees are usually quite resistant to fire (Silvertop Ash, many stringybarks) will recover following a fire event - except under the most severe burning. Re-sprouting of crown foliage from stem and branch buds (epicormic buds) can recover the canopy in one to two years. Regeneration of young trees from coppice and lignotubers can create advance growth in the stand.

Fire as a silvicultural tool
Many forests have a long history of frequent low intensity burning which was primarily carried out to provide ‘green pick’ for grazing of livestock. Although frequent fires under these conditions may continue to assist grazing practices the consequences of repeated tree damage, reduction in organic matter and nutrients and increased erosion risk to bare ground may be detrimental to the growth of trees on site and to the subsequent sustainable management of the forest.

Fire affects the growth of the forest due to damage to stems, crowns and regeneration. Fire damage, as crown scorch or bark damage, has been shown to have variable effects (positive or negative) on girth increment and usually detrimental effects on crown health and form.

Intense fire does considerable damage although the benefits of a fire that reduces competition from smaller trees may be beneficial if it burns at an intensity that does not do damage to stems or crowns of potential crop trees (Cheney et al 1990; Buckley and Cornish 1991; Cheney et al 1992; McCaw et al 1996; McCaw et al 1997; McCaw et al 2002). Research indicates that growth-retardation and detrimental wood quality effects are increased with the severity of damage - if the tree survives.

Control burning however can be used to thin some forests where a range of size classes exist. Fire intensity management is such that desirable trees are of a diameter class which will not be affected by the low intensity fire but smaller undesirable trees will be killed. Controlling fire intensity is the key (see Cheney et al 1990).

Kellas et al (1984) reviewed fire responses in a number of forest types. They reported on findings from a range of studies on growth -after intense fires- showing increased growth increments for older Jarrah in WA for 2-3 years, but reduced increments (~66% less) for Messmate in Victoria. No effect of low intensity fire on growth increment on Jarrah, Karri and Blackbutt; but increased increments for Spotted Gum, Broad-leaved Red Ironbark (E. fibrosa) and Grey Ironbark (E. drepanophylla); and reduced increments (~66% less) for Silvertop Ash. Often increments returned to “normal” after 2-3 years.

The long term effects of repeated prescribed burning on diameter growth of trees in mixed-species dry and wet schlerophyll forest sites in south-east Queensland (Guindo et al 1999) also showed that growth responses of species to fire were variable. However, for most species in these forests, recurrent burning had no serious effects on tree growth. Some species respond positively to annual burning (E.
tereticornis); smaller Spotted Gum *Corymbia variegata* – formerly *E. maculata*); Brush Box *Lophostemon confertus*). Sometimes larger trees are adversely affected.

The long-term consequences on quality and value have not been studied for regrowth burnt at an early age or post-thinning. Fire can damage stems and crowns of trees by:

- consuming bark, sapwood and heartwood of stems leaving fires scars; or
- desiccation and scorch from radiant heat and heat columns severely affecting bark and sapwood on stems or in the crowns where leaves, branches and bark are even more fragile.

Intense fires inflicting crown scorch on eucalypts often result in degradation and detrimental effects on form and vigour of developing forest and has lasting effects on crown shape and health (Wilkinson and Jennings 1993). Epicormic shoots which can develop in the crown and on stems may have lasting effects on wood quality.

Fire damaged trees may suffer wood damage and could be significantly downgraded in their sawn value. Species changes and effects on crown health and productivity caused by mortality and crown scorch can affect such activities as cut flower production and honey production.

For most species, tree mortality is both diameter dependant and fire frequency related that is, smaller trees have a lower chance of survival than larger trees and frequent burning further reduces this probability. Repeated burning may change species patterns but may also jeopardise the regenerative capacity of a particular forest area to maintain species diversity. However, without fire, recruitment may be dominated by particular species.

Managing fire protection, fire suppression and its associated fire risk, should be an integral part of the property and forest management plan and be discussed with the relevant fire authorities and agencies.

In summary the effect of fire, either as uncontrolled wildfire or as a silvicultural tool needs to be carefully considered for each forest type and management purpose.

**Positive effects of controlled fire**

- Fuel reduction
- Promotes grazing (‘green pick’)
- Promotes regeneration of some forest types
- Facilitates forest spacing
- Creates seed-beds
- Improves access
- For some species increases growth of retained trees
- Facilitates lignotubers and coppice management
- Protects assets

**Possible negative effects of controlled fire**

- Removes some woody habitat components
- Removes organic material from litter layers
- Removes nutrients
- Increases mortality of species/seedling/regeneration
- Causes crown scorch/crown health
- For some species decreases growth of retained trees
- May reduce long term wood quality
Grazing in native forest

Successful regeneration in forests usually relies on adequate rainfall and low grazing pressure. Grazing by animals can be managed in non-palatable tree species, and using preferential feeders such as sheep and some goats where the preferred and retained species suffer little or no damage.

Grazing over long periods of time (and periods of over-grazing) can deplete natural populations of native grasses and shrubs and seriously affect sapling survival, vigour and health of the eucalypts – affecting development of successional forest. Grazing by hard-hooved domestic animals can result in reduced rainfall infiltration, soil compaction and promote erosion in constantly used animal tracks. However, careful and selective grazing and choice of stock animals can be used to manipulate species, species density and fire hazard (Cremer 1990).

Silviculture enhancing or maintaining biodiversity

Enhancing biodiversity

The general compromise between the highest reasonable biodiversity values and the economic and sustainable production of wood products is sometimes a difficult argument. The principles of ecologically sustainable forest management apply more to localities and regions than to an individual stand or woodlot, however it is likely that the management of private native forestry for wood production will require a compromise between maximising timber production and increasing or at least maintaining local biodiversity value.

A publication by Murray and Thompson (2000) titled “Native regrowth: A farmers guide to maintaining biodiversity” includes general recommendations on applicable silvicultural practices for managing timber and biodiversity values. Particular attention is paid to the regeneration of over-logged areas to restore a nominal ‘balanced’ forest system. Figure 3.2 shows a generalised but modified diagram sourced from Murray and Thompson (2000). The diagram describes stand characteristics which can indicate the need for silvicultural treatment and some of the actions (especially thinning) which may be considered. Although this diagram can in no way take account of the myriad of forest types and conditions across Australia it does give indications of the sort of decisions and strategies that a landowner may need to consider for increasing timber and biodiversity values. The ‘do nothing’ approach, for instance, is not appropriate to all stands that do not have ‘crowns touching’. There may be stands where crowns are not touching but the majority of stems are highly defective as a consequence of “high grading”. The do nothing approach in this situation will leave the stand in a condition that will continue to degrade, decrease in vigour, productive potential and overall ecosystem health.

Silvicultural notes, local forestry professionals and Codes of Practice should be consulted with regard to particular on-farm forest types and conditions. To manage biodiversity sustainably in conjunction with timber production the same criteria of site conditions, crown health, vigour, spacing and potential products need consideration to determine the mix of habitat factors, tree removal and productive potential.

Combe et al (1998) presented a regrowth management system called the Eco-Production Model that is intended specifically for native forest management on farms. The system is based on the principle that nature conservation is essential for healthy balanced forest growth and the system combines silvicultural management with the need to contribute to the wider bio-economic environment of the land. Not all would agree. They further suggest that four phases of management are necessary to achieve ecologically sustainable management. These are:

- Assessment - timber flora and fauna, genetic fitness, economic value etc;
- Restoration - to meet ecological and production needs, involving harvesting and some disturbance to encourage regeneration where required;
- Conservation – maintaining species diversity to balance and establish a ‘healthy’ system.
• Production – to enable the bio-economic stability to be funded and implemented. Control over simplistic and damaging harvest techniques is a key element in the production process.

Figure 3.14. An example of a guide to thinning and biodiversity enhancement (modified from Murray and Thompson 2000).
Enhancing biodiversity and wood production

Table 3.1 illustrates two contrasting forest stands (higher and lower health and productivity) from Northern NSW and possible silvicultural strategies for improving and maintaining biodiversity values along with some increase in productivity. This achieves preservation of structural and aesthetic diversity while increasing timber production in the longer-term – albeit at a lower volume and value.

Table 3.1. Examples of silvicultural practices to meet increased production, aesthetics and biodiversity maintenance objectives (Adapted from Florence (1996), Ecology and Silviculture of Eucalypt Forests. p156).

<table>
<thead>
<tr>
<th>Forest condition</th>
<th>Silvicultural practice for conserving structural and aesthetic diversity</th>
</tr>
</thead>
</table>
| Good quality open eucalypt forest (grass/bracken/shrub understorey) with a mosaic of patches of mature Blackbutt from early selection logging and ringbarking, and pole stands (from logging 30 years ago); most trees capable of continuing to grow. | Progressively remove of the mature trees from each patch over the next two or more cutting cycles. Commercially thin within the pole component.  
(In managing this stand timber production is not maximised) |
| A mixed hardwood (Tallow Wood, White Mahogany) forest with no Blackbutt. It has been cut over periodically for sawlogs and durable poles and piles, and is now moderately stocked with pole size trees; there are a few high quality trees but most reflect crown restriction at some stage of development or relatively slow segregation into canopy classes. | Nurture a source of high value timbers for the future, (through the durability, strength and attractiveness of the woods) while maintaining the natural environment. To achieve this- intensive silvicultural practice might be: 
1. limit the harvest of high quality boles at the pole stage 
2. harvesting poorer quality trees as small poles and pallet and case logs 
3. site preparation for the establishment of seedlings if there is inadequate lignotubers 
4. regular light harvesting to maintain regrowth development |

Guideline 3.9. Silvicultural and biodiversity maintenance essentials

Understand the climatic, nutritional and habitat requirements of the flora and fauna species to be managed;

Maintain the range of habitats across the forest area, in terms of structure, species and age groups. This may include older hollow trees, grassy areas and watering sites, as well as some consideration of shrub and tree species composition.

Recognise that not all objectives can be met at one point in time or across one area of forest. Trade-offs are necessary, but be wary of any permanent effects particular management activities will have.
Maximising growth of wood products

Native forestry wood production profitability is influenced primarily by forest growth rate and the value of the timber. Farm foresters in higher rainfall and more fertile areas can be managing stands of the higher growth rates species such as Southern Blue Gum (*E. globulus*), Mountain Ash (*E. regnans*), Shining Gum (*E. nitens*) Silvertop Ash (*E. sieberi*) and Flooded Gum (*E. grandis*). Other species that show potential include Blackbutt (*E. pilularis*), Spotted Gum (*Corymbia maculata, C. henryii*), Sugar Gum (*E. cladocalyx*) as well as many acacia species such as Silver Wattle (*A. dealbata*), Black Wattle (*A. mearnsii*) and Earpod Wattle (*A. mangle; A. auriculiformis*).

Other value potential exists in growing species with higher furniture timber values such as Blackwood (*A. melanoxylon*), Brush Box (*Lophostemon confertus*) and Silky Oak, (*Grevillea robusta*). Species which produce predominantly clear wood may be useful for veneer production. Many other less known species are suited to a variety of smaller specialty timber products such as various grades of fuelwood, ornaments and furniture pieces.

Information on the utilization of particular species and their silvicultural requirements and recommendations can usually be found in the species information guides produced by the various State agencies (Queensland Forest Research Institute, Forests NSW, Conservation and Land Management WA, VicForests VIC) either as Silvicultural Notes, on CD Rom or on their respective websites (see Bibliography).

Silviculture as a priority to maximise timber production

Forest managers use silvicultural techniques to maximise growth of potentially valuable trees and improve financial returns. Treatment of the forest should also plan for its regeneration as a productive forest. The main native forest silvicultural principles include:

1. Selection of species with high value or growth potential (if this is appropriate);
2. Selection of trees with good form and apparent good growth potential
3. Removal of unwanted trees (for profit or to reduce competition) and of weeds; Removal of trees that are suppressed or over-mature and will not have the potential for accelerated growth when the canopy is opened. (Where needs for preservation of particular habitat values, some trees in this classification might need to be retained eg. trees with hollows that provide den sites for arboreal mammals))
4. Ensuring timely and effective regeneration after felling of merchantable trees.

Silvicultural can be undertaken at different stages of the rotation to increase the productivity and value of the forest (Figure 3.15). In healthy regrowth forests in particular, where growth potentials are high, more intensive silvicultural practices can be financially rewarding AND cater for biodiversity objectives. Silvicultural practices do however need careful consideration to ensure the cost does not outweigh the expected benefits.

A number of operational techniques to manipulate stand structure, stand density and stand and tree health are available to the manager of private native forest. Most improve the health and productivity of the trees remaining and can also be used to maintain or improve biodiversity health and habitat.

If we begin our examples with consideration of the mature forest then silvicultural manipulation may be required by:

- Culling, to remove some dead or dangerous trees and often to encourage regeneration
- Selective harvesting, for wood products and to manipulate stand structure, encourage faster growth of retained trees and products; or to encourage regeneration
- Commercial thinning for sale of products, to reduce competition and to encourage growth of retained trees.
- Spacing (non-commercial thinning to waste), to reduce competition and manipulate stand structure
- Control of regeneration, to manipulate species mix and stand structure, and enhance product development, to rejuvenate the stand
- Pruning of live branches from the stem or bole - up to a proportion of the green crown - of retained trees can enhance log quality in most species.

Figure 3.15. Silviculture to increase wood production and value.
Table 3.2 illustrates the same two contrasting forest stands (higher and lower health and productivity) from northern NSW which were previously considered for enforcement of biodiversity values (Table 3.1). This table indicates possible silvicultural strategies for improving and maintaining productivity where wood production is a higher priority.

Table 3.2. Examples of silvicultural practices to meet production objectives (Adapted from Florence (1996), Ecology and Silviculture of Eucalypt Forests. p156).

<table>
<thead>
<tr>
<th>Forest condition</th>
<th>Silvicultural practice for improved wood production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good quality open eucalypt forest (grass/bracken/shrub understorey) with a mosaic of patches of mature Blackbutt from early selection logging and ringbarking), and pole stands (from logging 30 years ago); most trees capable of continuing to grow.</td>
<td>It may be efficient and provide larger wood volumes for the longer-term future to remove all of the mature trees in the next cutting cycle. Concurrently commercial thinning within the pole component would provide further volume and maximise productivity of the remaining trees for future sawlog. (in managing this stand biodiversity value is less of a priority and compromises, if any, would be balanced by consideration of whole-of-farm, local and regional biodiversity and economic requirements)</td>
</tr>
<tr>
<td>A mixed hardwood (Tallow Wood, White Mahogany) forest with no Blackbutt. It has been cut over periodically for sawlogs and durable poles and piles, and is now moderately stocked with pole size trees; there are a few high quality trees but most reflect crown restriction at some stage of development or relatively slow segregation into canopy classes.</td>
<td>The present forest has limited production potential. One option would be to continue to selectively harvest from time to time for durable poles, piles and some sawlogs but yield would remain low. Or, it could become a source of high value timbers for the future, (through the durability, strength and attractiveness of the woods). To achieve this - intensive silvicultural practice might be: 1. Selective harvesting of high quality boles that are at the pole stage 2. harvesting poorer quality trees as small poles and pallet and case logs 3. site preparation for the establishment of seedlings if there is inadequate lignotubers 4. regular light harvesting to maintain regrowth development</td>
</tr>
</tbody>
</table>
Chapter 4. Case studies - illustrating the use of silvicultural strategies to increase wood production – particularly of sawlogs

Remember: A complete understanding of species, site and climatic differences in conjunction with legislative requirements is necessary to determine the silvicultural management of your forest.

Restoring productivity in uneven-aged ‘high-graded’ dry Spotted Gum-Ironbark in SE Queensland - Case Study 1

An, as yet, unpublished case study (Ryan and Taylor in prep) in south-east Queensland has been designed to assist private landholders with the confidence and skills in sustainable native forest management and to promote the integration of forest management into farm management plans. The authors of the guidelines and RIRDC extend their thanks to Sean Ryan and David Taylor for the use of this information. A series of demonstration plots have been established across a dry sclerophyll forest type of Spotted Gum-Ironbark (tall open) forest and a range of silvicultural practices (fire management, timber harvesting) are being applied. This forest type is representative of a large area of Spotted Gum-Ironbark forest in south-east Queensland.

Predominant species include Spotted Gum (*Corymbia variegata*), Red Bloodwood (*C. intermedia*), Grey Ironbark (*Eucalyptus siderophloia*), Broadleaf Red Ironbark (*E. fibrosa*), White Mahogany (*E. acmenioides*), Grey Gum (*E. propinqua* and *E. longirostrata*), Queensland Peppermint (*E. exserta*), Gum Topped Box (*E. moluccana*), Smooth Barked Apple (*Angophora leiocarpa*), Brush Box-Supple Jack (*Lophostemon ssp. aff. L. confertus*), combined with a mixed understorey of grasses and shrubs (hairy bush pea, wattles and grass trees). This forest type has no conservation restriction status at present (EPA 1999).

As with much of SE Queensland private native forests, a common practice for landholders working in this forest type has been ‘high grading’. High grading harvests all merchantable stems to a tree diameter limit usually about 35 cm (Taylor 1997). This commonly occurs when the landholder requires immediate cash flow and is not usually dictated by silvicultural needs or market advantage.

Stands are often left in very poor condition consisting of an overstorey of damaged, defective, suppressed or non-commercial trees with varying amounts and quality of advanced growth in the smaller size classes (20-30 cm dbhob). There may be significant but variable regeneration present and usually a substantial amount of woody residue from previous harvests.

Managing a forest after many years of high grading requires a considerable investment of time and money to rejuvenate the stand into reasonable condition and productivity. The first step being the removal of defective and inefficient stems in order to favour any advanced regrowth and the need to manage what regeneration is present.

Restoration using silvicultural techniques was examined on two areas representing common forest conditions:

- **Advanced regrowth stands** - previously cut over for poles and sawlogs and then recut for fencing material leaving little standing timber – this site has significant dense regeneration.
• **Heavy regeneration stands** - cut for poles and sawlogs and left (with higher proportion of spotted gum) which have been grazed since.

Treatments included controls (retaining the current poor stand); retention of 70, 100 or 200 retained stems per hectare in advanced growth; spacing of regeneration including culling, poisoning and burning; leaving - 4 x 4 spacing of regrowth with or without retention of understorey near the retained tree.

**Silviculture in advanced growth stands**

Stands used in the experiment have been subjected to ‘high-grading’ harvest for many years and as a result few stems over 40 cm dbhob are left. It is regarded as a regrowth forest with few old growth characteristics and therefore rated as having no conservation concerns attached to its management. More than 50% of the standing timber is defective or suppressed as a result of previous selection strategies. Advanced growth areas containing 200 – 300 stems ha⁻¹ have little regeneration or coppice present (Table 4.1).

**Table 4.1. Initial stand assessment of advanced regrowth areas by diameter class.**

<table>
<thead>
<tr>
<th>Diameter at breast height (dbhob in cm)</th>
<th>Stocking (stems per h⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>21-30</td>
</tr>
<tr>
<td>Average of 6 plots Block A</td>
<td>67</td>
</tr>
<tr>
<td>Average of 6 plots Block B</td>
<td>116</td>
</tr>
</tbody>
</table>

The thinning treatments were selected on the basis of effect on future growth and utilization:

- Control (no treatment);
- 70 stems ha⁻¹ (12 x 12m spacing) representing unrestricted growth with optimum product selection coupled with open conditions suiting pasture growth for grazing;
- 100 stems ha⁻¹ (10 x 10m spacing) representing relatively ‘free growth’ conditions and should maximise dbhob increment (favouring sawlog and girder production);
- 200 stems ha⁻¹ (7 x 7m spacing) representing stocking favouring pole production and should maximise returns for the site.

Trees to be retained were selected and paint marked for easy identification. Retained trees were selected on the basis of crown score (Grimes, 1983), location and freedom from defects. Treatments were applied to the selected spacing and treated all competing growth less than 10 cm dbhob.

In the advanced growth stand, variations in growth response are expected to occur in:

- Individual tree volume and dbhob increment;
- Quality, type and value of end product;
• Harvest cycle time;
• Future market options and $ returns; and
• Levels of pasture growth available for grazing.

Wood quality issues in advanced growth blocks

Often there were not sufficient stems of suitable quality or condition to provide retention of 200 stems ha$^{-1}$. This gives an indication of the level of damage of suppressed stems in the stand following previous high-grading strategies.

Thinning in advanced growth

Advanced growth areas have a stocking rate of 2 – 300 stems ha$^{-1}$ (high proportion of Spotted Gum) and a high proportion of damaged or defective trees. Generally, at least 100 of these stems are in good condition and would benefit significantly from thinning. It has good potential as a pole stand with predominant heights in the 30+ m range. Thinning (making sure that the stumps are cut low to ensure coppice is well grounded and not prone to wind damage) will also encourage regeneration and coppice to establish the next rotation crop.

In this case with residual stands down to 100 stems ha$^{-1}$, it may be better to cut to waste rather than treating or retaining stems that have no merchantable product. Trees that were suppressed after regenerating under a dominant stem are not necessarily genetically deficient and will quickly coppice to produce a quality product taking advantage of the open canopy.

Most thinning operations were at least cost neutral, with a range of saleable products (round timber such as mini-piles; fencing products or rounds for CCA treatment; house stumps; landscaping). In this case employing contractors to do the work still showed a profit and Table 4.2 provides calculations of merchantable product and value.

Table 4.2. Estimated return from two treatment (spacing) regimes of advanced growth.

<table>
<thead>
<tr>
<th>Costs and returns</th>
<th>70 stems ha$^{-1}$</th>
<th>100 stems ha$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merchantable products</td>
<td>2140</td>
<td>1400</td>
</tr>
<tr>
<td>Estimated cost of contract thinning</td>
<td>1070</td>
<td>690</td>
</tr>
<tr>
<td>Cost of contract treatment</td>
<td>210</td>
<td>200</td>
</tr>
<tr>
<td>Returns ha$^{-1}$</td>
<td>860</td>
<td>510</td>
</tr>
</tbody>
</table>

Silviculture in heavy regeneration areas

In heavily cut areas (which have been heavily disturbed) there was substantial regeneration response following the last cutting cycles. There are large quantities of logging debris present in the forest with large quantities of residues pushed into heaps against young, good trees. There is significant damage to retained trees from the previous logging operation.
Regeneration areas show a broader species mix (usually within increased ironbarks and White Mahogany). The areas were re-cut for fencing material leaving very few potentially merchantable stems. This triggered a heavy regeneration response (seedling, coppice and lignotubers), establishing 2-3000 stems ha\(^{-1}\). Without management, these may compete for many years before natural dominance is established (Taylor 1997).

Thinning should result in significant growth response with reasonable expectations of that growth continuing. A second thinning to 200 stems ha\(^{-1}\) (7 x 7 m spacing) in 5 – 7 years would probably produce a second excellent growth response. This will ensure unrestricted growth well into the advanced growth stage which could dramatically reduce the harvest cycle.

Lignotuber, seedling and coppice appear to produce similar growth rates in the longer-term (Bruskin 1992), so in any thinning regime all forms of regeneration can be regarded equally.

Trees to be retained were selected and paint marked for easy identification. Retained trees were selected on the basis of crown score (Grimes, 1983), location and freedom from defects. Treatments were applied to the selected spacing and treated all competing growth less than 10 cm dbhob.

In the regeneration plots due to the large numbers of lignotuberous regeneration and coppicing from the previous logging events, a high proportion of the regeneration were multi-stemmed. One stem was chosen from these on the same criteria as single stems. Coppice were chosen if the stem was well-grounded on the stump.

The regeneration areas were divided up to enable comparison of a medium intensity burn and unburnt areas. Each area then received a duplicate set of treatments:

- control, no treatment
- retained stems <10 cm dbhob at 4 m spacing, any retained stems 10-20 cm dbhob at 7 m spacing, >20cm at 10m spacing, all other stems were treated;
- retained stems <10 cm dbhob at 4 m spacing, any retained stem 10-20 cm dbhob at 7m spacing, >20 cm dbhob at 10 m spacing, all stems including wattles and any other dominant or co-dominant eucalypt were treated in a 1.2 m radius of retained stems.

**Herbicide spacing**

Treatments were applied to the selected spacing and treated all competing growth less than 10 cm dbhob.

Treatment of both advanced growth and regeneration of trials occurred during September 1999. Three treatment systems were assessed:

- cut and swab;
- woody weeder injection hammer; and
- tomahawk and calibrated tree injection gun.

Both ‘Tordon tree-killer’ and ‘Roundup’ were trialled. Treatment was excluded from the drainage lines as described in the Queensland Codes of Forest Practice (DNR 1999). Treatment in the advanced growth was applied to all unmarked trees <10 cm dbhob, using either the injection hammer or the tomahawk and injection system. The regeneration required a different approach due to the presence of high proportions of coppice and lignotuberous growth. All but one of the multiple-stem clump were
cut out using a chainsaw leaving only the marked stem (recently brush cutters mounted with tungsten tip ply cutting blades have proved to be quicker, easier to use and more economical with less down time – an improvement in all areas over small chainsaws). Single unmarked stems were cut and the stump sprayed with a small knapsack of ‘Tordon tree-killer’. Unmarked larger trees were stem injected using the same techniques as in the advanced growth plots.

Conclusions

- Continued high-grading harvests, particularly badly managed ones - leave a stand in a very unproductive state. The residual stand usually comprises a high percentage of defective or suppressed stems that in turn inhibit and suppress the natural regeneration that may follow (increasing rotation times).

- Intervention through removal of defective, damaged and suppressed stems will provide some harvest products and regenerate and rejuvenate the stands into a productive forest on shorter rotations. Increasing stand productivity and value. Even if less than half of the 200 stems in the final stand achieved pole size and criteria, the stand would be worth (in today’s values) $15,000 ha⁻¹ standing or $600 ha⁻¹ per year to the owner. This result would easily outstrip any other farming enterprise suited to the property’s attributes.

- After tree harvesting or in treating regeneration final retained tree spacing was effectively and efficiently achieved using herbicide injection. Of the methods trialled the tomahawk was the more effective across all species and size classes.

- These forests can be brought back into high productivity using high retention standards and optimum spacing regimes. Most stands have enough marketable product left to ensure this process is cost neutral and in many cases cost positive.

- These studies are continuing and future measurement will provide valuable information for management of this forest type (our thanks to the authors).
Sustainable sawlog production in even-aged regrowth forests of Silvertop Ash in SE Australia - Case Study 2

A case study of management strategies and timing for a rotation of Silvertop Ash (E. sieberi) forest in south east New South Wales and Eastern Victoria and is presented as an illustration of the links between strategies, costs and productivity benefits for more intensive management of native forest.

The case study is drawn from a number of separate silvicultural studies in this forest type. The studies were carried out in medium to high quality stands of even-aged regrowth dominated by Silvertop Ash but containing similar aged White Stringybarks (E. globoidea). Other species were present but not significantly so. Silvertop Ash forest is widespread in the lowland and coastal forest of south-east Australia and up to an altitude of 700 m.

This case study is an example of response and costs which may be present in an intensively managed stand and indicate strategies that might also be used to manage ‘patches’ of even-aged regrowth within uneven-aged stands.

Current management of Silvertop Ash stands

Broad scale harvesting commenced in the Silvertop Ash-Stringybark forests of East Gippsland and southern NSW in the 1960’s and until the 70’s and 80’s involved removal of mainly sawlogs. Changed policies in NSW and Victoria and the emergence of limited wood-chip markets have since provided the opportunity to harvest some pulpwood. On good sites, post-cutting regimes have been reasonably heavy, with usually clearfall or almost clearfall leaving only the seed trees required for regeneration. On poorer sites, more selective cutting has occurred, as in the past, leaving a variable number of defective trees (sometimes poisoned) which have slowed the growth of regenerating stands. Broadcast slash burning is usually used to prepare a seedbed, induce seedfall from the retained seed trees or distributed heads and to reduce fire risk. Regeneration is readily obtained with these clearfall or seedtree systems and in many instances is excessively dense (10,000 – 100,000 stems ha⁻¹), as is often the case after wildfire.

On private native forest selective cutting (sawlogs, posts, poles and firewood), has been the ‘norm’ although some clearfell has occurred. Where selective cutting and even ‘high-grading’ has occurred this has left the stands generally poorer in health and quality.

Moderate to severe wildfires have also contributed to long-term decline. However, there are often patches of healthy even-aged regrowth throughout the mosaic of multi-aged, poor quality forest.

Recent research in Victoria and New South Wales has been investigating the regeneration success and productivity of a range of silvicultural treatments in Silvertop Ash forest (and other forest types) which may maintain higher levels of biodiversity and aesthetic values without significant detriment to sustainable wood production. These include clearfall; clearfall and burn; clearfall and seed tree; shelterwood; and large and small gap harvesting.

Improving growth and value by controlling early stocking

Faunt et al (1994) showed that good control over initial stocking in the Silvertop Ash, Stringybark forests can be obtained by clearfelling, hot slash burning and aerial seeding coupes. The burn destroys seed contained in logging slash, and locally collected seed can be applied to achieve initial eucalypt
stocking of 2,000 – 5,000 ha\(^{-1}\). This method avoids the very dense (9,000 + seedlings ha\(^{-1}\)) regeneration which commonly occurs after wildfires, and the traditional ‘seed-tree’ silvicultural system. Control of initial stocking will minimise growth losses during the rapid early self-thinning phase of stand development, and reduce the need for early spacing treatment.

Spacing at a younger age (1-5 yrs) can be achieved by poisoning or a combination of mowing and poisoning to reduce competition. Overwood inhibits the growth of young regeneration (Incoll 1979), and retention of more than about 10% of stand basal area markedly lowers growth of seedlings during the first 3 years (Figure 4.1). This suppressive effect lasts for many years.

Figure 4.1. Effect of overstorey trees on growth of regeneration of silvertop ash (from Faunt et al unpublished).

Mature trees may be retained as habitat trees but are unlikely to show much basal area increment to compensate for the lower growth rates of regeneration.

Tree selection for desirable wood production characteristics is difficult at this younger age however form and espacement together with species selection has been shown to be worthwhile. Where understorey is vigorous spacing to 200 - 300 stems per ha\(^{-1}\) would avoid the need for a non-commercial spacing treatment before commercial thinning.

**Fertilization of young regrowth (<1 year)**

The effects of addition of 50kg P ha\(^{-1}\) to 6 month-old naturally regenerated Silvertop Ash forest is summarised in Table 4.3. Adding P increased eucalypt growth to the same levels found on ash beds after hot fires. The eucalypts displayed good form despite their low density. The dense Acacia understorey favour slender growth and good branch shed on the eucalypts. The additional N fixed by the acacias is expected to enhance rates of N cycling and maintain productivity at higher levels for an
extended period of time perhaps for the entire forest rotation. The habitat and changed nutritional quality of food available to fauna needs evaluation. However, these findings demonstrate a potential, with low cost inputs, to markedly increase the productivity of young regrowth stands growing on P-deficient soils. Subsequent measurements will evaluate this and other growth and quality factors.

Table 4.3. Effect of fertilisation with P on growth of eucalypts and *Acacia myrtifolia*. Data are means based on 3 (-P) and 6 (+P) replicate plots, and the effects of P are significant (Raison *et al* (1995)).

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>-P</th>
<th>+P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eucalypt height (cm)</td>
<td>4</td>
<td>238</td>
</tr>
<tr>
<td>Acacia height (cm)</td>
<td>4</td>
<td>190</td>
</tr>
<tr>
<td>Acacia biomass (t ha⁻¹)</td>
<td>2</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Spacing (non-commercial thinning) of young regrowth (9 years)

Kerruish *et al* (1992) evaluated efficiencies, costs and growth responses to 3 spacing techniques in 9 yr old Silvertop Ash regeneration. Techniques evaluated were hydro-axe, clearing saw and stem injection. Stocking was reduced from ~16,000 stems ha⁻¹ to ~7,000 stems ha⁻¹ in hydro-axe treatments and from ~18,000 stems ha⁻¹ to 1800 stems ha⁻¹ in hydro-axe + clearing saw treatments. Treatment costs varied greatly (Table 4.4) depending on method and the amount of ground debris (old logs) and amount of understorey (particularly wiregrass).

Stem injections was a more efficient means of spacing than hydro-axe slashed strips or hydro-axe strips + clearing saw treatments. The highest growth response of retained trees occurred in the stem injection treatments where the herbicide (Glyphosate) prevented coppice re-sprouting. Application of fertilizer to spaced trees increased growth by a further 35% (Connell and Raison 1996).

Table 4.4. Comparison of treatment costs ($ha⁻¹) (from Kerruish *et al* 1993).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>150-300 t/ha residual logs on the ground</th>
<th>&lt;50t/ha residual logs on the ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro-axe corridor</td>
<td>$739</td>
<td>$362</td>
</tr>
<tr>
<td>Hydro-axe + clearing saw</td>
<td>$1731</td>
<td>$1354</td>
</tr>
<tr>
<td>Hydro-axe + stem injection</td>
<td>$1060</td>
<td>$683</td>
</tr>
</tbody>
</table>

These costs could be substantially reduced by selecting slightly older stands (approximately 12 years old) with less understorey (particularly wiregrass) and residual logs and by cutting corridors 8-12 metres apart.
Further stem injection in trials of different age classes reduced costs considerably. In 5 and 8 year old stands in which more than 95% of the treated stems were killed and there was no mortality as a result of chemical transfer due to root grafting.

**Figure 4.2. Response of 12 year old Silvertop Ash to spacing and fertilization at 9 years old.**

![Graph showing relative growth response of spaced and spaced and fertilized trees]

**Crop tree selection and stocking**

Irrespective of the spacing equipment employed, the criteria for selecting crop trees to be retained is based on similar parameters (corridor spacing does not allow for tree selection). Crown health, form, vigour and espacement are critical to maximising tree and product potential. Of course, in very young stands (up to about 2-3 yrs) likely form will be difficult to assess and less important than other parameters. Spacing control is no detriment to form or growth as long as spacing is not too wide (depends on species) in relation to the size and number of stems (around 5000, 2000, 500, 250 and 150 stems ha\(^{-1}\) for 1-2, 5-10, 10-15, 15-35 and 35+ years, respectively) as a rough guide in Silvertop Ash regrowth forests.

Spacing between retained trees will be determined by site quality factors (higher retentions on higher quality sites) and by the product objectives. Where an earlier commercial thinning is planned for a potential sawlog stand then allowance needs to be made for maximising growth and yield to increase thinning yield and allow retention of 150-200 stems ha\(^{-1}\) after the commercial thinning operation. Younger stands will require more retained stems to ensure maintenance of desirable form and clear bole development. In the spacing example given above stems ha\(^{-1}\) were reduced from ~18,000 to 1,800 stems ha\(^{-1}\) following spacing to be reduced further at first commercial pulpwood thinning to ~250 stems ha\(^{-1}\) allowing for a second commercial thinning (small sawlog and pulpwood) to ~150 stems ha\(^{-1}\) for the final sawlog rotation.
Labour and product costs of stem injection treatment

Studies by Clinnick *et al* (2003) examined the costs and efficiencies of spacing Silvertop Ash forests with Glyphosate using stem injection axes and the principles described previously. Experimental treatments were applied that aimed to retain about 500 stems ha\(^{-1}\) which is nominally 4-5 m between retained stems. Trees were selected on vigour, crown health, form and bole characteristics.

The diameter distribution of the differently stocked Silvertop Ash stands is shown in Figure 4.3. Small trees less than 10 cm were ignored unless they were obviously competing with a selected crop tree. Treated trees were predominantly in the intermediate size class (~10-17 cm dbhob).

Figure 4.3. Tree numbers in various density and size classes (ages 14-19).

![Figure 4.3. Tree numbers in various density and size classes (ages 14-19).](image)

- **Dominant** trees: Crowns well developed and above the general canopy.
- **Co-dominant** trees: Medium sized crowns at the general canopy level.
- **Intermediates** trees – Medium sized crowns often less dense and generally below co-dominants.
- **Suppressed** trees - the weakest trees, receiving little direct light, few leaves.

Stem injection trials indicate that it takes about 5.5 hours/ha\(^{-1}\) to treat a forest with a density of 5000 trees/ha\(^{-1}\), leaving about 500 trees to grow on. Only about 2000 trees needed to be treated.

The following diagram (Figure 4.4) gives an indication of the costs of chemical, labour and total direct treatment costs for the stem injection operation in the stand density ranges (not all trees were treated).

- 2000 trees treated/ha = $35 for chemical + $57 for labour = $92/ha
- 4000 trees treated/ha = $53 for chemical + $75 for labour = $128/ha
- 8000 trees treated/ha = $80 for chemical + $113 for labour = $193/ha
Figure 4.4 shows that it will cost more to treat the more dense forest, but there are some efficiencies in the higher density forest because there are many small trees that will not need any treatment whatsoever. Above 2000 trees/ha\(^{-1}\), chemical costs are about 43% and labour 57% of the total.

**Figure 4.4. Breakdown of costs for stem injection treatment of Silvertop Ash (ages 14-19)**

![Graph showing breakdown of costs](image)

**Commercial thinning in 28 yr old Silvertop Ash regrowth**

Thinning studies were carried out in East Gippsland, Victoria and south east New South Wales (Connell and Raison 1996; Connell *et al.* 2003) using a grapple harvester/delimber to remove and process trees for pulpwood. A forwarder with grapple loader was used to collect and transport billets of ~5m lengths to the roadside landing for transport to the mill.

As sites were uniform in structure, but showed productivity gradients in the landscape, initial inventory was conducted as random plots within three management units which generally reflected productivity differences. Upper slopes and ridge areas where trees were shorter and basal area (BA) was relatively lower, lower slopes closer to gullies where trees were tallest and BA highest and the median range of both height and BA on the mid-slopes.

In experimental plots trees were marked for retention to facilitate harvesting efficiencies and to highlight for the operator which trees were to be protected from harvesting and damage during thinning. Stand basal area increments averaged 1.76 m\(^2\) ha\(^{-1}\) yr\(^{-1}\) and thinning did not significantly reduce stand basal area increment even in the first year after treatment.

Basal area increment for the potential sawlog trees (largest 150 stems ha\(^{-1}\)) in thinned-only forest exceeded basal area increment of potential sawlogs in unthinned forest by 40-60%. In forest where coppice competition was removed, growth rates were increased by a further 15-20% in all years (Figure 4.5). Smaller trees retained in thinned forest (potential pulpwood for a second thinning) grew 69% faster than similar sized trees in unthinned forest and removal of coppice competition increased this response by a further 38%.

Competition from coppice regeneration developing on cut stumps reduced potential basal area growth of retained trees by about 20% in all years following thinning. Coppice contributed additional basal area to the stand (from 0.7 m\(^2\) ha\(^{-1}\) yr\(^{-1}\) in the first year following thinning to 1.3 m\(^2\) ha\(^{-1}\) yr\(^{-1}\) in the 6th year). After 6 years, coppice regeneration from cut stumps persisted in thinned-only forest (but was reduced from 1100 to 500 coppice stems ha\(^{-1}\)) and contributed approximately 16% of total basal area, but less than 1% in volume.
Figure 4.5. Effect of coppice removal on growth of (a) potential sawlogs and (b) potential pulpwood in thinned *E. sieberi* forest 6 years after thinning (SE of the ratio approximated using Yates (1960) are not visible as they are less than 1%).

Relative basal area increase
(% of unthinned)

(a)

Relative basal area increase
(% of unthinned)

(b)
Benefits from fertilising thinned stands

Fertilisation studies in thinned regrowth eucalypts show small to large additional short-term responses to fertilisation (Raison and Connell 1992; Connell et al 2003; Connell and Raison 1996).

Similar studies in NSW confirm (at least in early response assessments) that thinned stands on lower quality sites respond well to fertilisation while response on high quality sites is more variable.

Figure 4.6 shows typical additional fertiliser response in thinned plots for some time after treatment and significant continued growth response during periods of drought stress in both thinned and thinned/fertilised stands compared to unthinned/unfertilised stands.

In an unthinned stand, application of 100 kg N ha⁻¹ increased stand growth by about 15% over 2 years, with most of the response occurring on the large (>30cm dbh) trees. If long-term significant response to fertiliser addition can be obtained in unthinned forest, this would be important because there are large areas of regrowth forests that could be readily fertilised to provide management flexibility by accelerating sawlog production. In contrast, commercial thinning is highly constrained by topographic and stand factors, and the area of forest that can be thinned annually is also modest (about 300 ha for each Waratah harvester operating).

Economic benefits from thinning and fertilization

Using the same case studies some detailed economic analysis is possible of the alternatives surrounding the use of commercial thinning of fire regenerated regrowth of E. sieberi at age 26. Immediately followed by fertilising, then clear felling at age 60. This rotation is chosen principally because in Victoria for instance it could help fill a projected deficit in the long-term flow of sawlogs which will occur around the year 2020 (DCNR 1995).

**Remember**

*Economic analysis requires detailed information from inventory; harvesting cost; projected growth rate; product and market assessments and predictions – and are specific to a particular locality, age class, forest type and structure. This information is specific to this case study and indicative only for other forest areas.*

Costs of Thinning

The costs of thinning are related to technology, scale of operation (including days operating per year), coupe size, topography, ground debris, stem size and stem numbers (Roberts and McCormack, 1991). Costs are based on the Waratah grapple-harvester and a Valmet forwarder/grapple loader operating for 5 days per week throughout the year. Debarking is carried out at the stump by the Waratah, which retains nutrients on the forest floor. A crew of 4 operate the system, the feller-buncher operating for 12 hours per day and the forwarder for 6-8 hours per day. The average daily production will be about 100 tonnes (a tonne equals about 1 cubic metre of young Silvertop Ash. The machines are expensive (new price $850 000 for the two machines) so it is important that they work throughout the year to reduce costs. The initial stand density at age 26 is ~3000 stems ha⁻¹ and this is reduced to ~250 stems ha⁻¹ removing about 50% of basal area. The cost of this operation is estimated to be $27/tonne. The costs cover taking thinnings from the stump to the roadside and loading onto a truck. This cost may be 50% higher than the cost of clearfelling principally because of the additional costs of handling small stems and taking care not to damage retained trees.

For the purposes of the following calculations an average haul of 100 km was assumed. Transport of thinnings were integrated into the general wood transport system. The estimated cost of transporting
the thinnings was 10 cents t\(^{-1}\) km\(^{-1}\) over the 100 km haul which gave a cost of transport of $10 per tonne.

**Figure 4.6. Periodic growth of trees since application of fertiliser (summation of growth of specially banded trees in treatments).**

![Cumulative increase in BA of dendrometer trees (%)](image)

**Costs of post-thinning fertilization**

A conservative fertilizer regime would involve spreading 50 kg of elemental phosphorus per hectare as 'triple super'. This concentrated and relatively expensive fertilizer would be precisely applied by helicopter shortly after the thinning operation. The costs of materials are estimated to be $210 per hectare and the cost of application by helicopter available close to the site is $30 per hectare.

**Returns from sales of thinnings as pulpwood**
Mamers et al (1991) has shown that the regrowth in East Gippsland Silvertop Ash is a high quality pulpwood. It has significantly higher kraft pulp yield than older Silvertop Ash and is comparable with plantation Blue Gum (E. globulus) and good quality Mountain Ash (E. regnans) regrowth. We assume for this economic analysis that the pulpwood logs will be worth $50/tonne which is the current value of older logs delivered to Eden. It is likely that the major opportunity for improving the economics of the system lies in securing the premium for the wood quality of the young Silvertop Ash thinnings. A summary of operational costs and returns for an average thinning operation in East Gippsland is given in Table 4.6 for three levels of thinning yield.

A first hurdle is overcome in that returns from sales of thinnings exceed the thinning costs plus the cost of fertilization if this was chosen to be added. This net return per hectare equates to a royalty of approximately $10 per tonne and would cover the forest growers’ costs of organizing the thinning operation.

Table 4.6. Costs and returns ($ ha\(^{-1}\)) from thinning a 26 year old E. sieberi forest of varying yield.

<table>
<thead>
<tr>
<th></th>
<th>@70 t ha(^{-1})</th>
<th>@ 100 t ha(^{-1})</th>
<th>@130 t ha(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of thinning</td>
<td>1890</td>
<td>2700</td>
<td>3510</td>
</tr>
<tr>
<td>($27 t(^{-1}))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costs of haulage</td>
<td>700</td>
<td>1000</td>
<td>1300</td>
</tr>
<tr>
<td>($0.10 t(^{-1}) km(^{-1}))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizing</td>
<td>240</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>(P @ 50 kg ha(^{-1}))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Returns from thinnings</td>
<td>3500</td>
<td>5000</td>
<td>6500</td>
</tr>
<tr>
<td>($50 t(^{-1}) at mill door)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Return</td>
<td>670</td>
<td>1060</td>
<td>1450</td>
</tr>
</tbody>
</table>

Returns at clearfall

One of the benefits of thinning is the re-allocation of site growth potential to the remaining selected crop trees - increasing their size and potential value. Larger sawlogs at 55-60 years of age could be a useful resource for supplementing shortfalls in sawlog availability predicted for around the year 2020 (DNRE 1996). Larger tree size reduces harvesting costs per cubic metre of wood and if premium prices are paid for higher quality logs, then there will be clear economic benefits resulting from thinning for a rotation length of 60 years, given that total stand merchantable volume will not be reduced by thinning. Similar benefits have been established for Pinus radiata plantations. For example Turner et al. (1996) found that thinning and fertilizer addition further increased the volume of larger trees, and sensitivity analysis by Knott et al. (1996) of the same experiments revealed that increased prices for larger sawlogs and volume gain were the main factors influencing investment performance.

At the time this study was carried out, for coupes close to the sawmill (within 20 km), sawlogs at the stump with a small-end diameter of greater than 45 cm sold for ~ $4.50 m\(^{-3}\) more than similar grade logs of less than 45 cm small-end diameter (Table 4.7). This is the extent of the premium for log size in the current system of log pricing (but there is an extensive system of price differentials (log classification) to account for defects and decay). Larger tree sizes will increase profitability even at this low differential in cost.
Table 4.7. Stumpage royalty rates (S m\(^{-3}\)) of logs of Silvertop Ash by distance from Orbost (prices as at Nov 96).

<table>
<thead>
<tr>
<th>Sawlog Grade</th>
<th>Size Class</th>
<th>20 km</th>
<th>100 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS ‘A’</td>
<td>&gt;45 cm</td>
<td>54.05</td>
<td>46.23</td>
</tr>
<tr>
<td>CLASS ‘B’</td>
<td>&lt;45 cm</td>
<td>28.17</td>
<td>20.35</td>
</tr>
<tr>
<td>CLASS ‘B’</td>
<td>&gt;45 cm</td>
<td>32.80</td>
<td>24.98</td>
</tr>
<tr>
<td>CLASS ‘C’</td>
<td>&lt;45 cm</td>
<td>20.77</td>
<td>13.21</td>
</tr>
<tr>
<td>CLASS ‘C’</td>
<td>&gt;45 cm</td>
<td>25.59</td>
<td>17.77</td>
</tr>
<tr>
<td>CLASS ‘D’</td>
<td>&lt;45 cm</td>
<td>5.40</td>
<td>5.40</td>
</tr>
<tr>
<td>CLASS ‘D’</td>
<td>&gt;45 cm</td>
<td>5.40</td>
<td>5.40</td>
</tr>
</tbody>
</table>

Any improvement in sawlog quality as a result of intensive management which may upgrade the “class” of logs produced even from ‘C’ to ‘B’ class will further increase value by as much as $7.50 m\(^{-3}\) using the available price structure. Improvements in premium prices paid for better quality, larger logs will improve the economics further, and this is likely given the expanding opportunities for value-adding of hardwood timber.

The volume of wood which will attract higher prices for the forest grower is dependent upon the magnitude of the responses to silvicultural treatments and is expressed in the size class distributions of treated forest at the end of rotation. These long-term changes in tree size are unknown, therefore the price differentials between treated and untreated forests are only conjectural, but could be large.

Waugh and Rosza (1991) calculated log values in relation to tree diameter by deducting sawing costs from product values for two sawing methods, to produce appearance and engineering grade timber, from Mountain Ash (E. regnans). Their highest values corresponded to producing engineering and structural products, and appearance products classified with a revised grading system. Trees of 40 cm diameter at breast height over bark were valued at approximately $70 per m\(^3\) and trees of 100 cm were valued at approximately $120 per m\(^3\) at the mill door. These might correspond to $45 to $95 per m\(^3\) for wood on the stump and would translate to large differences in sawlog royalties per hectare where larger volumes are contributed by the larger size classes. Similar results could be expected in Silvertop Ash.

**Additional benefits of commercial thinning following an earlier spacing treatment**

There is some evidence that, in addition to accelerating the growth of selected stems, early spacing will reduce the costs of commercial thinning, allowing a greater proportion of a stand to be commercially thinned. The effects of spacing at 10 years of age, on the efficiency of a commercial thinning operation and on stand characteristics 20 years later, are summarised in Table 4.8. The data were collected from adjacent 1 hectare areas. Early spacing increased thinning yields and reduced the cost of harvesting the wood; thinning damage was also reduced and the size of future crop trees was increased which will lead to substantial future benefits (shortened rotations, larger logs).
Table 4.8. The effects of spacing regrowth Silvertop forest to 1500 stems ha\(^{-1}\) at age 10 years on harvesting costs, yields of pulpwood and economic returns from thinning the stand 20 years later. After Kerruish \textit{et al} (1993).

<table>
<thead>
<tr>
<th></th>
<th>Unspaced</th>
<th>Spaced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulpwood: Lower costs and higher yields</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulpwood harvest (t ha(^{-1}))</td>
<td>132</td>
<td>174</td>
</tr>
<tr>
<td>Thinning costs ($t^{-1}$)</td>
<td>24.0</td>
<td>16.5</td>
</tr>
<tr>
<td><strong>Cost of spacing: all costs are recovered by first thinnings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return from thinnings ($sha^{-1}$)</td>
<td>1320</td>
<td>3045</td>
</tr>
<tr>
<td>Cost of spacing ($sha^{-1}$)</td>
<td>0</td>
<td>1130*</td>
</tr>
<tr>
<td>Net return to grower ($sha^{-1}$)</td>
<td>1320</td>
<td>1915**</td>
</tr>
<tr>
<td><strong>Remaining stand: significantly shorter sawlog rotations?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average volume of remaining trees (m(^3))</td>
<td>0.44</td>
<td>0.70</td>
</tr>
<tr>
<td>Volume of remaining trees (m3ha(^{-1}))</td>
<td>114</td>
<td>182</td>
</tr>
</tbody>
</table>

*assuming spacing costs of $350 per hectare and a 5% compound interest

**assuming stumpage of $10t^{-1}$ and harvesting benefits accrue to the grower

**Summary of case studies for silvertop ash forest**

- Increased productivity to accelerate sawlog growth can be achieved by manipulating both stand density and site fertility (fertilizer application) at several phases of the rotation - at the time of regeneration, at age 5-10 years (non-commercial thinning), at age 25-30 years (commercial thinning), or in older stands.

- Growth responses to reducing stocking and to fertilizer application can be large and analysis of changing patterns of tree growth suggests that responses are likely to be long-lived.

- Control of tree spacing at all ages can be achieved with no detriment to form factors which would affect sawlog value.

- Silvicultural treatments such as spacing, thinning and fertilization to increase the productivity and value of regrowth stands can be confined to selected areas of forest that are given priority for wood production within a regional conservation framework. Such management approaches can create new sawlog resources, maintain or increase biodiversity and improve forest health and sustainability.
• While investment at the beginning of tree rotation (non-commercial early spacing) may also provide net long-term benefits, it is likely that the priority will be in stands that can be commercially thinned (costs of thinning can be immediately re-couped) and where future sawlogs are likely to be generated within 20 to 30 years.

• Harvesting and regeneration research in Victoria and NSW shows that:
  1. systems other than clearfall systems can provide adequate regeneration
  2. under these systems mature tree retention during early spacing and thinning, and retention of seed and habitat trees at final harvesting and following regeneration reduces seedling growth and therefore productivity potential for wood products. Increasing tree retention can drastically reduce productivity.

Figure 4.7. A successful rotation strategy for increasing wood values and productivity in silvertop ash forests with a high component of even-aged regrowth.
Chapter 5. Protecting soil and water, biodiversity and aesthetics

Management of private native forests for timber production needs to be done in ways that respect all regional significant forest values and maintain forest ecosystem function. This is a core requirement of Sustainable Forest Management. It is outside the scope of this document to deal with all the value contributions that could be made by private native forests, however, three important sets of values; soil and water, biodiversity and aesthetics are critical to the sustainability and perception of good forestry practices and will be dealt with in this chapter.

Forestry practices have been developed that result in low effects on these values when well implemented. In most states these practices have been compiled into sets of rules and guidelines, usually referred to as the Code of Forestry Practice (slightly differing terms in each state). In some states these Codes apply to operations on both State forest and private forests, in others they are a requirement only on State forest.

Codes of Practice are usually comprehensive documents. Where the application of codes on private land is compulsory, you need to obtain and apply these Codes. In the other states where private forest is not covered, we still urge you to obtain copies which deal with similar forest types if possible.

The approach adopted in this chapter is to present a summary of the key points and some background to help explain the reasoning behind the Codes.

Soil and water protection

Soil compaction and soil erosion are usually the major environmental threats to soil and water values from forestry operations. Other threats such as salinity increase and nutrient depletion are sometimes present but usually of lesser importance at the farm scale. The contribution of forest harvesting activity to salinity is probably small or potentially beneficial provided there is effective regeneration and whole catchments are not treated at one time. Nutrient depletion is of lesser concern in most long rotation forestry because of the low frequency of effects.

Soil Erosion

Erosion is predominantly a natural ecosystem process caused by water and wind. Wind erosion in native forests is a small factor. Water induced erosion can occur where soil is exposed to moving water with sufficient energy to displace soil particles. The severity of erosion depends on the volumes of soil particles eroded, how far they travel and where they end up. Soil movement within the forest enriches some areas while denuding others. Commonly the greatest concern is where suspended soil particles reach waterways, where they detrimentally affect water quality.

Factors influencing erosion

Generally, undisturbed forests have very low rates of runoff and erosion. Increases in erosion following forest harvesting or road construction follow as a consequence of increases in runoff. Increased runoff is generated by compacted and exposed hard surfaced areas, such as roads and log landings where rainfall quickly run’s off rather than sinking in. Operations can also lead to changes in ground-surface shape that increase channelling of water, for example, along log-skidding tracks.

The extent to which this increased runoff increases erosion of soil depends on:

Soil type - capacity to absorb water and its erodibility (topsoil and subsoil). Erodibility is the ease with which soil particles can be detached. Soil particle size is also a very important factor because
small particle are carried much further before they fall out of suspension. Clay soils have some of the finest particles and these are very readily carried to streams and rivers.

**Rainfall** (amount and intensity). Raindrops themselves have some erosive power. Rainfall intensity (rate) has a strong influence. High intensity rain can quickly exceed the soils capacity for absorption and therefore generates runoff (frequently leading to localised flash floods. Low intensity rain, the kind called “good soaking rain” can deliver the same total volume of water over days without generating significant runoff.

**Slope** (steepness and length). Slope has an adverse effect because it causes an immediate increase in water speed which in turn increases the erosive power of the water flow. Doubling the speed of overland flow can treble the erosive power.

**Vegetation cover (trees, shrubs, grasses and mosses).** Tree or shrub canopy breaks up rainfall drop size (usually). Ground cover and debris in contact with the soil are very important for slowing water speed and thus reducing erosive power. Ground vegetation, litter and debris catch and hold other soil particles and debris suspended in the flow – reducing losses.

**Soil disturbance level (caused as part of the management activity).** Forestry operations cause widely differing levels of soil disturbance. Skidding for example can involve a mechanical tilling of the soil surface caused by dragging log ends and by the churning of machine tyres or tracks. Disturbance also varies with soil strength (and wetness). Some soils are very easily powdered to dust in very dry conditions. Most soils rapidly lose strength and structure in wet conditions; and continuing operations in very wet weather can readily lead to deep rutting and excessive soil damage, and further adverse channelling of water in subsequent storms.

**Controlling erosion**

Controlling the power of running water will control erosion. By following a number of simple rules the overland flow of water can be minimised – reducing erosion and allowing more water to penetrate and be stored in the soil:

- Minimise the area of exposed soil, particularly with more erodable soils and in areas of high erosion hazard. This starts with planning, for example, to minimise road lengths
- Schedule operations to avoid periods of high rainfall risk where these are known (eg. some areas experience prevalent summer storms, so conduct the operations in dry periods.
- Ensure slope length on roads and tracks are broken at regular intervals;
- Ensure canopy is preserved and that ground cover and debris are well spread to increase surface roughness.

**Stream area protection**

In almost all native forestry operations steam protection zones (usually termed buffers) are preserved for water quality protection. These also play an important part in biodiversity conservation. In fact, in some areas, biodiversity protection requirements lead to wider buffers than those required for water quality protection. In this section the focus will be principally on understanding the principals as to why and how streams are protected during a forest operation. Biodiversity protection (including the role of protected areas) is treated in the next section.

Effective measures for protection of water quality usually start at the planning phase. In some locations in Australia it is the dispersible nature of the soil, especially the subsoil, which creates a water quality problem. While the forest and its roads may not be losing a lot of soil, significant damage can be done to water quality and aquatic life. How is this situation best managed? - The best cure is prevention.
Codes of Practice

Soil and water protection rules and guidelines are usually one of the largest sections of Forestry Codes of Practice. All the states with a hardwood forestry industry now have Codes of Practice covering timber harvesting, at least for public land. In some cases, State forestry agencies also have supplementary regional-level guidelines that are more specific to local conditions. Farm-forestry managers are urged to obtain and study these documents.

A number of key control measures are common to most codes and replication of these many guidelines is not attempted here. Instead, we draw attention to the most important factors which may have differing importance in different soil and forest types. They are presented here as general guidelines only and reference should be made to the relevant Codes of Practice in your State or region:

Roads and drainage run-off from managed forest

Planning is the first key factor in controlling and minimising water quality effects. Roads, tracks and landing must be located to avoid or minimise the creation of runoff and flow paths that will permit turbid runoff reaching streams. Table 5.1 provides a general example of the maximum spacing of cross or outfall drainage for forest roads. Table 5.2 presents similar indicative information for snig tracks which are usually drained by the formation of a high diversion bank after skidding is completed. The aim is to turn flowing water away from the road and onto the forest floor (Figure 5.1) before it builds up in volume (i.e. minimise length) or speed (relates to slope):

Monitoring of roads and tracks and run-off areas is essential:

1. Ensure that harvesting operatives stick to the plan and the relevant Code’s rules and guidelines.
2. Within these pay particular attention to mechanisms that control runoff water flow during high rainfall events.
3. The recommended spacings depend on soil erosion hazard. There are no standard classification systems for soil hazard rating in Australia, so referral to the relevant Codes of Practice is recommended.

Figure 5.1. Culvert drain to take away run-off from the road.
Table 5.1. Typical table drain spacing along a road (m) for different road grades and erosion hazard.

<table>
<thead>
<tr>
<th>Road grade</th>
<th>Soil erosion hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low-Moderate</td>
</tr>
<tr>
<td></td>
<td>Distance between drainage points</td>
</tr>
<tr>
<td>&lt;10%</td>
<td>90 m</td>
</tr>
<tr>
<td>10-20%</td>
<td>60 m</td>
</tr>
<tr>
<td>(Short sections only)</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.2. Water diversion bank spacing (m) along an extraction track for different track grades and erosion hazard.

<table>
<thead>
<tr>
<th>Track grade</th>
<th>Soil erosion hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low - Moderate</td>
</tr>
<tr>
<td></td>
<td>Diversion bank spacing (m)</td>
</tr>
<tr>
<td>&lt;10%</td>
<td>60 m</td>
</tr>
<tr>
<td>10-20%</td>
<td>50 m</td>
</tr>
<tr>
<td>20-27%</td>
<td>40 m</td>
</tr>
<tr>
<td>27-35%</td>
<td>25 m</td>
</tr>
<tr>
<td>35-45%</td>
<td>20 m</td>
</tr>
</tbody>
</table>
Buffer zones

How do buffers work?

The functions of a water quality buffer zone are (i) to keep potentially harmful soil disturbing operations away from drainage channels, and (ii) to trap sediment and suspended clay particles, before they enter a stream or drainage line. In most rainfall events, runoff generally only occurs where the surface has been compacted, such as on snig tracks and roads or on already wet areas, such as stream or wetland margins.

The buffer acts like a sponge, absorbing water, slowing it down and trapping sediment in small pools. If the area of buffer is insufficient to absorb all the flows from say, a culvert outfall at an agreed storm intensity and duration, then water will flow through the buffer and reach the stream. In such cases it would be necessary to reconsider the culvert or road location, or install some type of diversion material to slow flow.

Determining the size of the buffer

Codes of Practice, include specifications on buffer location and width. Buffer widths in these Codes are commonly between 10 and 20 metres, and up to 40 and even 100 metres in some States. These Codes typically require buffers on permanent streams and larger non-permanent streams and drainage lines. Buffer size should be increased in steeper areas and on more erosion prone soil types.

The effectiveness of buffers are determined by the volume of water to be carried, what it carries with it and how effective the surrounding soil and plant materials are at halting or absorbing the flows. Some additional points to be considered in design and effectiveness are:

- Volume to be controlled - how large are likely volumes from the upslope general harvesting area? Are they effectively controlled and dispersed before potential flows can reach the buffer edge?
- Particle size – fine particles (clays) remain in suspension longer than coarse ones and thus can be transported further.
- Slowing water flow increases chance of soils falling out of suspension. Greater absorption can potentially extinguish surface flow.
- Local rainfall intensity and duration are particularly important factors as these determine likely surface water volumes.

Harvesting in buffers strips is usually avoided. However, highly selective harvesting is sometimes possible with appropriate machinery and without damage to the integrity of the buffer. Trees should be felled outward, away from streams, and logs removed without significant ground disturbance. For instance, using excavator based felling heads, it is possible to reach into buffers and remove whole trees, which are lifted back into the harvesting area to be processed. The ground and much of the understorey vegetation can remain largely undisturbed. Any disturbance that forms a water flow channel must be repaired to prevent flow.
Guideline 5.1. Creating buffer zones

The most important land to protect in most small catchments is the point of water confluence or springhead. Where soils are hard setting, or as land becomes steeper, there is a need to increase the width of the buffer to accommodate increased overland flow.

Buffers need to extend well beyond areas that are likely to be saturated during wet periods.

Figure 5.2. The scene below shows some key considerations in road and buffer networks illustrated on a clearfelled plantation site.
Protecting water from industrial pollutants

The use of chemicals including herbicides, pesticides and fertilizer requires utmost care, as does the handling of fuel and oils. As a general rule, protective embankments should surround any fuel or chemical storage. There are State and Commonwealth Regulations (Occupational Health and Safety Act 1983 and the Pesticides Act 1999) governing the use and application of chemicals and various Australian Standard Codes apply (AS 1940-1988 and AS 2906-1991). Undertaking a farm chemical users course will provide accreditation and knowledge needed to apply most of the chemicals used in farm forestry operations. Records should be kept of all chemical operations.

**Guideline 5.2. Chemical care and advice**

Activity involving chemicals should not be conducted within 20m of any drainage feature – including drainage depressions, unless it is to target specific weeds such as blackberries or lantana. Expert advice should be sought where chemicals are going to be used in runoff zones.

Protecting biodiversity

Native forests on farms cover a wide range of forest types from widely-spaced woodland remnants in dryland regions; through to the highly stocked stands of tall wet forests of Tasmania. They are also in many stages of forest growth - from dense young seedlings, through pole and multi-aged sawlog stands up to widely spaced mature and old-growth stands. Forests also contain great landscape diversity from moist creek-lines with deeper soils, through varied mid-slopes, to ridges tops - often with shallow soils and exposed aspects.

These forests provide the habitat for a large range of plants and animals, the entire fabric of which is termed the ‘biodiversity’. Protecting diversity is one important aspect of sustainable forest management. Protecting biodiversity in any specific forest setting depends first and foremost on adequate knowledge about what’s present, how common the species present are and how those populations relate to other local and regional areas. This knowledge also needs to extend to habitat requirements. Habitat is the term used to describe the living space and conditions needed for plants or animals, particularly those components providing food and shelter.
Forest management, including the protection of biodiversity resources where needed, mostly involves management of the effects of forestry on habitat. It recognises several critical processes. The first is re-colonisation, that plants and animals return to disturbed areas as habitat conditions once again become favourable, and a second is critical minimum population levels, avoiding the threat that if numbers or area fall too low, other change events (fire, drought, and predation) might detrimentally tip the balance and a viable local population could be lost. Changes may be small scale and temporary - with forest dynamics and species adaptability quickly adjusting with little or no overall effect on structure and populations.

**Forestry operations that affect habitat also affect biodiversity**

Forestry activities - particularly forest harvesting - undoubtedly affect habitat in different ways to natural processes (primarily fire and wind). The importance of the effect depends on the size of the area affected and on the nature and intensity of change, and may not be substantial for an individual private forest operation.

Food, shelter and refuge are the key constituents of habitat. Changes to the forest as a result of harvesting are:

- Direct - in the removal of selected trees that might have been providing any or all of these key components, and
- Indirect - as a result of changes in sunlight, moisture, temperature, shading etc. that influences the way the forest changes and grows after the harvesting.

**Direct consequences**

Direct consequences are most obvious. Clearfelling obviously causes the greatest changes while selective logging taking a few trees per hectare might have minimal effects. A conventional harvest operation focusing on the larger trees might have a disproportionate effect when the larger trees are providing shelter or nesting sites. On the other hand, it might be easy to retain a few trees with hollows to meet this need (this is a requirement of some Codes of Practice). Tree and shrubs disturbed during harvesting can cause direct food source loss. Changes in the structure of the forest canopy (larger trees and understorey) can expose smaller species to predation, smaller birds for example. Regeneration activity may also cause effects. Fire, sometimes at high intensity, is needed to effect good regeneration in some moist southern forests. However, these fires parallel in some aspects, the periodic natural stand fires that occur historically. Mechanical soil disturbance that exposes mineral soil has been found necessary in other forest types and these operations also have effects on shrub and understorey components.

**Indirect consequences**

The indirect consequences are more pervasive. Harvesting a significant proportion of a canopy certainly changes the sunlight and moisture regime for the remaining plants. The changes are most extreme where broad-scale fire is used although farm-forestry is somewhat less likely to employ high intensity fire techniques because of the high level of technical resources needed to carry them out.

There are also effects from the patterns in which harvesting operations are carried out. While individual harvesting blocks (and their effects) might be small, the harvesting of a series of adjoining blocks in successive years on one farm, or even on adjoining farms clearly has a bigger effect. These larger patterns of harvesting can have an effect of fragmenting forest habitat, particularly for species such as the larger animals that might require larger contiguous areas for foraging.

Regardless of the type of operation, removal of even a few trees (viz. large trees) can alter the structure of the forest, and it is probable that the more intensive the operation, the more significant the effect on immediate conservation values will be (Figure 5.3). Private forest owners are probably not interested in managing their forest for either an exclusive 100% focus on wood production or a 100% focus on conservation. There is a general recognition of sustainable forest management goals and managers are expected to be seeking efficient trade-off between biodiversity, economic and social
values. This will probably see them managing different parts of their forest at different extents of disturbance

**Figure 5.3. Conceptual relationship between different forest values and the extent of site disturbance (Adapted from Raison et al. 1997).**

![Graph showing the relationship between conservation value, wood production value, and extent of disturbance.](image)

**How much protection is needed?**

Individual farm-forests are not and cannot be solely responsible for preserving all biodiversity values. Almost all values are present at scales beyond the individual property. Animal and plant populations spread across many properties, even regions and States. In Australia, planning in the major forest regions has been revaluated under the Regional Forest Agreement process and State and Federal governments have agreed to set aside target proportions of conservation area for each of the major forest types to help assure preservation of biodiversity values. Management of the remaining forests is expected to protect biodiversity to the extent feasible, but to allow disturbance such as forest harvesting. Thus individual farm-foresters have the freedom to undertake management that has some effect on biodiversity, but with an understanding that they will manage toward sustainable forestry.

Biodiversity protection requires protection of habitat. Some disturbance is inevitable, both direct (short-term) and indirect (longer-term). It is part of the trade-off of values involved in sustainable forest management.

Individual farm-forests cannot shoulder the full burden of regional biodiversity conservation, but individual landholders must protect any officially listed species.

Individual property owners (forestry and others) do have an absolute obligation in all States in regard to rare and endangered species. You are unlikely to be able to harvest in those areas where such species are known, or thought to occur.

The main problem in relation to protection of biodiversity at the farm-scale, is that at this stage knowledge of the presence and distribution of species is still limited. The current focus in native forest management on private land is to advise farmers to manage biodiversity issues prudently by seeking information from wildlife experts on likely issues (if any) and then adopting practices to provide a general level of protection.

**Managing the effects on habitat to protect biodiversity**

Management of habitat in farm-forestry is mostly about management of disturbance. It is unlikely that landowners will have the biological knowledge required to determine management effects on many or all species. Many local and regional organisations allow landholders to seek direct advice on likely...
species occurrence and effects from experts. Departmental officials responsible for biodiversity protection at the state level (generally the departments with responsibility for National Parks) usually have comprehensive maps and tools to predict the occurrence of important species at farm scale. These organizations will assist in identifying important habitat elements for any important species identified. National Parks (or other responsible agencies) usually has relevant detailed information. Advice might be available from State forest management agencies or from Codes of Practice in your State.

Typical actions affecting habitat and therefore requiring consideration during harvesting operations include:

- Retention of some standing dead trees, or other mature trees with hollows for den or nest sites. The retention of younger trees to provide future hollows may also be important.
- Retention of dead trees on the ground and in streams.
- Treatment of specific species of living trees that provide food for particular groups
- Reservation of areas from cutting where possible, for example where economic returns might be poor (steep or rocky areas which may have low yield and / or expensive harvesting costs).
- Retention of habitat in corridors along streams and drainage lines. These areas are usually already marked for protection for water quality reasons and readily serve double purposes.
- Provision of linkages between habitat elements (across farm boundaries also). Extending wildlife corridors formed along drainage lines is often a simple option. A related approach is to avoid fragmentation, prefer fewer larger reserved areas to many smaller ones.
- Excluding stock and controlling vermin. Stock and vermin can exert a heavy grazing pressure on regeneration

All of the factors identified above form critical parts of the forest management and harvesting plans. Planning should also ensure sequencing of operations through time to control adverse effects of disturbance.

**Guideline 5.3. Steps to improve biodiversity protection include:**

Seek advice on presence of any officially listed species and important habitat requirements.
Reserve areas from disturbance where possible
Retain habitat along drainage lines and ensure linkage of habitat elements.
Exclude stock and vermin
Build habitat protection into your forest management plans.

**Minimising the visual effect of harvesting**

Native forestry can vary from light selective sawlog cutting in mixed forests to high recovery clear-fall logging with a comparable range of very apparent visual effects on skylines and vistas. However, the
full visual effect of a harvesting operation as viewed by a member of the public is also influenced by other factors. These include proximity to the operation; the attitude of the viewer toward forestry, the operation’s position in the landscape and what else is around it, in addition to the look of the operation itself.

**Figure 5.4. A dense vegetation buffer will reduce the visual effect of harvesting.**

Private native forestry activities are not generally subjected to official requirements for assessment or approval in most states. However, it is still prudent to assess the likely potential for effect and forestall it where possible. Important questions that determine your approach to visual amenity might be:

- What is the frequency of visitors and how close will they come to the harvesting area?
- Is the site adjacent to a major local road such that it might attract a lot of attention when the trees start falling?
- Are there any major or minor tourist attractions in the area who may perceive a detrimental effect on their trade

Adopting some or all of the following approaches can reduce the visual effect in both the short and longer term.

- Plan to manage visual effect. The management of landscape should be an incorporated part of your forest management and harvesting plans. The plan should clearly indicate the sequence and location of harvesting activities with coupes arranged to take account of local sensitivities. Use the plans as a basis for discussion.
- Log selectively removing a limited number of trees at any one time, in forests that support selective logging, or log in patches for forests that need clear ground conditions for regeneration. Trees that make up the buffer can be harvested at a later date when the coupe area has regenerated sufficiently.
- Leave a buffer or vegetation screen, if possible, between the road and the harvesting area.
- Establish irregular boundaries that blend in with the topography or the structure of the forest. It may be possible to clearfell in the harvest area proper and to thin close to the edges.
- Stagger the harvest over several seasons and do not log adjacent coupes in successive years.
- Harvest in patches and ensure regeneration is evident before harvesting an adjacent patch.
• Clean up the larger debris within the harvest area and stack residual wood (possibly for later sale as firewood) but leave logging slash on the ground to protect against erosion

• Leave islands of residual trees and understorey (also important for regeneration and habitat). This will also break up the harsh appearance of the area.

• Angle the entrances off the road to enhance the effectiveness of the visual buffer.

• Keep the harvest area edges in sympathy with the terrain and avoid cuts that go over ridgelines.

• Redistribute any bark heaps away from landings after harvesting;

• Be proactive. If the operation is readily visible and the wider community will be affected, then consider discussing issues with neighbours and local shire planning staff. Be prepared to discuss ways to minimise the visual effects

Guideline 5.4. Practical steps to reduce visual effects include

Plan to reduce visual effects where possible
Log selectively where possible, or harvest in patches
Use irregular boundaries, keep them in sympathy with the terrain and avoid skyline cuts
Stagger harvest and avoid logging adjoining blocks until regeneration is well grown
Preserve residual trees and groups
Clean up debris and redistribute any bark heaps.
Chapter 6. Product recognition

There are a large range of ‘products’ that can be utilised from the forest – providing both wood and non wood values:

<table>
<thead>
<tr>
<th>Timber Products</th>
<th>Biodiversity</th>
<th>Recreation</th>
<th>Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawlogs</td>
<td>Habitat trees</td>
<td>Aesthetics</td>
<td>Water quality</td>
</tr>
<tr>
<td>Pulpwood</td>
<td>Habitat structure</td>
<td>Bush walking</td>
<td>Soil protection</td>
</tr>
<tr>
<td>Firewood</td>
<td>Fauna</td>
<td>Solitude</td>
<td>Non-timber products</td>
</tr>
<tr>
<td>Posts and Poles</td>
<td>Flora</td>
<td>Tourism</td>
<td>Honey</td>
</tr>
<tr>
<td>Sleepers</td>
<td></td>
<td></td>
<td>Cut flowers</td>
</tr>
<tr>
<td>Burls &amp; Ornamental timber</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To maximize value and/or utilization of the forest environment an understanding of potential products and forest health is essential. Non-wood values are considered important (see Chapter 5) but are not the focus of this chapter on timber products. Biodiversity values will be discussed as most of ten wood and biodiversity values need to be compromised into the one management area.

Understanding potential non-wood values

All forest has some intrinsic value for some sector of fauna and flora irrespective of its condition or health. Very poor health and condition does not necessarily render it of little value but may represent a state which is non-sustainable. In unhealthy forests of poor quality those species of fauna and flora present may be transitory as trees continue to decline which may lead to drastic changes in species mixes or even the loss of some species, including trees. Healthy forests usually exhibit more sustainable habitat structure.

Forest condition – health and potential

Most managers would wish that their forest types provide a range of opportunities (products; values) that can be integrated into farm management systems. The greatest range of values and possibilities are likely to be found in a healthy and productive forest.

The best indicators of forest condition are those which reflect the health of the trees and other vegetation such as those discussed in Chapter 4. Those that reflect both tree health and growth potential are by far the most important – crown health and espacement.

Crowsns are likely to indicate poor health and productivity when they contain dead branches, mistletoe, epicormics or irregular structure and this also affects the ability of the crown to respond to changing resource conditions (such as increased nutrients or reduced competition).

The amount of growing space available to the trees affects not only their crown development but factors of form (boles, stem height vs. crown spread) and quality (damage through rubbing, insect transfer). If trees suffer suppression and structural changes, or are inhibited for too long then valuable increases in wood product as a proportion of any growth responses are likely to be lost.

In Chapter 5 the importance of habitat structure was discussed. Increased diversity of structure, vegetation (layers and species) usually leading to a general increase in biodiversity. The density and number of structures and species can be used to assess likely habitat value – although management of habitat for a particular species or group of fauna (or flora) usually needs quite detailed assessment and strategies.
Habitat trees and structure

Tree health and species richness in a forest management area can be assessed for both potential wood products and many other non-wood values (food, foliage and wildflowers). Assessment of the non-wood values will not be dealt with in any detail in this document but local agencies and many government agencies (i.e. RIRDC) can provide technical reports and evaluations of non-wood forest products.

Assessment of habitat trees which may be required in silvicultural systems takes into account their age, defects, presence of hollows and dead branches and crown structures. Older trees usually have further developed habitat structures and more of them. Younger trees may have the beginnings of habitat structures and may often need to be included as retained trees because they can develop further to maintain or improve biodiversity value of a forest. They are then called ‘potential’ habitat trees in forest assessment.

Some systems require a minimum number limit of habitat trees or potential habitat trees to be retained amongst the managed forest.

Understanding potential wood products

Substantial economic inputs from private native forest are most likely to come from timber products and are therefore most often the landowner’s main interest for management. Timber products are sold in a number of forms. Logs are the most common form; although a wide variety of others might be considered, ranging from high value furniture pieces to firewood.

The majority of saw mills produce rough sawn hardwood timber which is used for low value applications such as joists and bearers for construction; battens; fence palings and rails; and various size rough sawn posts and stakes. The by-products of sawmills can be firewood, sawdust and woodchips. The on-site sawmiller (portable mills) can produce a similar range of products.

Farm-foresters with small parcels and infrequent sales will not be familiar with all products and can find it difficult to estimate products or potential sales. The following sections detail some of the most common products, terminology and grade information used by potential buyers which should assist landowners with recognising existing and potential products.

For timber products there is a diverse range of markets and products available (from firewood to extremely valuable ‘peeler logs’) although not all opportunities will be available to any one area. They each have their own sets of Australian and/or local Standards of quality measures which reflect the control and protection of the industry.

Physical properties affecting potential timber use

Density

Timber density is a useful indicator of the "hardness" of the timber and reflects its strength and workability. The more dense the timber, usually the stronger it is and more usable for load bearing construction.

Strength

Standards Australia has an agreed set of specifications and stress grading (F values) which grade the strength of various timber sizes and its capacity to carry load. The indication of strength determines what end use the sawn timber can be used for and is affected by the species and the presence of imperfections such as knots, veins, gum pockets etc. Visually graded timber considers the extent, size and nature of the imperfections in the grading process – whereas mechanical stress grading is achieved
by applying a lateral force to the timber and measuring the amount of timber deflection. Both
assessments provide a strength rating. The subsequent F Rating ranges from F4 to F27 in hardwoods
and F4 to F8 or perhaps more for softwoods. The higher the rating the higher the strength of the
timber piece and generally the higher the value.

Whether selling logs or sawn timber from the farm long clear boles or lengths of sound timber are
likely to return premium prices. The presence of damage, large branches and knots, gum exudations
and other visual defects and deteriorations are likely to reduce the potential value of products – and
may render some trees or species unusable for certain products.

**Colour**

Natural timber colours can be in demand for appearance grade timber products and colour richness and
board uniformity is of particular importance (returning higher prices) in some flooring and furniture
timbers. Conversely there is also limited market for variability and ‘character’ in specialty products.

**Susceptibility to fungi or insect attack affecting potential timber use**

The principal causes of damage and deterioration of timber for the farm seller and/or user are from
fungi and wood boring insects.

Fungi can be divided into two main groups:

- The sap stain fungi which cause discoloration (especially in sapwood), and
- The decay fungi.

Deterioration caused by fungi is worst under moist conditions and most commonly a problem when
susceptible timbers are used at or near ground level, (i.e. poles and posts). Usage in dry conditions
extends service life but less susceptible and more durable species will return the highest prices.

Insect attack however can not only cause deterioration of timber integrity but may also lead to serious
dangers in susceptible timber used in construction. Important insect pests for softwood and some
hardwoods are:

- Powder post beetle (*Lyctus brunneus*) – which attacks the sapwood of susceptible species and
can cause considerable damage (reducing sapwood too dust in a short time). Preservative
treatment can be applied to timber. Qld, NSW and Vic legislation restricts the sale of non-
treated susceptible species of timber used for manufactured material (furniture, mouldings,
plywood etc), or structural timber with small amounts of sapwood present.
- Common house borer (*Anobium punctatum*) – attacks mainly softwood. Hardwood attack is
rare.
- European house borer (*Hylotrupes bajulus*) – it will readily attack most softwoods and attack
sapwood of some hardwoods.
- Termites or white ants (various genera) – timber framing, poles, posts, railway sleepers and all
forms of sawn timber and most species are liable to be attacked.

For all forms of decay and insect damage “prevention is better than the cure”. For the farm seller and
the customer knowledge of susceptibility, the legislative restrictions, and the possibilities and
cost/benefits of preservation treatments are a sensible guide to utilisation and potential.

**Durability of timber**
The natural resistance of the heartwood of a tree to rot (decay) and insect attack is termed its durability. It is a reflection of the serviceability of the timber in a number of uses. The sapwood of a tree is commonly less durable but can be treated with preservative to increase its serviceability in many end uses.

Natural durability of the species present in a stand has a determining effect on its suitability for products – particularly for in ground service (Figure 6.1). Durability classes of the species given in Timber Standards will have a direct effect upon both the methods of assessment as well as the product classes harvested. The following classification system is used to define heartwood durability:

- **Class 1** - The highest naturally durable timbers which may resist decay and termite attack for 25 yrs or more
- **Class 2** - Highly naturally durable timber, may have a service life of 15-25 years
- **Class 3** - Moderately durable timber, may have a service life of 5-15 years
- **Class 4** - Low naturally durable timbers which may have a service life of only 1-5 years.
  
  Note: ALL SAPWOOD irrespective of species is regarded as Durability Class 4

Further information is available from your regional State Agencies and Timber Standards.

**Figure 6.1. High durability fence posts, sold on-farm can achieve high returns for effort (Photo: K. Matthews).**

**Possible timber preservation treatments**

The heartwood of a few low durability timbers and the non-durable sapwood on many timbers can be treated with preservatives to increase their serviceability. Preservative treatments vary and local industry experience and operators should be consulted.

All pines and the sapwood of some hardwood species are immune to lyctid attack. For susceptible species a range of acceptable preservative treatments can be used to immunise the timber. In Queensland the Queensland Timber Utilisation and Marketing Act 1978-1990 (TUMA) prohibits the sale of lyctid susceptible timbers without immunisation unless specified by the purchaser. Other States are following.
Sawlog timber products

Sawlogs are generally saleable if they are over 25 cm diameter (if they are good quality) and generally 3.9 m or longer in length. Larger logs are still preferred. Sawlogs frequently need to be at least 5.9 m long with a small end diameter more than 25 cm under the bark. The standard for sawn timber is a length unit of 2.4 m, but 2.5 m is required for the log length, so that any damaged end material can be docked at the mill. However, handling and transporting ‘shorts’ is both a logistic and an economic issue. The on-site portable miller however will usually be happy to work with logs of 2.5 m length if they are of larger diameter.

_Cypress pine_ is special case. Sawing grade logs typically need to be longer than 2.6m, more than 16cm under bark at the butt and 12 cm under bark at the top. Sweep must be less than 20% of log centre diameter. Knots must be less than 12cm and not closer than 1m apart. Other defects are also taken into account in assessing the grade of the log.

**Defect in sawlogs** will substantially affect the class and hence the value placed on a log. The following terms briefly describe different types of defect.

**Sweep:** This term refers to the degree of bend in a log. Sweep is generally expressed in relation to log diameter.

**Pipe:** This is commonly a hollow section or rotten area in the centre of the log.

**Lims and bumps:** Any limb more than 10cm diameter will generally result in a down grade of the log class.

More detailed information on log grading can be obtained from the RIRDC publication “Defining the product - Log Grades used in Australia” by R.N. James (2001) and is also discussed in Chapter 8.

**Poles**

Poles need to be long (8 metres +), straight, have high strength and good appearance. There are also four strength groupings for poles (Australian Standard AS 2209 [http://www.standards.com.au](http://www.standards.com.au)). Poles need to be durability class 1 or 2. Limiting standards for defect are stringent and only a few centimetres in length can change value and use considerably.

**Veneer logs**

Veneer logs have very high quality requirements and generally need to be more than 50 cm diameter, straight and 2.6m long, or a length specified by the processor.

**Sawn timber (from sawmills on-farm and mobile mills)**

A range of markets exists for sawn timber; categorised as green sawn, air-dried or kiln-dried. Sizes and products can be cut and seasoned on-site or in specially designed kilns. Some producers generate products in all three categories. Green sawn product provides an immediate return off the saw. Air-dried timber requires an investment in time and care in the extra handling. Kiln dried timber requires additional handling again and substantial capital outlay. Although costs of production rise in the latter case, the profit margin will be greater for the value-added product.

**Non-sawlog timber products**

Most trees contain significant sections of lower-value wood. Segregation and grading of wood products allows you to achieve the best price for your timber, but until the trees are harvested and cut into logs the precise proportion of products can only be estimated (sometimes relatively roughly). However, the private grower can usually afford to be more selective in the sorting and grading process.
to maximise the sections with quality attributes that bring high value. Mobile mills are an added asset in this process, because the operator can select small sections or even sides of a log for high-grade product; whereas a less discriminating industrial sawmill may make judgements on the whole log, perhaps sending it all to the chipper.

In marketing timber, species, log size, straightness and defect determines the product groups. Tall healthy trees can supply a sawlog in the base, a pulp log on top and the rest as firewood or potentially some other product such as chips for landscaping. Non sawlog products can be divided into several categories:

**Pulp logs**

Pulp logs are generally greater than 10 cm diameter and more than 3m in length. Not all species are suited to the pulpwood market. Colour in particular is important, with light coloured wood being preferred, fibre length is also a consideration. Pulp logs must be straight enough to be debarked and feed into the chipper. Presence of charcoal or dry rot in a log will cause it to be rejected. Standards are also set for moisture content and stain in the wood. Further details on species and size limits can be obtained from local State Agencies.

**Smaller diameter wood**

Smaller diameter wood (<10 cm diameter) can be used for posts and landscape timber, props for horticulture or even firewood. Most material greater than 10 cm diameter and 3m in length can be sold as pulpwood, provided it does not contain too much colour, fibre properties are favourable and it is within economic range of the pulp or paper mill.

Post and rails for fencing and sleepers for landscaping can often be produced with on-farm resources and these can find profitable local markets. Specifications vary and should be negotiated with customers.

Figure 6.2. Cutting fencing timber on farm.

**Wood Chips**

Chips for pulp have the same quality standards as logs for pulp. However, chips for landscaping or fuel may have lower standards tolerating bark and rot.
Chapter 7. Forest inventory – collecting the appropriate forest information

Forest inventory is the process of gathering information about the forest (eg. expected harvest volumes, average tree dimensions, forest quality, habitat values etc.).

Native forests are frequently characterised by high variability that makes measurement and estimation more difficult. Forest inventory techniques focus on (a) developing efficient methods of measuring trees and (b) developing methods of locating sample plots across the forest to be measured to more accurately estimate forest parameters. Generally basic measurements can be easily carried out and some landowners may feel confident enough to carry out more detailed estimates. However, if unsure you can seek expert advice which might be beneficial if your forest area is large or highly variable, or if you have limited experience in forest measurement.

The need for assessment and measurement

Knowledge about tree sizes and of potentially harvestable volumes is essential for good forest management and business planning. However, it is usually not possible to measure every tree in the forest. Foresters have developed a range of techniques to assess volume, condition and potential value of forests by measuring trees in sample plots. Collectively these processes of forest measurement are called forest inventory. The reliability of the inventory will depend upon how well the plots are located, how many there are and how accurately they are measured; therefore it will be worthwhile taking the time to measure each plot carefully. The information collected will also be a very valuable reference point for later determination of growth rates and structural change, as well as making comparisons with what might be achievable when the best management practices are applied.

The variability of native forest makes the process complicated and potentially expensive. Complex sampling approaches are sometimes needed to help minimise a potentially expensive measuring effort.

The most important decision when beginning an inventory assessment is the accurate delineation and stratification of the management unit boundaries – as measurements taken will generally be multiplied by calculated areas to estimate product volumes, values and costs and the relative importance of some habitat values.

Be willing to seek support and advice from your local forestry extension officer or consultant if you require it – it could save you time, energy AND costly mistakes.

The information provided here is introductory providing a guide only. ‘Trees for Rural Australia’ (Ed: Cremer 1990) and the ‘Tree measurement manual for farm foresters’ (Abed and Stephens 2002) provide more detailed information on how to go about measuring standing trees. Several other authors have also produced user-friendly advice for assessing the quantity and quality of native timber on different sites. These include the ‘Farmers Log’ (Reid and Stephen 1999) and ‘Sustainable Management of Native Forest on Private Land’ (Baynes 2000).

There are four major components of forest inventory:

(a) understanding the management objectives and relationships between components of the forest (site and climate factors, trees, understorey, wildlife, potential products- wood and non-wood, and human values);

(b) accurate management unit identification;

(c) efficient and accurate measurement of individual trees within selected plots; and
(d) efficient and representative sampling of a number of plots across the forest to better estimate stand and unit characteristics.

Native forest inventory is very different from plantation inventory in that wood quality may be extremely poor in minor patches due to changes in soil type, past stand structure, moisture availability, etc. Trees can be growing defect such as a rotten pipe faster than they are putting on merchantable diameter. Even the most experienced forester can be fooled by appearances.

In native forest with variable species, age and size classes it is extremely difficult to get the accurate “ANSWER” to the question of merchantable volume. Regardless of how skilled the assessor, how consistent the species mix, the evenness of the distribution of size classes, bole length, etc, there is still the unknown: “wood quality” variable. ‘We presume it will make a pole, we believe it will make a sawlog’, we may even be convinced it will be a veneer billet, but ‘the proof of the wood is in the cutting’. At the end of the day, estimated figures need to be applied as a guide, - a starting point. As forest management progresses over many years, greater knowledge of the stand history and its implications on wood quality will be understood.

Therefore CAUTION should be applied when using inventory to estimate potential merchantable value $$$! It is always better to underestimate value and be rewarded with a pleasant surprise, than to overstate the figures and then be disappointed as a landholder or manager.

Understanding the resource components

Assuming that management scenarios and proposed objectives are reasonably clear, even though detailed knowledge of the resource may not have been undertaken, it is important that forest inventory assesses those factors and components which will assist the decisions on products, values (wood and non-wood), strategies and sustainability.

Determining management units

Forest inventory is usually based on small plots located within forest areas which are then used to calculate or estimate amounts and values of wood and non-wood products. Detailed information can be gathered in the plots but this information can only be used to estimate the amounts and values that may occur over the larger areas outside the plots.

Management areas – broadly similar characteristics within

Efficient systems of assessing broad areas are based on dividing the forests up initially into areas (management areas or strata) that share some common characteristics, and then allocating plots randomly within the similar areas. The idea is that the averaged information within the broad areas of similar characteristics, (for example different forest types; larger areas of disturbance (wildfire, regenerating paddocks); large river flats; hill slopes; or even just because that’s the large area (block) I think I would like to use for wood production) will provide a starting point to begin to understand the forest resource and the variability in its characteristics.

Detailed assessment is usually by establishing measurement plots randomly on a grid pattern for larger forest resource areas. The grid pattern removes a lot of the bias (preventing the assessor from deliberately picking good or bad areas within) and provides information on what is there and how different or similar the forest within a management area might be. Accuracy and confidence in the estimates is increased by increasing the number of plots. Any number of management units may make up a management area.
Management units – very similar characteristics within

The results of these initial surveys can identify discrete units of forest which are more uniform in characteristics (species mix, structures, forest condition and development) where the ‘patch’ (small or large unit) has developed under very similar conditions and is therefore very likely to require the same management strategies to achieve the landholder’s objectives.

The idea is that the averaged information within the areas of similar tree characteristics, for example creek flat, hill-slope and ridge areas will provide more accurate predictions. Forest variations can arise as a result of past management and disturbance.

Most often landholders will already have an appreciation – for their own property at least - of similar areas of forest with similar histories, or similar species and structures. Within the river flat or the block they may be already aware of different and similar patches. Forest variations can arise as a result of position in the landscape (creek lines, upper slopes, westerly aspects etc.), past management, fire or logging activity. Many of these may be known to be appropriate as management units. Broad sampling of the total area may not be needed to indicate the discrete units.

It is obvious that an understanding of forest structure, health and condition and familiarity with the resource will be invaluable in visually assessing likely management areas and therefore reducing the need for the initial broad scale sampling to indicate possible management units.

Sampling strategies within management units

Measurement plots

We have previously discussed forest condition, disturbance and management histories (Chapters 3 and 4) potential products and habitat value (Chapter 6) and these can be assessed and recorded for each management unit. The next step is to estimate as accurately as possible (given time, energy and $$$ constraints) how much “value”, products and amounts we have in each management unit.

Once the management units have been well identified, their net productive area can be calculated. We then need to sample the management unit using measurement plots which ‘represent’ the larger net productive area. The measurement plots need to be of a sufficient in size to give us a meaningful ‘picture’ of what the management unit contains.

Imagine if we only measured a couple of trees in a plot (one big eucalypt, one smaller wattle) – what are the chances that these two trees tell us what we need to know about the value of potential products, the variation in age and size classes, the amount of defect, species numbers etc across a total management unit? Conversely we don’t have time to measure every tree in the management unit. We need large enough plots to realistically estimate similar general characteristics and proportions of the much bigger management unit. Plots should represent the stand.

Plots can be square, rectangular, circular or even odd-shaped. Because we are assessing small areas representing larger areas we need to multiply our results up to the area of the management unit so it is essential we know the area of the plot. Choosing a convenient and generally applicable plot size can make things easier and more efficient.

If we choose a plot size of 500 m² then 20 plots of that size would be equivalent to 1 hectare (plot measurement X 20) – a very convenient multiplier and a plot size which usually contains enough trees and forest characteristics to be ‘representative’. Using this plot size means that a number of inventory plot types can be used:

- Square plot – 22.5m X 22.4m
- Rectangular plot – 20m X 25m
- Circular plot – 12.6m radius
And each multiplied by 20 will equate to the hectare i.e. 12.6 m radius circular plots (1/20th ha). A 12.6 m radius equals 500 m². If there were 10 trees within the plot then the stocking would be 10 x 20 = 200 stems per hectare (sph). Detailed estimates and calculations are dealt with later in this chapter.

Transects are another useful inventory tool. They can be extremely efficient depending upon stand characteristics. Using transects also allows the user to stratify the forest by recording significant changes in vegetative cover as they occur across the landscape.

A limiting factor for transects is that they usually require two people to be efficient. One person to measure distance, bearing and maintain the bookwork, and the other to assess either side of the strip line.

An example of useful Transects can be measured by using a 50 m tape on a compass bearing. The assessor then records the data of all trees growing 5 m either side of the line.

The plot size is easily calculated:

\[ \text{Transect distance} \times 10 \text{ m} = x \text{ m}^2 \]

Therefore 500 m transect would equate to 0.5 ha, which can be multiplied up by 2 to equate to hectares.

**Measure and assess everything?**

In previous chapters lists of characteristics and variables of importance and interest to record and measure have been presented. For a more complete understanding and generally more useful data base of plot and management unit information measure and record as many things as is convenient and reasonable (practical). You are already there and it took time to get there and would take more time to come back for just one more thing.

Along with information on the location (exact position, aspect, slope etc) within each plot the following base information should be assessed.

- Species
- Crown condition
- Crown position
- Diameter at breast height over bark
- Merchantable length
- Presence of hollows
- Retain or remove - decisions for trees
- Product class

Even from the above 8 parameters the following can be extrapolated:

**Measures** - Existing stocking, stand basal area per ha, basal area to be removed, retained basal area, volume per ha, harvestable volume, retained volume per ha & per unit, volume of each product type per ha, volume per unit & per ha, per product type, treatment per hectare, retained stem value, average stem volume.

**Assessments** - presence of habitat trees which may need retention, forest condition, degree of suppression within the stand, likely potential response to release, possible products etc.

It might take a little extra time, but it is worth collecting tree height and the diameters at breast height (DBH=1.3 m) data in the plot for all the trees that will make potential products now, or at some point in the future, not just the currently large ones. Counting the number of small unmeasured trees is also useful for future assessments of mortality and growth of size classes.
After all plots within a unit have been measured then the data is averaged – if you are confident in the “unit” and the representativeness of the plots - then the averaged data can be used to calculate the management unit estimates

**Marking plot locations**

The convention is to place a permanent marker at the north-east corner of square or rectangular plots or in the plot centre for circular plots. Being able to return to a plot for re-assessment to study stand dynamics or to evaluate the achievement of harvesting and management objectives is very useful.

**Sampling intensity**

The most often asked question is ‘How many plots do I need to estimate the “value”’ which is more often a way of saying ‘What is the minimum number of plots I have to do?’

The number of plots will depend on the variability of the stand. A statistical guide for a very good sampling of a fairly uniform stand is:

<table>
<thead>
<tr>
<th>Size of Stand (ha)</th>
<th>Number of Sample Plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5-2</td>
<td>8</td>
</tr>
<tr>
<td>2-10</td>
<td>12</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>many more plots but will probably divide into further management units</td>
</tr>
</tbody>
</table>

More plots are needed as the variability of the stands increases. Typically, the total area of all plots would be about 2% of the forest area. For example, a variable stand >10 ha may need about 16 plots to obtain a highly reliable estimate of the volume of timber in the forest. If other uniform but different patches occur within what was thought to be a large but similar area then those patches will need to be assessed separately.

Clearly if we are talking about a large area of forest, then time and cost (if inventory is contracted) will probably become prohibitive for most landholders. Reducing the number of plots to a manageable number and still retaining confidence in the estimates of the chosen forest parameters and products is an essential skill and an imperative.

Therefore the decision process for determining the management units is critical to the whole process. Accuracy and appropriateness here will save a lot of time and energy and provide the estimates we can use with confidence.

**An example is useful**

A very similar area of forest already appropriately designated as a ‘management unit’ of, for example, ~10 ha could be visually assessed for any different patches within (variations) in about a half an hour of walking.

- **All very similar - no different patches** Establishing 3-4 measurement plots would probably suffice to estimate products and the confidence in the result (because you can see how different the answers from each plot are.) If the estimates of tree numbers, size classes, and volumes -within classes and for the plot- are very different then your original visual assessment of the ‘unit’ was probably incorrect.

- **One small patch is different – the rest is very similar** Establish 3-4 measurement plots in the similar area. For assessing the confidence in the results for the ‘similar’ area - see dot point
above. In the small patch decide whether or not it is large enough or “valuable” enough to be treated differently or at all. If it is important then perhaps only one plot in the different small patch will suffice. Then you have estimated/calculated the values for the patch.

- **The trees get bigger (diameter and/or height) as you walk from the hill to the gully** – Establish 1 or 2 measurement plots in each of the hill, mid-slope and gully. This will establish estimates for these ‘sub sets’ which can be used to estimate volumes for the area according to the proportions of area of hill-slope, mid-slope and gully which you can estimate.

- **There are reasonable patches of regeneration in small and large gaps and hardly any regeneration under the big trees** - Establish measurement plots in 3-4 of the regeneration patches, and in 3-4 of the non-regeneration areas. Assessing the confidence in the results for the regeneration and non-regeneration areas consider if more plots are needed. Then you have estimated/calculated the values for ‘regen’ and older forest. Each could be regarded as – and written up as -separate ‘management units’

The number of plots is determined by the ‘variation’ in your management unit and assessment of the closeness / differences in estimates, size classes, height, etc and the experience of the assessor will assist that decision. Seek professional guidance if you require it. Larger differences between what you measure in the plots means you need to rethink your strategy – either more plots to use in your average of “similar” plots or separation into more management units. Experience may also show that in some areas you needed less plots.

The cost of inventory is directly related to the quality of the forest stratification. Inventory intensity has very little to do with unit size. (Size doesn’t matter). 100 ha of highly consistent forest structure and species composition can be accurately assessed with as few as 10, 1/20th ha plots (1 to 2 per hectare).

*Once the management units have been well identified, net productive area calculated, the number of plots required is drastically reduced.*

Remember these are estimates and are based on our best knowledge of what we can see. The real product volumes and value can only be determined during conversion to marketable product. **“The proof of the wood is in the cutting”**

**Plot measurements and calculations**

**Individual tree measurements**

Following the steps above provides the planning of your sampling strategy. To carry out the basic measures used in assessing trees, products and values there is a simple set of convenient equipment you require (Table 7.1). Although there is more sophisticated equipment available for the landowner the basics are more than adequate.
Table 7.1. Equipment used forest inventory.

<table>
<thead>
<tr>
<th>Basic equipment</th>
<th>Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible measuring tape (30m or 50m)</td>
<td>Flexible measuring tape (30 m or 50 m)</td>
</tr>
<tr>
<td>Bush compass (to enable walking in straight lines)</td>
<td>Surveyors chain</td>
</tr>
<tr>
<td>Measuring tape (preferably graduated for direct diameter readings and for standard length (3-4 m) for circumference)</td>
<td>Compass and Suunto (for direction and slope)</td>
</tr>
<tr>
<td>A small piece of small diameter dowel about 5 cm in length (or a small stick)</td>
<td>Graduated Diameter tape with standard length (3-4 m) for circumference)</td>
</tr>
<tr>
<td>A piece of medium diameter dowel cut at 2.0 m length (or a measured straight 2.0 m stick)</td>
<td>Vertex or similar machine using laser optics</td>
</tr>
<tr>
<td>Pocket knife with fine pointed blade</td>
<td>Bark thickness gauge</td>
</tr>
</tbody>
</table>

From the tree measures we can estimate tree log volumes, then calculate plot volumes, then estimate total volumes for management units in the forest. Note that the method deals with the volume of timber under the bark.

**Basal Area or Tree Cross-Sectional area (BA)**

Firstly, to find the tree diameter, measure from the graduated ‘diameter’ tape – or measure tree circumference (C) using a standard tape - at breast height over the bark (DBHOB), that is 1.3 m above ground. On sloping ground stand on the uphill side of the tree.

**Equation 1(a):**

\[
\text{Diameter Over Bark (DBHOB in cm)} = \text{Circum (C)} \times 0.318310
\]

Secondly, measure the bark thickness (BT) using a pocket knife or measuring at cut tree ends) because we need to obtain a measurement of diameter under bark at breast height (DBHUB). Hardwoods maintain a reasonably constant proportion of diameter under-bark to diameter over-bark (DBHOB) along the bole of the tree. The diameter under-bark at any point along the tree may be calculated by multiplying over-bark diameter by the proportion of under- to over-bark diameter at breast height. For example, if at 1.3 m height (DBHOB) DOBOB = 30 cm and bark thickness is 3 cm, the proportion of bark to wood is 1/10; then up the bole at 6 m where DBHOB is 20 cm, thickness is 20/10 = 2 cm.

**Equation 1(b):**

\[
\text{Diameter Under Bark (DBHUB in cm)} = \text{DBHOB} - 2 \times \text{Bark thickness (BT in cm)}
\]

Basal area (BA) of the tree (under bark) at 1.3 m height can then be calculated as:

**Equation 1(c):**

\[
\text{Basal Area under bark (BA in cm)} = 0.0000785 \times \text{DBHUB} \times \text{DBHUB}
\]
**Height (H) of a tree**

There are many ways to measure the height of a tree (H). The following is a very simple field method - that works (Figure 7.2).

To estimate tree height (H), the distance from the ground on the uphill side of the butt to the top of the tallest shoots needs to be estimated.

Place a 2.0 m length of dowel (or small branch) upright against the tree to be measured and walk back about 30 m and pick up a small stick about 5 cm long. A measured dowel is easy but you don’t need to be carrying a 2.0 m dowel all over the countryside. You have your dbhob tape on you that has standard measurements on one side, measure from the ground to 2.0 m up the tree and make a mark. Just walk back until your 5 cm stick correlates to the 2.0 m mark (or stick) and then work out the increments.

Hold it vertically with your arm fully extended. Move back or forward (or adjust the length of the small stick) until it appears the same length as the 2.0 m dowel.

Count (from the stump height) how many sticks it would take to reach the top of the first, second etc, log in the tree (>10cm diameter for a pulp log), or to the top of the canopy to get tree height. Multiply the count by 2.0 and this gives log length in meters.

**Equation 2:**

\[
\text{Tree Height (H in m)} = 2.0 \times \text{number of small stick counts}
\]
**Length (L) of each product**

To estimate a sawlogs or other products volume, the distance (L) from the top of the stump (usually assumed to be 0.3 m) to the top of the last clear bole or first large branch junction needs to be estimated.

Using the same method described for height - only count to the top of the “product” you are estimating (i.e. first sawlog length)

**Equation 3:**

\[
\text{Log length (L in m)} = 2.0 \times \text{number of small stick counts}
\]

**Tree and log volumes**

To estimate log volume with reasonable accuracy the measurements above are essential. These measures are taken at convenient heights in standing trees, but as trees become smaller (taper) in diameter as you reach the crown, account needs to be taken of the particular shape of the log. Preferred logs are reasonably straight and exhibit some symmetry although they are not cylindrical.

It is often assumed that coniferous species (most of the pines); young eucalypt saplings and poles; and many plantation trees are close to conical in bole shape from butt to high up in the crowns – allowing their volume (both total and merchantable) to be estimated using standard conical formulae. However, most eucalypts exhibit a more dramatic change in taper and shape at the crown break which makes this estimate of ‘total’ volume less accurate and the calculation of the more meaningful merchantable volume slightly more difficult.

It is however sometimes convenient to do quick total volume estimations when visiting stands for visual inspections, and rough outlines of management planning where simple ‘eyeball estimates’ will aid ‘first cut’ decisions and discussion.

**An useful approximation of tree volume**

From above you have measurements of:

- diameter at breast height over bark (DBHOB)
- total tree height (H) was also measured,

allowing an individual tree volume over bark (TOTVOL) to be approximated using the following formula:

**Equation 4:**

Approximate Total Tree Volume

\[
(TOTVOL \text{ in m}^3) = \left(\frac{\text{DBHOB}}{200}\right) \times \left(\frac{\text{DBHOB}}{200}\right) \times H \times 3.143 \times 0.3
\]

**Remember**

(a) this is a formula for assumed conical shaped trees - due to more cylindrical boles and the shorter (less than conical shape) of most eucalypt crowns it will probably underestimate total volume,

(b) you measured height of the crown so this over-estimates the cone height

(c) diameter was measured over bark so this over-estimates volume also.

(d) Although these measures tend to compensate one another - This is not a calculation of merchantable volume.
**Accurate calculation of merchantable log volume**

To establish a more accurate estimation of the volume we need to estimate the volumes of individual log of known length and sum them for the stand. To allow calculation of individual log volume we need to know the diameter (under bark) of the log at the mid-point of its length.

From above you have measurements of individual logs or product:

- diameter at breast height over bark (DBHOB)
- Estimated log length (L) from average stump height (0.3 metres)
- Bark thickness (BT)

Using these values look up a table of bark thickness deductions (Table 7.2), using the column which is appropriate to the thickness of the bark of the species you are measuring. Then use the corresponding deduction value to estimate centre diameter under bark (CDUB) - *This is a very useful measure for log volume calculations.*

**As an example:**

\[
\begin{align*}
DBHOB &= 50 \text{ cm} \\
L &= 10 \text{ m} \\
BT &= 2.5 \text{ cm} \quad \text{reading from the table our Deduction} = 9.6 \text{ cm}
\end{align*}
\]

We can then calculate centre diameter under bark (CDUB)

**Equation 5:**

\[
\text{Centre diameter under bark (CDUB in cm) = DBHOB - Deduction}
\]

in our example (CDUB) = 50cm dbhob – 9.6cm from table = 40.4cm. This figure is then used to calculate the merchantable volume of the log (MERCHVOL):

**Equation 6:**

\[
\text{Merchantable Log Volume (MERCHVOL in m}^3\text{) = CDUB} \times \text{CDUB} \times L \times 0.0000785
\]

**Estimating plot totals and comparing plots**

Plot totals come from number counts of species, trees in size classes and summation of product volumes or numbers. Other subjective assessments of factors such as percentage of tree cover, health etc are either visually averaged over the plot or determined by the analysis of scores given to various assessment criteria such as crown density.

Accurately knowing the area of the sample plot allows calculation of measured parameters to be estimated at per hectare equivalent values.

**Standing log volume (PLV) per plot**

Total log volume for a plot (PLV) is the sum of the volumes for all of the individual logs in the plot. Or it could be used as a total of a particular product or type of log. i.e. the sum of the volumes of all pulpwood logs which might be written as \(PLV_{pulp}\).

**Equation 7(a)**

\[
\text{Plot Log Volume (PLV in m}^3\text{) = MERCHVOL of log1 + log2 + log3 + etc}
\]
Or for just pulpwood logs

**Equation 7(b)**  
Plot Pulpwood Log Volume (PLVpulp in m$^3$/ha) = MERCHVOL of Pulplog1 + pulplog2 + etc

Plot size (area) should be measured accurately and then standing saleable or merchantable log volume (under bark) in the plot can be calculated to a per hectare estimate for ease of comparison with other plots, forests and stands. In the same way as Equation 7 (b) above it can be used to describe a particular product.

**Equation 8(a)**  
Standing Log Volume per ha (SLV in m$^3$/ha) = 10000 X PLV / plot area

Or for just pulpwood logs

**Equation 8(b)**  
Standing Pulp Log Volume per ha (SLV pulp in m$^3$/ha) = 10000 X PLV pulp / plot area

**Stems per hectare**

Conversion to per hectare estimates for total trees, number of trees of a particular species or the number of habitat tree the calculations are the same format:

**Equation 9**  
Number of trees per ha (stems per ha) = 10000 X No. of stems in plot / plot area

As useful table for visually assessing retained stocking and for planning of other density management operations such as spacing or thinning is presented for quick reference (Table 7.3 )
Table 7.2. Calculation of deductions for bark thickness and taper in *Eucalyptus sp* (from Matthews 2003)

Centre diameter under bark deduction allowing for bark thickness @ 1.3 m, stump and taper

<table>
<thead>
<tr>
<th>Log Length</th>
<th>Bark 0 - 1.5</th>
<th>Bark 1.6 - 2.5</th>
<th>Thick 2.6 - 3.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>3.3</td>
<td>5.3</td>
<td>7.3</td>
</tr>
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<td>3.0</td>
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<td>12.0</td>
<td>14.0</td>
<td>16.0</td>
</tr>
</tbody>
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Based on 1cm/m taper, 0.3m average stump height (KR Matthews 2003)
Table 7.3. Ready reckoner for retained tree spacings in native forest.

<table>
<thead>
<tr>
<th>Spacing between potentially retained trees (m X m)</th>
<th>Approx. retained tree spacing stem per hectare</th>
</tr>
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<tbody>
<tr>
<td>1 X 1</td>
<td>10000</td>
</tr>
<tr>
<td>2 X 2</td>
<td>2500</td>
</tr>
<tr>
<td>3 X 3</td>
<td>1111</td>
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<tr>
<td>4 X 4</td>
<td>625</td>
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<tr>
<td>5 X 5</td>
<td>400</td>
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<tr>
<td>6 X 6</td>
<td>278</td>
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<tr>
<td>7 X 7</td>
<td>204</td>
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<td>8 X 8</td>
<td>156</td>
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<td>9 X 9</td>
<td>123</td>
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<td>10 X 10</td>
<td>100</td>
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<td>11 X 11</td>
<td>83</td>
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<td>59</td>
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<td>51</td>
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<td>24 X 24</td>
<td>17</td>
</tr>
<tr>
<td>25 X 25</td>
<td>16</td>
</tr>
</tbody>
</table>

Averaging the plot values

As discussed previously an estimate drawn from only one sample could be incorrectly representing the stand you are sampling (because you may have picked a very good, a very bad or unrepresentative place to put the plot). With two plots one could be high, the other low, or they could both be incorrectly high or low. With three plots the problem is similar but as you increase the sampling number (providing you choose representatives as best you can) then an average of all the plots you measure should increase the reliability of that average to ‘represent’ the stand you are assessing. You can compare any appropriate plots of any area if you have already converted the values to a per hectare basis.

Using stem numbers in plots after they were converted to stems per hectare as an example:

**Equation 10**

\[
\text{Average (stems per ha) = } \frac{\text{Plot1 sph} + \text{Plot2 sph} + \text{Plot3 sph} + \text{etc...}}{\text{No. of Plots}}
\]

If the plot values are close to the same value as the average, then that suggests that the variation is low and your judgement of similar factors in the management unit are reasonable for that measure (i.e. stems per hectare). Other indicators provide insight into your accuracy and appropriateness of determining management units:
• If one value is way off it could be a ‘different’ plot for some reason.
• If the plots are wide ranging above and below the mean you need to look for variation in the unit you didn’t see or other factors may be causing variation.
• If you have a grouping of lower values (or high values) it may be that another management unit is indicated.

Experience, or advice may help you, but it will always come back to how well you stratified the important characteristics you used to determine your management units.

**Estimating for management unit or forest type**

For any measure from your inventory (best to be an average of the value from a number of appropriate plots) you can extrapolate to a stand or similar forest management unit by multiplying the per hectare value of your measure by the number of hectares in your management unit. As an example - your estimated average standing log volume (SLV) by the number of hectares of similar forest

**Equation (11)**

\[
\text{Management unit SLV (m}^3) = \frac{\text{Average SLV plots (m}^3 / \text{ha})}{\times \text{Area of unit (ha)}}
\]

Professional help with important inventory is advisable, but it helps to have an understanding of the techniques employed and can assist with measurement. Having compiled an inventory of the plot and estimated log availability, the next step will be to calculate what the trees are worth in economic value and what profit can be made, given the various costs. These issues are addressed in Chapter 8.

**Making the harvesting decision**

Decisions on tree harvesting are the most important from an economic and silvicultural viewpoint. They need to consider both the forest condition (before and after harvesting), the economics of the operation and the long-term forest and financial effects.

Unfortunately, many forests lack long term growth data, and important aspects of future marketability are unknowable.

Decisions will need to be made on-the-ground, made on the best information and advice available and guided by sound silvicultural principles.

**Forest Condition**

Harvest timing decisions depend foremost on forest condition and market factors. Growth rate of individual trees in the larger sawlog sizes usually declines with age. Individual tree growth rate will decline if there is too much competition. On the other hand native forest sawlogs must generally reach relatively large minimum sizes to be saleable. The application of silviculture in the field has a strong component of on-the-ground individual tree assessment as part of decision-making. Some of the key attributes of forest condition affecting the economic value and timing of a harvest are:

- **How big** are the trees and what species – do they contain sawlogs? Not all native species can be sawn effectively and the local sawmill may have some strong preferences. Some products like veneer logs have very specific value and acceptance parameters. If they are a species suitable for poles, have they reached their full economic potential. **How many** trees are of merchantable size? Total resource volume, distribution and value will determine the size and economic feasibility of the operation.
- What other species are there? Different species are suitable for a range of products.
- How fast are the trees growing? Growth rate will determine if the operation is better conducted now as a one-off, occasionally or as an on-going activity.
- What is the quality, is there evidence of past fire, frost or insect damage that prevents cutting or sawing for solid products such as posts or boards?
- Is there a need to harvest and start again? If the existing stand has poor form and vigour and needs heavy thinning or harvesting, a regeneration strategy is needed. Species and site productivity play a role here.

For individual sawlog trees, there may be a greater advantage in growing them on for a future harvest. There may be a need to reduce some of the competition to obtain the best growth value for these future sawlogs or product. Often the forest is diverse in structure, type and density; a silvicultural management strategy will often need to be applied on a tree-by-tree basis.

**Potential silvicultural strategy**

Assuming that the forest contains saleable logs what is to be done?

*Strategy 1.* Heavy thinning or removal of a significant percentage of the larger trees for sawlogs or other products. This has the advantage of early net return, but if too much wood is removed long-term profitability will suffer. The matter of concern when selectively removing just the large trees is that there are a sufficient number of vigorous (co-dominant) trees remaining that are capable of responding to the growth opportunity that will be created. Selective harvesting or thinning is a balancing act between, how often - and how much wood is taken from the forest.

*Strategy 2.* Thin over a range of size classes (eg. in a Spotted Gum forest) and to distribute the products to sawlog, pole, pile, girder, landscape, veneer and pulpwood or firewood markets. The distribution of products is influenced by a range of factors including, diameter, length, maximisation of utilisation and value. This strategy is applicable in well- to over-stocked stands. In each case, the viability of the strategy is dependent upon the intensity of harvesting and availability of markets for the various products.

*Strategy 3.* For those species that require it, clearfelling and regeneration may be an option although a number of states do not allow ‘clearfelling’ operations.

*Strategy 4.* For the other species that can regenerate in smaller groups and in lower light conditions - selective harvesting. Silvicultural prescriptions for selective harvesting vary with the species and are designed to improve forest growth by managing competition and to secure effective regeneration.

The harvesting decision is also controlled by potential economic return.

**Optimal timing**

Market demand and current prices in the marketplace are a very big factor. This is further outlined in Chapter 8.

Economic analysis is able to generate a number of options that farm-foresters might find useful in considering a harvest decision. A common one applied to even-aged forests (and very commonly to plantations) is ‘the forest is ready for harvesting when it has reached its maximum value growth measured by the economic parameter Net Present Value (NPV)’.

Gross margin based on today’s prices is easily applied and is an effective indicator. There is no need to forecast discount/interest rates, CPI, future market price fluctuations, etc.

This criteria is not really practical in uneven-aged native forests where data for long term management are generally not available. Here economic criteria need to be related to small stands and even trees.
and can only be used as a general guide. Some information might be obtained from a marginal analysis: “What is the value now?” compared to “What is the value if the tree or group of trees are left to grow?”. Predictions of future value are particularly difficult for logs because of the need to project so far into the future (commonly decades).

Current growth (and predicted growth) information would be very helpful in supporting these decisions. However, reasonable growth data for most native forests can only be collected over very long time periods (tens of years), and few, if any, private native forests have such a history of long term inventory. State forest management agencies have some data for their forests and some information can be obtained from published reports. There are two important terms commonly used in reports discussing forest growth, Mean Annual Increment (MAI) and Current Annual Increment (CAI). An understanding of these is helpful if the farm-forest manager is to be able to gather indicative data from these sources.

**Estimating increment**

Increment is growth in standing volume. Mean Annual Increment (MAI) over the life of a stand is the accumulated standing volume (SV in m³) of timber since establishment divided by stand age (Years) measured in m³ ha⁻¹ yr⁻¹. It is most commonly applied to even-aged forests which have a known regeneration date and thus age.

**Equation (12)**

\[
MAI = \frac{Present\ SV}{Age\ of\ stand\ (Years)}
\]

To calculate MAI for periods within the life of a stand, calculate the volume change between periods of measurement and divide by the number of years between those measurements.

MAI is usually calculated from total volume based on total height estimations. This is a reasonable estimate for most conifers, and for native pole-shaped and mid-age plantation grown eucalypts. However for many natural forests the mean merchantable annual increment (MMAI) will be more useful as it takes into account the crown break and the taper of natural eucalypt stems. Merchantable volume is much more useful in determining cost/benefits and is covered in more detail in the preceding discussion.

**Current annual increment**

Current annual increment (CAI) is the current rate of growth, that is, the volume of wood that the forest grew in the past period, usually a year (measured in m³/ha/yr).

**Equation (13)**

\[
CAI = SV\ now - SV\ measured\ last\ year
\]

Care is needed to be sure exactly what component of the forest’s standing volume is being considered. Usually leaves, twigs and small branches are excluded. Commonly the volume measured is that which is considered merchantable. This will almost always include the higher quality sawlogs but may or may not include smaller sawlogs or pulpwood. Small log and pulpwood volumes are commonly much greater than those of high-grade sawlog.
**Decision without objective data**

Australian native forest managers are seldom able to make their decisions on the basis of objective detailed forest-growth or condition data. If possible, visit comparable forests where growth data has been obtained and make at least visual comparisons. Collect information on silvicultural rules-of-thumb that are used by other managers. Lastly, seek expert advice.

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**Guideline 7.5. Factors that will determine the right time to harvest.**

If the forest is dense, but has some marketable trees (e.g. for pulpwood), then the potential for further growth probably still exists. In this instance some thinning is required. Generally stems which would make logs at least 10 cm small end diameter can be commercially harvested for pulpwood. Trees smaller than this can become firewood and the 400 or so largest trees per hectare might be left to grow-on, provided they are more than about 3-5m from their neighbours.

If there are only a limited number (e.g. 150 trees ha\(^{-1}\)) of mature large, evenly spaced trees without substantial regeneration present it is probably time to consider a regeneration or a harvesting and regeneration program.

Single tree selection and selective harvesting of patches is becoming the number one silvicultural strategy, coupled with coppice management, top disposal and management for a range of products.

Timing of operations must be well planned and appropriately managed. Some wet sclerophyll forests containing species such as Blackbutt, Sydney Blue Gum, Tallowwood, Brush Box, etc. where seed set in the prior season has been poor can and does result in wall-to-wall invasive weed and the loss of a forest. The retention of seed trees does not mean that there will be a regeneration event. Fire intensity and timing also plays a major role in the success of such an operation.

Taxation is an issue for harvesting if a large cash flow from logs is going to upset the farm accounting. Consider phasing operations, harvesting discrete ‘lots’ of timber over several financial years with staged payments. It is useful if expenditure is incurred in the same financial year income is received.

Opportunity cost is another factor to take into account. Rather than wait for the last log to reach maturity on the existing stand, heavier selection strategies and moving to a new production cycle may facilitate fast regrowth and quicker returns.

Biodiversity requirements and the need to have a range of age classes distributed across the landscape can also be an incentive to implement harvesting. A forest in different stages of regeneration will be a more diverse environment and cater for a different suite of fauna and flora from that which dwells in the older forest. The newly developing forest may be managed for a species mix more typical of that which existed prior to grazing and other development.

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**Other help and tools**

The website [http://www.anu.edu.au/forestry/mensuration/index.htm](http://www.anu.edu.au/forestry/mensuration/index.htm) provides useful explanations and further detail on the methodology for assessing farm forest timber resources. Several software tools have also been developed to assist in this process, for example, the South East Forest Calculator and the Tasmanian Farm Forestry Toolbox.

**The South East Forest Calculator (SEFC)** (Brack *et. al.* 2002) has been developed by the Australian National University, Faculty of Forestry as an inventory tool to assist native forest managers in the Eden and the East Gippsland regions. The calculator provides information on the average dimensions and volume of trees and stands.

For individual trees the SEFC provides a spreadsheet for the calculation of total tree volume and merchantable volume. The spreadsheet is programmed for use with 18 different native tree species.
occurring in the Eden region of NSW. The inputs required by the spreadsheet are, total height, merchantable height, stump height and diameter at breast height (DBH). The outputs provide an estimate of total volume under bark, and merchantable volume under bark.

The Tasmanian Farm Forestry Toolbox (http://www.privateforests.tas.gov.au/toolbox) also provides a very useful method for recording timber assessment information and log grades, together with assigned financial values. The ‘Toolbox’ also allows calculations of income and expenditure over a rotation. Although principally designed for plantations, there is sufficient flexibility in the software to use it for native forest inventory and financial analysis.
Chapter 8. The market place

Marketing is more than selling. It also involves all the steps you can take to find out what customers might be prepared to buy from your forests. It covers both existing products, and for imaginative or creative marketers, new products that haven’t been tried yet. Taken together, marketing can be seen as all the activities that assist in finding out about, and matching what customers will buy, with what you have to sell.

The existing market

In the foreseeable future the downward trend (Figure 8.1) for total hardwood production, particularly from publicly owned native forest, is likely to continue. This reduction in supply should work in favour of the private forest owner. That is, wood prices will rise if demand is sustained and production is limited.

There is a substantial volume of sawn wood imported into Australia (718,400 m$^3$ of softwood and hardwood in 2000-2001). This means that there are opportunities for hardwood from private forests to be substituted for at least some of our imports, the key is to find the right market niche for what the landholder has to sell.

Figure 8.1. Australian sawn hardwood production from 1994-2001 (Source: ABARE 1995-2001).

As with all primary production commodities, timber prices are subject to fluctuations in demand. Watching product price trends is a part of gathering market information and achieving profitable business outcomes. The graph below (Figure 8.2) indicates a rapid rise in hardwood log exports in recent years. Most of the logs are being shipped to Korea for sawing or for veneer manufacture. There may be opportunities for some private growers with larger holdings to tap into this export market.

Forest growers, particularly log sellers, are frequently price takers; there is therefore a need to research, identify and earnestly pursue the best paying market opportunities.
Get to know your market

The saleable forest products for any landholder will vary from one area to another depending upon a range of factors. Obviously species, merchantable length, available volume, etc all have an effect. For each forest product there are sets of specifications, which need to be met in order to access the market. For some products such as poles, veneer logs and girders the specifications are particularly tight and uniform throughout the industry. The degree of variance from the specification is limited by Australian standards, industry standards and building codes.

For other forest products such as piles fencing material and to a degree sawlogs there is a higher degree of variability from one purchaser to another. This is especially common with piling material even though there is an Australian standard. Minimum product length, small end diameter, centre diameter, allowable defect and species requirements vary from one purchaser to another. It is very time consuming, expensive and frustrating to deliver even one load and have it rejected.

Once timber is landed in the mill yard, the purchaser has the upper hand in rejecting or accepting the product. Then the supplier has to either accept a lower price or pay for the haulage to another purchaser. The easiest way of avoiding this situation is to negotiate all specifications, cut a sample load and then have the purchaser inspect the product on the logging ramp/dump before haulage.
What wood products can I sell?

The intent of this information is to provide a guide to the marketing factors for the range of timber products that may be available from native forests.

Farm-foresters with small parcels and infrequent sales can find it difficult to achieve sales. It helps to be familiar with the terminology and grade information used by potential buyers.

Durability is an important requirement of many timber products which may be used outdoors (as furniture and rails and girders above ground or as posts, piles and piers in ground or submerged). Durability ratings are applied to many applications and species that have high durability usually attract higher returns.

As examples Table 8.1 lists some of the common species from northern NSW and their valuable attributes. Local sawmillers and State Agency representatives will be able to assist with durability and strength groupings for species in your region. Timber product orders may nominate one or more species, stress grades and durability classes.

Table 8.1. Strength grades, durability ratings and Lyctus susceptibility of some common Northern NSW eucalypts.

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Botanical Name</th>
<th>Strength Group</th>
<th>Durability Rating</th>
<th>Lyctus Susceptible</th>
<th>Min sapwood Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey Gum</td>
<td>E. major, propinqua and longirostrata</td>
<td>S1</td>
<td>1</td>
<td>Resistant</td>
<td>N/A</td>
</tr>
<tr>
<td>Grey Ironbark</td>
<td>E. siderophloia</td>
<td>S1</td>
<td>1</td>
<td>Resistant</td>
<td>N/A</td>
</tr>
<tr>
<td>Blackbut</td>
<td>E. pilularis</td>
<td>S2</td>
<td>2</td>
<td>Resistant</td>
<td>N/A</td>
</tr>
<tr>
<td>Broad Leaved Red Ironbark</td>
<td>E. fibrosa</td>
<td>S2</td>
<td>1</td>
<td>Resistant</td>
<td>N/A</td>
</tr>
<tr>
<td>Grey Box or Gum-Topped Box</td>
<td>E. moluccana E. woolstiana</td>
<td>S2</td>
<td>1</td>
<td>Susceptible</td>
<td>N/A</td>
</tr>
<tr>
<td>Gympie Messmate</td>
<td>E. cloeziana</td>
<td>S2</td>
<td>1</td>
<td>Resistant</td>
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<tr>
<td>Narrow Leaved Red Ironbark</td>
<td>E. crebra</td>
<td>S2</td>
<td>1</td>
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<tr>
<td>Red Mahogany</td>
<td>E. resinifera</td>
<td>S2</td>
<td>2</td>
<td>Susceptible</td>
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<tr>
<td>Spotted Gum</td>
<td>Corymbia citriodora</td>
<td>S2</td>
<td>2</td>
<td>Susceptible</td>
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<tr>
<td>Tallowwood</td>
<td>E. microcorys</td>
<td>S2</td>
<td>1</td>
<td>Susceptible</td>
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<tr>
<td>White mahogany/Yellow Stringy</td>
<td>E. acmenioides E. umbra</td>
<td>S2</td>
<td>1</td>
<td>Resistant</td>
<td>N/A</td>
</tr>
<tr>
<td>Forest Red Gum</td>
<td>E. tereticornis</td>
<td>S3</td>
<td>2</td>
<td>Resistant</td>
<td>N/A</td>
</tr>
<tr>
<td>Red/Pink Bloodwood</td>
<td>C. gummifera &amp; Intermedia</td>
<td>S3</td>
<td>1</td>
<td>Susceptible</td>
<td>N/A</td>
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<tr>
<td>Turpentine</td>
<td>Syncarpia glomulifera</td>
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<td>1</td>
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<tr>
<td>Carbeen/Moreton Bay Ash</td>
<td>C. tessellaris</td>
<td>S1</td>
<td>2</td>
<td>Susceptible</td>
<td>N/A</td>
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<tr>
<td>White Stringybark</td>
<td>E. eugenioides</td>
<td>S3</td>
<td>2</td>
<td>Resistant</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Take the time to investigate and understand the markets in your region as well as the potential products that your forest can produce. Depending upon the location of your property, some markets may be less favorable due to distance constraints. Opportunities may exist to add value to the trees you are growing by directing the management for specific products.

**Non sawlog timber products**

*Pulp logs*

Pulp logs are generally greater than 10 cm diameter and more than 3m in length. Not all species are suited to the pulpwood market. The species requirements are more stringent for ‘white’ products. Colour in particular is important, with light coloured wood being preferred, fibre length is also a consideration. Pulp logs must be straight enough to be debarked and feed into the chipper. Presence of charcoal or dry rot in a log will cause it to be rejected. Standards are also set for moisture content and stain in the wood. Pulpwood pieces do not necessarily have to be whole. Split wood is usually acceptable.

*Chips*

Woodchips for pulp have the same quality standards as logs for pulp. However, chips for landscaping or fuel may have lower standards tolerating bark and rot.

*Firewood*

The firewood market is quite large in some regions and firewood is again a good option for trees that are suppressed or have bad form. Smaller diameter wood (<10 cm diameter) can be used for firewood. Most durable and dense species make suitable firewood although some species are preferred for their calorific values. Local State Agency staff can advise on species and seasoning requirements. Offcuts and residual log material can be used as firewood to supplement returns in sawlog operations.

*Fencing materials*

Fencing material includes strainer posts, split posts and rails. Post and rails for fencing and landscaping can often be produced with on-farm resources and these can find profitable local markets. Specifications vary and should be negotiated with customers. Species preferences vary between districts. Fencing material is a good option for trees that are suppressed or have bad form. The durability of the species is important. Timber for caps and rails can be class 2 species and unless appropriately treated with preservative, posts and strainers need to be durability class one species. Generally fence timbers need to be slow grown with little sapwood. Due to the thick sap wood often associated with Red Bloodwood (unless very slow grown) rounds need to be sapped, but even so is often not well regarded. Big, old trees suitable for splitting are the opposite and considered to be nearly as good as yellow stringy.

All fencing material needs to be well presented, debarked and any branch stubs and branches trimmed back to the round of the post. The following list gives some fencing material specifications.

**Yard posts** - 250-400mm D x 2.4m long or as specified, straight, can have trimmed branches, must be straight, durability 1

**Strainers** - 200 – 250 for driven posts, 200-350mm D for rammed, 2.1-2.25m L, trimmed branches, can have wobbles or one bend if rammed, durability 1
Light Strainers or in Line Round Posts - 150-200 mm D, usually driven, 2.1m L, straight, durability 1

Splits - 125-150mm arc measurement, 2.1m L, durability 1

Caps and Rails - Usually 150mm+, often requested to match size of posts, usually 3m L, durability 1-2

Stays - 100 – 150mm D, can be a bit bent, little sap, 3m L, durability Class 1

Sawlog timber products

General eucalypt specifications

Sawlogs are one of the standard products that come from forests. As described in Chapter 6 (Product Recognition) a general minimum sawlogs size is 250 - 300mm small end diameter and a minimum of 2.4m long increasing in 0.3 m increments, plus 0.1 m for each cross cut. The standard for sawn timber is a length unit of 2.4m, but 2.5m is required for the log length, so that any damaged end material can be docked at the mill. Smaller sawlog sawing, recovery and value are being researched in most states as regrowth forest becomes the major source of native forest logs. It has already been suggested that the on-site portable miller will usually be happy to work with logs of 2.5 m length if they are of larger diameter. Markets and specifications will vary with regions and sawmills.

Bridging Girders

Bridging girders (Main Road's standard girder): are a premium forest product. The minimum length is 9.6 m with a small end diameter of 450 mm. Girders need to be straight, have a minimal amount of pipe or knots and be durability class 1 and 2 species.

Poles

It is estimated that there are 5 million timber utility poles in Australia with a current net worth of 10 billion dollars. In South-East Queensland alone, there are 500 000 poles in service. Poles are amongst the highest valued forest products, although it is the larger sizes that are by far the more valuable (Figure 8.4). It is extremely important to understand the regulatory guidelines (AS 2209-1979) that govern if a log meets the pole standards.

Figure 8.4. Truckload of valuables poles (Photo: K. Matthews).
Electrical transmission poles vary from a minimum of 8.0 m long and 175 mm diameter under bark (UB) 2 metres from butt end (D-line) through to 30.5 m long, 565 mm diameter UB.

Some of the limiting factors in pole specifications are:

- No fault in critical zone (approx 1m to 3m from butt end depending on length)
- No two faults per metre above critical zone, max of 6 (encased bark must be drained)
- Branches cut flush with bark (encased bark must be drained)
- Presence of rot or insect attack
- Degree of pipe or gum veins.
- Thickness of sapwood
- Degree of mechanical damage

**Veneer logs**

Have very high quality requirements and generally need to be more than 50 cm diameter, straight and 2.6m long, or a length specified by the processor.

Sliced veneer logs need to be of a very high quality, free of defect such as borers, knots, bends, bumps or fungal decay. High prices can be received for sliced veneer logs.

A detailed reading and understanding of the specifications is warranted if maximum potential value is to be realised from such products. Especially with regard to measuring and treating defect characteristics.

**Piles**

Piles are like poles except that the small end of the log is driven into the soil and then they are used to anchor and support concrete slabs being laid over suspect ground. Specifications are similar to poles but piles usually have less stringent defect specifications e.g. No critical zone. Piles are saleable down to as small as 4 m with a 150 mm small end diameter (SED).

**House poles and stumps**

House poles and stumps are round-wood that meet specifications such as: very straight, very round, minimal defect and Durability Class 1 and 2 species. Round-wood suitable for stumps can be as short as 2.1 m long. House poles generally are a minimum of 8 m long.

**Sawn timber (on-farm and mobile mills)**

A range of markets exists for sawn timber; categorised as green sawn, air-dried or kiln-dried. Some producers generate products in all three categories. Green sawn product provides an immediate return off the saw. Seasoned timber can provide substantial value-adding if done correctly – either on-farm or by sub-contract.

**Sawlog specifications**

**Defects affecting sawlog class and value**

Defects will substantially affect the class and hence the value placed on a log. Salvage grade logs are of poorer quality than standard Sawlogs. The salvage classification is given to logs failing sawlog specifications due to pipe size, number and size of limbs, degree of bend or small end diameter. Many mills will accept salvage grade logs with a small end diameter of 27 cm under bark and usually 2.4 m billets; occasional 2.1 m are accepted.
Growth defects

**Limbs and bumps:** Any limb more than 10cm diameter will generally result in a down grade of the log class. Limbs should affect less than 50% of the circumference of the log at any point.

**Sweep:** This term refers to the degree of bend in a log. Sweep is generally expressed in relation to log diameter. For example in NSW and Victoria a maximum deviation of 1/5 of the log diameter over 2.4m length is acceptable while in Tasmania it is 1/7 of the diameter over 2.4m length. Queensland use a sliding scale; for a 50cm diameter log it is 1/6 deviation before it is downgraded to an optional log. Degree of bend, this varies with centre girth, (as a guide, < 40 cm girth - 2.5º, 40 to 49 cm girth - 5º, 50 cm+ girth - 10º), often a bent log can be cut into 2 shorter straight logs.

**Pipe:** Pipe is a longitudinal cavity along the centre of a log as the result of the breakdown of the wood in the tree’s centre by growth stresses, fungal and/or termite attack, and/or biochemical means. This is commonly “boxed out” when assessing the log. If there is too much pipe (e.g. in NSW 18cm pipe for a 40cm log) the log will be downgraded to a salvage log which might go to the sawmill or to the chip mill. Table 8.2 gives indications of allowable pipe dimensions in sawlogs.

**Unsound Knots:** A knot is the remaining portion of a branch with fibres of the wood deflecting around the entire knot. ‘Unsound’ usually means the knot has either rot associated with it, is not solid across the face, is checked, or split - and is a defect on the surface of a log.

**Ring Shakes, Loose or Open Gum Veins and Encased Bark:** A ring shake is a partial or complete separation of adjoining layers of wood due to causes other than drying and usually originating either in the standing tree or in the log during felling or processing. Gum veins are ribbons of gum (kino) between growth zones, which may be bridged radially at short intervals by wood tissue. Gum veins can develop in trees as a result of injury to the cambium layer. Some species, such as the Bloodwoods, are especially prone to gum vein development and there are some indications that they may be influenced by genetic as well as environmental factors. A loose gum vein is one associated with extensive discontinuity of wood tissue.

**Spiral grain:** The inclination (gradient) of the grain at the surface to the axis of the pile shall not exceed 1 in 10 when measured over any 1 m of its length. Excessive grain can affect defects caused by splitting, strength of timber products and the recovery of product on the sawbench.

**Mechanical damage**
Caused by harvesting and processing severely reduces value and recoverable volume in sawlog products (Connell 2004). Slabbing and splitting of logs through application of stress forces can cause substantial damage and the necessity to dock considerable volume from a potential sawlog. Tong and cant hook punctures from rough handling can reduce grades and value in poles and piles.
Table 8.2. Specifications for allowable pipe in sawlog.

<table>
<thead>
<tr>
<th>Centre Diameter of Log under bark (cm)</th>
<th>Pipe Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-34</td>
<td>5</td>
</tr>
<tr>
<td>35-39</td>
<td>17</td>
</tr>
<tr>
<td>40-44</td>
<td>20</td>
</tr>
<tr>
<td>45-49</td>
<td>24</td>
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<tr>
<td>50-54</td>
<td>24</td>
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<tr>
<td>55-59</td>
<td>28</td>
</tr>
<tr>
<td>60-64</td>
<td>34</td>
</tr>
<tr>
<td>65-69</td>
<td>38</td>
</tr>
<tr>
<td>70-74</td>
<td>42</td>
</tr>
</tbody>
</table>

**Log Grading**

More detailed information can be obtained from the RIRDC publication “Defining the product - Log Grades used in Australia” by R.N. James (2001). Figure 8.5 illustrates log marking carried out by log graders which record information about the log and facilitate sorting and selection at the landing and mill yard. Table 8.1 provides a guide to the different log grades in each state and their relative values. A qualified cutter or log grader marks the butt end of each log. The product in the photo (Figure 8.5) is an 18.5/20kn pole which was sold for $520.00 +GST (K. Matthews Pers comm.).

**Figure 8.5. Log marking at the butt end of a sawlog (Photo: K. Matthews)**
Table 8.2. Comparison of Log grading for native forest logs Data derived from R. N. James and "Timber Harvesting in W.A." Dept CALM.

<table>
<thead>
<tr>
<th>Log products</th>
<th>Western Australia</th>
<th>Tasmania</th>
<th>Victoria</th>
<th>N.S.W.</th>
<th>Queensland</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High value veneer</strong></td>
<td>Veneer logs</td>
<td>Veneer Logs - VQ1 and VQ2</td>
<td>A Grade</td>
<td>Veneer logs</td>
<td>Veneer logs</td>
</tr>
<tr>
<td><strong>High value sawlogs</strong></td>
<td>Premium grade sawlogs</td>
<td>Category 1 (large diam)</td>
<td>A grade</td>
<td>Quota logs</td>
<td>Compulsory logs</td>
</tr>
<tr>
<td></td>
<td>First Grade</td>
<td>Category 3 (smaller diam)</td>
<td>B grade</td>
<td>Quota logs</td>
<td>Compulsory logs</td>
</tr>
<tr>
<td><strong>Medium value sawlogs</strong></td>
<td>Second Grade</td>
<td>Category 2</td>
<td>C grade</td>
<td>Quota logs</td>
<td>Compulsory logs</td>
</tr>
<tr>
<td><strong>Low value sawlogs</strong></td>
<td>Third grade</td>
<td>Category 8</td>
<td>D grade</td>
<td>Salvage logs</td>
<td>Optional logs</td>
</tr>
<tr>
<td></td>
<td>Small sawlogs</td>
<td>Category 8</td>
<td>D grade</td>
<td>Small graded logs</td>
<td>Optional logs</td>
</tr>
<tr>
<td></td>
<td>Short sawlogs</td>
<td>Category 8</td>
<td>D Grade</td>
<td>Salvage logs</td>
<td></td>
</tr>
<tr>
<td><strong>Speciality products</strong></td>
<td>Feature sawlogs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High value</strong></td>
<td>Poles</td>
<td>Poles</td>
<td>Poles</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bridge and jetty timbers</td>
<td>Piles and girders</td>
<td>Piles and girders</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chip logs</td>
<td>Pulpwood</td>
<td>House stumps</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Mining timbers</td>
<td></td>
<td>Landscape rounds</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Charcoal logs</td>
<td></td>
<td>Fencing (Splits, stays, strainers, rails)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low value</strong></td>
<td>Domestic firewood logs</td>
<td></td>
<td>Firewood</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Product Value Hierarchy

By assessing the value of potential products at the farm gate rather than their potential value standing, a value hierarchy can be established. This will prioritise your products and the range of linked products (by-products). Merchandising according to the value hierarchy can improve returns by as much as 30% or so. Depending upon input costs, which are effected by a large range of variables, what seems to be higher in the “standing value” order may actually provide a significant reduction in revenue (through size limits, cutting & processing costs and current market values).

Value is relative to cost

For example: A 9.5m 150mm SED pile at stump is generally able to return a minimum of $26 for the length when the property is within a 100 km haulage distance.

This size pile has an average volume of 0.3 m³ so it would take 3.33 of these piles to make a cubic meter of timber. When comparing the “relative value” per cubic meter of the pile i.e. $86 m⁻³ to many other products (such as local high quality and durability fence posts) taking into account all input cost it is often surprising to realize the true hierarchy of values. This is also affected by the ability to access the market based on critical mass, haulage distance, appropriate machinery, skills, time, etc, etc.

There have been occasions where supplying fencing material of durability class 1 species to the local market has provided a higher net return than any other product could have for that property. It is easy to be fooled by the “High Value Sawlog” mantra.

The value hierarchy is really site, situation and market access specific.

When preparing for a timber sale it is worthwhile considering the informal cooperation between adjacent landholders who also may have timber ready for sale. This form of co-operation does not need to be any more involved than accessing markets with greater volumes. In addition, efficiencies for logging operations in relation to floating machinery and increased duration of product supply can be a stumpage bartering point.

Options for selling

Selling timber involves two major types of decision. The first choice is “What you sell”, for example, cutting rights, standing trees, logs to roadside or logs delivered to mill. The second series of choices relate to “how you sell”, that is arranging the sale, eg. Do-It-Yourself or using a broker or cooperative.

What you Sell

There are three main approaches to the “What you sell” issue. These are:

Delivery (or Mill-Door) Sale

The seller is responsible for delivering the logs to the mill and therefore needs to arrange and carry out all aspects of harvesting, grading and transport. The sales quantity (either volume or weight) are measured at the mill. The advantage of controlling harvesting is that you can ensure that your tree stems are cut into the most profitable mix of logs. An intermediate method (very commonly used in northern Europe) is sale of logs stacked at roadside, with the seller still responsible for harvesting and log making, and the purchaser undertaking the transport.

Stumpage (Sell on the stump agreed before cutting)

Here the buyer arranges and undertakes harvesting and transport. This is by far the most common form of sale in Australia. The seller may mark the trees to be removed or allow all merchantable trees to be removed. Sales values are usually calculated by measuring logs on the landing. A
potential disadvantage is that the log makers (and the contractor) are working for the buyer, and
have lesser incentive to maximise value of log products recovered. Other common issues are site
damage and logging standards, and close supervision by a knowledgeable owner (or their agent)
is required.

**Sell on lot or area basis (also called “lump sum”)**

The buyer offers a defined forest area for sale for a fixed price, whatever is removed. Both buyer
and seller have to estimate the potential log yield from what they see standing. This form of sale
is very common in North America but rarely used here.

**How you sell**

There are two common ways of arranging the sale (a) arrange the sale yourself, or (b) use and
intermediary.

**Sell it yourself**

**Direct negotiation:** One on one negotiation is the way most wood is sold from native forests in
Australia. For the forest owner, the advantage of conducting you own sales negotiation is that you
develop an intimate knowledge of what’s going on. Using an advisor such as a consulting forester can
help avoid some of the pitfalls (see the Australian Forest Growers website http://www.afg.asn.au ).

**Auction or private bid:** If you have logs of high value (or there are large areas with reasonable
volume) several buyers might be interested. Auction or sale by tender promotes competition between
buyers. This technique is common in USA and it regularly used by state agencies, but less common in
private sales.

**Use an Intermediary**

**Co-operatives:** Timber co-operatives are a common mechanism used around the world by small
forest owners to try to gain some the economies of scale enjoyed by large producers. Aggregating
supply from numerous producers reduces transaction costs with buyers making purchase from the co-
op more attractive with potentially higher return to members. Co-ops frequently employ full time
skilled staff able to assist in harvest planning and management. Some co-ops extend to providing
operational (contract) logging services for members. Co-operatives are active in some form in most
states.

**Intermediaries:** Timber marketing agents and brokers of marketing agents can be employed to act
as middle-men between owner and mill. This type of arrangement is common in the well-developed
private forestry markets on USA but not yet common in Australia. This type of arrangement has the
advantage that the agent should have high levels of market knowledge and good buyer contact. They
should be well acquainted with the buyers’ requirements and preferences - therefore improving the
efficiency of the sales process. Where they work on commission, there is an incentive to maximise
returns. Their functions in the US context are summarised in "Marketing for wood products
companies" (Smith 2001) (http://www.ext.vt.edu/pubs/forestry/420-145/420-146.html).
A CASE STUDY  (RIRDC/CSIRO Investigation of Co-operatives - Peter Clinnick, in preparation)

An investigation of timber co-operatives was undertaken in 2002. Co-operatives are familiar to people involved in many rural industries and have emerged in forestry and timber supply industries. Where they exist they present a means by which individual operators can tap into a wood-flow system, aggregating their harvest and probably getting better prices for their product. Moreover, there is the potential to actually sell a range of wood products especially low-grade material.

What makes co-operatives successful?

A recent CSIRO survey of forestry based co-operatives found seven co-ops actively seeking markets and/or trading in hardwood, and/or softwood timber products. In the establishment phase the administrative load may be an impediment to the success of some groups, principally because in the early days of the business the group relies heavily on volunteer management.

The successful co-ops generally have more than 30 members with two of the most successful co-operatives having 400 and 1100. One exception is a group of ten Victorian sawmillers who formed a co-operative marketing group (similar to an NGC). In the more traditional grower co-operatives the larger numbers provide a secure base of capital backing and the resource availability necessary for business success.

The groups that are operating have placed considerable emphasis on developing a clear direction and supporting their vision with a detailed business plan; moreover, the successful groups sought professional advice whenever it is required. However, there was a noticeable lack of market planning among the groups.

On the wood-supply side, some of the more successful co-ops supplemented their own wood with wood sourced more widely at the national level and one co-op actually sourced supplies from Asia.

On the demand side, the highest demand originates closer to home. It is of interest, that overseas sales were targeted for Asia and the USA, but not Europe. It was also notable that some co-ops had been established to market “difficult to sell” small lots of softwood but had failed to achieve success, despite continued efforts by the co-operative managers. For many co-operatives there is an issue relating to acquisition of a critical volume to achieve profitability and prosperity.

A hybrid model

A problem which emerged for the North East Victoria Forest Growers Co-operative was that growers saw no real advantage in using the co-operative versus selling through a broker. The solution has been for the co-operative to act as an agent for a preferred broker, so that a grower enters into a three-way marketing partnership agreement with the co-operative and the broker. The broker offers a discounted fee to the grower and pays commission to the co-operative. In this arrangement there is added incentive to the grower, as the co-operative is a party to the agreement, thus lowering grower uncertainty, particularly with regard to prices. Furthermore there is greater incentive for the broker to promote co-operative membership.

The answer to the question – “What makes a co-op successful?” is:

“Pig headed determination!” Ross Henderson, Farmwood Tasmania Co-op Director
Determinants of on-farm timber price

Stumpage

The variable that has the greatest effect upon market access is the distance to the prospective purchasers. Some of the forest products that may be sold in your area could include: Sawlogs, salvage grade logs, poles, piles, mining timber, bridge girders, and a range of fencing material (splits, rails, caps, strainers and stays). You may have a property that grows the best quality poles in Queensland yet is 700 km from the nearest pole purchaser. This is not to say that when demand is high, buyers would not bear the extra cost of long haulage, but knowing the state of the market is critical to this decision.

Contacting local timber merchants/sawmillers should identify the applicable products, stumpage value and their minimum specifications in relation to species, amount of defect, length and diameter. This information alone does not give you a very clear idea of who to sell to.

Stumpage is drastically reduced at greater haulage distances, with poor property access, with long snigging distances, etc)

Price alone should not be the determining factor for making a sale. For example a sawmill may offer $75 m$^3$ for your sawlog and $20 m$^3$ for salvage compared to a second mill that offers $65 m$^3$ and $20 m$^3$ for salvage. The first mill may have a set of specifications, which push 50% of your sawlogs into the salvage class, where as the second mill may take all your logs as sawlogs.

In addition to this changing quality standard, the second miller may in fact pay you on a 14-day account; while the first sawmill may frequently stretch the friendship to 60 days before payment.

After considering price, the end state of the forest should be a major consideration as a higher price received may be reflected in the way operations are performed and compromises in forest protection may be experienced.

There are many other scenarios, which prompt the simple recommendation “Do Your Homework”!

It is not difficult to find out the properties that have been logged by purchasers in the past. It may be possible to inspect a block that was cut in the last 6 months and assess the utilisation level, damage to retained trees and drainage of snig tracks. Landholders are often prepared to talk about their experiences, concerns and recommendations relating to communication, payment history, etc.

Landholders who have the suitable skills, equipment and experience can achieve higher stumpage values by taking on tasks that reduce cut, snig and haul rates. Major causes for the reduction of landholder stumpage are:

- Available volume
- Distance from the market
- Product length
- Product diameter
- Property access, road quality
- Property terrain e.g. Steep, rocky
- Average snig distances to loading ramp
- Product quality
- Market demand
Return measured at the stump depends on three main factors:

(i) the prices that customers are prepared to pay at mill door and
(ii) the costs of harvesting, and
(iii) transport.

Stumpage Return $ m^{-3} = \text{Mill gate price } $ m^{-3} - \text{costs (infrastructure } $ m^{-3} + \text{ harvesting } $ m^{-3} + \text{ transport } $ m^{-3})$

Infrastructure costs are the planning, inventory, permit and roading costs incurred to reach the harvesting phase of the enterprise, and additional costs to finalise the operations and closure of the contract.

Harvesting costs include the cost of cutting, snigging, debarking, grading and product preparation.

Transport costs include haulage contracts and / or any running costs, maintenance etc for transport and roading.

**Factors influencing mill door pricing decisions**

*Final Consumer Demand*

The level of demand from your purchasers (the sawmillers’) or customers is one of the most important factors in selling products. Look past your customer and consider what the complete markets are for the things they make from your logs. If locally produced sawn timber goes into local houses, what is the state of the local housing business? If sawn timber is sent to a regional or capital city market, what is the state of that market? If your logs go for pulpwood, what is the state of the domestic or export pulpwood markets?

*Competition*

How many competitors are there for your logs? Having a number of mills within economic distance is likely to increase the competitiveness of the local market. How many competitors do you have trying to sell logs? In many regions a large component of the log supply comes from State-owned forest and the prices paid for these logs (usually called “Royalty”) usually set the benchmark price for logs when adjusted for distance and accessibility. It is of note, however, that supplies from many State forests sources are declining, that the sales agreements are frequently long term and they involve specific millers and not others. In many States these log supplies are termed “quota” logs. Mills needing additional logs or mills without a quota allocation will be the customers for private forest logs. If private supply levels are low then the market is likely to operate as a marginal one. There are advantages as well as disadvantages in being a marginal supplier. Prices paid for marginal supplies can be much higher than the prevailing regional averages (eg. State royalties) in periods of high demand or log shortage because millers are only paying the high price on a small fraction of their supply. Under high demand conditions logs of lower quality may become saleable. Conversely, in periods of low demand, log sales from private sources may be impossible and / or quality requirements may rise considerably.
By-product markets

Mills can pay more for logs if there is also a local market for their residue or waste material that may go into energy production or woodchips for a range of uses, including paper manufacture or landscaping. In most parts of Australia hardwood log price is driven by the demand for structural grade housing timber.

Species

Some species are highly sought after while others are almost un-saleable. Species that are in demand for sawing include a range of ash species, Messmate, Brown Barrel, Spotted Gum, Blackbutt, Sydney Blue Gum and Rose Gum, to name just a few.

Other species are in demand for their durability and these include red gums, ironbarks, many box species and Spotted Gum. The light colour of mature wood makes some other species such as Southern Blue Gum (*E. globulus*) and Manna Gum (*E. viminalis*) more desirable for use in the pulpwood-paper industry, but these species may also be used for sawn products.

Factors influencing to costs of getting your logs to the point of processing

Accessibility

Obstacles such as gully crossings and steep terrain affect the costs of road construction, the type of equipment to be used and the time taken to harvest an area. Poor access means lower prices and it may be difficult to sell the logs. Similarly, any constraints on traffic movement to protect certain areas, or limit soil damage because of wet weather, may contribute to a decrease in the price a buyer is prepared to pay for logs, because of the extra time that machinery will take to move logs, or be otherwise tied up on site but unable to work.

Accessibility not only influences the cost of building roads, it may also affect transport costs. Transport cost includes vehicle wear and tear as well as time for travel per kilometre, fuel used during standing time etc.

Distance to market

Transport costs are less for logs close to the mill, although relative costs are higher per cubic metre per kilometre for short hauls, (Figure 8.6) due to the effect of standing time for loading and unloading.

Figure 8.6. Cost reductions in log transport over distance (base data from ANU Market Report No 7, Bati 1999).
Regional markets are not always fair. Prices offered may not fully incorporate transport costs as buyers often seek to even out costs.

Log quality

Logs that are straight with few or no branches and solid core are worth considerably more than logs with any or all of these defects. In native forest internal defect is a major consideration that determines grower’s revenues.

Volume

Some costs associated with managing the sale and the harvesting are effectively fixed and independent of the size of job (e.g. transporting equipment to site). Larger amounts of wood mean that the fixed costs are corresponding less per tonne or cubic metre.

Contractor Willingness

The prices required by contractors to undertake farm forestry contracts depend in part on their appreciation of all the factors listed above (accessibility, distance, log quality, volume). They also depend on demand for their services (competition) and their prior experience in working on farm forests.

Wood sales contracts

Wood sales contracts are legal documents and as such it is best to cover all specifics and foreseeable possibilities related to guarantees about the outcomes and performance of harvesting operation. Covering anything that might arise when you sell stumpage or product and the presence of contractors on your property.

When you arrange your sale your expectations are

(i) to be paid,
(ii) that the quantities sold and purchased are measured accurately, and
(iii) that the harvesting process (if not controlled by you) didn’t cause undue damage to your forest or property.

These issues should be addressed in the sales contract. For instance if you do control the harvesting, then you are responsible for the outcome of (ii) and (iii) through your harvesting contract.

Sales Contracts

Having the detailed contract for sale allows everyone to know where they stand, what has to be done and when it should be expected to be completed. A good contract involves some costs to set-up but provides limits in your exposure to risk factors (legal and financial) and can also reduce uncertainties. The capacity of the buyer must be assessed, especially with regard to contingent liability (local knowledge and experience may be helpful here).

Guideline 8.2. Achieving sale expectations

Have a contract that specifies a payment schedule with staged payments;

Ensure capacity to pay;

Engage an expert to verify volumes cut and delivered and correct grading as the logs go out the gate.
The following are typical headings in sales contracts and are provided as examples of the sorts of factors you should consider:

- Names and affiliations of all parties;
- Term of the contract;
- Timber harvesting descriptions;
- Schedule of works;
- Product specifications;
- Contractor and resource owners obligations;
- Payment (amounts and timing);
- Responsibility of parties (Codes of practice documentation, roads, fences);
- Disputes and termination clauses;
- Indemnity and insurance;
- ‘Force majeure’ (resolution of unforeseen circumstances);
- Interpretation of terms;
- Law and jurisdiction,
  - Administration of the contract
  - General provisions and variations
  - Schedule for signature and seal of all parties.
  - Completion of obligations and winding up of the contract.

Seek assistance and advice from legal specialists in setting up a contract. Guidelines 8.3 provides case study information from the experience of others in contractual circumstances.

**Notes on the typical contract**

- Terms of sale need clear specification. Species, location, quantity, form of trees or logs as well as categories of logs or other produce needs to be stated. Include the grade specifications. Define the requirements for grade assessment (see sub-section below)
- The price to be paid for each grade of log or other product must be specified.
- The point of sale should be established – at stump, on-truck, farm gate or mill door. In addition, there is a need to ensure that the buyer does not transfer the rights of sale without the consent of the owner of the resource.

It is very important that all the points that are negotiated are detailed in the contract. In case things need to change later, then build in a variation clause that sets out who has the power to vary and negotiate and where such variations will be documented.
Guideline 8.3. Learning from experience

Case study 1  What is the agreement?

“It took a long time, debt collectors and an expensive protracted legal battle to get my money.”

Remedy: A written contract might have specified that a deposit was required, as well as when and progress payments were to be required. Some written contracts have penalty clauses for late payment such as a lump sum additional payment, or interest accruing on the account. When you have a written contract it lets the other party know that you mean business and are serious about prompt payment. Check the purchaser’s performance with previous clients.

Case study 2  What goes out the gate and what you get!

“How do I get the best price for what I have?”

An original assessment of 3.2 ha of mixed species private forest near Bombala, indicated that there would be 913 tonnes (830m³) of pulpwood and 230m³ of sawlog material produced. If Dave could get an average of $20 m⁻³ for sawlogs and $6 m⁻³ for pulpwood, the profit would be about $9600.

In finding a buyer, several sawmills and the pulpwood mill were approached as well as few firewood contractors and a mobile miller. The firewood contractors felt that 150 km was too far for them to travel, they had employment opportunities closer to home. Some mills offered a good price for sawlogs, but only wanted the select species, leaving the rest unsold or to be sent for pulpwood.

Finally, Dave settled on dividing the available sawlog volume, selling one half to the mobile miller who paid $25 m⁻³ (for 63 m³) and the other half (70 m³) to a commercial miller across the border, who, in the end, only paid $5 m⁻³. The pulpwood was sold at $6 m⁻³. Given the low level of demand for lower grade sawlogs, the rest of what might have been sawlog was sold as pulpwood, simply because there was no other market.

Following harvesting and sorting, 1085 tonnes of pulpwood and 133 m³ of sawlogs left the farm gate, yielding a total income of $10600. Although this was slightly above what had been expected, the result could have been better if some of the sawlogs had achieved a higher return.

In conclusion, the expectations of the landholder had not been satisfied. If the expectation was to at least achieve $9600, then the expectations have been achieved.

Guideline 8.4. Tax traps

The form of contract by which timber is sold can affect what tax is paid on the proceeds. Growers who have not previously sold forest products should consult their accountants or professional advisers about the form of the contract before they sign. In certain circumstances a pre 1985 owner can sell free of tax (see TR95/6 example 6 and Ashgrove vs. FC of T 124ALR.315). If entering the business of forestry for the first time, TD96/8 provides a process for determining the market value of mature trees acquired and used for non-forest operations, but later ventured into a new business. This value is used in determining the net profit that is returned as assessable income.

Product Grading and Measurement

Grading has been described previously. It is important to establish the qualifications of log graders. If there are a number of grades of log being produced and particularly where there are significantly different commercial values or tight mill requirements, you should establish a procedure for check grading. Check grading is the practice of using a second grader to re-grade a sample of logs as an audit of grader performance. You should also develop a procedure for dispute resolution between the forest owner and purchasers covering grading issues.

Considerations: Harvesting Contractor performance under Stumpage Sale

When the harvesting contractor is being employed by the sawmill, (eg. as under a stumpage sale) the forest managers need to ensure that their sale contract includes necessary provisions covering agreed minimum standards of performance by the harvesting operation. These should include adherence to any applicable codes of practice, limits on damaged to residual trees, soils, forest roads and fences, and requirements (if needed) for rehabilitation.

Where the contractor is employed by the forest-owner, these factors would be directly included in the harvesting contract.

Additional and potential new markets

Forest management for private land has traditionally responded to existing market needs. Potentially new products are emerging which will require a slightly different management approach to past practices. The landholder must assess the potential for involvement in the emerging markets, such as carbon, salinity and biodiversity credits as well as bioenergy production. The following information provides an introduction to these potential new markets and indicates what action can be implemented.

These markets can also be extended from static involvement (conservation of the current resource) to management to increase carbon storage (related to greenhouse gas reduction), biodiversity protection, salinity mitigation and bioenergy generation. While none of these is yet well established, each has the potential to provide income to private forest owners in the future.

Carbon Credits

Carbon credit trading is based on the amount of long term carbon that can be stored (sequestered) in a forest system. Carbon sinks such as plantations, are seen to have an important role to play in helping countries meet and trade their emission obligations under the Kyoto Protocol (http://www.greenhouse.gov.au).

Rates of carbon capture (sequestration) vary dramatically with time, tree type, and hydrological, geological and biophysical conditions. Victorian information indicates that carbon can be captured at rates ranging from 3.1 to 8.6 t ha⁻¹ yr⁻¹.

The removal of carbon from the atmosphere by this form of a carbon sink is of course not permanent, since the harvesting or logging of trees results in the release of much of the stored carbon.

As for sustainably managed native forest, it is difficult to include this in a carbon trading. This is because net changes in carbon storage over the very long term are difficult to quantify. The exception may be forest regenerated on land cleared prior to 1990. The Australian Government, as well as industry has indicated support for an emissions trading scheme. In response the Australian Greenhouse Office (AGO) is developing protocols on the basis that a system of international trading will be established.
Guideline 8.5. Income from bush regeneration

To achieve benefits (obtain carbon credits) from reforestation during the first commitment period (2008-2012) under the Kyoto protocol, trees would need to be regenerated or planted on land cleared prior to 1990.

Salinity Credits

The market for salinity credits is also gaining momentum, especially in NSW. There is increasing acceptance at government and community levels that setting up such a market will assist in mitigating salinity problems. In the case of salinity credits the traded commodity is likely be the volume of water transpired by trees - and the benefit will be lowered water tables.

Biodiversity credits

The concept of trading in biodiversity credits is still in its infancy. Currently Forests NSW is looking at starting a biodiversity credits trade for organizations that re-establish threatened ecosystems on lands that were previously cleared for agriculture. The system of biodiversity credits, as with carbon and salinity credits, is based on ‘profit a prendre’ use of land title. In the future biodiversity credits may be worth more than carbon credits (S. Gilbert, Pers. Comm., Forests NSW).

Bioenergy

Bioenergy derived from wood residues and other waste products will constitute an important source of renewable energy for electricity generation in the future. Processes and conversion techniques for utilising thinnings and waste wood include combustion (co-generation, co-firing), gasification, pyrolysis (charcoal, gas, liquids), digestion and fermentation.

Wood, as a biofuel, faces heavy competition from low cost electricity. But, for owners of native forest, an industry based on biomass utilization may have multiple advantages, including income diversification. Bioenergy from wood also offers an opportunity for renewal of private forest degraded by past excessive logging. Under a program of renewal, forest diversity and productivity can be restored.

A further advantage of such a system is that bioenergy stations can be located along the electricity grid in decentralized locations. As with the plantation development scenario, there will then be opportunities for landholders to implement management, harvesting and sales that would have previously been non-existent or uneconomic.
Guideline 8.6. Establishing a carbon sink

Several programs have already been established to enhance Australia's carbon sink capacity. These will put Australia in good stead, if and when an international carbon credit trading scheme is established. The initiatives include:

Bushcare, the National Vegetation Initiative - to reverse the long-term decline in quality and extent of native vegetation;

Farm Forestry Programs operating in several states to encourage incorporation of commercial tree growing and management into farming systems;

Plantations for Australia 2020 Vision - aiming to treble Australia's forest plantation estate by 2020, by establishing an additional 2 million hectares of plantations; and

Bush for Greenhouse aiming to provide corporate Australia with investment opportunities in carbon sinks to offset their greenhouse gas emissions. This Federally funded program is seeking to build partnerships between the corporate investors and tree growers. Funding can be secured for revegetation for the purposes of:

- conservation of biodiversity and wildlife habitat;
- rehabilitation of degraded areas;
- improving agricultural production;
- lowering of water tables and
- improvement of water quality and wetlands management.

Contact your local forestry or conservation department for more information.
Chapter 9. Harvesting and transport

Harvesting is a difficult and potentially dangerous aspect of forestry. The term “harvesting” covers the wide range of activities needed to plan, execute, oversee and finalise the removal, transport and delivery of logs to mills. A common sequence of the activities involved in typical harvesting operations is illustrated in Figure 9.1. The planning of harvesting operations is linked to the results of forest inventory and the farm and forestry management plan objectives.

The harvesting and processing methods available; and the planning steps and priorities that need to be considered fall under a sequence of decisions and operations such as:

- Choose the silvicultural systems;
- Choose the appropriate harvesting systems;
- Selecting equipment for harvesting, extraction and processing;
- Planning roads and transport;
- Preparing the harvesting plan; and
- Implementing the harvesting operation

Figure 9.1. Operational activities in the harvesting and transport of timber.

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Preparing the Harvesting Plan including map</td>
</tr>
<tr>
<td>Tree &amp; boundary marking</td>
<td>Ensure boundaries are clear and stems to be removed are identified</td>
</tr>
<tr>
<td>Road and landing construction</td>
<td>Locate, construct or upgrade all necessary roads and landings.</td>
</tr>
<tr>
<td>Felling and trimming (crosscut)</td>
<td>The activity of felling the tree and cutting of the upper branches (&quot;the head&quot;) from the stem. Under short-length systems stems are crosscut at the stump.</td>
</tr>
<tr>
<td>Extraction</td>
<td>Moving the stem from the stump area to roadside - also sometimes called skidding or snigging</td>
</tr>
<tr>
<td>Debark (if required)</td>
<td>Removing all (or most) of the bark from the log - usually performed by machine or crowbar.</td>
</tr>
<tr>
<td>Crosscut (to grade)</td>
<td>Cutting the long tree stem into individual logs (if needed) according to log grading rules and requirements of miller or owner.</td>
</tr>
<tr>
<td>[Mill on-site]</td>
<td>Portable sawmilling at landing or frequently close to stump</td>
</tr>
<tr>
<td>Truck loading</td>
<td>Loading of logs (or sawn timber) on to road trucks.</td>
</tr>
<tr>
<td>Transport to market (e.g. sawmill, pulpmill)</td>
<td>Transport over farm and public roads to the point of sale.</td>
</tr>
</tbody>
</table>
Harvesting systems

Native forest harvesting in Australia commonly involves two main stages. Firstly the felling and initial preparation of the product for movement from its origin (falling, heading and crosscutting) and secondly its extraction form the stump area to the roadside landing (snigging, skidding, forwarding).

Harvesting systems are usually described by the length of the wood as it is transported from stump to landing. The simplest division is into:

- long-length systems – stems are skidded to roadside in maximum practical length,
- short-length systems - trees are converted at stump to logs (usually less than, 6 metres) and forwarded to roadside
- whole-tree systems – involving the transport of whole stems - felling only no cross-cutting.

Long-length harvesting systems

A long length system involves topping or heading the trees at the stump area to produce a long-length log and subsequent skidding or snigging in these long lengths to the landing (Figure 9.2). Long length harvesting is by far the most common method of harvesting native forests logs in Australia. At the landing long-length logs might be further trimmed, and are sometimes crosscut to shorter lengths for transport.

In the case of very long logs, cross-cutting to intermediate (but still long) length may occur at the felling point. Logs may range in diameter from 25cm to over 100cm. A 100cm diameter log 5.9m long weighs about 5 tonnes. This weight of wood is beyond the skidding capability of a farm tractor and it will be necessary to use a skidder, excavator or bulldozer to skid (move) the log and load it onto a truck. Specially equipped and operated farm tractors are appropriate for smaller diameter logs.

Advantages

- The system can be applied in a wide range of terrain in different types of felling operations including selection harvesting, group selection and clearfelling operations;
- Cross cutting and transporting whole-tree or long lengths involves less handling than other systems, but may necessitate more powerful and strengthened equipment as the diameter of the log increases;

Delivering whole logs to the landing allows for a better selection of different log products (and value).

Disadvantages

- Less suited to extraction over long distances(<300m);
- More operator care is needed to ensure that damage to remaining trees is minimised. For example, during thinning a sacrifice tree (felled last) is sometimes left on corners to protect valuable remaining trees;
- Higher potential for soil disturbance, compaction and visual effect than short-wood (forwarder) or cable systems where these are applicable;
• Require somewhat more roading than short-wood (forwarder) systems for best economic performance.

Figure 9.2. Long-length systems for native forest logs.

Short-length harvesting systems
Short-length (short wood or cut to length) harvesting, involves felling, heading, delimbing, cutting to length and segregating close to the stump (Figure 9.3), products such as pulpwood in short pieces, fence posts and firewood. Lengths may range from 2-6 m. The logs may then be transported on a trailer, or in some instances a forwarder, to the roadside for transfer to a road truck.

Figure 9.3. Short-length systems for native forest logs.

Advantages
• Small to intermediate sized wood can be efficiently handled;
• Suited to extraction over long distances (up to 1-2 km), reducing the need for extensive high-grade track work;
• Different products can be segregated easily (but this may reduce efficiency);
• Minimal damage to remaining trees during thinning;
• Low visual effect.

Disadvantages
The large number of pieces, frequently of small diameter, dictates that bulk handling methods are needed to make the operation profitable. Equipment such as boom loaders and grapple loaders have been developed specifically for this purpose.

The equipment used, such as forwarders and tractor/trailer combinations have operational slope and manoeuvrability limitations over about 18° (30%), especially in areas where large pieces of debris are left over from previous logging operations.

Whole-tree harvesting systems

With this system the whole tree is extracted to roadside (Figure 9.4) where it is mechanically processed into log products or chipped.

Whole-tree systems are mainly used for clear-felling very steep slopes where processing (delimming, debarking, cross-cutting to log length) is more difficult. It is done at the roadside. Where the whole tree is to be chipped for fuel or fibre the intact tree is taken from the stump to the chipper or breakdown machine. Chipping whole small trees can increase chip yield by 50 to 90% compared with the harvesting of only round-wood.

Figure 9.4. Whole-tree systems for native forest logs.

Equipment for extraction and loading

By definition timber extraction is the transport of logs from the felling point (stump area) to a landing area where logs are loaded on trucks for road transport to mills. The efficiency and effectiveness of extraction is influenced by both equipment selection and the planning and location of the access track network. – see the planning section)

Skidding is the most common extraction method employed in native forest operations in Australia. Skidding involves dragging the logs along the ground, usually with one end suspended by the skidding machine. The two common forms of skidding machine are the purpose built rubber–tyred skidder (Figure 9.5) and crawler tractors (Figure 9.6). Either machine type can be fitted with winch and wire rope for securing the log, or with a hydraulically operated steel grapple, which has the advantage that the machine operator need not leave the machine.

Forwarding involves loading and carrying the logs, cut lengths or billets (Figure 9.7 & 9.8) to the landing. It is less frequently used in native forestry except in thinning operations. Forwarders are usually purpose-designed machines for forestry application, although they were first constructed from agricultural tractor and trailer units and such simpler systems are widely used in farm-forests overseas. Forwarders are more frequently owned by contractors who predominantly use them in operations for small diameter (<30cm) logs of shorter lengths.
Figure 9.5. Rubber-tyred skidder.

Figure 9.6. Crawler tractor skidder.
Figure 9.7. Traxcavator tractor used forwarder and loader.

Figure 9.8. Forwarder with hydraulic boom loader
**Excavator based logging or ‘shovel’ logging**

Excavator or ‘shovel logging’ is a relatively new technique in Australia and is being practiced by a number of logging contractors in Tasmania and Victoria. The system involves moving logs from the stump area to a roadside landing by grapple-equipped excavator alone. The excavator repeatedly moving logs in small piles toward the landing by lifting and swinging them from one piling position to the next (Figure 9.9). The technique has an advantage in that much of the required debarking occurs during the moving process.

The system has the added advantages of only one type of machine being used on the site and generally causing minimal soil disturbance compared to tractor skidding. A limitation is that it does not work well on uphill slope of more than about 10° (15%). Research trials indicate that the practical maximum economic distance to move logs in a shovel logging operation is about 200m.

**Figure 9.9. Excavator extraction using two machines in tandem.**

**Cable logging**

Cable logging systems are usually based around a large capacity stationary winch and a logging tower (Figure 9.10). Logs are transported by attaching them to skidding carriages which are then pulled toward the tower by wire cable. A second cable (called a skyline) is frequently slung from the top of the tower to a distant tail-hold to provide lift for the attached carriage, even allowing full suspension of logs under some circumstances. Cable systems are generally employed in terrain where wheeled or tracked equipment cannot work safely, for example on slopes over 25 - 30°. The expertise and capital investment required for these systems is usually high and most farm-forest owners would need to employ appropriately equipped contractors.
Loading

Loader choice depends on the log size and the loading productivity required. Loaders range in size from light capacity boom loaders for tractors and trailers; hydraulic knuckle booms on trailers, trucks, forwarders and excavators (Figure 9.11); and independent wheeled or tracked loaders (Figure 9.12).

Wheeled and tracked front-end loaders were previously very common in native forest operations. They have now been substantially replaced by hydraulic excavators, which have proven more economic and versatile. Hydraulic boomed excavators can segregate and debark material and in addition, efficiently handle large volumes of small diameter material. Under some conditions they are also used for shovel or excavator logging and when fitted with a bucket, for road building. However, they are usually tracked machines with limited mobility. Some farmers have justified the purchase of a second hand machine by using it on the farm for fencing, dam construction / cleaning and road building.

Figure 9.11. Excavator based grapple loader.
Figure 9.12. Crawler tractors (top) with grab loading truck and (b) with blade using loading ramp.
Log processing systems

Felling equipment and methods

Chainsaws

Portable chainsaws are the most commonly used tool for felling and cross cutting. Larger hydraulically powered chainsaws are fitted to machines for both mechanised felling and cross-cutting. Chainsaws range in size from small 36cc engines with 35cm bars, suitable for thinning saplings and falling smaller trees, up to the professional saws with 120 cc engine capacity and 100cm bar length used for harvesting very large trees.

The advantage of chainsaw felling is that it is flexible and efficient in small tracts of forest, unlike the more mechanized systems which are costly to relocate. Its main disadvantage is that it is dangerous. Unless you have the correct accreditations and safety equipment do not undertake any felling or cross cutting operation.

Mechanical harvesters

Some contractors employ mechanical harvesters for tree falling, using either fixed or rotating felling heads to bunch or process. Feller-bunchers (as the name implies) mainly fell and place trees in bunches where required. Bunching is a useful technique, especially in smaller trees to facilitate efficient extraction. Rotating and floppy heads with debarking rollers and manoeuvrable grapples can both fell and process the trees (fell, delimb / debark, measure and crosscut to log lengths and easily segregate them into different products groupings).

Felling heads have mostly powerful hydraulically driven chainsaws, but are occasionally shears or disc-saws. Saws are contained within the specially designed heads (Figure 9.13) attached to hydraulically operated booms. Stem diameters that are up to 1 metre can be safely handled - but this depends critically on the head size, power, weight and stability of the base machine. Mechanical harvesters are available as tracked or wheeled machines, the latter having the advantage of being more mobile, although typically, restricted to smaller trees. Feller-bunchers are usually used in long-length and whole-tree systems, while grapple harvesters, with their capacity to cross-cut and debark are more commonly used in short-length systems.

Figure 9.13. Detachable felling heads are available in several sizes.
Grapple harvesters are very productive in smaller timber with a high degree of safety. Nonetheless, care is still required in their use in thinning operations to minimize damage to remaining trees. If only small areas are available for harvesting, machine running costs and relocation can make the use of large machines un-economic. Co-operative arrangements between nearby landholders might allow several small tracts to be scheduled sequentially to minimize machine transport costs. Also the use of more mobile, wheeled machines may minimise costs enough to make the operation viable.

**Directional falling**

Felling of trees in controlled directions is important, for example felling large trees across other trees or stumps results in breakage and product losses. Where falling trees contact standing trees during their fall, there is both potential for damage to the standing tree and the increased risks to fallers from falling limbs. Directional falling can also improve extraction productivity by placing trees in favourable positions. For example, alignment with the extraction track minimizes the turn angle for stems during winching and can reduce damage to remaining trees.

Directional falling on steeper slopes is more difficult. The use of wedges or a tree jack may be required to push the tree in the correct falling direction. A tree jack can exert pressures up to 1.8 tonnes at the base of a tree.

*Tree jacking and felling is a specialised procedure and should not be attempted without appropriate training.*

**Felling small diameter wood**

Small diameter trees are sometimes felled during culling or thinning. Attachments such as tractor powered slashers can be utilized in the first few years of regeneration. Larger woody stems can be felled most efficiently with brushcutters. Chainsaws are used to fell small diameter wood although this work can be dangerous.

**Delimbing and debarking**

Delimbing is a minor aspect of eucalypt harvesting when compared to conifers (pines). Eucalypts have few branches in the conventionally merchantable log section of the stem. Delimbing is achieved by removing the head and large branches. Some large side limbs are occasionally removed to extend the merchantable log length (Figure 9.14). During thinning operations delimbing is a side-benefit of the debarking which is usually the main task of the mechanised harvester. Mechanised delimbing equipment requires large capital expenditure and for most private native forest circumstances the expense is unwarranted.

Many, but not all eucalypt logs are debarked, however eucalypt species vary widely in debarking difficulty (mechanically or otherwise). Traditionally this debarking has been conducted in the forest using an axe, sharp shovel (manual methods), or by dozer blade, skidder tyres or excavator grapple (mechanical means). Manual debarking by hand is easiest when the sap is rising in the tree in spring or after good rains. Manual debarking involves making sequential cuts in the bark in a zigzag pattern, along the length of the felled tree. The axe, adze, crowbar, barking bar or other lever is then pushed under the cuts and larger sections of the bark levered off.
In mechanical debarking, excavators with loading grapples are frequently used to debark a range of species, including stringybarks. Debarking is also carried out by grapple harvester heads which can carry out all operations at the stump on smaller diameter trees (Figure 9.15). Excavators are used to debark, cross cut (when the grapple is fitted with a hydraulic chainsaw), sort and stockpile different log products and then to load the trucks from comparatively small landings. This machine type has become central to industrial scale native forest logging, replacing wheeled or tracked front-end loaders which usually had higher operating costs and created more landing disturbance. Farmers with large areas of native forest might consider owning an excavator, particularly where it can be put to other uses.

Figure 9.15. The excavator harvester-processor, fells debarks and cuts to length.
Excavator based loaders have proven less efficient in debarking of smaller stems. More commonly these are debarked by mechanical harvester which have proven a very efficient technology in smaller and well stocked stands and form the basis of mechanised thinning systems. Ring debarkers have been used extensively overseas with plantation eucalypts, but usually with smooth barked species. Ring or rotary machines have so far proven to have some limitations when it comes to dealing with stringybark species.

The economic debarking of small volumes of eucalypts by other than manual techniques remains a problem. The nature of the problem and some bark removal options are described in more detail by Wingate-Hill and McArthur (1992).

Guideline 9.1. Debarking eucalypt logs

The speed of an excavator in debarking will far outstrip the rate at which manual debarking can be conducted. A single operator can manually cut and debark about 17-20 trees per day compared to hundreds of trees per day using an excavator fitted with a grapple. Clearly, the diameter and price to be received for the wood determines the profitability and method of debarking that will be used.

In trees, most of the nutrients are in the bark and crown. Following felling, harvesters can redistribute material, flatten branch and head material, which should a fire occur in the years immediately following harvesting, reducing flame heights and damage. Often some deliberate soil disturbance is required to provide a seedbed for regeneration and this can be achieved as a side activity of the operation and redistribution techniques.

Most debarking on farms is often done by hand but in large enterprises in Europe (see Figure 9.16) rotary and flail debarkers are used.

Figure 9.16. Demuth tractor powered rotary debarker (Photo courtesy Demuth).
Crosscutting and log making

Crosscutting describes the activity of cutting tree stems into individual logs or products. This involves both the judgement and decision about where to cut the stem and the activity of making the cut. Crosscutting is sometimes also called log-making or bucking.

The crosscutting can be done at a number of locations (stump, mill) but is commonly done at roadside landings (Figure 9.17). Cutting at the mill is commonly practiced where facilities and conditions allow better and safer crosscutting to be carried out. After cutting logs are usually graded into categories according to species, quality and size. This activity is referred to as log sorting and grading. Several states require formal qualification and certification for log- graders who inspect, crosscut or determine usage and destination of the log products.

Crosscutting involves two important sets of tasks, (i) deciding where to cut the stem into logs, and (ii) performing the cutting. Incorrect cross cutting can easily (and routinely does) lead to a considerable loss of valuable material, timber sawing problems and worst of all personal injury, if the chainsaw work is not done correctly.

Figure 9.17. Crosscutting by hand at the landing.

The where to cut? decisions are made after assessment of the stem and consideration of the log grading rules. The decision can critically influence the financial return from forest operations where the different grades of log have significantly different value. Under these circumstances experienced and expert graders should do this job. Most contractors are paid on a quantity (volume or weight) basis thus have a lesser incentive to maximise total return.

It is important for the forest owner or his representative to fully appreciate and explore market opportunities for specific resource, products and sizes. Also to ensure competent supervision of the operations.
**Guideline 9.2. Cross cutting**

Measure accurately to required length;
Cut square on to the log and cleanly;
Trim scarf from butt;
Paint log ends with timber sealer (available from petroleum suppliers) in hot weather, or if the log is to be stored.

Chainsaw use requires skill and training. Some of that factors that are considered essential for safe crosscutting include knowledge of where tension and compression zones form in the logs during cutting and stacking and the ability to recognise potential directions of log movement. It needs to be recognised that the forest landing is a dangerous place to work. The work is done in proximity to heavy machinery and involves the potential for rolling or moving logs. Chainsaw work should only be undertaken by qualified and experienced personnel.

**Whole-tree or long-length chipping**

Whole-tree chipping is frequently applied in stands with many smaller stems. Feller-bunchers are commonly used in these stands to fell and assemble larger loads for skidding. A skidder or a forwarder moves the material to the mobile chipper, located at the roadside or landing. This is a highly efficient operation that is well suited to thinning and selective logging operations, wherever there is a high volume of low value material to remove. Large chippers (which are not very mobile) can process up to 60-80 tonnes per hour (Figure 9.18). Strict specifications are applied to the size of chips, and there are upper limits on the amount of bark, grit and charcoal if chips are to be used for pulping. Lower specifications are acceptable is chips are used for particle board, landscaping or fuelwood.

**Figure 9.18. Whole-tree chipper used in plantations and regrowth.**
Farm-scale chipping

The market for bio-energy fuels and wood chips for landscaping can utilise lower quality chips than those for the pulp and paper manufacturing. Bark and crown material are acceptable and chip shape is not critical. This allows smaller chippers down to tractor mounter versions to be used on farms (Figure 9.19). These smaller chippers are not usually able to produce the uniform chip sizes needed by pulp mills. Smaller chippers can be used closer to the stump. This might reduce the range of equipment (and investment) required to conduct the operation and make a profit. As with field chipping for pulpwood, these operations are common in countries where there are well-developed energy and landscaping markets, but not common in Australia.

Figure 9.19. Chipping on-farm for landscaping material can turn a waste-product into profit.

Farm tractor systems

Skidding

Using the tractor as a skidder usually requires the attachment of a logging winch or grapple. Specialist tractor logging winches and skidpans are in widespread use overseas. The winch is usually mounted on the three-point-linkage implement and operates from the power take off at the rear of the machine (Figure 9.20).

The logging winch (Figure 9.21) supports the end of the logs tightly against the winch frame, which is lifted off the ground, thus eliminating hang-ups and reducing drag. Snigging logs without the proper equipment is highly dangerous and inefficient. Farm-tractor based winch-skidders are obviously only appropriate for smaller logs.
Figure 9.20. Three-point-linkage grapple on 4WD tractor (Photo: K. Matthews).

Figure 9.21. Farm tractor fitted with a logging winch and safety gear.
THE FARM TRACTOR CAN BE AN EXTREMELY HAZARDOUS LOGGING TRANSPORT MACHINE. TRACTORS ARE DESIGNED PRIMARILY FOR THE ROLE OF PLOUGHING, TOWING TRAILERS OR CARRYING LOADS IN FRONT LOADER CLAWS. THEY ARE LESS SUITED TO SNIGGING LOGS BECAUSE THEY HAVE A WEIGHT AND TYRE DIMENSIONS WHICH PREDISPOSE THEM TO BACKWARD ROLLOVER WHEN OVER-LOADED FROM BEHIND. THE DIAGRAM BELOW (FIGURE 9.22) ILLUSTRATES JUST WHY THE FARM TRACTOR, PARTICULARLY TWO WHEEL DRIVE MODELS ARE OFTEN A POOR OPTION FOR SKIDDING, PRIMARILY BECAUSE OF THE WEIGHT DISTRIBUTION OVER THE AXLES. TRACTORS USED IN FORESTRY APPLICATION CAN HAVE COUNTERWEIGHTS FITTED AT THE FRONT. LARGER FOUR-WHEEL DRIVE UNITS ARE BETTER SUITED AGAIN AS THEY HAVE INCREASED FORWARD WEIGHT WHICH LEADS TO BETTER FRONT-BACK LOAD DISTRIBUTION. THE 4WD USUALLY ASSISTS STEERING CAPABILITY UNDER LOAD.

Figure 9.22. Machine weight distribution comparison (from Murphy 1983).

ROLL OVER PROTECTION (ROP) AND FALLING OBJECT PROTECTION (FOP) CANOPIES ARE COMPELSARY FOR MACHINERY USED IN THE TIMBER INDUSTRY AND MUST CONFORM TO THE REQUIREMENTS OF AS 2294-1979 AND AS 1636-1994 FOR AGRICULTURAL MACHINES.

FORWARDING

FARM TRACTORS CAN ALSO BE USED EFFICIENTLY AS A TRACTOR / TRAILER COMBINATION FOR FORWARDING SMALLER LOGS. FIGURE 9.23 SHOWS A EUROPEAN PURPOSE-BUILT FORESTRY TRAILER FITTED WITH A KNUCKLE BOOM CRANE FOR LOG LOADING AND UNLOADING.

LOADING

LOADING WITH FARM-BASED EQUIPMENT SHOULD BE APPROACHED WITH CAUTION. MOST FARM TRACTORS HAVE LIMITED LIFTING CAPACITY (FIGURE 9.24) WHEN COMPARED TO THE WEIGHT OF LARGER NATIVE FORESTS LOGS. FARM TRACTOR FRONT AXLES ALSO HAVE FREEDOM TO PIVOT IN THE ROLL DIRECTION, AND ARE THEREFORE LESS STABLE AS THE WEIGHT TRANSFERS TO THE FRONT UNDER HEAVIER LIFTING, ESPECIALLY WITH LONGER LOGS, AND UNEVEN GROUND SURFACES.
Figure 9.23. Purpose built logging-trailer towed behind 4WD farm tractor (Finland – Valtra Company).

Figure 9.24. Tractor mounted front-end loaders.
**Guideline 9.3. Using tractors for skidding**

If a tractor is to be used (a four wheel drive tractor is preferred) in the forest as a skidder or forwarder it will need:

- Underside protection and strengthened axles;
- Roll bar or protective cab with top, front and rear screen protection (AS 2294-1979 and AS 1636-1984);
- Radiator protection and engine side guards;
- Heavy-duty (10-12 ply) tyres with valve stem protection plates; tyre chains, skid resistant footplates;
- Counterweights on the front for stability;
- Muffler spark arrestor;
- Fire extinguisher and also knapsack in summer; Box for chainsaw;
- First aid kit, communications radio.

**Guideline 9.4. Safety Guidelines:**

Farm tractors can be employed in farm-forestry roles, and this is widely done overseas for both skidding and forwarding. However, eucalypt forestry presents some difficulties because of the often variable terrain and the large log sizes.

Tractors need to be properly equipped and must be fitted with roll-over and tipping protection.

Tractors used for skidding should be fitted with rear butt pans or other devices to prevent backward tipping.

Farm tractors need to be operated very conservatively on slopes because of generally lower stability than purpose built forestry skidders.

Tractors fitted with loading forks also need to be operated carefully, particularly with longer or heavier logs and uneven ground surfaces.

**Roads and transport**

Forestry roads are a critical component of the operating system of the farm forest and their cost a major determinant on your economic return. This discussion presents basic information about aspects of on-farm forestry roads - their siting, construction, and maintenance, and some information on trucking.

Most of the trip to the mill uses public road, although it is the section on-farm that frequently causes the most difficulty. The farm-road section frequently needs either new construction or upgrading to handle log truck traffic and is a direct cost to the forest manager or contractor.

Trucking is usually a choice between use of existing on-farm trucks, or of contracting out to specialist log carriers. Farm trucks usually require some special purpose modifications (log bolsters and poles) to adequately restrain the log cargo. If only used intermittently, these must be fitted and removed and total operating costs might be considerably higher per tonne transported than those of larger specialised log trucks.

**Roads, tracks and stream crossings**

Effective road access is important for efficient management throughout the life of the forest, not just at harvest; for example, when the forest has to be monitored or protected from fire. A well-designed and
located road will service the needs of the forest over the long-term and require a minimum of expense in maintenance. It should also minimize environmental effects.

Designing an effective forestry road system is a balancing act between a number of inter-related factors. Relatively high cost (per metre) skidding operations (stump to roadside) must be balanced against the lower cost of truck transport - plus the costs of necessary road and stream crossing construction. In turn skidding costs depend on the type of skidding machinery to be used and again in turn, the selection of appropriate skidding machinery depends on the log size and terrain.

Because of their economic and environmental importance, major road access is usually considered in the preparation of the forest management plan. Access level tracks needed for individual logging landings are frequently only planned and constructed just prior to harvest time. Constructing harvesting roads in advance is an advantage because it allows access to the coupe at the planning time and allows the road to settle. A well constructed track or road will be available for future farm planning and utilisation.

The road standards required depend on the type of trucks being used and the volumes to be moved.

**Guideline 9.5. Road width and grade**

Most forest roads on-farm need to be about 4-5 m wide with grades generally less than 10%.

*How much road and track work is needed?*

The goal in roading is to develop the most economically effective network (minimum track length) for extracting timber while minimising harmful effects on the environment. Specialised equipment is needed for road making (Figure 9.25).

*Figure 9.25. Excavators can be more effective in controlling and minimising soil disturbance during road construction in steep terrain.*
**Road Location**

Effective road location is a key to a successful road system that minimises transport, construction, maintenance costs and environmental effects. Roads and tracks can cause accelerated runoff and the potential for erosion that can lead to off-site negative effects on water quality and degradation of aquatic habitat. To minimise such problems, track length should be minimised (Figure 9.26). Wherever possible use an existing track in preference to creating a new one. Roading often poses its greatest risks where roads cross drainage lines or streams. It is therefore important to plan and construct roads with minimal interference to drainage features. Roading along natural terraces is an often an effective option.

**Figure 9.26. Minimising total access costs (Sedlack 1982).**

On hilly terrain road location is limited by:

- Topography, especially slope,
- Stream pattern and density;
- Geology and slope stability.

Advantageous locations for roads are on ridge lines, and using gentle slopes for easier alignments, turnabouts and landings. For complicated and long-term road layouts seek professional advice.

**Guideline 9.6. Reducing extraction costs**

Choosing the best road and track length principally depends upon the opportunity afforded by the terrain, the type of harvesting system and the volumes to be harvested. The key factors are road construction cost and extraction costs - the most economic solution depends on balancing the two. Slower snigging equipment, such as a traxcavator or crawler tractor (higher cost per hectare), push the solution to shorter snigging distance and more roads. Lower harvested volumes mean lower returns per hectare, and lower extraction cost per hectare and push the solution to longer skidding and less road.
Roads at the bottom of slopes frequently require more stream and gully crossings which are both more expensive to construct and more deleterious to water quality. Conflicts can arise between the cost-savings that can be made by snigging downhill and the additional costs to the landholder of constructing a road at the bottom of the slope.

Guideline 9.7. Costing the roadworks

Consider the following activities when costing road and track construction:

Planning, survey and supervision;
Preparation (felling, blasting etc);
Drainage (culverts, water bars);
Base construction (Gravelling grading and compaction);
Structures (permanent stream crossings, gabions);
Uncosted contingencies - allow +10% or more depending on terrain.

Stream crossing structures

Culverts

Large diameter culverts are frequently used to cross minor or intermittently flowing steams or drainage lines. Large dimension pre-cast concrete culverts are used as an economical crossing in farming situations. Culvert design involves sizing to meet potential runoff or design to ensure safe overtopping. Where culverts are used to build a stream crossing, make sure the side faces are protected with rock or geotextile to prevent washaway and the deterioration of aquatic values. The web site (http://www.extension.umn.edu) provides useful detailed information.

Bridges

The most common type of permanent bridge in most native forest is made from log stringers (Figure 9.27). These can be costly and time consuming to construct for what is often only a brief need for harvest access. Temporary bridge alternatives should be evaluated.

Temporary bridges

Temporary bridges have a role in crossing drainage lines that only carry water after heavy rainfall. The use of temporary bridges can often be cost efficient (Table 9.1) and have little effect on disturbance and water quality. Some advantages and disadvantages in the use of temporary as opposed to permanent structures are given below:

Advantages of temporary bridges

- On-site materials can be an option and therefore potentially efficient and low cost;
- If built as a free standing unit the bridge can be relocated, saving on construction and installation time as well as materials;
- The structure does not need to cater for extreme flows;
Disadvantages

- Denies long term access.
- Cost of installation and removal;
- Stream banks may be damaged if care is not taken in installation and removal.
- In the case of intermittently flowing minor drainage lines, an alternative to a bridge can be to use PVC pipe bundles, underlain by geotextile (a tough fabric) and the pipes are covered with soil. 'Geotextile' can also be used to form the base for a log (corduroy), brush or crushed rock crossing. The advantage of using geotextile is that the integrity of the base of the drainage line is maintained. These do pose additional environmental risk if overtopped by storm runoff as the entire structure can more readily be washed away.
- A wide range of materials are available for temporary bridge construction and costs can also vary considerably.

Guideline 9.8. Temporary bridges

Temporary bridging is useful where some form of bridge us required to prevent pollution of streams, stream banks but the requirement for access is only temporary.
Table 9.1. Comparison of costs and capabilities of different temporary crossing structures.

<table>
<thead>
<tr>
<th>Portable bridge construction</th>
<th>Length x width (m)</th>
<th>Load capability (T)</th>
<th>Span capability (m)</th>
<th>Cost ($AUs) approximate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plank, timber</td>
<td>3.6</td>
<td>6.5</td>
<td>2.4</td>
<td>700</td>
</tr>
<tr>
<td>Stream crossing mats, Timber</td>
<td>7.2 m x 1.8m 2/crossing</td>
<td>Varies with base material</td>
<td>Indefinite</td>
<td>Low, but varies</td>
</tr>
<tr>
<td>Steel with hardwood deck</td>
<td>7.8 x 3.3, 6 x 5.2, 15 x 5.2</td>
<td>15 and 50 tonne models</td>
<td>~6.5, ~5, ~13.5</td>
<td>18,000, 19 - 40,000</td>
</tr>
<tr>
<td>Railroad flat car</td>
<td>15 x 3</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
</tr>
</tbody>
</table>

Road Drainage

Design and construction of adequate road drainage structures are necessary to ensure long service life of the road and to minimise water pollution effects from runoff. Road drainage is achieved by the provision of cross fall (deliberate sloping of the road surface across the roadway; roadside ditches to collect run-off water; adequate turnouts of mitre drains to discharge the water from the roadside ditches onto the forest floor; and culverts or surface drains to pass water from one side of the road to another.

Designing and appropriately locating these structures requires expertise in forest roading and most roading projects are better left to qualified and experienced practitioners. Indications and examples of what is required can be obtained from the various Codes of Forest Practice which have been developed in several States. The most important factors are to ensure that water that falls or runs onto the road surface from upslope is not allowed to concentrate or build up speed because increasing water speed rapidly increases its erosive power. Thus the frequency of turnouts or mitre drains must be increased in areas with higher rainfall rates and where roads have steeper gradients. Tables of recommended drainage spacings can be found in the Codes of Practice.

Culverts and other forms of cross-drainage play an important part in conveying runoff water under or over roads to permit effective discharge onto the forest floor. Cross drainage on forest roads takes two main forms, pipe culverts and surface ditches.

Guideline 9.9. Safety issues - take all precautions

Whatever road transport is used ensure that local bridges, as well as farm tracks, curves, culverts, and bridges are adequate to take the loads and truck lengths that will be travelling over them. Signage will probably be required to warn motorists. Warn neighbours and check with any local government requirements. The contractor or log buyer will not necessarily have these things in hand. Be sure to discuss the situation with all parties at the planning stage.
Chapter 10. Detailed forest management planning

Detailed forest management planning is required to ensure that all involved in the forest operations understand the rationale, requirements and their obligations to successfully achieve the product, legislative and environmental outcomes. Such planning and operations may be wholly carried out by the landowner/s or may be fully or partly sub-contracted to experienced operators or industry customers (such as a sawmill which operates with its own sub-contractors). The right decisions in self-management, in engaging assistance and interpreting the legislative requirements are imperative for successful and sustainable management of the forest resource.

Who should conduct the forest operations?

Harvesting and transport operations are a major cost component in the sales price of logs delivered to the mill. Where farm-foresters have the capability, harvesting using farm resources can make good economic sense. However, newcomers should make a detailed assessment of the labour and equipment requirements; and the expertise that will be needed to undertake harvesting, roading, loading, or other activities. Decisions can then be taken about “Do-It-Yourself” or engaging contractors with the necessary specialised equipment and skills.

The following information can help in making the ‘who should do what’ decisions.

Do It Yourself

For farm-foresters with access to both equipment and skills, conducting the forestry operations can be financially rewarding and satisfying. Owner-managers may be able to lower production costs and increase cash income by conducting their own harvesting and transport, rather than utilising contractors. However, these activities do require higher skill levels, are hazardous, and might require specialist equipment. Issues about size and scale are captured in Figure 10.1.

Internationally, there is some evidence of a move toward specialist contractors. In northern Europe for example, where there is a strong farm-forestry sector that has had high levels of farmer involvement in harvesting activity, there is a trend towards the use of contractors for harvesting. It is worth noting that there, however, the contractor might frequently be a local farmer who has acquired the necessary equipment and capability to log his own and nearby farmers property.

In Australia, the opportunities for small forest farmers to become involved in native forestry operations are frequently limited because of the large tree sizes encountered. These generally impose requirements for specialist falling skills and large skidding and loading equipment.

Developments in mobile milling have provided some solution to the problem of handling large size logs in native forest. In many circumstances the mill can move to the log and much of the processing can be completed close to the felling area.
Contracting out

Contracting-out the harvesting can greatly reduce the inputs needed from the farm-forester. However, it does not eliminate the need for expert input entirely. Satisfactory results from contracting need a clear and fair contract to be developed in the first instance, and then effective supervision of the contract terms.

Usually, at least three parties will be involved in setting up the contract. (i) - the resource owner, (ii) the harvest contractor and (iii) the purchaser (eg. sawmiller). Consultant foresters are sometimes engaged by farm-forest owners to assist in the setting up and/or management of contracting.

It is useful to note the different interests of the parties -

- The forest owner will be seeking maximum recovery of product for the least cost and a minimum effect on the land and remaining timber resource.

- Contractors will likely want to complete the task in the least possible time and at a time that fits into their longer-term schedule. Their interests are to harvest the products that have a return relative to the inputs of labour, time and equipment. The contractor wants to avoid inexperienced owner supervision that leads to dispute, job interruption or un-met expectations.

..Big is not always efficient or desirable - but small may not produce the quality of product....
• Sawmills are concerned to ensure that the logs purchased meet the appropriate quality specifications at competitive prices. Delivery timing is often of limited concern to many millers, who usually have log stockpiles, but can be of concern to smaller millers whose log stocks might be low.

Using a contractor – Points to Ponder

Problems with small scale in contract operations

The scale of the harvesting operation influences everyone’s costs and consequently their returns. There are a number of start-up costs that are similar whatever the operations’ size (eg, equipment transport at job start and finish). The relative effect is larger on costs of small-scale operations. However, small-scale operations can also have advantages. For example, they can be “fitted in” at opportune times for the contractor. Big is not always efficient or desirable and small may not produce the quality of product that is required for a particular market.

If some parts of the harvesting task are within the capability of on-farm resources there may be the alternative to contract out some of the jobs. For example, it may be possible to engage a professional feller to do the dangerous work and a farm labourer to assist with snigging, sawing and stacking.

On-site milling

Contract on-site milling is often a possibility, using a small-scale mill to process and sell either green, air dried or kiln dried timber out of the farm gate or to a local retail outlet;

Contracting a portable mill operator to produce green timber is a good way to achieve a profitable return, provided there is a reasonable recovery rate from the logs; good sawing techniques and costs are fully taken into account. In most circumstances less than 40% of the original log volume is converted to usable timber. The operator’s experience, equipment and sawing methods will all influence the forest owner’s profitability. (Refer to Chapter 8 - The Market Place for an example).

Portable mill contractors generally charge on an hourly rate rather than a per volume cost of timber milled. This is because of concerns about low recovery rates from farm logs and lack of certainty about log quality and consistency.

Conduct a site visit with the contractor

It is important to resolve the site management issues before finalising the contract or at least before work commences. For example some problems that may arise include such things as site degradation due to compaction and/or erosion, or logging the wrong trees.

“Work Care” and environmental liability issues may also become the property owner’s responsibility, if the contractor is not appropriately accredited, or licensed. It is important to establish (sight) that the contractors have licences for harvesting and transport before operations commence.
**Tree marking for efficiency and control**

Once the general principles, specific requirements (location of roading, landings etc) and objectives (retained stocking and spacing; products harvested and retained etc) of the operation are affirmed on site then the next decision is determining which trees are to be retained. Tree marking is often carried out by owners, consultants or contractors to increase harvesting efficiency, ensure adherence to agreed objectives or to assist visualisation of the objectives. Very good operators can do a very good job without tree marking. Although adding to the time costs much of the cost can be recovered in harvesting efficiencies and achieving cost efficiencies in product objectives.

Table 10.1 presents the main factors to be considered when marking trees for retention or removal. Generally it will be more useful to mark the trees to be retained, unless the operation will only be a light harvesting of proportionally few trees.

<table>
<thead>
<tr>
<th>Mark for Retention</th>
<th>Mark for Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less marking is required</td>
<td>More trees need to be marked</td>
</tr>
<tr>
<td>Less time costs</td>
<td>More time is required</td>
</tr>
<tr>
<td>Clearly defines trees to be protected</td>
<td>Marks can confuse further marking for different products during processing</td>
</tr>
<tr>
<td>Allows easier visualisation of final (spacing, quality, product potential)</td>
<td></td>
</tr>
</tbody>
</table>

**Guideline 10.1. Site actions**

Some actions to minimise future management difficulties might include:

- Specifying the forestry code of practice and safety codes or regulations that need to be followed;
- Specifically marking the coupe boundary, buffers, trees to keep (habitat and seed), trees to be felled, and what remedial measures will be undertaken and who will pay for any breaches of codes of practice;
- Specifying the management of habitat and seed trees and how regeneration will be conducted;
- Discussing fire management in advance, not after the event. Walk the harvesting area with the forestry advisor and the contractor.
Case studies as examples of contracting issues - Where did I go wrong?

The following points are examples of what can go wrong and some possible precautions and planning considerations that can be applied when the forest owner engages others to conduct various parts of the operation.

1. A dispute arose about insurance, property damage or ownership.

**Precaution**: Indemnity against injury, property loss or damage resulting from the logging and transport operation should rest with the contractor or buyer. Responsibility for fence removal and replacement, damage and reinstatement and any animal stock losses should be addressed. Failure to identify the risks and agree on responsibilities may lead to expensive legal disputes.

**Prior planning**: The log buyer/contractor may require some proof of ownership (e.g. title search or survey). There will also be a need to notify any person with a legal or equitable interest in the property of any intention to sell the timber. Others with an interest could be unwillingly dragged into any disputes.

2. The amount of timber produced did not meet expectations.

**Precaution**: Conducting a sound assessment prior to harvest allows the forest owner to estimate reasonably well the volume of individual outputs of clearwood, sawlog, pulpwood and firewood. Informed discussion of the expectations can be carried out before committing to the enterprise. There are many reasons why the amount of timber may not meet expectations – most of which can be avoided by adherence to accurate forest inventory and acceptance of “best practice” utilisation standards. Common causes of discrepancies originate from insufficient inventory intensity, over calculation of net harvestable area, higher proportion of defect than expected, or poor utilisation standards, etc.

There are times of course, when volume does not meet expectation, due to the variability of resource quality, regardless of all precautions - apart from always allowing an error factor.

**Precaution**: Establish if logs are to be measured or weighed, by whom and where. In addition, there is a need to keep a tally of the number of truck loads that leave the farm.

**Prior Planning**: Engaging a forestry advisor to oversee the operation might be worth considering if the owner is not directly involved or does not have the necessary experience. Continuous progress and output (yield, products) reports will highlight deficiencies and problems during the operation and allow discussion and decisions for improvement or re-assessment.

3. There was a lot of what looked like usable timber left on the ground.

**Precaution**: The contractor may have specific size or species standards, some logs may be undersize and are thus left behind. Small scale and industrial contractors will often have different views of what is achievable. The forestry advisor should have these aspects sorted out so that other markets can be found for the various log sizes and species.

**Precaution**: Specify the minimum size of material to be removed and maximum stump height (15-20cm). A clause in the wood sale contract should stipulate that saleable wood (define the specifications for this) remaining on-site should be charged to the timber buyer or harvest contractor.

**Precaution**: Agree to conduct progressive assessment of products; and site and forest condition (through yield reports and site inspection).
**During harvesting:** If harvesting is still in progress within the property it may be useful to renegotiate the specifications or to create a lower class of product at a lower stumpage rate to encourage higher utilisation.

If harvest operations have been completed it may be possible to put through a salvage operation for the sake of higher utilisation, reduction of fuel load and overall higher return. Once the timber is on the ground, any increase in return is a bonus.

4. **Regeneration was poor or non-existent following logging.**

**Precaution:** Prior to harvesting develop a regeneration or replanting plan with a timetable for implementation, who will carry out the activity and who pays. This matter may form a part of the harvesting contract.

If regeneration is poor or non-existent there may be a need for further site disturbance/scarification, top disposal burning, direct seeding, enrichment planting, etc. Regeneration strategies were discussed in Chapter 4 and these need to be considered carefully during the planning of the forest operations as any remedies will be governed by the outcomes (resultant structure, forest condition, retained tree seed crops,) of the forest after harvesting is completed. Planning failures may dramatically reduce the options for fixing the problem and considerably increase the costs.

5. **Roads were constructed poorly or in the wrong place and without adequate drainage.**

**Precaution:** Prepare a road access design plan. The proper placement of a road will save construction, maintenance and drainage costs while also reducing environmental damage. Wet weather closure standards should also be specified.

If the proper agreements and responsibilities were made in contractual arrangements then those responsible (contractor or owner) will need to address the problems. If the harvesting operation is still in progress operations over the problem roads should cease until remedied. Seek the advice of a professional to suggest remedies or relocation as necessary.

**Engaging an Advisor**

Professional advice can avoid unforeseen problems and save money. A range of consulting forestry, business and legal advisors are available to assist in aspects of forest management and in particularly harvesting and sale.

Where farm-forest managers are new to the task of forest harvesting, it is probable that they have not yet developed the full range of expertise needed. For larger scale operations, it might be necessary to engage advisors in a number of fields, e.g. engineering, forest silviculture, accounting, legal.

**Questions you should ask yourself:**

- What are your objectives for the planned operation?
- Do you want to hand over the conduct of the operation entirely, or do you want to maximise your learning with a view to doing more of the tasks yourself next time?
Questions that you should consider asking the advisor:

- What is the extent of their expertise?
- What do they know of tree species performance and growth for local species?
- What about flora and fauna values, protection and managing for conservation of species?
- Do they have an understanding of the current State and local government regulations?
- Do they have competency in harvesting systems choice and management?
- Do they have expertise in forest roading and access track design and construction?
- Do they have buyer contacts and knowledge of likely prices for the range of products from the forest?
- Can they advise on forestry financial planning in addition to silvicultural management
- Can they advise on project timing
- What changes in management might be needed to make the enterprise more profitable at a future date?

Guideline 10.2. Engaging the advisor

An advisor’s contract of service and their terms of engagement should specify:

- How will they communicate their results?
- Establish Draft and Final Report dates;
- Their fees for various activities and levels of service e.g. travelling and travel time versus fact finding analysis and reporting;
- Payment of expenses, travel and professional fees;
- Proof of Professional Indemnity.

Preparing the harvesting and operational plans

A harvesting plan functions as the work instruction to the team carrying out the job. Its contents are the operational information and a map of the harvest area. In some States, plans must be submitted for official approval. Plans help communicate ideas to others and provide a valuable record for the future.

Preparing the plan will involve four steps:

1. Assembling supporting information (including permits and constraints);
2. Detailing the management prescriptions for each operation
3. Mapping the area’s resources: specifying systems and protective measures; locating boundaries and preparing the operational maps and layouts
4. Implementing the operations (assuring completion and closure)

Specific operational plans contained within the harvesting plans are the bottom layer of the planning hierarchy. These are the plans that provide direct work instruction and govern specific activities in the forest (Figure 10.3).
It is desirable that all significant activities are documented in a corresponding operational plan (eg. harvesting, burning, non-commercial thinning, fertilising). Operational plans typically follow a where, what, who and when format and form the basis for detailed work instructions and agreement between a forest owner and the operations contractor.

Some of the topics covered in the forest management plan, and the harvesting plan, may also be addressed in greater detail, in the operational plan. It should be noted that the detail and mapping requirements vary for different properties, forests and various State government approvals.

**Assemble supporting information**

*(Phase 1)*

The purpose of this phase is preparation of support data. It involves assembly of all relevant information that has a bearing on the next planning stage.

**Check Legislative and other requirements and permit approvals**

- Check (twelve months ahead of the activity) with various State and local government officers for all legislated requirements (This should have been done at the forest management planning stage)

- Check the silvicultural regimes that are permitted within your state? (Clearfell operations and even group selection/coupe harvesting systems are limited or excluded in some states)

- Establish what codes of practice apply to your area and intended operation. Identify the specific requirements that these will place on you. The local shire planner, forest or conservation department officers should be able to provide information. Any of the following might apply to your harvest area

  - Flora and fauna conservation - species listing and special area management. Surveys can be required. These might set specifications on the location of refuge and corridor areas, understorey islands, numbers of habitat trees

  - Soil and water protection measures that are required This might include Slope, soil type and limitations, topsoil management on landings, drainage feature buffer and filter zones, stream crossing protection measures, sediment fences, fuel storage, transfer and machinery servicing arrangements, post harvest ripping compacted tracks and landings

  - Weed and feral animal management programs that might be required

  - Coupe size and shape restrictions, sequence of cutting, seen area, edge effects, roadside buffers, feature protection (e.g. rock outcrops, water bodies).
**Forest resource Information**

For each forest type and harvesting area identify:

- The size of the area;
- Structure - age, height;
- Condition - Volume, basal area, size-class distribution, health, defects;
- Utilization – Type and volume of product outputs.

**Products, markets and transport**

- Timber – Veneer, sawlog, posts, poles, chips;
- Markets – Export, interstate, local or niche.
- Transport carriers and costs for different products;

**Specify the detailed forest management prescriptions**  
*(Phase 2)*

The next steps are to decide the proposed management activities and detail their objectives and the operational plans to achieve the outcomes:

**Silvicultural systems**

- Mature tree logging or thinning, harvest intensity and locations, sustainable harvesting volume, rotation period, annual harvest area;
- Regeneration methods.

**Environmental management (relating to Codes of Forest Practice)**

- Describe or map flora and fauna conservation and special management areas;
- Soil and water protection features;
- Landscape considerations - intensity, sequence and location of harvesting;
- Archaeological, heritage and cultural site protection.
Harvesting layout and timing

(Phase 3)

This section should consider and describe the likely broad choice of methods and equipment for harvesting and transport (Table 10.2) and the restrictions or requirements that these imply. Broad choice of harvesting system usually has strong implications for the development and management of the road system. A more complete discussion of harvesting systems and considerations is provided in Chapter 9. For example, one of the following combinations in Table 10.2 could be used for felling, extraction and loading.

The purpose of this phase is to design the field harvesting operation. This involves establishing the boundaries, locating roads and landings and in many cases marking trees. This is usually a combination of office and field activity. The office phase assembles the relevant restrictions and requirements gathered in the preceding information stage. The field phase involves the design of the harvesting operation. This is usually an on-ground activity and is commonly termed harvesting layout. It should generate a corresponding map and set of work instructions, which will provide the key communication link between the planner and the harvesting crew. In some States these are also required to be submitted to relevant authority for approval.

Harvest planning requires skill and judgement. The quality of the plan effects on harvesting costs, environmental effects and the condition of the forest. Where the farm-forester is unfamiliar with planning of harvesting operations and contractors are employed, there is a common tendency to “leave it to the contractor” and in many cases this has led to harvesting without a documented plan. While this has produced good results in many cases due to the professionalism of the contractor and crew, this is not always so. For other than very small jobs, insist on a documented plan. For larger or more complex operations consider engaging a skilled forestry consultant if you are unsure. Steps to be followed in setting out the plan:

1. Identify, map and field-mark boundary restrictions and limitations in the field

   - Identify and map harvesting exclusions and any modified prescription areas. These include no logging ‘zones’, conditional logging zones, habitat, steep areas, stream buffers and archaeological sites. Most of these boundaries will require field marking where they are not an obvious feature.

2. Design the transport and landing layout – roads, tracks, snig tracks and landings

   - This defines expected truck access and predominant snigging patterns. Particular attention should be paid to stream and drainage line crossings for roads and snig tracks. Road and track preparation needs to incorporate drainage control measures. Uphill snigging to a landing on a ridge top is usually favoured because the pattern of snig tracks diverges as you go downhill and this spreads water flow; downhill snigging usually leads to converging tracks which concentrate water (Figure 10.2).
Determine the program of development and cutting sequences

In any forest where the decision has been taken to divide the area into separate management units, the strategic plan should indicate at least broadly the expected sequence of operations (usually harvesting and regeneration). Most native forest operations are conducted in sections or zones. These are primarily defined by the landing location. The sequence in which zones are harvested needs to be planned to allow orderly felling and to permit the closing off of truck and snig tracks as sections are finished. Usually, some zones are more operable in wet periods and plans usually schedule these areas near the end of operations if possible to permit relocation if needed.

The program of development outlines the sequence and perhaps seasons in which various individual management areas are likely to be developed or harvested. Choice of the cutting sequences have important implications for the effects of forestry activities on plants, animals, soils and water, as well as forest growth, sustainable harvest levels and income.

Design of the management sequence is frequently a skilled activity, needing knowledge of all the listed factors and how they interact. Aspects of forest protection are further described in Chapter 5 and silvicultural considerations outlined in Chapter 3.

If your circumstances and opportunities appear complex, you should consider engaging professional advice such as a forestry consultant to help design this crucial aspect of the plan.
Table 2.1. Felling, extraction and loading systems.

<table>
<thead>
<tr>
<th>Falling</th>
<th>Extraction</th>
<th>Loading</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chainsaw</td>
<td>Tracked tractor</td>
<td>Blade or winch</td>
<td>Semi trailer to sawmill</td>
</tr>
<tr>
<td>Chainsaw</td>
<td>Wheeled skidder</td>
<td>Front end loader</td>
<td>Farm trailer – on-farm sawing</td>
</tr>
<tr>
<td>Chainsaw</td>
<td>Wheeled tractor</td>
<td>Hydraulic log loaders on tractor</td>
<td>Tray truck to mill</td>
</tr>
<tr>
<td>Excavator harvester</td>
<td>Forwarder (small logs only)</td>
<td>Forwarder (small logs only)</td>
<td>Semi trailer to pulpmill</td>
</tr>
<tr>
<td>Excavator harvester</td>
<td>Excavator</td>
<td>Excavator</td>
<td>Semi trailer to sawmill</td>
</tr>
<tr>
<td>Chainsaw</td>
<td>Cable</td>
<td>Crane</td>
<td>Semi trailer to sawmill and pulpmill</td>
</tr>
</tbody>
</table>

Fire protection and suppression during harvesting

Determine the fire protection, emergency and suppression plans suitable to the forest and operations during the harvesting. Strategic breaks, equipment, fuel management and safety procedures need to be mapped and documented. After significant harvesting activities further detailed aspects may need to be addressed.

Guideline 10.13. Drawing maps

Hand drawing:

Purchase either an aerial photograph or copy a contour map and enlarge it (photocopy) so that it is at a usable scale (usually ~ 1:5000 or 1:2500). Secondly, obtain some transparency sheets from the local newsagents or craft suppliers. These can be held over the map or photo using a sheet of ply as a base with dog clips to hold it all together. Some registration marks in the corners of each overlay are useful. Permanent overhead projector pens are required for marking various features and areas on the plan. Some method and tissues is useful to erase any errors.

Computer drawing:

Scan the contour map or photograph into the computer. Use a program such as ‘LView’ or ‘Adobe Photoshop’ to add lines and text. It is worth saving into a different file, at various stages, so that if something is lost or can’t be easily removed, it is possible to go back a step without starting it all over again. These programs may take some perseverance and practice to get the right result.

The website http://www.extension.umn.edu provides useful information on forest mapping and planning.
Figure 10.3. Example of operational coupe harvesting map.

On the harvesting map mark in:

1. **Harvesting area boundaries** (………);
2. **Vegetation types** ( __ Ash, Mixed species).
3. **Buffers on water features**
4. **Exclusion zones**
5. **Roads, tracks, firebreaks** ( ----- )
6. **Log landings / storage areas** ( ⚫️)

On all maps use a linear scale so that when it is copied the line length will still indicate the relative distance. Add a north pointer.
Implementing the harvesting operation
(Phase 4)

The preparation of the harvesting and operating plans aims to ensure the effective communication and common understanding of the proposed operation to all involved (governing bodies, contractors, owners). During implementation the plan provides for the monitoring of compliance and may include possible corrections as circumstances dictate (within the established codes and agreements).

Following completion of the operation the plan details the actions required to complete the obligations and documentation.

It is important while carrying out the harvesting operations that the documented plan remains available for discussion and updating. The harvesting plan should be provided to the harvesting crew and supervisors in a form that allows them to easily record relevant information such as key events and agreed changes. There are critical activities before, during and after the on-ground operations.

Before harvesting begins

- Create a list of names and contact details for contractors and supervisors and record in the working harvesting plan
- Occupational health, safety and accreditation: Check all activity accreditations - licences, insurance, equipment, procedures, emergency plans and signage. Safeguarding yourself and your equipment will reduce the risk of personal injury and equipment damage. There is a developing trend toward implementation of safety management systems by harvesting contractors to cover their operations.
- Pre-harvest briefing: Ensure that all parties are familiar with the requirements of the plan. This is usually best done on-site, particularly if the harvesting contractor / crew were not involved in drawing up the plan.
- Establish supervisory responsibilities and procedures for agreeing the inevitable plan modifications.

During harvesting

Some supervision is essential during harvesting operations. Even in the hoped for case of a competent harvesting contractor and crew implementing a model operation, supervision of contract execution by the forest manager on a regular basis is also necessary. Contracted specialists (eg. consulting foresters) can be employed as supervisors.

Oversight is needed of factors such as:

- Adherence to boundary restrictions;
- Any requirements of Codes of Practice particularly erosion control and water quality protection;
- Damage to soils or residual forest;
- Log making and product segregation.
**After harvesting is completed**

Allocate time and resources for:

- Clearing debris from the base of standing trees;
- Heaping debris for burning (where required);
- Track barring, road closure and ripping compacted areas where necessary. Ensure that all required operations (track closure etc.) are completed before heavy machinery leaves the site.
- Review the fire protection and suppression plans to ensure that it is still appropriate to the final forest and management area structure.

**Keep accurate and appropriate records**

Records are valuable for many reasons – taxation, occupational health and safety, business efficiency and succession, to name just a few. Records can include:

- Timber inventory management and coupe harvesting plans;
- Activities completed (who, what, where and when);
- Contracts, insurance;
- Problems encountered - and the solutions
- Write a summary of the operations, recording any information which may assist you in planning and developing improved management plans for the future.

**Safety during harvesting operations**

A strong and effective safety attitude is of critical importance in forestry operations. All owners, contractors and involved parties are encouraged to develop and manage a safe forestry workplace.

Forestry operations are a dangerous workplace activity and the adage “You don’t know what you don’t know – until it’s too late!” is very appropriate given the number of critical and fatal injuries which occur in the forest industries – especially amongst fallers and log handlers.

The work related death rate (97 per 100,000 in 1989-92) for timber harvesting workers is seventeen times that of all other industries in Australia (NOHSC 1999). Many of these accidents are occurring to professional full-time timber workers.

Considerable skill is needed to undertake forest harvesting. Farm-foresters without prior experience and/or training are urged to seriously review their level of skill before undertaking any harvesting activities. The appropriate accreditation or certificate of competency should be obtained. For example, most forestry regions have TAFE or industry courses available to train chainsaw operators.

A study of safety and forest workers in Victoria (Mitchell and Murphy 1993) revealed that most accidents (80%) involving contractors occurred within the harvesting coupe, during felling and snigging operations, with the remainder at the landing, or on the road during log transport.
Causative incident or accident factors in the forest work environment include:

- Natural factors (climate, debris, animal activities)
- Work practices (risks, inherent danger in operations)
- Personal factors (short cuts, rushing, tiredness, inexperience).

The nature of the forest environment accounted for 37%, personal factors were reported to account for a further 46% and wind played a role in 17% of incidents. The most common accident for fellers was during cross cutting of the head of the felled tree. Other work on safety issues (Henderson 1990) concluded that fellers thought they had greater control over events than was actually the case.

Common danger situations for fellers included working on uneven ground, inexperience, fatigue, hang ups in other trees and dead material falling from trees as they are being felled. In addition, kickback, where the nose of the chain bar contacts other material, and using the saw above shoulder height are all major contributors to injury.

Chainsaws must have safety features such as safety chains, chain guard and a chain brake. Effective sharpening may also help avoid accidental injury or death. Essential personal safety equipment needs to include steel capped boots, Kevlar Chapps, head, eye and ear protection.

**Guideline 10.4. Safety tips**

Some safety tips are provided below; but, the list is by no means comprehensive. The operators must assess the many different situations for themselves and make the appropriate adjustments to ensure the safety of all involved.

*Don’t undertake dangerous tasks alone and if there is any doubt about attempting something, don’t do it. Get help, or consult with expert.*

If you are working alone in the bush tell someone where you are and roughly what time you’ll be back.

Around machinery, tie up long hair, wear close fitting clothing and don’t wear rings and jewellery;

Don’t work at dusk, or when fatigued;

Drink plenty of water on the job and watch for the signs heat exhaustion – feeling weak, dizzy or ill with clammy skin;

Carry hand tools by your side, holding the handle close to the head of the tool and preferably on the downhill side of your body;

*Keep an eye in the air for dead limbs that may dislodge when felling, wear that safety hat religiously;*

Be willing to do other types of farm jobs (outside the forest) when there is a lot of wind in the canopy.

Don’t work downhill of the felling operator; rocks and logs can move easily, unpredictably and without warning;

Don’t work downhill of the log when cross cutting;

*Wear the correct protective clothing for the task. (e.g. in the tractor - ear muffs);*

Keep the first aid pack, CB radio and fire extinguisher close-by;

If you see something that needs doing (for example, moving a fuel can) – do it - straight away.
Guideline 10.5. Complete a comprehensive forest management plan

Specify the management objectives
Describe (map) land and forest including management history (where known)
Specify the broad management plans and possible management units
Conduct detailed inventory of forest condition and values
Describe the detailed management plan for each discrete management unit
Support the whole process with detailed mapping
Develop the business plan
Maintain good records
Glossary

**accumulating head** – mechanical felling head that can hold previously severed trees to accumulate a bunch before placing them on the ground

**Advance growth** – Regeneration occurring under an existing canopy that is sufficiently developed to survive relatively independently but is not yet merchantable size

**adze** – a kind of axe with the edge at right angles to the handle

**aesthetic value** – perceived beauty and appropriateness of views in the landscape

**age classes** – Stands or patches of trees originating at a defined time i.e. wildfire or harvesting disturbance.

**agroforestry** – The combined enterprise of conventional agriculture and tree growing. Usually associated with planted trees

**air-dried** – dried to equilibrium with the surrounding air, commonly a moisture content of about 12%

**ANU** – Australian National University, Canberra, ACT

**appearance products** – timber products which are used where the grain is exposed as a feature (e.g. flooring, exposed beams, furniture)

**arboreal** – tree dwelling

**area plot** – sample plot of known area

**artificial seeding** – hand or mechanical seeding operations where natural seed fall is unavailable or unwarranted

**AS No.** – Australian Standard number

**ash species** – Eucalypts with ash-type characteristics (particularly wood) e.g. Mountain Ash, Alpine Ash

**Australian Group Selection** – deliberate creation of open gaps during harvesting specifically to facilitate regeneration and increase growth of edge trees

**average** – equivalent to the mean e.g. average height of 5 trees equals the sum of the 5 heights divided by 5

**back cut (chainsaw)** – final cut for directional falling, opposite the scarf cut

**bark thickness gauge** – tool with sharp pointed edge which penetrates the bark of the tree (to the sapwood). The ‘depth’ of penetration is shown on a graduated slide

**barrel checking** – longitudinal checks or separation of fibres along the grain of the curved surface of the round log, not extending to the centre

**basal area (plot)** – the total cross sectional area of standing tree stems on a given area of forest, measured at breast height usually expressed as m² ha⁻¹

**basal area (tree)** – the cross-sectional area of a stem at breast height and expressed as m²

**basal area increment (BAI)** – increase in basal area between measurements and expressed as m² ha⁻¹ yr⁻¹

**bay** – the growing forest area between out-rows, snig trails or walkways in a harvesting area

**bearing** – compass bearing

**bend (in log)** – large radius bend in a bole or log

**bending (during felling)** – caused by application of pushing forces to the falling tree in effect accelerating the tree’s fall and bending the stem

**bias** – non-average or non-representative measurement

**billet** – round timber of usually short lengths (2-5 m) produced during thinning or cross-cutting (usually pulpwood billets)

**binding** – closure of the saw cut caused by the tree leaning back on the saw blade during cutting

**biodiversity** – general term for the mix and variability of fauna and flora in an area (i.e. forest)

**biodiversity credits** – a rating or value of biodiversity applied (to forest) which may be used to trade or sell to off-set reductions in similar biodiversity components in other land uses or industrial production

**bioenergy** – energy derived from biomass of plants and trees

**biofuel** – any fuel made from organic products (e.g. ethanol, methanol)
bole – the trunk or stem of the tree large enough for conversion into sawn timber

boxes – eucalypts described as having box bark (usually rough bark or bark plates of varying shapes and sizes which are persistent at least on the main bole of the tree)

branch stubs – obvious branch origins (often with a small amount of dead branch remaining)

breast height – 1.3 m above upper ground level (see dbhob)

brittle – a condition that permits breaking or snapping easily across the grain

brittleheart – wood characterized by abnormal brittleness caused by compression failures in the fibres. It is usually located in the heart but may occur elsewhere in the stem

broad scale – carried out over a large area

bruising – small fractures spikes and protrusions evident in the sapwood usually caused during debarking

brushcutter – see clearing saw; usually a motor driven saw blade on the end of a protected shaft for clearing grass, shrubs and small saplings

bucking – cutting to length during processing (see crosscutting)

buffer – protected area between managed areas or surrounding special management zones such as streams or habitat

buffer tree – see pivot tree and/or sacrifice tree; usually a tree which is used to protect other trees

bunching – accumulating trees or logs in the forest to facilitate heading or snigging in the stand prior to extraction

burl – an extrusion (often massive) on the trunk or branches of a tree caused by fungal or insect activity (ants, termites etc) over many years

butt log – the lower (base) log of the selected tree stem

butt pull – tearing of the last of the hinge wood when the tree is forced from the stump

butt splitting – tears or splits in the butt of the severed stem which occurs during felling

cable logging – the removal of cut trees from the stump area by dragging or suspension on long retrievable cable systems (often used in steep country)

cable skidder – a skidder usually articulated, rubber tyred, fitted with a winch and wire rope to accumulate trees to form and hold a load during skidding

callous – the recovery bark and wood growing over a wound on the tree

calorific value – the heat energy produced from burning wood

cambium – the sheath of dividing cells that lies between wood and bark and gives rise to these tissues

canker – fungal disease in the bark and cambium causing dead tissue surrounded by distorted growth

canopy closure – the time at which leaf canopies of neighbouring trees touch each other to the extent that the ground underneath is fully shaded

capping – capping is exhibited as an unnatural/unplanned split in solid wood extending along the log. Capping is generally caused by poor falling and cross cutting techniques

carbon credits – a rating or value of actual or potential carbon storage applied (to forest) which may be used to trade or sell to off-set greenhouse gas and pollution emissions in other areas

carbon sequestration – the accumulation of carbon in the eco-system (crowns, branches, boles, roots and soil organic matter)

carbon sink – the biomass, soil or organic materials which contain carbon

carbon storage – see carbon sink

carrying capacity – the number trees (or animals) which can exist in an area or patch or management unit without detriment to their health and condition

case study – a study relevant to a particular situation (e.g. forest type or product management scenario)

centre diameter – the diameter under bark at the central distance between the 2 cut log ends

certification – recognition of quality of timber products; or the recognition of particular management strategies for environmental management i.e. green certification, organic certification
CFFP – CSIRO Forestry and Forest Products

chain saw – rotating cutting chain either manual or contained in felling head

chatter marks (logs) – ridges and lumps in the outer surface of a log (usually sapwood) caused by compression forces during rolling and debarking

check – separation of the fibres along the grain forming a fissure, but not extending through the piece or log from face to face

chipper – machine producing wood chips

circular plot – a measurement plot where selected trees are measured in 360° to a measured distance outwards from the centre peg

circumference – the lineal measurement of the girth of a tree or log

clear – free from all visible defects and imperfections

clearfelling – felling of all trees from a specified area excluding habitat trees, streamside reserves and wildlife corridors

clearing saw – see brushcutter

clearwood – timber free of knots

closed forest – forest in which the tree canopies touch and overlap creating continuous shade

Codes of Forest Practice (Codes of Practice) – often legislative rules, regulations and limitations designed to facilitate protection and sustainable management of forest

co-dominant – trees with crowns forming the general level of the canopy; usually with medium sized crowns

cohort – a group of trees of the same age class, not necessarily of the same species

compaction – compression of the physical structure of soil which reduces air spaces and water holding capacity

competition – the relative growth of trees, stem and canopy, as a consequence of the ‘competition’ for the limited availability of water, nutrient and light

compression failure (induced) – a deformation or fracture of the fibres across the grain resulting from excessive compression parallel to the grain either by direct end compression or bending. It appears as a minute fracture running across the grain, the fibres being crinkled by compression or broken transversely, and is often difficult to detect until the timber is machined

compression failure (natural) – natural compression failures may develop in standing trees due to internal stresses set up by rain, snow, unequal growth, etc. They are commonly associated with brittleheart and may become visible as a result of felling stresses

compression wood – inner sections of most eucalypt boles have wood fibres under compression. Also describes other areas of abnormal wood which is more dense, more brittle and prone to greater longitudinal shrinkage than normal wood

connectivity – describing continuous vegetation between areas of forest resource

contour map – a map showing topographic features with elevational contours marked

control burn – a controlled fire to achieve a specific management purpose e.g. fuel reduction

conventional logging – typical logging systems using chainsaws or ground-based felling machinery, wheeled or tracked snigging machines and based on common sawlog practices

co-operative (wood) – large or small group of sellers or customers with a common purpose for management, marketing, or purchasing of wood products

coppice – shoots arising from strands of bud-producing tissue that originates from leaf axils within the phloem and generally arising from cut or broken stumps

corridors (treatment) – cleared or treated swathes within growing forest (e.g. slashed corridors between timber bays removing all trees within the corridor to give access, reduce stocking or provide fire breaks)

corridors (wildlife) – vegetated areas with suitable structure and cover connecting important areas of forest resource and biodiversity

Corymbia species – formerly a group of Eucalyptus species recently changed

coupe – a convenient and usually uniform area of forest of variable size, shape and orientation from which logs for sawmilling or other industrial processing are harvested

CPI – Consumer Price Index
**critical zone** – from the butt end of the sawlog up to 1 m or even 3 m depending upon end use

**cross cutting** – cutting of tree stems into predetermined log sizes by cutting across the grain

**crown class** – description of the relative position and condition of a tree crown

**crown condition** – general health, vigour and shape of the crown of the tree

**crown scorch** – the desiccation and partial burning of the crown of a tree caused by flame contact or radiant heat from a fire

**CSIRO** – Commonwealth Scientific Industrial Research Organisation

**cull** – a tree of merchantable size but which is unmerchantable due to defects in the wood

**cutting cycle** – planned sequence of harvesting operations (i.e. 60 year rotation; spacing at 5 years followed by thinning at 25 years and clearfelling at 60 years)

**damage (consequences)** – that proportion of the volume of a log which cannot be used to produce desirable products in the wood flow stream

**damage (during thinning or harvesting operations)** – any injury or damage caused that devalues the potential products (see also defect)

**DBH** – diameter of a tree at breast height (1.3 m above upper ground level) usually over bark (DBHOB)

**DBHOB** – diameter of a tree at breast height over bark (1.3 m above upper ground level)

**DBHUB** – diameter of a tree at breast height under bark (1.3 m above upper ground level)

**debarking** – removing the bark from logs

**debris** – waste material in the forest usually associated with previous or present harvesting operations; including other non merchantable wood, branches, bark and leaf material left in the stand

**debris matting** – loose bark removed from the logs which accumulates on the landing and is often used as a mat on landings and snig tracks (includes leaf and branches) to minimize soil disturbance. Can be used as a cushion during log handling.

**decay** – the process of breaking down or rotting

**decline** – usually referred to as becoming poorer in health or quality

**deep ripping** – mechanical ripping to the subsoil to increase root and water penetration

**defect** – any irregularity in timber that lowers its strength, durability or utility. That proportion of a volume of a log which cannot be used to produce sawn timber due to knots, keno, unfavourable grains, fungal decay or insect attack (see also damage)

**defoliation** – loss of leaves from a plant or tree caused by fire, insect attack, drought or chemical application

**degrade** – a perceived lowering of the value of a log as a result of natural or imposed defects and damage

**density** – basic density of wood calculated as oven dry mass per unit of green volume expressed as kg m\(^{-3}\).

**diameter** – straight line passing through the centre of a circle (tree) from the extremities (bark to bark) (see DBHOB)

**diameter distribution** – the numbers and arrangement of trees of different sizes or size classes in a forest

**diameter tape** – a tape specifically designed and graduated to show tree diameter measurements when passed around the circumference of a tree

**directional falling** – techniques used in either manual or machine falling to dictate the placement of the fallen tree to reduce damage or facilitate further handling

**discharge** – water flow from forest areas, banks and water channels (drainage channels)

**disk saw** – cutting saw with a spinning head with teeth on the outer rim

**dispersible** – easily separated and dispersed (in water)
**diversion bank** – a raised bank or levy to direct the flow of run-off

**diversity** - the expression of different and various components

**docking** – cutting to length. Cross cutting timber to a specified length or to free it from defects (see also bucking, crosscutting)

**dog ears** – protrusions and ‘spikes’ occurring on the outer surface of the log usually caused by the points of grabs or debarking machinery

**dominant** – trees with crowns extending above the general level of the canopy; larger than the average trees in the stand and with the crowns well developed

**dominant height** – mean height of the largest trees in the stand

**downer** – a log which has been on the ground for some years (as a result of felling or wind) (see also morganer)

**downgrade** – decision to devalue the log to a less valuable sawlog product or to waste

**drainage channel** – a depression to direct the flow of water

**drainage line** – the lowest point where run-off and flow accumulate and move downward

**dry schlerophyll forest** – drier eucalypt forest in generally lower rainfall areas

**durability** – describing the resistance to insect and fungi attack and the longevity of timber for specific purposes (particularly in-ground)

**early spacing** – early removal of competing stems which are removed to increase growth of retained stems. Usually non-commercial (see also non-commercial thinning and pre-commercial thinning)

**ecotone** – transition area between 2 eco-system types often with variable species mixes

**edge effect** – the increase in growth of trees near the edge of a forest or plantation and the possible decrease in growth adjacent to larger trees

**end coating** – application of wax or other sealant to prevent/reduce evaporation losses from the cut ends of logs. Retards drying and consequent checking and splitting

**end splitting** – end splits are checks caused by air drying and are created as stress cracks during rapid surface evaporation of the log. They usually occur after processing and holding in storage at either the landing or the mill yard

**endangered species** – plant or animal whose survival is at risk due to loss of population numbers or suitable habitats

**endangered species list** – legislated list of plants and animals which are identified as requiring specific management and protection for their survival

**enrichment planting** – hand or mechanical planting of seedlings in areas where other methods have failed

**enterprise** – a particular project or operation embarked upon to achieve a management or product objective

**epicormic shoots** – shoots produced by sprouting of special buds directly from the bole or branches of trees

**epicormics** – shoots of new growth from basal branch and stem buds which occur after damage, defoliation or trauma to trees and tree crowns (see also epicormic shoots)

**erodibility** – susceptibility to erosion and dispersion in solution (a rating given to soils)

**eucalypt** – one of the species of the genus *Eucalyptus* (see also Corymbia)

**even-aged stand** – stand predominantly of the one age. Usually originating as a result of an intense burn or harvesting activity

**exclusion zone** – an area which is not to be harvested (or treated) within a management unit (e.g. special protection area, buffer, vegetation island)

**exotic** – not natural, usually refers a plant or tree species (see also feral)

**exploitive** – utilisation without due regard to sustainability

**extension officer** – usually a representative of a forest or an agricultural organization who assists farmers with related enterprises (often as a ‘gratis’ service)

**extraction** – removal of tree products (logs) from the stump area to the landing

**extraction track** – the tracks used by skidding or forwarding machines during extraction

**extrapolate** – use the information from one area to assume the results and effects in a similar area
F rating – strength rating (resistance to distortion under load); used to grade sawn timber

cellar-buncher – a harvesting machine which fells trees and then places them into bunches on the ground

cellar-forwarder – a harvesting machine that fells trees, cuts them to length and loads the logs on to itself and forwards them to a landing

celling – falling the selected tree

celling head – a mechanical or hydraulically operated device attached to an articulated boom used to fell trees

feral – a wild previously domesticated animal

fire protection – management to limit or avoid damage from fire

fire suppression – strategies to extinguish and limit fires that occur

first thinning – first commercial thinning for sale of a product

fixed head – a felling head which has limited rotation and movement and requires the base machine to be aligned in the direction of cut or fall. Often capable of feller-bunching

flashback – the subsequent poisoning of surrounding trees or stems resulting from a selective poisoning treatment (some trees are joined beneath the surface by root grafts which transfer poison from one tree to the next)

flitch – a large piece of sawn log intended for further cutting. A flitch is sawn on 2 surfaces at least

floating (machinery) – the transport of machinery on flatbed semi-trailers

floppy head - a felling head or processing head which has considerable rotational movement in more than one direction. The base machine can maintain position and utilize the rotations of the head to carry out felling operations. Often used for processing and debarking

FMA – Forest Management Area

follow plate – a plate of steel which follows the opened kerf and prevents the cut tree from closing onto the cutting edge of an auger, chainsaw or disc saw. Also called a base plate

forcing – the act of accelerating the fall of the tree or forcing the tree to fall in an unnatural direction. Also used to describe the forces applied when bending the tree away from the kerf

forest coupe plan – a plan prepared for each harvesting operation containing a map of the area, and schedule incorporating specifications under which the operation is to be administered and controlled (see also operational plan)

Forest Management Plan – a plan produced to address the full range of values and uses in a given Forest Management Area (usually larger areas)

form (of a tree) – the taper and general shape of a tree, particularly its stem

forwarder – extraction machine which carries rather than drags its load of logs to the landing (usually fitted with a crane grab for loading)

forwarding – extracting logs and billets from the cut stump to the landing

fracture – fracture occurs as hairline separations across the grain although - usually a natural defect caused by wind movement in the growing tree, however it can also occur when logs have suffered severe impact during falling

fragmenting – isolating areas of (usually) pockets of understory and overstorey which may affect movement of animals; and future management and sustainability of tree and plant species

free – during felling making sure the tree is not forced

free growth – growth (trees) which is unrestricted by competition or resources

freeness – characteristic of the cut log to release growth stresses by splitting

FTP – Forest Technology Programme

fuelwood – woodchips, splitwood or roundwood used for fuel (firewood)

furniture grade – attractive and sound timber with visual appeal (popular for furniture construction)

FWPRDC – Forests and Wood Products Research and Development Corporation

gabions – a wire basket filled with earth and rocks to create barriers to run-off and erosion

gallery (termite) – a passage or burrow, bored or excavated by termites in the wood or bark. Also attributable to borers
**gang plates** – metal plates nailed to the cut ends of logs after processing to minimize end splitting

**gap** – an opening in the forest canopy allowing eucalypt germination and establishment, release of lignotuberous seedlings, or increased growth of surrounding trees

**gap selection** – see Australian Group Selection

**grabs** – pincer type arms or claws to grasp stems or logs during falling or processing

**grade** – to sort timber into different established classes according to quality, market or use

**gradient (change)** – sometimes refers to a gradual change in character of the forest (a gradient in height from ridge to gully – shorter on the ridge to tall in the gully)

**gradient (road)** – slope or steepness of a road or track;

**grain** – the general direction of the fibres or wood elements relative to the main axis of the stem, bole, log or timber (see also spiral grain)

**grapple skidder** – a skidder usually articulated and most often rubber tyred fitted with a hanging grapple used to pick up and secure logs during extraction

**grapples** – see grabs

**grasslands** – vegetation zone dominated by grasses with few trees and shrubs

**green crown** – a dimension used to describe only the green-leafed portion of the tree crown.

**green pick** – intentional regeneration or development of grasses and shrubs achieved by burning grassland, shrubland or woodland to facilitate grazing

**grid pattern** – overlaying of a regular grid for sampling or management purposes (sample plots are sometimes placed at the intersections of the grids on a resource map)

**group selection** – a silvicultural system in which all trees in a small patch are felled, with the gaps created scattered over the forest compartment. For regeneration purposes, gap size is no more than about two tree-heights in diameter, so that natural (or induced) seedfall from surrounding trees can be used (see also Australian Group Selection)

**growing stock** – the group of trees which collectively form the source of a particular product; sometimes refers to all useful (potentially merchantable) trees

**growth stresses** – tensile stresses developed in the cambial layer which can induce splitting and distortion in logs during processing and sawing

**gum (or kino)** – a natural exudation produced in trees as a result of fire, insect or mechanical damage

**gum vein** – a ribbon of gum or kino between growth rings

**gums** – eucalypts with smooth bark over most of the trunk and branches

**habitat structure** – characteristics and features of particular habitats

**hardwood** – more dense wood products and trees generally referring to eucalypts and related species

**harvester** – the machine dedicated to tree falling

**harvesting plan** – the detailed plan for a management unit describing and controlling the harvesting system and defining the areas to be harvested and any special conditions to be adhered to (leads to the operational plan for particular sections or coupes of the management unit)

**haulage** – transport of the timber products, generally from the landing to the mill or point of sale

**head burn** – a fire protection burn used to remove the elevated dry leaves from felled tree tops without aiming for continuous burn cover. Also called top disposal burn. Can be used to facilitate regeneration

**head saw** – the initial saw used to break down the log into suitable pieces (flitches) for further sawing

**heading** – removing the crown and unwanted upper portion of the stem (usually done in the stand)

**heads** – the green crown and branches of a fallen tree

**heartwood** – the innermost and oldest wood between the sapwood and the pith

**HEMS** – High Elevation Mixed Species. Generally mixed species forests about 750 m elevation, but also some forests in frost hollows and on wetter aspects greater than 600 m.
Successful regeneration generally occurs from spring germination

**High grading** – the removal of the largest and best trees for profit leaving behind the smaller, damaged, poor quality and non-merchantable trees

**High pruning** – the pruning of a majority of the bole of the tree often removing some percentage of the green crown; may be extended in a number of separate operations

**Hinge wood** – the last portion of the holding wood used to facilitate directional falling

**Hollows** – potential nesting and den sites in fallen logs or standing trees; habitat hollows

**Honeycomb** – a group of internal checks

**Hot spot** – a small area of very intense burning (heat) that occurs in and around large woody debris during a control burn or wildfire (ashbeds)

**Hydro-axe** – hydraulically operated wheeled slasher usually rubber tyred or tractor based

**Impact** – the physical force created by collision of stems or logs with other solid objects (other trees, logs, stumps, rocks, ground or machinery)

**Increment** – tree growth or forest growth over a given period of time

**Injecting-axe** – tomahawk or axe with the facility for injecting poison in to the fresh cut

**Intensive management** – silvicultural activities and intervention concentrated in a forest management area to (usually) increase production

**Inter-** - between trees of the same age class or cohort (i.e. between regrowth trees in the same patch)

**Intermediate** – trees shorter than those that are dominant or co-dominant (shorter than average); usually with small crowns

**Intra-** - between age classes or cohorts (i.e. between regrowth and overwood)

**Inventory** – assessment and measurement of what is present

**Ironbarks** – eucalypts with very hard and usually deep fissured bark over most of the trunk and perhaps branches also

**Joist (or joist log)** – an undervalued log used as support on landings and in mill yards to keep more valuable logs above the ground surface to facilitate loading, sorting and cross cutting

**Kerf (saw)** – the space created in the timber being sawn by the cutting ‘blades’ (chainsaw, disc saw, blade saws)

**Kiln-dried** – controlled drying of timber to a specified moisture content which is carried out in large, specially designed ovens

**Kink** – an abrupt offset occurring in the length of a log

**Kino** – sap or gum exuded or internally compartmentalized in many eucalypt species

**Knot** – a section of a branch which is imbedded in the wood of the trunk of a tree or larger branch

**Landing** – a place where sawlogs and residual roundwood are snigged to for sorting and then loaded for transport from the forest

**Leaf area** – surface area of leaves on a plant; akin to picking all the leaves and laying them flat on the ground

**Leaf area index (LAI)** – the area of leaf in a canopy per unit of ground area covered by that canopy; there are no units

**LEMS** – Low Elevation Mixed Species. Generally mixed species forests below 750 m elevation, except for some forests in frost hollows and on wetter aspects between 600-750 m which act as HEMS. Most successful regeneration occurs from autumn germination

**Lignotuber** – a growth at the base of many dry area eucalypts consisting of carbohydrate reserve and growth buds

**Litter layer** – the layer of shed leaves, twigs and organic matter which when present covers all or part of the soil surface

**Loader** – mobile machine usually with grabs to pick up and place logs or billets carefully on to trucks and trailers for transport to the mill

**Loading** – the final process of loading onto road transport for delivery to the mill

**Log (peeler)** – peeler log - a length of log prepared for conversion into veneer products

**Log (pulp)** – pulpwood (residual log) - a length of log for conversion into wood chips or wood fibre
log (saw) – (sawlog) - the length cut from the stem of a tree from which sawn timber is to be produced

log classification – see grading

log length – the prepared section of the log for a particular product

log-making – cutting to selected market length after determining log grade and/or product

long-wood (harvesting) – systems working with log lengths up to 12 m, logs headed or initially cross-cut at the stump and snigged to the landing for processing

long-wood (thinning) – a system for harvesting thinnings where full length felled trees are skidded out to a landing where all subsequent processing occurs

lug marks – small to large indentations and compressions in the outer surface of a log (usually sapwood) caused by processing machines during docking, rolling, grabbing, debarking, sorting and loading (see chatter marks)

lugs – raised portions of grabs and rollers to facilitate gripping the logs

Lyctus – a wood borer which is quite damaging to hardwood and softwood timber logs and products

management area – generally the largest unit of management representing an administrative area of forest

management strategy – planned activities to produce product or environmental outcomes

management unit – an area of similar forest which can be managed by the same strategy

mast – the upright frame of the felling head which encaptures the tree when the head and/or grabs are applied to the trunk

matting – either manufactured layering or relocated forest debris (branches, crowns, bark) used to reduce bogging, erosion or contamination on and around landings and snig tracks

mature forest – forest at or beyond nominal rotation age but before it reaches the over-mature stage. (Generally 60-15- years, MAI and CAI will be declining)

mean – in most cases used in the same way as ‘average’

mean annual increment (MAI) – average yearly increase in log volume over the life of the stand (m³ ha⁻¹ yr⁻¹).

mensuration – the group of measurement activities in determining forest growth and resources

merchantable – a term used to describe timber suitable for processing into forest produce and for which a market exists

merchantable height – the height in the tree where the last part of the product length would be crosscut (bucked) from the head or crown (e.g. may be 25 cm diameter over bark for sawlog; 10 cm diameter over bark for pulpwood)

merchantable mean annual increment (MMAI) – the mean annual growth of only the merchantable portion of the tree or trees

merchantable volume – the volume contained only in the merchantable part of the tree

microclimate – climate of a small, localised part of a forest. Vegetation, soil conditions and small scale topographic changes may create pronounced microclimatic differences

mineral soil – the minerals and organic matter (without recognisable leaves, twigs etc) incorporated into the soil mass which is immediately under the litter layer

mixed species forest – generally consisting of more than 3 or 4 species of trees (messmate, peppermint, gum or stringybark species). Does not include ash, red gum or box ironbark forests as these are usually dominated by only one or two species

monitor – regularly measure or reassess

morganer – a log which has been on the ground for some years (as a result of felling or wind) – see also downer

mosaic – a chequered pattern of (forest areas) of different ages, structure or ‘values’

mowing – non-selective slashing and removal of trees within a forest usually in corridors

net productive area (NPA) – the area of forest which will actually be used for products (after leaving out ‘exclusion zones’, buffers and inaccessible areas)

nominal spacing – the planned average stocking or spacing which the forest will be reduced to during a silviculture operation
**non-commercial thinning** – a thinning operation in which no wood of any commercial value is harvested. The primary purpose is usually to increase the growth of the retained trees (see also early spacing, pre-commercial thinning)

**non-wood values** – other products or biodiversity values from a forest which are not related to timber sales

**occlusion** – the origin of the branch on the bole, partly or wholly grown over after the branch is shed

**OH&S** - Occupational health and safety (rules and regulations which must be followed to ensure the safety of operators and the general public)

**open forest** – forest in which crowns are generally not touching and unfiltered light can reach the ground

**operational plan** – the detailed planning and control of harvesting or treatment in specific parts of the harvested area (coupes, special zones)

**outrow and bay method** – thinning practice aimed at minimising damage to retained stems and ensuring coverage of the entire coupe by the thinning machinery. Out-rows (maximum 4.5 m wide) have all trees removed and other areas are thinned by reaching into the retained bays (maximum 12 m wide)

**outrows** – the access pathways where all trees are removed during thinning or harvesting which allows machine access into the harvestable area (usually 4-6 m wide with 10 to 12 m bays of forest in between)

**overland flow** – surface flow of water

**over-mature forest** – a forest beginning to senesce, being beyond its best timber production potential. The forest inputs more energy into internal maintenance than active growth (generally greater than 150 years)

**overstorey** – the taller trees forming the upper layers in a vegetation area

**overstorey islands** – untouched groups of trees in patches (may be variable in area) retained within harvested coupes

**overwood** – trees in the top-most stratum of the forest (see also overstorey)

**overwood removal** – removing the larger older age class trees in a mixed age forest and allowing the retained poles and regrowth to continue growing to form the next crop

**parcel** – either a patch of land or a bundle or load of timber product

**patch** – small area of forest similar in origin and structure often within a larger forest area i.e. patch of regeneration, patch of advanced growth

**patch cutting** – treatment of smaller very similar patches of forest within a larger area

**peeler log** – a log of specific quality used for producing veneer

**peppermints** – eucalypts which have distinctive oil aromas or leaf characteristics exuding oils

**piers** – short poles used to support construction; used in-ground

**piles** – poles generally submerged in fresh or salt water

**pipe** – a longitudinal cavity along the centre of a log

**pith** – central core of a stem consisting mainly of soft tissue

**pivot tree** – a tree left on the corner of a snig track to protect other trees within the coupe while snigging. This tree is removed last (see also buffer tree or sacrifice tree)

**plantation** – a planted area of trees for future products

**planting density** – the number of trees planted per unit of ground area (often expressed as the number of trees of stems ha⁻¹)

**PNF** – often used abbreviation for private native forest

**popping** – forming excessive end splits (see end splitting)

**portable sawmill** – easily transportable sawmill operated by one or two people able to efficiently handle small and medium size log breakdown and processing, often operated near the stump

**potential habitat tree** – a younger tree or mature tree which is capable of developing hollows and other structures which could become habitat for fauna and flora

**potential sawlog** – trees with the potential to grow into a high value sawlog
**pre-commercial thinning** - a thinning operation in which no wood of any commercial value is harvested. The primary purpose is usually to increase the growth of the retained trees (see early spacing, non-commercial thinning)

**prescription** – the designated actions to carry out a silvicultural strategy during forest management

**preservation of forest** – generally used to describe conservation of forest where no intervention is permitted

**preservation of habitat** – generally used to describe conservation of habitat where no intervention is permitted

**preservation of timber** – the treatment of timber products with chemicals to reduce or prevent insect or fungal attack

**processor** – usually applied to the debarking head which may also cut to length

**product** – saleable timber (log, piece, billet, firewood, poles, piles, pulpwood, etc)

**productivity** – the capability of an area to produce desired products; often related to growth rate and increment

**provenance** – the place of origin of a particular seed lot from natural forest or the population of trees growing at the place of origin (trees from different provenances may differ greatly in their performance at a particular site for various climatic and genetic reasons)

**pruning** – removal of branches from the bole or stem to increase growth, wood quality and merchantability of the stem (log)

**pruning shears** – specially designed shears with one flat edge to facilitate close cutting of branches on the stem of trees

**pulpwood** – stems and branches (and residual wood) which is destined for wood chipping or pulping to produce converted products (i.e. paper)

**QFRI** – Queensland Forest Research Institute

**quartering** – the result of large and active shakes in the log. Sometimes the stresses are so great that the whole log separates into a number of sections

**quota** – contracted amount of wood volume or trees (number) to be removed in harvesting

**radius** – from the centre (pith) to the outside of a tree; from the centre to the outside of a circular plot

**rainforest** – moist forest dominated by tall trees other than eucalyptus

**reaction wood** – abnormal wood formed typically in leaning and crooked boles. Also occurs in large branches. Wood laid down is tending to restore the tree or branch to the original shape or position (see also tension wood)

**re-colonisation** – the natural succession of fungi, mosses, herbs, grasses, shrubs and trees which revegetates a disturbed or bared area

**regeneration** – the renewal of a tree crop through natural or artificial means

**regrowth forest** – a forest originating from fire, disturbance or harvesting activity which is younger than the nominal rotation age (generally 1-60 years)

**remnants** - usually small areas or individual trees within an area which reflects the vegetation of previous forests or eco-systems

**representative** – reflecting the average or most usual conditions of structure, habitat or forest

**reservation** – a reserved area

**residual trees** – unwanted trees remaining after a selective or clearfell forest operation (see also retained trees)

**residual wood** – wood left over after conversion to product (in a sawlog operation this residual wood could become firewood or pulpwood or other products)

**retained trees** – trees purposely retained on a coupe during a harvesting operation because they serve as seed or habitat trees, or are selected to be grown on after thinning or selection harvesting (see also residual trees)

**retention** – choosing to keep trees in place as future products or bio-diversity structure

**RFA** – Regional Forest Agreement

**ring shake** – ring shake is a natural weakness in the growth rings and the timber separates along the growth rings

**ripping (soil)** – machine cultivation of the soil by dragging large prongs through the surface and/or subsurface of the soil to facilitate water and root penetration
RIRDC – Rural Industries Research and Development Corporation

road network – the infrastructure of snig tracks, tracks and roads to facilitate haulage of products from the forest to the property boundary

root grafting – effusion of roots from different trees into one connected root system

rotation – the planned number of years between the regeneration of a forest stand and its final harvest

rotation length – the nominal length of time to produce the desired product (usually referring to sawlog rotations)

round timber – generally all unprocessed and processed logs for conversion into other products

roundwood – any timber sold as un-split or un-sawn product

RPC – Regional Plantation Committee

run-off – water flows over the surface of the soil

rupture – defamation or fracture of wood fibres across the grain due to excessive compression parallel to the grain caused by direct end compression or bending

sacrifice tree – a tree left on the corner of a snig track to protect other trees within the coupe while snigging. This tree is removed last (see also buffer tree or pivot tree)

salinity credits – rating or value given to forest or plantations to recognise their contribution to mitigating or preventing salinity

salvage (logging) – removal of any merchantable products (sawlogs, pulpwood, firewood etc) from an area after some other disturbance or operation (logging, disease, fire or storm damage)

sampling intensity – the number of plots sampled or required to have confidence in a survey of a forest area

sapling – regrowth stem 5-12 m tall

sapwood – the new wood formed in the outer part of the tree which transports water and nutrients between roots and stems

sawlog thinning – thinning of the forest down to the retention of only the future sawlog trees which will remain until the end of rotation

scarf – the undercut applied to the tree to initiate directional falling

seasoned – air dried or kiln dried timber

second thinning – a second cut for commercial products which creates growing space for the retained trees

secondary log – the second or third log cut from the stem of a taller tree

SED – small end diameter (usually referring to sawlogs or pullogs)

seed shed – the release of seed from the woody capsules of eucalypts or the capsules and pods of other species

seed tree – a tree left standing following harvesting to regenerate the site by release of seed contained in the crown

seedbed – the receptive soil and debris mix which will nurture the germinating and establishing seedlings

seedling – a plant originating from seed and generally between 1 to 24 months old

selection harvesting – a silvicultural system in which trees above a certain size class are removed singly or in small groups while retaining regrowth, pole timber and habitat trees. Regeneration is established in the gaps to maintain an uneven-aged forest

self-pruning – the ability of some species to easily occlude branches from the stems under most growing conditions

senescence – the absorption of nutrients from leaves back into twigs and branches of the crown prior to leaf shed

shade-tolerance – the ability of a tree to maintain growth, health and vigour in partially shaded conditions

shake – a partial or complete longitudinal separation between adjoining layers of wood fibre. Often showing as a split in the end of the tree or log. One shake is dominant and a second shake will often appear at right angles to the first shake

shake (felling) – a shake caused by felling operations when fibres are torn or compressed

shatter – shatter is an unplanned break in the wood fibres generally caused by an impact of the falling tree over another tree, rock, stump or gully. Shatter can also be caused by rough handling during extraction and processing –
often described as a concentration of long splits or shakes (sometimes also described as fracture)

shearing head – mechanical shears which use a pincer or scissor movement to cut the tree

shelterwood – a silvicultural system in which the original stand is removed in two fellings, the ‘regeneration’ cut and the ‘removal cut’, with the intervals between fellings being normally 5-15 years. The retained trees, which are the seed source, are usually the best quality trees, and comprise 20-30% of the basal area of the original stand

shorts – short lengths (of logs) which are left over after bucking or crosscutting of the tree into desired log lengths

short-wood – systems working with shorter lengths (2.4 to 5 m), generally processed at the stump

shovel logging – process of moving logs from the stump by grasping ‘grab loads’ and progressively moving the logs and machine closer to the landing

shrublands – vegetation zone dominated by shrubs and some grasses with few scattered trees

silvics – the biological, physical and environmental factors that influence the management of a tree species

silvicultural regime – silvicultural strategy

silviculture – the theory and practice of managing forest establishment, composition and growth, to achieve management objectives

single tree selection – felling of scattered mature individual trees, at intervals (generally 10-30 years) over the rotation. Regeneration in the small gap is largely from lignotubers and coppice

site inspection – a visit by the contract participants (owners, advisors, contractors) in the proposed management unit or coupe for the purpose of assessment and discussion of requirements and constraints

site preparation – preparation of the ground to provide conditions suitable for regeneration from seed or seedlings

site quality – potential of the site to grow timber. A function of soil quality, rainfall, aspect and other factors

size class distribution – see diameter distribution

skidded – an extraction machine which drags (skids) its load to the landing

skidding – extraction technique where logs are dragged to the landing usually with one end of the load suspended behind the machine

slabbing – longitudinal splits caused by the release of the hanging weight of elevated logs during cutting to length

slash – green leaf, branch and crown components of the tree which remain in the stand after heading

slash burn – the planned combustion of logging debris (slash) to reduce fire hazard and/or to create receptive seedbed

sleeper backs – half rounds (sometimes called splits) which are the residual cuts from processing logs into sleepers

slope – the aspect and steepness of the landscape; the shape of the slope when looked at side on; usually measured in degrees

slovens – a general descriptor of protrusions from logs after processing

snig track – the temporary pathways through the coupe along which cut (headed) logs are transported to the landing

snigging – the towing or winching of a log by a tractor or dozer from the stump to the landing for processing

softwood – usually the various species of pines suitable for wood production (see also hardwood)

soil disturbance – any activity which disturbs the soil surface such as ploughing, ripping, cultivating, churning by wheels or dragging logs and debris across the surface

spacing – non-commercial thinning; or description of the distance between trees

specialty timber – timber products other than conventional structural timbers

spikes – usually small protrusions from sapwood caused during debarking and handling

spiral grain – where the grain appears to be winding around and/or across within the stem

splits – see sleeper backs

stand condition – health, age, size class distribution and stocking of a forest stand
standing volume – the present volume in the stand as estimated by inventory (may be expressed as total or merchantable volume)

stem injection – injection of herbicide into the sapwood of a tree using special tools

stewardship – managing and caring for the forest resource (see also silviculture)

stocking – the density of a given forest usually expressed in terms of the number of trees per hectare

stocking rate – the current number of live trees per hectare

strainers – roundwood used to anchor fence posts under strain

strata – the various vegetation levels of the forest e.g. overwood, understorey, mid-storey

stratification – dividing the resource into similar units for management or treatment i.e. management zones, management units

strength – the resistance of wood to distortion (sometimes equated with hardness)

stress graded – timber that has been machine tested for its resistance to distortion (see F value)

stringers – supporting logs for bridges over a span

stringybarks – eucalypts with generally fibrous (soft) bark which is usually adhering to most of the trunk and branches

strip thinning – thinning of forest stands by removal of trees in parallel strips

stubs – see branch stubs

stump – the remainder of the bole of the tree left in the ground after felling

stump height – height of the cut of the felled tree above the ground (high stump heights reduce volume recovery considerably and may be specified to be a maximum of 30 cm)

stumpage – the price paid for wood after all other costs have been assessed and deducted

support log – a log placed on the ground to keep valuable logs above the ground and to facilitate handling and sorting

suppressed – trees with crowns overtopped and below the general level of the rest of the crowns and trees; usually in poor condition

sweep – a large radius bend in a log or tree

tail-swing – rotation of the rear section of machines during slewing of the cab or crane base of a machine (usually excavator based)

tension wood – outer sections of boles of eucalypts are under tension longitudinally with a tendency to decrease in length when released (see also reaction wood)

tenure – the condition of occupancy i.e. freehold, leasehold, crown land

thinning – removal of a proportion of the trees in a stand to allow greater growth of the retained trees (see commercial thinning, non-commercial thinning)

thinning from above – removing the larger and better quality trees from a stand to allow advanced growth and young trees to develop

thinning from below – removing the smaller and poorly formed trees from a stand and allowing the larger, better-formed trees to increase their rate of growth

topping – see heading

transect – an assessment or inventory measurement along a line or compass bearing through the forest

tree density – a measure of the number of trees per unit of area (a dense forest has a high number of trees per patch or per hectare)

tree girdler – the machine used for ringbarking trees

tree jacking – the process of forcing the tree to fall in a different direction to the natural tendency following cutting

tree marking – labelling or indicating trees to be removed (or retained)

trimming – using a chainsaw to trim branches and bumps off sawlogs at the landing

under-cut – belly cut or scarf cut used to facilitate directional falling

understorey – the strata of grasses, shrubs and intermediate layers beneath the forest canopy

understorey islands – undisturbed areas of understorey vegetation which are retained within a harvested area

uneven-aged stand – a stand containing two or more age classes of trees growing together

value-adding – describes activities designed to increase the value of potential or harvested
products (including the conversion and marketing into many other by-products); also used to describe the conversion of a log into smaller and more valuable products

**vegetation islands** – see overstorey and understorey islands

**veneer** – a very thin slice or peeling of timber which is glued to other timber products

**visually graded** – grading done by eye according to visual characteristics of the wood and associated defects

**waste** – residual or unwanted wood

**water bar** – a barrier to the flow of water

**water yield** – ability of a forest area or management unit to contribute to surface flow, groundwater and streams

**wedge** – used to lever (or ‘jack’) the tree by hammering a steel, plastic or aluminium wedge into the back cut during felling

**wet sclerophyll forest** – more moist eucalypt forest in higher rainfall areas and usually of medium to high quality

**whole-tree** – systems where the whole tree is transported to the landing for processing

**widow-maker** – large branch nearing occlusion in the crown of the over-storey trees which would severely injure personnel if it fell

(e specially during contact, impacts and movement of crowns during harvesting operations)

**wildfire** – uncontrolled fire, bushfires, ‘escaped’ controlled burns

**wildlife corridors** – vegetated areas with suitable structure and cover connecting important areas of forest resource and biodiversity

**windrow** – rowed heaps of slash and debris piled up after site preparation; often burnt.

**windthrow** – blowing down of trees by wind storms either individually within the stand or as whole stands

**wood quality** – describing the characteristics sought after in timber products (clearwood, strength, colour etc)

**woodlands** – vegetation zone dominated by grasses and shrubs with scattered trees, larger open gaps between tree crowns

**woodlot** – parcel of forest used for wood products

**woody residue** – residual wood and sawdust etc.

**wounding** – damage to stems and boles of living trees caused by rubbing or impacts by machinery or other trees

**WUP** – Wood Utilisation Plan
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http://www.quadco.com  Large front mounted tractor driven brush cutters.

http://www.sba.gov/starting/indexbusplans.html  Useful instructions on developing a business plan.


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