# Forest Management Guidelines

Local Land Services

September 2023


NSW
GOVERNMENT

# Foreword

The Department of Regional New South Wales and Local Land Services acknowledges that it stands on Country which always was and always will be Aboriginal land. We acknowledge the Traditional Custodians of the land and waters, and we show our respect for Elders past, present and emerging. We are committed to providing places in which Aboriginal people are included socially, culturally and economically through thoughtful and collaborative approaches to our work.

*This publication is provided as a guide to landholders and should not be relied upon as the only basis for any decision to take action on any matter that it covers. Readers should make their own enquiries and obtain professional advice, where appropriate, before making such decisions.*

# Contents

# Introduction to farm forest management in NSW

01

# 1.1 What is farm forestry?

Farm forestry supports the long-term productivity of native forests on private property in accordance with the principles of ecologically sustainable forest management. This may include the harvesting of timber for a variety of products such as flooring, construction, power poles, furniture and firewood.

# 1.2 How to use these guidelines

This introduction to farm forest management in NSW is designed to give landholders and forest managers the key information they need to develop long-term objectives and plan their forest management (including the development of Forest Management Plans).

This document explains ecological and silvicultural principles, helping landholders to balance economic, environmental, cultural and social forest management objectives.

As a landholder, you can use this information to plan and undertake a range of farm forest management and silviculture operations in line with NSW regulations.

**PNF Codes:** These guidelines should be used with the Private Native Forestry Codes of Practice (PNF Codes), which set the minimum operating standards for harvesting in farm forests in line with ecologically sustainable forest management. It is critical to consider the relevant PNF Codes when planning forest management.

# 1.3 Forest management

Farm forest management is an ongoing, long-term practice that keeps the forest healthy and productive for future generations. Silvicultural practices help maintain diverse, healthy and productive landscapes by:

- Conserving biodiversity, such as retaining trees for habitat and food or structural diversity
- Maintaining productive capacity and sustainability of ecosystems
- Keeping forests healthy through the management of pests, weeds and diseases
- Enhancing and protecting Aboriginal cultural heritage.

### 1.3.1 Silviculture: the ecological basis of forest management

Silviculture is the science of forest management for a range of benefits, including:

- Economic – production of sawlogs, veneer logs and non-wood forest products
- Environmental – protection and conservation of flora, fauna, water and landscape features
- Social – visual landscape, recreation and heritage.

You can use silvicultural practices to manage forests for wood products and future growth and to maintain diverse forest values. Preserving native species patterns can improve the condition of existing forest and ensure continued regeneration.

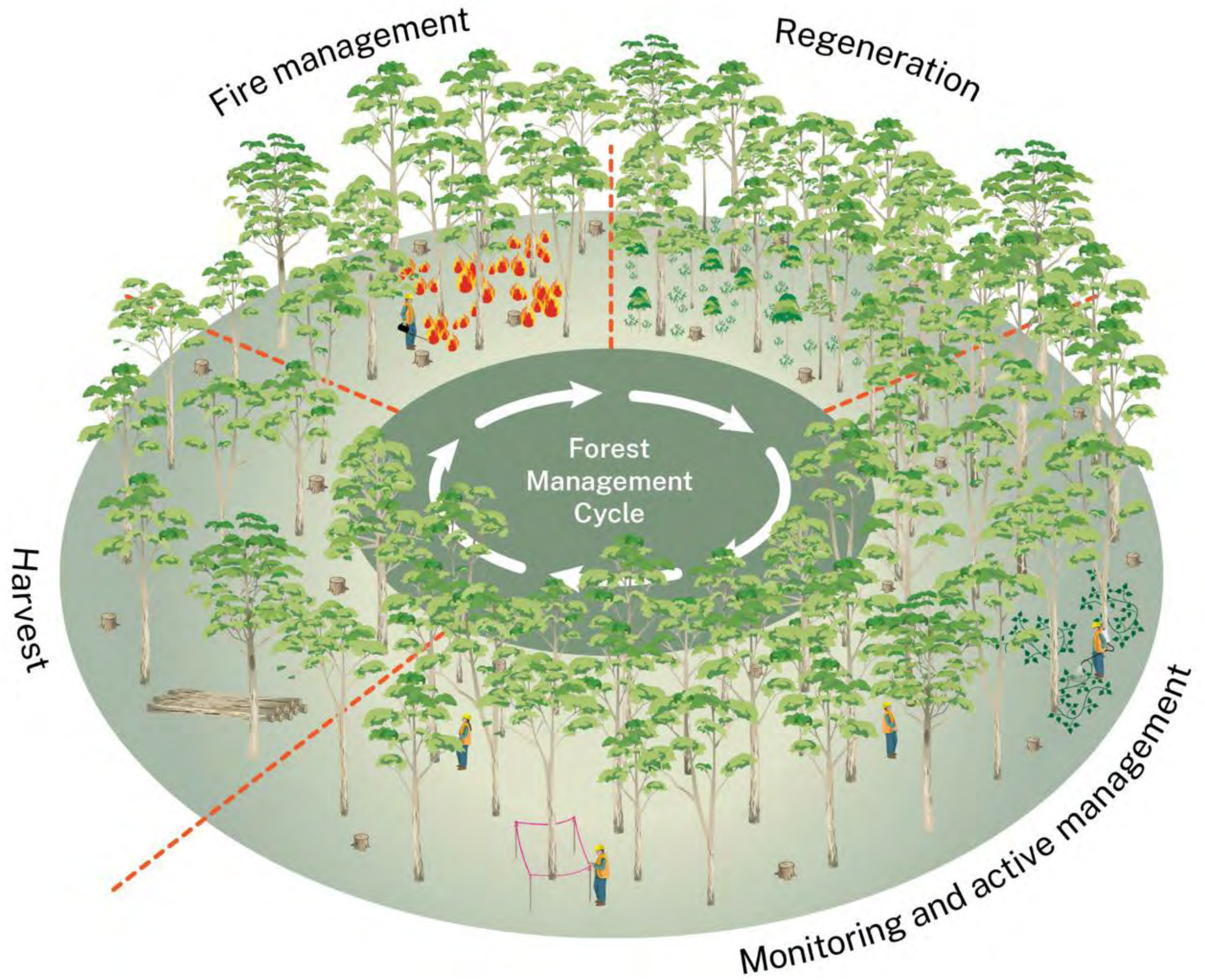



**Figure 1:** An example of a forest management cycle for active forest management

Farm forestry should balance environmental values, wood production and future interests. Forest managers should plan their operations, taking into consideration trees to be harvested now or left for future resources, and ensuring trees are kept for habitat reasons (including food, shelter and connectivity), biodiversity and structural diversity within the forest. When harvesting, you must protect key features, establish adequate regeneration and support healthy tree growth.

The protection of Aboriginal cultural heritage is critical to sustainable silvicultural practices. Forests can be home to ceremonial sites, cultural pathways, songlines, and animal and plant species that are important for ceremony, food and medicine. Forest management and harvesting activities must identify and protect cultural heritage.

# 1.4 The objectives of native forest management

The diverse farm forests of NSW provide a variety of products and services to landholders and the NSW public. Across many forest types with as many different owners, forests are managed for many different reasons, including timber production, environmental conservation, cultural values and social benefits. No matter the goal, management must be sustainable.

## 1.4.1 Ecologically sustainable forest management


**Figure 2:** Multiple objectives of forest management

Sustainable forest management combines several sustainability goals:

- Environmental – Maintain species makeup and ecological processes, protect soils, food chains, biodiversity and nutrient cycles, and promote good health and diversity.
- Economic – Maintain the productive capacity of the forest for the future.
- Social and cultural – Follow social expectations and maintain Aboriginal cultural knowledge, values and practices.

Balancing objectives is key to successful forest management. Diverse, healthy forest ecosystems are productive, providing economic, cultural, social, and environmental benefits into the future.

The benefits of good native forest management include:

- Healthy natural landscapes that contribute to clean air, water, and well-being
- Protected and enhanced Aboriginal cultural values, supporting cultural practices and knowledge sharing
- Income that sustains rural communities
- Diversification of farm income that brings income security and flexibility
- Continued opportunities for work and recreation, contributing to the economy and society
- A more certain future of forests and forestry for generations to come.

# 1.5 Regulation of farm forestry in NSW

The harvesting of native forest on private land in NSW is regulated by:

- The *Local Land Services Act 2013*
- The Private Native Forestry Codes of Practice (PNF Codes).

The PNF Codes set the minimum standards for native forest operations on private land. The PNF Codes have been developed in line with the principles of ecologically sustainable forest management, to support the environmental, economic, social and cultural values of a forest. This benefits landholders and the wider community, ensuring continued habitat and biodiversity, water and soil quality, recreation, timber production, cultural heritage, and employment in regional communities.

Local Land Services (LLS) is responsible for approvals and advice for farm forestry in NSW. A private native forest manager should contact LLS for approval of a Private Native Forestry Plan (PNF Plan). Once a PNF Plan has been approved, LLS will provide information and advice to help landholders, consultants and contractors develop a Forest Management Plan in line with the relevant PNF Code.

**PNF Codes:** All forest management planning must be in line with the requirements of the PNF Codes.

# 1.6 The forest management process

Successful forest management is an iterative process requiring several steps.

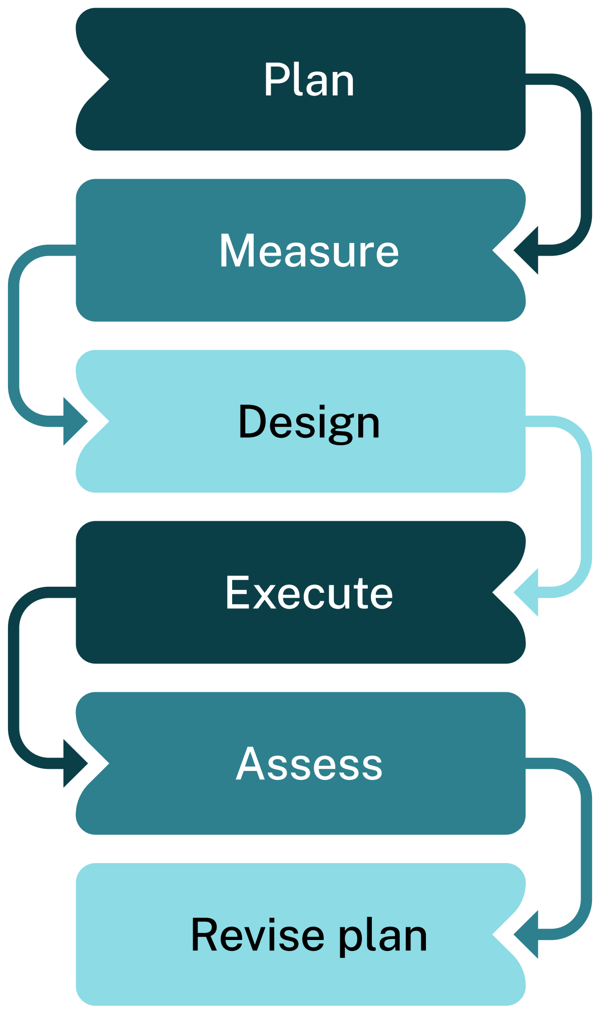



**Figure 3:** Forest management process

**Plan:**

Define management objectives and outline how objectives will be met. Make sure you address all regulatory requirements.

**Measure and design:**

Forests are dynamic. They are home to living things that constantly change and must be considered. You need to measure the characteristics of the forest and understand how species adapt within it. These measurements and information can then be used to design silviculture practices and management regimes for a healthy, growing forest. This includes managing pests and diseases, fire regimes, threatened species management, carbon sequestration and timber production.

**Execute:**

You will need the right approaches, tools and knowledge to grow and manage the forest.

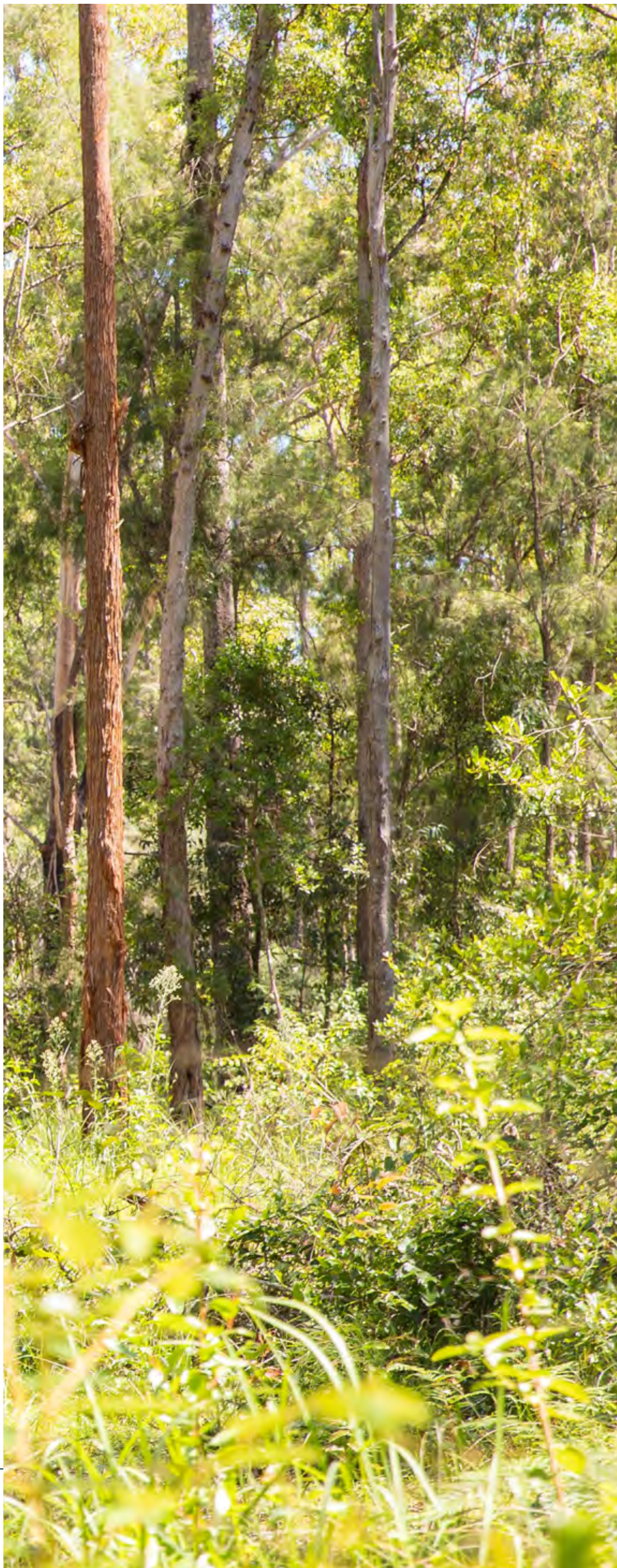
**Assess and revise:**

Adapt your management plan as you get new information, such as if regulations change or if you realise your plan isn't working. Regularly review and revise your plan to make sure you are meeting your goals and complying with regulations.

# Planning: The first step in forest management

# 02

## Planning is crucial for successful forest management that meets your objectives and regulatory requirements. In NSW, all farm forestry landholders must develop a Forest Management Plan.



The plan will outline:

- Important features of the forest, such as threatened species, cultural heritage, protected habitat, and landscape features
- The forest structure and composition, the condition of forest areas, and the products that will come from your forest
- What silvicultural practices and other forest management practices you will use
- Any infrastructure construction or maintenance that may be required.

**PNF Codes:** Plan your forest management activites ahead of time to achieve the best outcomes and to make sure you meet the PNF Code requirements.

# 2.1 Evaluating the condition of the forest

Before you harvest, you need to know the condition of the forest so you can choose the right silvicultural practices for your goals.

You can evaluate the condition of the forest by systematically observing the following aspects.

### Forest type

- Note the individual tree species, their relative frequency, and the characteristics of the understorey.
- What is the forest type: dry sclerophyll or wet sclerophyll? (See Chapter 3.)
- What are the dominant species?
- Is the area of forest you want to harvest relatively uniform in type and composition, or are there differences throughout the area?

### Forest components and their condition

- Identify growth stages of trees in the forest, such as saplings, poles, mature and over-mature trees (see Chapter 10).
- What is the productive condition of trees in each of these stages?
- What proportion of trees would you describe as growth-restricted?
- What proportion of trees have good quality, straight, defect-free trunks with good growth potential, such as healthy crowns, access to light and limited competition?

### Forest structure

- Observe the way trees in different size classes are arranged.
- Is the forest even-aged?
- If there are several growth stages, are they arranged evenly by age, or in a less structured pattern?
- Does unsatisfactory tree condition reflect an unsatisfactory forest structure and silvicultural history?

### Wildlife habitat

- Observe wildlife habitat characteristics, such as trees with hollows, recruitment trees, food trees, nest and roost sites, and condition of the forest floor.
- Will it be possible to meet the wildlife conservation requirements?

### Forest health

- How healthy is the forest?
- Is there evidence of dieback, other pests or weeds, such as lantana, that could limit regeneration or impact timber quality?

### Forest regeneration

- Will the existing forest simply be thinned, or will the canopy be opened in patches?
- If canopy openings are to be created, is there a useful quantity of established eucalypt growth? If not, is disturbing the soil likely to lead to seedling regeneration, or will you need to actively regenerate using techniques like burning?
- Are different harvesting or disturbance activities needed throughout the block to account for changes in landscape, such as slope, aspect, or forest types and conditions?
- Can seed trees be kept close to the canopy openings?
- Are there sufficient seed stocks in the current forest canopy? If not, should you consider seed collection and planting to assist with regeneration?

### Historical influences

- Note any evidence of past disturbances, like fire or harvesting, which might have influenced the condition of the growing stock. For example, the height and condition of tree stumps will tell you about harvest history, while the number and depth of fire scars on older trees, and carbon blackening of fibrous-barked trees, may reveal fire history.

### Together, these observations should allow you to:

- Understand the composition, components, structure and condition of the growing stock
- Determine what prospects there are for a commercial harvesting operation
- Develop a Forest Management Plan to achieve your goals in line with the PNF Codes.

# Forest types in NSW

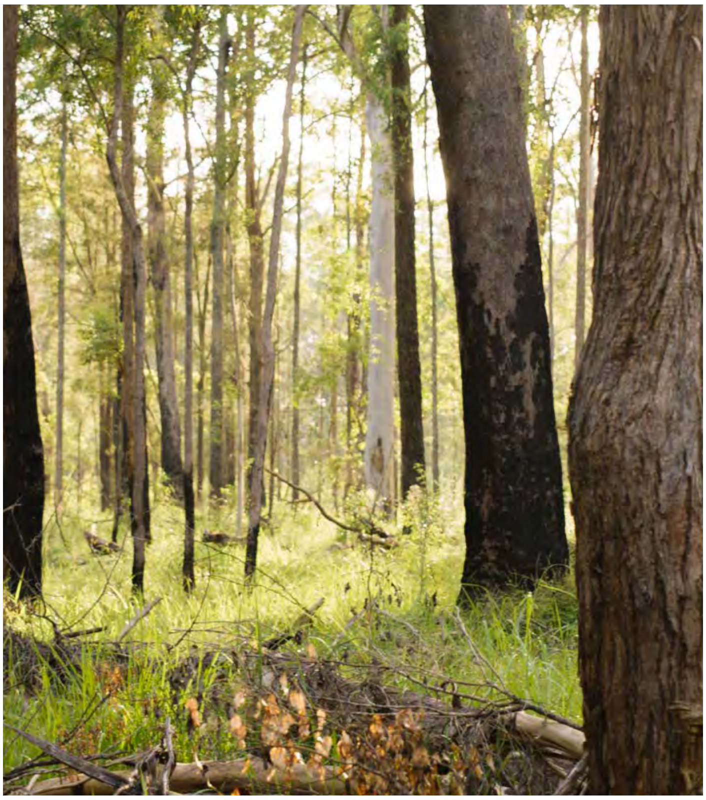
# 03

NSW forests, and the species within them, are incredibly diverse, thanks to the forests' landscapes, plants and animals. Environmental conditions, like rainfall, altitude and temperature, will affect the species you find within a forest and, therefore, the forest type. The distribution of species throughout a forest may be determined by changes in topography and soil:

- Aspect, slope and slope position will influence water availability, fire regime and temperatures.
- Soil texture and structure will affect its capacity for holding water and impact root development, meaning some species won't survive in those areas.

When planning silvicultural practices, it is important to understand how site factors impact the forest and its composition. Species you find naturally on your land are well adapted to the site's conditions, and each have different resource demands. Trying to significantly change natural species patterns is not likely to work and is not recommended. For example, increasing the numbers of a fast-growing species will use more water and nutrients, which can cause stresses and negatively impact the health of the forest.

This is an important guiding principle in the management of any forest. Understanding the forest type and how it grows is also important to ensure the yield of products is sustainable (see Chapter 11.2).



**Blackbutt and natural species distribution**

The species found in a forest are influenced by local environmental factors including slope, topography, soil type and the availability of resources.

Blackbutt grows rapidly and uses more water than slower growing species. On a site where conditions are optimal for blackbutt, it will out-compete slower growing species that grow in similar environments (such as white mahogany or tallowwood) and form nearly pure forests. However, in forests where there is less water, blackbutt growth will be limited and a mixed community of blackbutt, white mahogany, tallowwood and other species is likely to form.

# 3.1 Identifying forest type

Classifying a forest based on height, density and species found, and identifying the forest type, is the first step in developing a forest management regime. This allows silviculture practices to be developed based on the forest's ecology.

Broadly, NSW forests can be classified into three main types based on structural characteristics and species: rainforest, eucalypt forest and cypress pine forest.

Eucalypt forests can be further classified into sub-types based on characteristics such as moisture gradient (Figure 4).

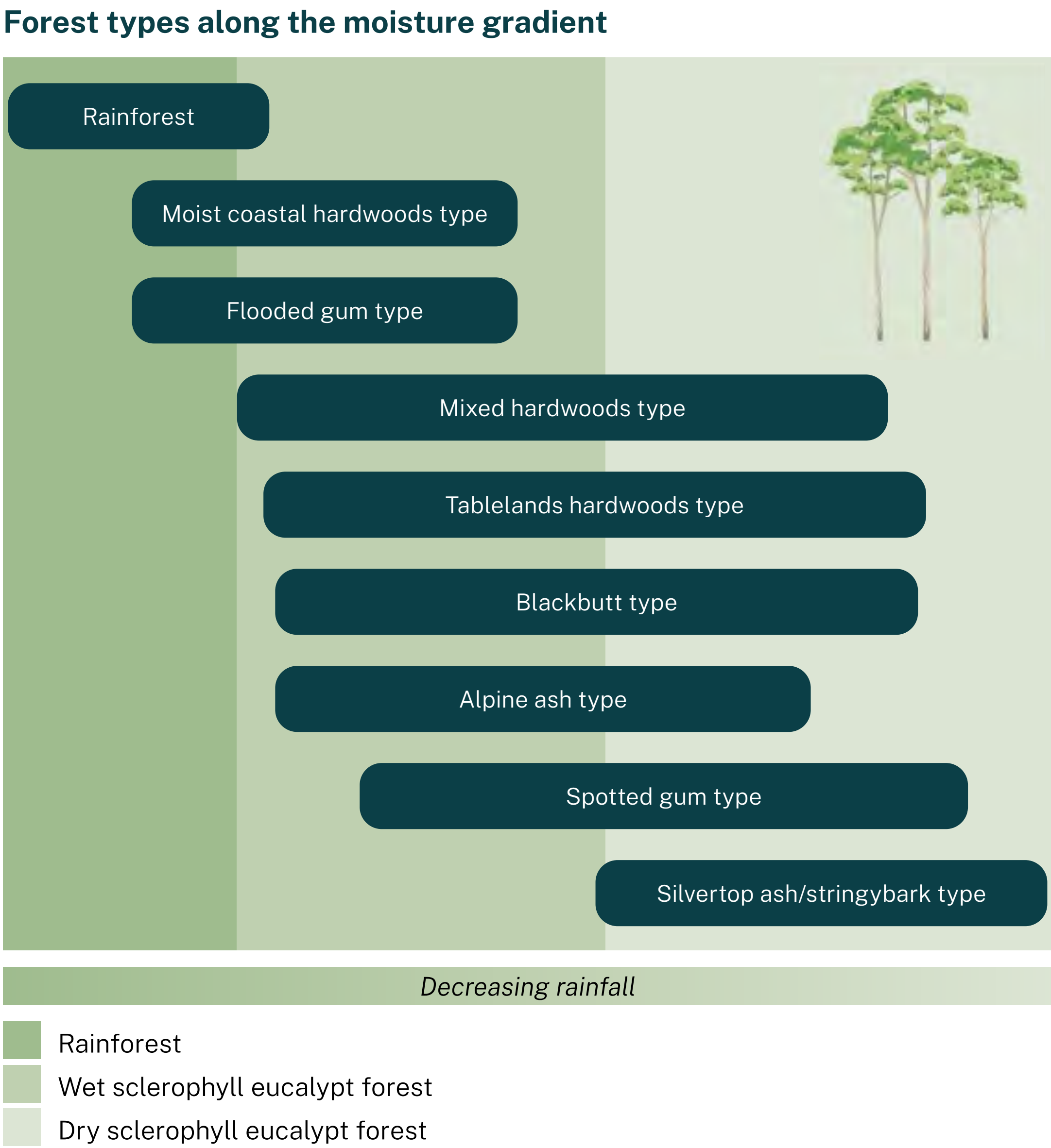



**Figure 4:** Forest types along the moisture gradient

### 3.1.1 Rainforest

Rainforests are generally restricted to coastal lowlands and mountains. Rainforests usually develop on fertile soils, such as those derived from basalt, in areas protected from fire, or on nutrient-rich lower slopes. Rainforests can grow uniformly in structure and/or species composition or in complex patterns with eucalypt communities.

**Figure 5:** Rainforest
N. Westman

**PNF Codes:** The harvesting of rainforests is prohibited under the PNF Codes.

### 3.1.2 Eucalypt forests

There are more than 700 eucalypt species in Australia. Eucalypt forests in NSW are highly diverse, growing at different rates on a wide range of sites. The appearance of different species and how they grow in a region are influenced by temperature and rainfall. Across a forest, growth is influenced by other environmental factors, including soil fertility, soil physical conditions, soil moisture, aspect, topography, fire history and harvesting practices.

Eucalypt forests exist on a scale or gradient based on access to soil water and nutrients, from relatively low productivity, dry sclerophyll forest (Figure 6) to higher productivity, wet sclerophyll forest (Figure 7). Trees that have more resources, including water and nutrients, will typically grow better. The height of the tallest trees, the type of understory, and the species found, are commonly used to differentiate between types of eucalypt forests along this gradient.

### *Dry sclerophyll eucalypt forest*

Dry sclerophyll eucalypt forest is the most widespread type of eucalypt forest in NSW and an important timber resource. It has the following characteristics:

- The dominant trees are eucalypts, although some acacias, casuarinas, and banksias may be present.
- The dominant trees are 10–30 m in height.
- The understorey may either be shrubby or grassy.
- Understorey shrubs usually have small, tough leaves.

**Figure 6:** Dry sclerophyll eucalypt forest

### *Wet sclerophyll eucalypt forest*

Wet sclerophyll eucalypt forest is more productive than dry sclerophyll eucalypt forest and has the following characteristics:

- The overstorey of tall trees may consist of various genera, including eucalypts.
- The dominant trees are 30–60 m in height.
- The understorey consists of ferns, soft-leaved shrubs and small trees of mainly rainforest origin.

A well-developed wet sclerophyll eucalypt forest will eventually merge with rainforest.

**Figure 7:** Wet sclerophyll eucalypt forest

**Figure 8:** Cypress pine forests

### 3.1.3 Cypress pine forests

Cypress pine, or Callitris, forest is found widely across NSW, especially in inland areas. There are two key species of cypress pine.

White cypress pine is the most extensive and productive species, and it provides a valuable timber resource. White cypress pine grows in a range of soil types and climates and is found in almost pure forests or with a variety of dry climate eucalypts.

Black cypress pine is also common but usually grows on poor quality, steep country. It has very little timber value but is a source of cypress oil which is used in termite control.

**PNF Codes:** In the PNF Codes, some of the mixed eucalypt and cypress pine forests fall into the western hardwoods broad forest type. This includes forest types 124, 176, 177, 180–185, 204–207, 209 and 210. The NSW Department of Primary Industries (DPI) provides details on Forest Types in NSW.

## 3.2 Broad forest types

Forest types are based on the dominant overstorey species (for guidance see Table 1). For help identifying the specific forest type at any location, refer to Forestry Commission of NSW Research Note No.17, which groups the discrete and easily recognised forest types from Baur (1965).

| Region / Location | Broad forest types |
|---|---|
| **Northern NSW**<br>North and central coasts, extending into the escarpment, mountain and tablelands | • North coast blackbutt<br>• North coast dry mixed hardwood<br>• Spotted gum<br>• North coast moist mixed hardwood<br>• North coast flooded gum<br>• Tablelands hardwoods |
| **Southern NSW**<br>South coast extending into the escarpment, mountain and tablelands | • South coast ash/stringybark<br>• Spotted gum<br>• Silvertop ash<br>• Tablelands hardwoods<br>• Tablelands ash |
| **Riverina** | • River red gum forests |
| **Western NSW** | • Cypress pine<br>• Western hardwoods |

**Table 1:** Broad forest types in each region

As a landholder developing a Forest Management Plan, you will need to describe the overstorey species type and composition. You will need detailed knowledge of species composition, the structure of the forest and the form of the trees to understand what products can be harvested. See Chapter 11 for economic considerations, such as the timber products possible from individual trees and calculating the yield of a forest.

There is no system of classification where everything fits perfectly, and there are transitional forest types that have attributes and species from two forest types. A common example is the blurred border between rainforest and wet sclerophyll eucalypt forests.

# Managing habitat and biodiversity

04

Habitat diversity is important at all scales, from the landscape down to individual trees. To maintain biodiversity, all forest operations must be carefully planned and managed. Understanding the habitat requirements of the flora and fauna on your land is essential when designing silvicultural practices.

As a landholder or forest manager, you need to know what wildlife lives in your forest, the habitat requirements of each species and how to manage forest planning and operations to meet those requirements.

Sustainable forest management considers and protects threatened plants, animals or communities that are rare or are only found in a small area and are therefore vulnerable to additional impacts.

Key biodiversity goals will be unique to each forest, but might include:

- Allowing wildlife to move through the landscape by maintaining connections with other forest areas
- Identifying and protecting habitat for plants and animals that may move through or use the property for food or shelter
- Maintaining habitat for key threatened species
- Improving habitat for priority species, such as creating artificial hollows for gliders and other animals that rely on tree hollows for shelter.

**PNF Codes:** Check the PNF Codes for your requirements for protecting habitat and biodiversity, including key components that must be looked after. Consider how you can contribute to wildlife conservation by maintaining habitat in other areas of your property.

# 4.1 Managing forest habitats

As forests grow and mature, they become more complex, with the development of habitat features such as ground layer debris and individual tree hollows. Trees at different stages of maturity provide habitat for different wildlife species. A variety of species of different ages and sizes, and diversity in structural features, will increase habitat diversity. A complex forest with diverse habitats might have multiple canopy layers, large dead standing trees and logs on the forest floor, and dense understorey vegetation.

While it is not possible to keep all features in all situations, forest management should try to increase and improve the forest's habitat diversity.

Native animals that live in forests are crucial to keeping the forest healthy and productive. They help with pollination, keep pests away, improve soil by turning soil and leaf litter, and transport fungal spores beneficial to forest trees.

## 4.1.1 Habitat for tree-dwelling wildlife

Many tree-dwelling (also known as arboreal) mammals and birds make their nests or homes in tree hollows and need several hollows near their home to cope with changing weather, parasites and breeding. Trees can take more than 100 years to grow to the size where they develop hollows that are useful for large wildlife species. Forest areas that have previously been harvested may only contain a few large, old trees.

**PNF Codes:** As hollow-bearing trees take so long to mature, you must maintain trees that are capable of developing hollows in the future. Known as recruitment trees, it is required under the PNF Codes that you retain these trees and allow them to become the next generation of hollow-bearing trees.

Different forest growth stages will provide habitat for different tree-dwelling mammals (see Chapter 10.1 for more on forest growth stages). A mixed-species, multi-aged forest can be a home for large numbers of different fauna. You can maximise habitat by maintaining a diverse range of saplings, poles, mature and over-mature trees, and a varied understorey.

**Possums, gliders and forest growth stages**

South coast populations of common brushtail possums and squirrel gliders are usually seen during the pole stage of forest development (and into the early mature stage). Yellow-bellied gliders and greater gliders are often found in mature and over-mature forests, while common ringtail possums, mountain brushtail possums and eastern pygmy possums prefer declining old-growth forests with a rainforest understorey.

### 4.1.2 Habitat for ground-dwelling fauna

Which ground-dwelling (or terrestrial) animals you're likely to see in your forest, and how many, will depend on site factors such as:

- Vegetation type
- Soil type
- Moisture levels
- Whether there are old stumps, logs or rocks
- Condition of the understorey and the groundcover layer
- What food is available.

To provide habitat for ground-dwelling wildlife in a forest, you must pay attention to the management of lower canopies and the ground layer, including course woody debris from fallen timber.

Management practices and natural forest processes can impact forest habitat. Harvesting and prescribed burning have both been found to increase the level of woody debris in the forest, while wildfires can decrease the amount of woody debris. Coarse woody debris is important habitat for wildlife and is a substantial carbon store. Careful forestry and effective fire management can help maximise available desired habitat.

### 4.1.3 The influence of grazing and fire on habitat

Grazing, frequent low-intensity burning and high-intensity fires can all have a negative impact on the availability of habitat for wildlife, by reducing structural complexity or removing stumps and fallen logs. Planned, moderately intense fire has been successfully used to create the patchwork of dense understorey, including bush and regrowth trees, needed for shelter and food for some wildlife species.

Effective fire management is critical to successful forest planning and management which maintains habitat and biodiversity. Poor fire management ranges from excessively frequent burning which changes the understorey, to high-intensity bushfires that can remove habitat features and burn moist forest types, including rainforest. Resilience in plant communities has been seen through a range of prescribed burning regimes, including experimental regimes with more frequent burning than in operational practice. See Chapter 6 for more on fire management.

### 4.1.4 Aquatic ecosystems

Streams, rivers, and wetlands are important for the conservation of biodiversity, including aquatic life and clean water. Areas adjacent to water bodies, known as riparian areas, are sensitive to disturbance and should be considered when planning forest operations nearby so you can protect biodiversity and maintain water quality and aquatic habitat. This is particularly crucial after fires, as less ground layer vegetation can increase the risk of erosion and soil pollution into waterways.

**PNF Codes:** The PNF Codes outline requirements for riparian exclusion zones and the protection of wetlands.

## 4.2 Habitat connectivity across a landscape

A key objective of successful forest management is to preserve local animal populations and make sure they can move about the landscape. Maintaining diversity across the size, arrangement and connectivity of habitat patches is crucial. Key habitat elements for both tree and ground-dwelling species need to be retained and properly distributed.

Firstly, you should work to maintain and improve the oldest age class of trees. The remnant forest – areas that have not been significantly impacted by disturbances – and areas with no known logging history should be connected by corridors. In planning, this can be addressed through harvest exclusion zones and maintaining habitat corridors and forest connectivity.

Some species will travel beyond individual patches of forest and need a network of corridors to connect habitat patches. Riparian areas with old trees and other habitat features can connect different parts of the landscape and act as refuge areas. Habitat features should be distributed throughout the landscape to provide shelter and resources for both mobile and less mobile wildlife.

Improve the conservation of fauna by planning for the animals' needs at a farm or broader scale. As a forest manager or landholder, consider how you can link habitat from within forestry areas to other formal and informal reserves on the property or neighbouring properties.

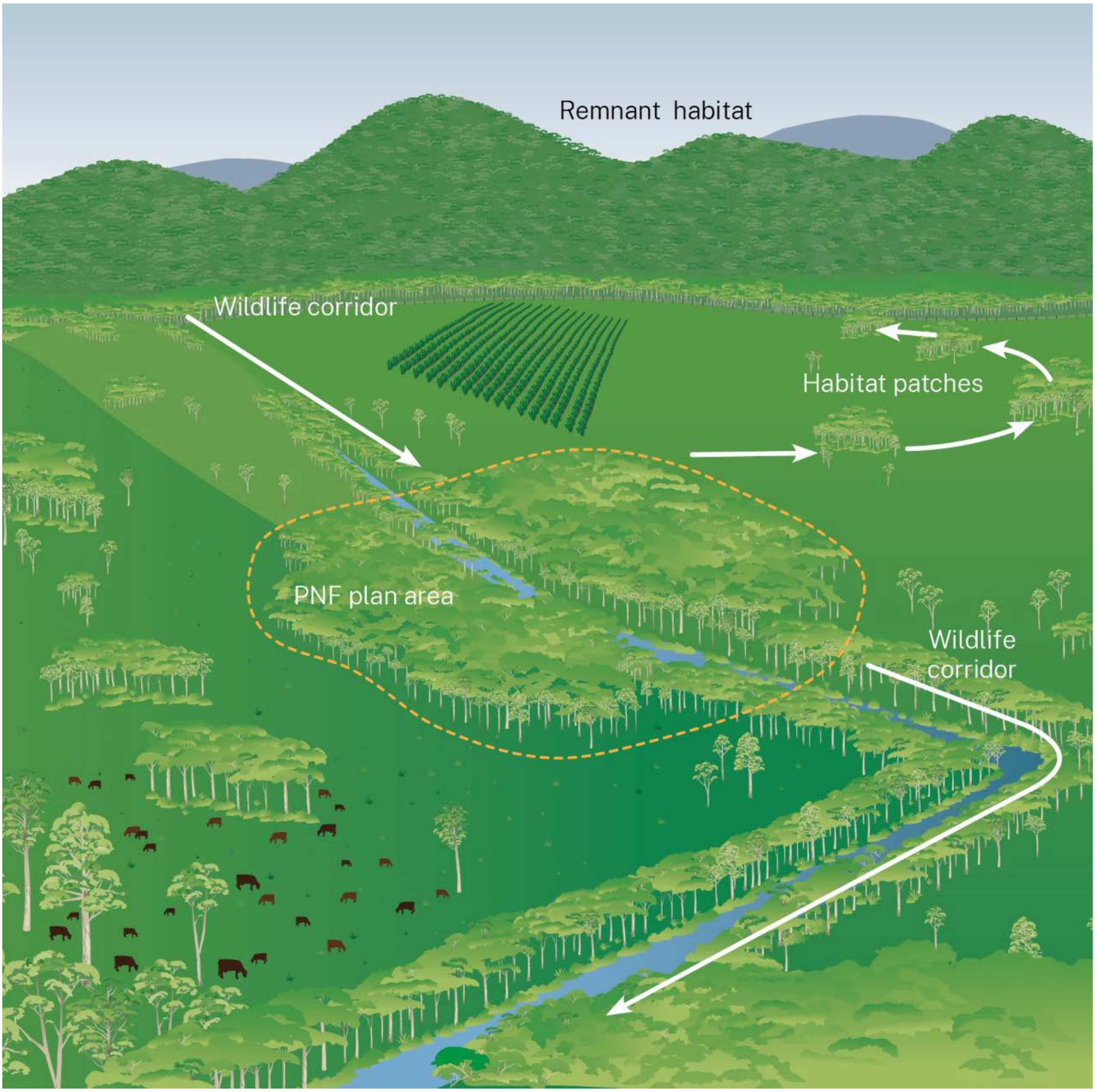



**Figure 9:** Maintaining habitat connectivity in a landscape through wildlife corridors and habitat patches

# 4.3 Managing wildlife during harvesting

Managing habitat and undisturbed areas helps conserve plants and animals in harvested forests. Areas where harvesting doesn't occur act as habitat refuges for sensitive flora and fauna to avoid impact and eventually recolonise harvested areas. During planned fire and harvesting, retain key habitat features, such as old logs, rocks, groundcover and hollow-bearing trees, to encourage recolonisation.

Landholders and forest managers need to know what protected plants, wildlife and communities might be in their forests. Known records of threatened species in and around your PNF area will be provided with your PNF Plan approval and threatened species prescriptions from the PNF Codes must be applied.

When harvesting, keep an eye out for signs of threatened species, especially those that may be sheltering in tree hollows or using particular species in your forest for food. For example, a V-shaped mark on a tree could show where a glider has been feeding, or scratches could have been left by a koala.

**PNF Codes:** Harvesting is not allowed in high-value habitat areas such as rocky outcrops, wetlands, heathland, old-growth forest and rainforest. Threatened species or communities can be found in many forests and the PNF Codes outline how to manage this, including exclusion and buffer zones or additional tree retention requirements. You may need the help of experts to identify species and communities. Assistance and advice on how the PNF Codes apply is available from LLS.


**Figure 10:** Variable retention – aggregated

# 4.4 Habitat maintenance as part of a harvesting operation: Variable retention

As well as maintaining habitat connectivity across a landscape, steps can be taken as part of harvesting operations to support the long-term retention of forest structure, ecological function, species and habitat types in a post-harvest forest. The method can be approached in three ways: dispersed, aggregated and mixed retention.

Dispersed retention focuses on retaining individual or small clumps of trees with associated undisturbed understorey. Aggregated retention keeps larger patches of unharvested forest with the goal of supporting successful regeneration and maintaining structural/biological diversity and productivity. For the best chance at success through aggregated retention, stands need to be big enough to include all the site's different characteristics or species, usually more than 10 ha. To meet ecological and productivity objectives, 75% of the planned harvest areas should be within two tree lengths of an aggregated patch of retained forest. Mixed retention is a combination of dispersed and aggregated retention.

The use of variable retention should be considered within the context of applying the most appropriate silvicultural harvesting systems (see Chapter 12.3) for your forest.

# 4.5 Monitoring biodiversity

Monitoring before and after forest operations will allow you to track and measure if you have met your biodiversity goals. By keeping track of the impact of operations, you gain critical insights into whether or not your forest management plan is working and can then adapt your processes to better meet your objectives. Biodiversity priorities can be monitored either directly within a forestry operation or as part of a regional monitoring program.

As with biodiversity planning, monitoring takes place at several scales, as some species are only found in a local area, while others are spread out across the state, and some communities will travel only a few hectares compared to others that range much further.

The impact of broader scale events means information from beyond the farm gate is necessary, allowing different management regimes to be compared. For example, drought events may affect flora and fauna across a region, regardless of management. By partnering with regional monitoring programs, landholders can demonstrate how their forest management practices contribute to regional biodiversity and learn more about the plants and animals in the area.

Monitoring allows forest managers to evaluate, learn from and improve practices. Biodiversity monitoring should:

- Monitor objectives at appropriate scales within the forest area
- Use field measurements repeated at appropriate intervals
- Provide status and trend information on the objectives
- Determine if management actions have met, or are working towards meeting, the biodiversity objectives
- Provide early warning signs if changes should be made to the forest management to meet the biodiversity objectives
- Provide information for how forest management can be more effective.

### 4.5.1 Regional and local monitoring programs

LLS or local research organisations can help landholders find planned or ongoing local and regional monitoring programs. Forest managers can then use information from these programs to confirm that their biodiversity objectives and targets are being met.

Many volunteer organisations, like Birdlife Australia, collect data from the public in citizen science programs. Forestry Corporation NSW and the NSW National Parks and Wildlife Service conduct monitoring programs and the data from these programs is available on NSW BioNet.

If you decide to conduct your own biodiversity monitoring independently, it is recommended that you consult a qualified expert to ensure that monitoring is scientifically sound and that you use the right equipment which is correctly calibrated. Your local Private Native Forestry Officer may be able to provide advice on who to contact.

**PNF Codes:** As a forest manager or landholder, you should record your biodiversity priorities, objectives and monitoring activities in your Forest Management Plan.

# Identifying and managing Aboriginal values in a forest

# 05

Aboriginal cultural heritage is irreplaceable and is key to sustaining the knowledge and values of Aboriginal peoples. It is important that Aboriginal objects, places or sites are identified and protected. Action must be taken to minimise damage and harm during all forest operations and activities, including fire management, timber harvesting and any track and road works.

Aboriginal cultural heritage is protected under the *National Parks and Wildlife Act 1974*. Heritage NSW provides information on identifying, registering and protecting sites. Requirements for managing Aboriginal cultural heritage for landholders are outlined in the PNF Codes.

Aboriginal peoples are central to identifying cultural values and how to maintain and protect them. This is fundamental to understanding Aboriginal values as part of the cultural landscape. Aboriginal peoples can also provide important insights into effective sustainable forest management based on thousands of years of Aboriginal knowledge and science.

The following practices ensure good forest management.

### Protect Aboriginal objects, places, sites and practices

- Identify and protect Aboriginal objects and places as required by the *National Parks and Wildlife Act 1974* (see further information on the Heritage NSW website).
- Identify whether other sites of cultural value are present or likely to be present.
- Consider and mitigate any possible harm to Aboriginal objects, places, sites and practices from planned forest management activities.
- Make sure any contractors are aware of their obligations.
- Consult the Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales, available from DPE's Environment and Heritage Group, to ensure due diligence in protecting Aboriginal objects from the impact of certain activities.

**Beyond the *National Parks and Wildlife Act 1974***

There are many listed Aboriginal objects and places protected under the *National Parks and Wildlife Act 1974* and many not protected under the Act but listed on the Aboriginal Heritage Information and Management System (AHIMS). Best practice forest management should identify and protect all sites of cultural value, even those not listed under the Act or on AHIMS.

### Protect Aboriginal knowledge

- Respect confidentiality about the location and details of Aboriginal objects, places, sites and knowledge shared by Aboriginal peoples.
- Refer any requests for information to the relevant Aboriginal knowledge holders.
- Respect the needs and interests of Aboriginal peoples.
- Aboriginal knowledge is Indigenous Cultural Intellectual Property (ICIP), and sharing of that knowledge does not give ownership to a third party. When engaging with Aboriginal communities where knowledge is being shared, an agreement should be entered into that protects ICIP rights.

### Provide access for cultural access

- Provide access to animal and plant species sought for food or for medicinal purposes.
- Provide access to areas of cultural value in forest.
- Communicate genuinely with appropriate local Traditional Owners, Elders, knowledge holders and community representatives
- Explore opportunities to work together to support Aboriginal access and practices and share effective sustainable forest management practices based on Aboriginal Knowledge and science.

As a forest manager, you must record any cultural heritage and management actions in your Forest Management Plan.

**For further information, contact your local Private Native Forestry Officer at LLS.**

# Fire management

# 06

## Well adapted to the forest, most eucalypt species can survive intense fires. As a normal part of forest ecology in Australia, fire must be managed by landholders.

You can use managed fire as a tool to:

- Reduce fuel loads and the risk of severe wildfire
- Promote regeneration
- Control pests and weeds
- Manipulate or maintain the forest understorey and habitat features.

Clear goals and objectives will guide your approach to using fire as a management tool in your forest. A professional fire practitioner, or initiatives like the Hotspots Fire Project, may be able to assist you in meeting your objectives. There is information available on the benefits and use of controlled burns in forests, including how cultural burning practices can protect biodiversity and ecosystems.

An important part of Aboriginal culture, fire has been used in land management by Aboriginal people in Australia for thousands of years.

Increasingly, cultural burning practices are being used in broader Australian fire management due to its many benefits, including:

- Ecological outcomes
- Increasing landscape resilience
- Hazard reduction
- Asset protection
- Community engagement.

Aboriginal fire practitioners can and should be consulted for guidance on cultural burning.

The NSW Rural Fire Service (RFS) provides information on how to safely and effectively manage a controlled burn and what approvals are required.

# 6.1 How fire influences regeneration

Some tree species rely on fire to trigger a regeneration event. These fire-dependant species can be split into the following categories.

### Obligate resprouters

- Dormant buds grow into new shoots after the tree is scorched by fire.
- The location of the buds above or below the ground influences the type of resprouting.
- Species resprout over multiple fires and typically have long, overlapping generations.

### Obligate seeders

- Fire-resistant seed banks germinate after fire.
- Seeds may be stored in the tree's canopy or in the soil.
- Fire typically kills adult obligate seeders and exhausts the seed bank meaning plants grow in groupings of the same age, in line with fire events.

### Facultative seeders

- Regenerate by both resprouting and from seed after fire.

# 6.2 Fire behaviour and regimes

The severity of individual fires varies due to a range of factors, including:

- Fuel load size, volume, arrangement and moisture content
- Climatic conditions, especially temperature and wind
- Topography.

Individual fires impact landscapes differently depending on the fire severity and extent (Table 2). While most eucalypt forests are adapted to fire and can regenerate even after a severe fire event, forest management needs to consider all possible effects of the fire regime.

| Fire intensity | Characteristics and impacts |
|---|---|
| **Low** | Little damage to overstorey trees, with no crown scorch and minimal burn up the bark of the trunk. Groundcover, mid and upper canopies are expected to return to pre-burn levels within two to four years, with no permanent negative impacts to the forest stand. |
| **Moderate** | Trees burned well up the trunk but with limited crown scorch. Can include areas with a mix of low and severe fire patches or areas. |
| **Severe** | Extensive or complete canopy scorching. Can result in extensive regeneration of a new cohort of pioneer, early seral and shade-intolerant tree species. Very hot fires may also impact the soil seed bank, which can reduce some understorey and ground layer species mixes. |

**Table 2:** Characteristics of low, moderate and severe bushfires in Australia

A forest's fire regime is described by characteristics that determine its impact:

- Magnitude – intensity and the area burnt
- Frequency – average time between fires
- Spatial distribution – where the fire is located, which may include many small, isolated areas or large, connected areas
- Randomness – unpredictable in both timing and spatially
- Seasonality – especially as related to breeding or seeding.


**Figure 14:** Important characteristics of a fire regime

Fires impact forest ecosystems in complex ways. For example, prescribed burning can minimise fuel loads and reduce the likelihood of a high-intensity fire until fuel loads build up again. Fire intensity varies across the landscape due to topographic features and weather conditions, which can mean that some areas not burnt or only lightly burnt by one fire event, can burn in a subsequent event only a short time later.

Australian forests are adapted to regular fires. In forests where fires burn every year, an understorey will develop that regenerates rapidly either from protected underground shoots or storage organs (such as grasses or lignotubers), or annuals that can set seed. Plants that require several years to mature and set seed are less likely to grow where there are regular fire regimes.

The spatial pattern of burning can be very important. Areas that don't burn become refuges for animals to escape fire. High-intensity fires burning over large areas can wipe out local fauna populations.

# 6.3 Fire management to avoid adverse impacts

The intensity and timing of a fire regime are key to how it will negatively impact a landscape. For example, if a fire is too hot or too soon after a regeneration event, it can kill growing stock.

Eucalypts of different species will have different abilities to survive higher temperatures. Without enough time between fire events, some species won't be able to set seed for regeneration. Too much time and a species may be overshadowed by other plants and, if it relies on fire, not be able to regenerate. This can change the mix of species in an area, which is very difficult to reverse.

Fire exclusion (preventing both natural and prescribed burning) can have negative impacts that stop you from reaching your forest management goals, such as the goal to maintain a productive and dominant eucalypt forest. It may cause unwanted weed species to grow or the forest may transition from one forest type to another. For instance, wet sclerophyll eucalypt forest can transition into rainforest, where there are long time intervals between fire events.

Prescribed burning is low intensity, including after harvest operations. Most large eucalypts won't be harmed, depending on species tolerance, bark thickness and fire intensity. Lower intensity prescribed burns will also minimise the risks that come with higher intensity fires, such as smoke damage and soil erosion caused by reduced groundcover.

The NSW RFS provides standards and resources for hazard reduction and guidelines for bushfire smoke management, while the NSW National Parks and Wildlife Service has developed a detailed Fire Management Manual. These documents will help you understand what is needed to safely undertake a prescribed burn.

## 6.4 Management of native forests after fire

As a manager of a private native forest, it is unlikely you will need to intervene to assist forest regeneration or re-establish groundcover following low or moderate fire. Many species found in native Australian forests are typically resistant or resilient to this severity of fire, while some need fire for regeneration. Unless there is a considerable change to the fire regime, species should survive the fire and/or regenerate. Canopy cover usually returns to pre-fire levels via epicormic flushing, while soil seed banks of understorey and ground layer species ensure recovery.

Seed banks and regeneration may be affected if there are substantial changes in a fire regime, such as increased frequency and magnitude. A few months after the first significant post-fire rainfall, check the forest function, structure and composition, paying attention to soil surface stability, the presence of regenerating overstorey, mid-storey and understorey species, and the absence of weeds. You may need to intervene, only if substantial connecting areas are showing negative signs.

If you notice forest areas struggling to regenerate after a fire, restricting of grazing with fencing and replacing coarse woody debris may help.

Sometimes localised patches of more severe fire within a moderately burnt area can lead to clusters of badly damaged but still living trees. Careful application of the Australian Group Selection silvicultural method may reduce the impacts of epicormic-based re-crowning and encourage regeneration of shade-intolerant species.

If groundcover or soil stability is impacted by a fire event, take measures to slow sediment movement downslope and into watercourses to limit erosion. Check and repair any damaged structures that slow erosion, such as drains and water crossings, and reintroduce any coarse woody debris or other physical barriers that have been burnt away. Coarse woody debris acts as a barrier to water flow and modifies the micro-environment by reintroducing habitat and assisting regeneration and recolonisation.

## 6.5 Harvesting and non-commercial thinning after fire

Harvesting and non-commercial thinning may be planned and carried out after fires as long as groundcover has re-established and you take appropriate soil stabilisation measures. When planning harvest operations be aware of the following factors:

- How soil conditions have been impacted by fire, considering the underlying soil type, slope and inherent stability of the soil
- The weather conditions surrounding a planned harvest
- The harvesting approach
- The machinery to be used, such as tracked versus wheeled
- Methods that eliminate or reduce potential movement over affected soils and allow for flexible spatial planning are recommended.

Fires can remove forest structural elements associated with biodiversity. Many structural elements, such as litter, logs, and fine and coarse woody debris, can be replaced from the crowns felled and left scattered around the area. As long as levels of both living and dead standing trees exceed an average threshold, they won't need to be replaced and won't significantly impact biodiversity. Habitat trees with hollows or other features have minimum thresholds for retention set by the PNF Codes (see Chapter 4 – Managing habitat and biodiversity).

Extensively fire-damaged trees may continue to live and regenerate extensive crowns, which may impact the regeneration of shade-intolerant trees. Damaged trees are unlikely to produce useful commercial products and internal damage may limit their growth and carbon sequestration. Once habitat tree requirements have been met, it may be appropriate to use Australian Group Selection methods to remove patches of extensively damaged and dead trees. This can encourage the regeneration of a new cohort of productive trees.

Increased frequency and intensity of wildfires in recent years have introduced more uncertainty and highlighted the importance of proactive fire management.

# Pest, weed and disease management

07

A healthy forest is free from disease, weeds and insect infestations that interrupt the forest's ability to function ecologically. Healthy, well-managed forests will grow vigorously and be less vulnerable to pests and diseases. Drought, fire, flood or other stressors can temporarily make forests more sensitive to attacks from insects and diseases, but a healthy forest can recover.

Health issues are often a sign of an ecological imbalance in the ecosystem. A healthy forest can be thought of as proof of successful forest management. Sustainable forest management practices aim to balance forest health and maintain productive capacity of the forest. Landholders must work to control and manage factors and processes that affect forest health, such as weeds, pests and extreme weather events.

While it is not always possible or effective to directly treat symptoms of poor health, there are management actions that improve a forest's resilience to health problems. For example, insecticides can be expensive, risky and don't stop pests from recolonising the forest. Thinning and fire can increase tree growth and vitality, indirectly reducing vulnerability to disease. This chapter explores common forest health problems and some possible management strategies.

### *Biosecurity Act 2015*

Biosecurity is a shared responsibility between government, industry and the people of NSW. Working together, we can protect the economy, environment and community from the negative impacts of animal and plant pests, diseases and weeds. Under the *Biosecurity Act 2015*, landholders must manage pests and weeds on their property. The Act's imposed 'general biosecurity duty' means that anyone dealing with a biosecurity matter must prevent, eliminate or minimise risk as much as possible. Additionally, all known notifiable pests, weeds and diseases, prohibited matter and biosecurity events need to be reported to the NSW Department of Primary Industries (DPI) immediately. Consult LLS for information about your obligations concerning invasive pest and weed management under the *Biosecurity Act 2015*.

LLS can provide advice and direct you to your Regional Strategic Pest Animal Management Plan and your Regional Strategic Weed Management Plan. These plans provide advice on priority pests and weeds in your region, management actions for each species, details of local control programs, and other information for landholders.

It is essential that you take a strategic and proactive approach to pest management, including collaborative planning with other public and private managers.

Remember that native animals are protected under the *Biodiversity Conservation Act 2016*. If you have concerns about native animals in your forest, you will need to consult with the NSW Department of Planning and Environment (DPE). LLS can provide initial guidance.

## 7.1 Pest and weed management

After a harvesting or natural disturbances, pests and weeds can easily spread into unoccupied areas of the forest. Once established, weeds are difficult and expensive to control. When planning forestry operations, always consider pest and weed management.

General strategies for managing pests and weeds in forest areas include:

- Clean machinery and personal vehicles before entering different forests so that weeds and diseases are not transferred from one property to another.
- Be aware of weed locations and, if necessary, control access to reduce spread.
- Consult LLS for guidance on large pest animals as baiting or trapping programs may be running in your area (see Chapter 7.2 for information on the use of baits in forest areas).
- Make sure any pesticides or herbicides are handled correctly (see Chapter 7.2).
- Fire is the most cost-effective tool for managing pests and weeds within a forest. Frequent controlled, low-intensity fires can reduce the understorey that can hold increased soil moisture and related soil-borne pathogens. Some native species need fire to regenerate and if this regeneration does not happen the forest area may be invaded by weeds (see Chapter 6 for more on fire management).
- Use thinning to decrease competition between trees. This reduces stress and associated sensitivity to disease (see Chapter 10 – Tree growth and development).

For information on pests and weeds specific to your region and forest, contact LLS. DPI's NSW WeedWise archive profiles hundreds of species of weed, including detailed descriptions, control methods (including recommended herbicides) and duties under the *Biosecurity Act 2015*.

**Figure 15:** Lantana

### 7.1.1 Lantana

Lantana is a persistent, widespread and common weed found throughout NSW. It is listed in the state's Regional Strategic Weed Management Plans as a priority for asset protection, placing the focus on ensuring lantana does not impact important assets.

Lantana is a dense plant that smothers native plants and produces biochemicals that hinder growth (a biological phenomenon known as allelopathy). Lantana can significantly change forest structure and fauna habitat and can increase the intensity of wildfires. Lantana is poisonous to humans and livestock if eaten and is linked with bell miner associated dieback (see Figure 16).

Lantana likes warm, humid environments but can survive long droughts and frost by temporarily shutting down and losing its leaves before reshooting from its base following rainfall. It favours disturbance and will grow in forests after harvesting. A single plant can produce up to 12,000 fruit a year and their seeds can remain viable for up to five years in dry conditions.

Lantana seeds and plant parts are spread by:

- Birds and other animals that eat the fruit
- Water
- Soil on machinery
- Garden waste.

Lantana also spreads vegetatively, meaning stems that have been cut can take root and grow when they touch soil.

Herbicides can be sprayed on leaves, applied by splatter gun and swabbed onto stems or cut stumps. Biological control agents have had some success in reducing lantana infestations, however other control methods are still needed. The plant must be actively growing for herbicides or biological control agents to work, meaning management can be ineffective during lantana's temporary dormancy in dry periods or after frost.

Mechanical control techniques, like removing by hand, can be effective and can encourage native regeneration. Be careful not to harm native vegetation and follow up to check that soil and groundcover have not been badly impacted.

Fire does not kill lantana but can reduce its height and density, so only use fire with a follow-up treatment.

For more on lantana, see WeedWise.

### 7.1.2 Bell miner associated dieback

Bell miner associated dieback (BMAD) is a complex ecological condition that degrades forest health and causes tree death. BMAD occurs in several eucalypt forest types between Victoria and southern Queensland. It is a key threatening process under the *Biodiversity Conservation Act 2016*, meaning it adversely affects threatened species and ecological communities.

Eucalypt health is impacted by BMAD when:

- Bell miners (also known as bellbirds) protect sap-sucking psyllid insects from other predators for a ready food source
- An overabundance or infestation of psyllids builds up in the forest canopy
- Too many psyllids leads to defoliation, dieback and death of trees.

Forests affected by BMAD become increasingly degraded. A dense understorey full of lantana and other weeds, or that has developed due to infrequent fire, provides habitat for bell miner colonies and makes BMAD worse. The loss of canopy density creates ideal conditions for increased understorey development and high-quality nesting sites, increasing bell miner populations, and resulting in a feedback cycle.

A control strategy for BMAD can include:

- Monitoring the impacts
- Weed control measures to minimise nesting sites for bell miners
- Rehabilitation of the site
- Removing bell miner populations.

For more information on identifying and controlling BMAD in your forest, contact your regional LLS office.

**Figure 16:** Bell miner associated dieback

**Figure 17a:** Baccharis Halimifolia Groundsel Bush in flower

Image by © Kempsey Council, NSW

**Figure 17b:** Groundsel Bush Infestation

Image by B. Trounce, NSW DPI © State of New South Wales

### 7.1.3 Groundsel bush

Groundsel bush is a densely branched shrub found in warm, humid subtropical regions and disturbed areas such as coast swamps, degraded pastures and forests, including pine plantations in NSW and Queensland. It is poisonous to livestock.

Groundsel bush grows rapidly, often forming a canopy faster than the forest species, stopping the growth of native species. The shrub produces large amounts of windborne seeds which germinate easily and can spread through water, agricultural produce, soil and machinery. Groundsel bush may spread into open or poorly developed forest areas after harvesting, when canopy cover is low and soil is disturbed.

Control measures include mechanical control, management of stocking rates on healthy pasture, machine wash down procedures when moving from affected to non-affected areas, and reafforestation through good forest management methods.

Some parts of NSW are considered grounsel bush exclusion zones and core infestation areas. In these locations, you must destroy the weed, notify Local Control Authorities of outbreaks, mitigate the risk of new weeds being introduced and monitor for changes in current spread. See WeedWise or your LLS Regional Strategic Weed Management Plan for more information and for requirements in your area.

**Figure 18:** Tropical soda apple

### 7.1.4 Tropical soda apple

Tropical soda apple is an aggressive, prickly and persistent shrub that is 1–2 m tall. It invades open to semi-shaded areas including pastures, forests, riparian zones, roadsides, and recreational, horticultural and cropping areas.

Tropical soda apple reduces biodiversity by displacing native plants and disrupting ecological processes. The shrub's thorny thickets form a physical barrier to animals accessing shade and water. It is a host for many diseases and pests of cultivated crops and contains solasodine which is poisonous to humans.

Tropical soda apple can float and move in water, and cattle often eat the fruit and spread seed via manure. It is extremely fast growing; if not controlled, a few plants can form a hectare-sized thicket within six months. Each plant can produce 150 fruit per year, each containing 45,000 seeds.

The eradication of tropical soda apple is a state-wide objective. If you find tropical soda apple on your property, immediately contact your local council weeds officer or the NSW DPI Biosecurity Helpline for advice on how to control it. Tropical soda apple is often spread via stock, so landholders should hold cattle and horses in a paddock that can be easily inspected for weeds for at least six days. The paddock should be regularly inspected for growth over several months. Check your land regularly, especially during spring and summer when the plant is more likely to grow. If found, the plant needs to be killed before two months' growth to prevent fruit and seed regeneration.

Options for controlling tropical soda apple may include physical removal, fire management or treatment with herbicides. Dispose of plants and seeds carefully so that reshooting from stems or seeds is not possible. Herbicides will only kill the plant and not the seeds.

For more on tropical soda apple, see WeedWise.

### 7.1.5 Wild dogs

Found throughout NSW, wild dogs can be a threat to forest biodiversity because they spread disease and prey on native fauna. Wild dogs are a threat to livestock, pets and, in some cases, humans.

Effective wild dog management requires a strategic and proactive approach, including collaborative planning between public and private land managers. This usually involves mapping areas affected by wild dogs, recording attacks on livestock, and the use of dog-proof fences.

Other options for controlling wild dogs include poisoning with 1080 baits, trapping with soft jaw leg holds, shooting or GPS tracking.

Contact LLS for advice and information on wild dog management, and refer to the NSW Wild Dog Management Strategy. For information on the use of 1080 baits in forest areas, see Chapter 7.2 – Chemical use.

**Figure 19:** Wild dogs
Local Land Services

### 7.1.6 Blackberry

Blackberry is one of Australia's worst forest weeds. A prickly, scrambling shrub with dark coloured berries, it can quickly infest a large area, forming dense thickets. Blackberry thrives in temperate climates with a warm summer and cool winter and an annual rainfall of at least 700 mm. It may also grow in drier climates if it has access to water, but it does not like heavy shade.

**Figure 20:** Blackberry
Image by K. Blood © Department of Primary Industries, Victoria

Blackberry reduces the native habitat for plants and animals, while providing shelter for other introduced pest species such as rabbits and foxes. Seed production is prolific; there can be up to 13,000 seeds/m$^2$ under a blackberry bush at the end of a fruiting season, with seeds spreading via birds and animals feeding on the berries, or through movement of water and soil.

Blackberry control requires a combination of methods. While physical removal is essential for access to the land, the roots are difficult to remove, so you should also use herbicides. Spray herbicides on the outer and inner leaves of healthy, actively growing plants. Try to catch it early, as first-year blackberry plants are easier to eradicate than well-established thickets which may need multiple treatments. There are many varieties of blackberry and some are more resistant to certain herbicides than others, so correct identification is needed. Biological controls or some grazing species can be effective, as long as they are compatible with your broader forest management goals.

For more on blackberry, see WeedWise.

### 7.1.7 Privet

Privet is a serious environmental weed found throughout Australia. It grows as an evergreen shrub or small tree (4–10 m tall) and prefers warm, humid environments with moderate to high soil moisture. Privet can invade ecosystems including:

- Subtropical and coastal rainforest
- Rainforest margins
- Warm-temperate and dry rainforest
- Wet and dry eucalypt forests
- Grassy woodlands
- Grasslands
- Riparian vegetation.

When it invades native forests, it reduces wood yield.

Privet is commonly spread by fruit-eating birds, flowing water, or the sale of garden plants. Spread by birds and water cannot be controlled, so it is important to remove young seedlings and trees before they can produce seeds. The disturbance of removing the plants can lead to reinfestation, so you will need to revegetate quickly.

Regardless of the chosen control technique, the cost of managing privet is high. The main methods to control privet are:

- Manual removal, which is suitable for small to medium-sized plants. Broad-leaf privet can be pulled out easily, however small-leaf privet needs to be dug out and the plants placed upside-down to dry out the roots.
- Mechanical removal, which is useful if there is a large infestation and the soil disturbance can be tolerated. However, this will only reduce seedling capacity, and will not eradicate the plant.
- Herbicides, which can be applied by either foliar treatments, basal bark applications, or stem injections. If whole trees are removed by being cut out, the cut stumps must be treated to prevent regrowth.

For more on privet, see WeedWise.

**Figure 21:** Privet – 16531

# 7.2 Chemical use

While many weed and pest issues can be managed using fire, mechanical methods or trapping, the management of these issues will often require the use of chemicals. Before turning to chemicals, always consider alternative methods (biological control agents may also be available – see DPI for more). Where it is unavoidable, chemical use should be minimal to reduce the risk of any adverse impacts on the environment and human health.

The use of chemicals such as pesticides, herbicides and fertilisers in forest operations must follow the relevant legislation, guidelines, and product use and safety instructions.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) controls the registration and conditions of use for all pesticides and herbicides in Australia. If you need to use a pesticide or herbicide in a way not directed on the product label, you will need a permit from APVMA. DPI provides information on your legal responsibilities in applying pesticides.

You may be required to complete regular compulsory pesticide training; information can be found on the NSW Environment Protection Agency (EPA) website.

The use of any chemicals should be documented in your Forest Management Plan in a chapter on pest and weed management. Include a record of the chemical used, why it is being used, a site and boundary description, and the rate and method of application.

Contact your regional LLS office for advice on chemical use in your forest operation.

### *Non-target species*

Chemical use in forest operations can have a negative impact on species that aren't the target pest you're trying to remove. You should assess which species are in the target environment and how they might be harmed by any chemical use according to the advice on the label or by contacting the manufacturer. Consider other options, such as fire management (see Chapter 6), which may be less harmful to non-target species.

### *Chemical drift*

Droplets of a sprayed chemical can easily be blown by wind into areas you aren't trying to target, such as neighbouring properties. There are a few things you need to do to minimise the risk of this chemical drift. Identify any sensitive areas nearby and establish a buffer if necessary. Check the weather and avoid spraying in the following conditions:

- Variable or gusty winds (ideal wind speeds are 3–15 km/h)
- Fog, dew, frost, smoke, dust hanging in the air
- Temperatures above 30°C with low humidity.

Always use the right equipment for the environmental conditions, as recommended by the manufacturer, and only apply the recommended amount of chemical. Nozzles must be calibrated to spray the correct droplet size.

DPI provides more information on reducing chemical spray drift.

### *Watercourses and drainage features*

Many forest operations have drainage features that lead into natural waterways. When using chemicals close to watercourses and drainage features, you must be careful not to contaminate nearby water supplies.

Some chemicals are specifically approved for direct use on or near waterbodies, or you can consider techniques such as wick-wiping (direct application to weeds) and spot or shrouded strip application. Buffer zones should be used around watercourses and drainage features to avoid the risks of chemical run-off.

### *Work, health and safety*

Be aware of your work, health and safety (WHS) requirements when it comes to chemical use. In NSW, anyone responsible for applying pesticides as part of their work must be certified and undergo a compulsory training course (see the EPA for more).

Key things to remember:

- Always properly store, label and transport chemicals to avoid accidental spillage.
- Only prepare, mix or dilute chemicals in low-risk, hazard-free environments.
- Always use personal protective equipment when preparing, applying and cleaning up from chemical use to avoid inhalation, skin contact or ingestion.
- No one should enter the target area without protection for at least 24 hours after application or until the chemical has dried.

### *Incidents*

If an incident occurs and there is an immediate threat to human health or the environment, call 000 and help the authorities to control and contain the incident. If an incident happens, such as a major spill, where there is not an immediate threat, contact the EPA on 131 555.

### *Prohibited chemicals*

Chemicals which have been classified by the World Health Organization as Class 1a and 1b pesticides cannot be used in a PNF area unless they are legally approved for use under certain conditions.

Commonly known as 1080, sodium fluoroacetate is a Class 1a pesticide which you may need to manage pest animals on your property. You'll need to develop and implement a management strategy to minimise the amount of 1080 you use. You can only get 1080 from a registered Authorised Control Officer employed by a NSW public authority. No other Class 1a or 1b pesticides should be used in PNF areas.

Australia is part of an international environmental agreement – the Stockholm Convention on Persistent Organic Pollutants – which means several other chemicals are also banned in PNF operations. The APVMA regulates the availability and use of pesticides in Australia to ensure we meet our international obligations. Many banned pesticides were used in older generation products that were once cheaply available and may now have been de-registered for use in Australia.

Forest certifications, such as Responsible Wood (formerly the Australian Forestry Standard), also have strict standards for chemical use. For example, you cannot use pesticides which accumulate in the food chain, such as chlorinated hydrocarbons.



# 7.3 Fertilisers

Most native forest species are adapted to the nutrients in local soils, meaning fertilisers aren't needed and are rarely used in native forests in Australia. Fertiliser can also be difficult to apply to just a target species, making it inefficient and costly. However, fertilisers can be useful when you need rapid early growth of replanted native species, such as when revegetating degraded sites. Where soil is degraded, it might be more efficient to plant a nitrogen-fixing native species which supports growth, such as acacia.

You must have a justified reason for using fertiliser and take the necessary steps to eliminate or minimise adverse impacts. This should all be recorded in your Forest Management Plan.

Follow any instructions and guidelines for application of the product to ensure fertiliser is used where it is intended and to minimise negative impacts. For example, when replanting tree seedlings, bury a small amount of fertiliser directly next to the seedling root ball. By burying the fertiliser, you reduce the risk of runoff and damage to waterways, while maximising use by the tree and promoting rapid early growth.

The impacts of fertiliser on water quality in waterways are similar to that of cattle and runoff after a fire. As outlined in the PNF Codes, you can minimise these risks with protective buffer and exclusion zones.

# Forest management, carbon and climate change

# 08

In forests, as in all ecosystems, carbon is exchanged between land, water, the atmosphere and living things. During photosynthesis, forests remove carbon dioxide ($CO_2$) from the atmosphere and store the carbon as wood, other plant tissues and in soil. This highly effective process is called carbon sequestration and the stored carbon is known as carbon stock. Approximately half the dry weight of a tree is carbon.

You can maintain or increase carbon stock in your forestry operation through good carbon and fossil fuel management practices, which can also help lower fuel costs and increase forest growth for better efficiency and profits.

Sustainable forest management with harvesting can help reduce the net production of carbon to the atmosphere each year. Carbon stock harvested as logs can be stored in timber long-term, while more carbon is removed from the atmosphere as the forest regrows.

A collaborative project between the NSW DPI, CSIRO and state forest agencies in NSW and Victoria studied the long-term average reduction of net greenhouse gas emissions in forests where harvesting or conservation were the primary management objective. Forest harvesting produced a greater reduction in emissions than conservation approaches in most scenarios, in particular, when there were alternative options for using or removing forest products, like converting biomass to energy or recycling wood products. However, the study also noted ways forestry operations needed to improve greenhouse gas outcomes, including by reducing wastage, and increasing recovery, carbon storage in hardwood forest products, and the use of wood biomass to produce energy (see Forest & Wood Products Australia for the full study).

# 8.1 Management to minimise net carbon emissions

Forest management objectives can be designed to reduce emissions during operations and in the timber supply chain, if you consider the ways carbon is sequestered (see Figure 22).

Forest regeneration is critical. A vigorously growing young forest rapidly sequesters carbon until carbon stock reaches the levels of a mature forest. Improving the productive capacity of the forest majorly increases carbon stock. You can delay the release of $CO_2$ that would otherwise be released from rotting or burning wood, by harvesting wood products (see Chapter 11.3.2 – Timber products).

You can reduce the risk of releasing large amounts of carbon through fire management practices that reduce severe bushfire risk, as severe bushfires can contribute up to 25% of Australia's annual carbon emissions.

You can reduce fossil fuel use in forest operations by minimising the length of snig tracks and roads in your forest. This will mean less machinery used for clearing and reduced impacts from commuting between operations.

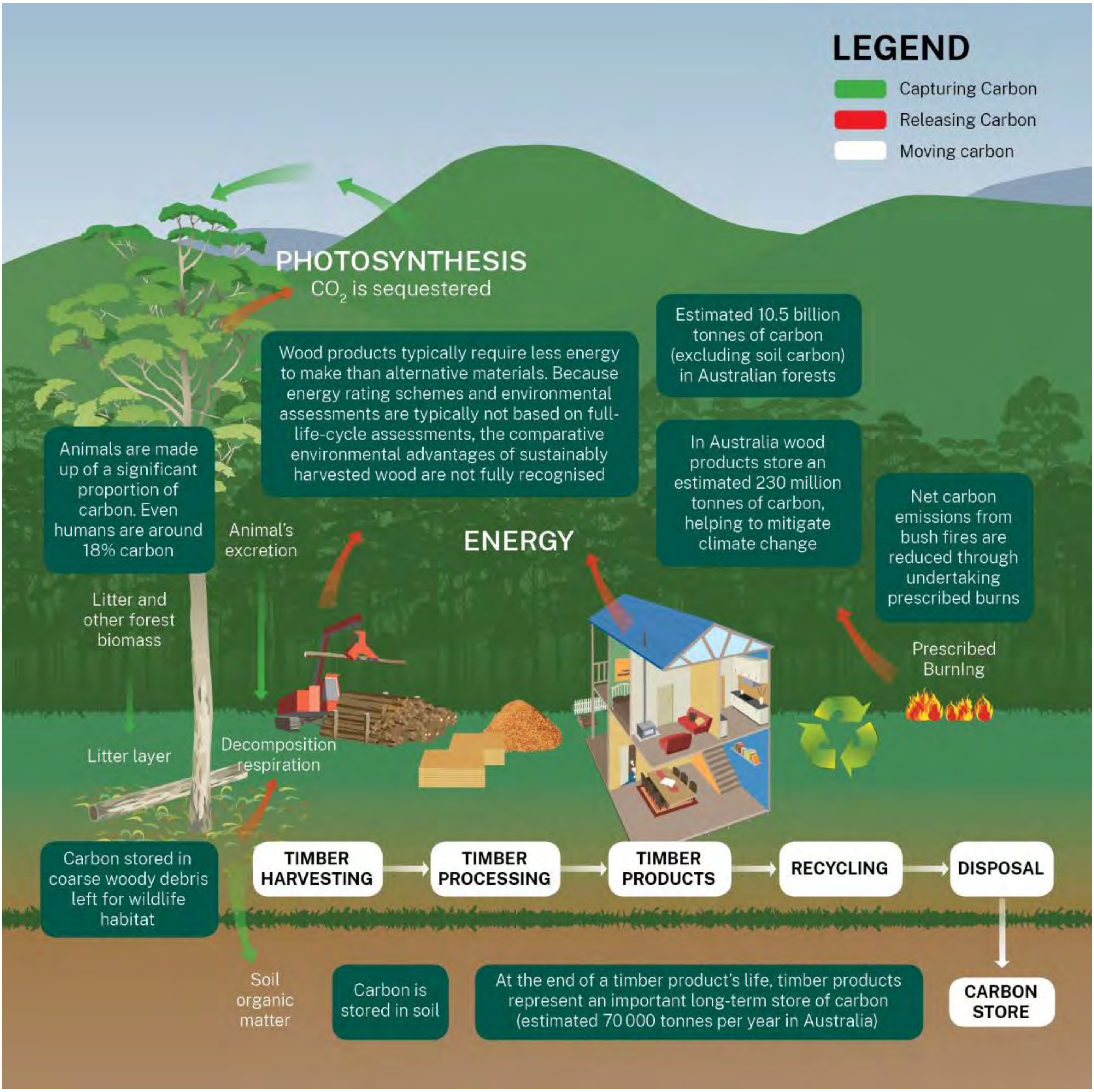



**Figure 22:** Forest carbon cycle

You can help maximise carbon storage through certain choices along the timber supply chain. Carbon can be stored for a long time in timber products that have a long-term use. When wood products replace concrete or steel, both of which require a lot of energy to manufacture, net emissions are reduced. Consider how you manage residue and waste. Mills that utilise residues for products, rather than burning for residue disposal, will store carbon longer. Mills that burn waste for energy will offset the use of fossil fuels for energy and therefore offset the release of carbon. Alternatively, waste wood stored in landfill takes a long time to decompose, emitting less $CO_2$ than if burnt.

**PNF Codes:** If your forest management practices follow the PNF Codes, your operations are likely to result in equilibrium or a net increase of carbon stock. While working to increase carbon stock through your forest operations, you should also consider ways to maximise overall reduction of net greenhouse gas emissions through the market supply chain (see Chapter 11).

### 8.1.1 Calculating carbon estimates

Estimating how much carbon is in a forest can be complex, so many landholders work with experts to calculate the amount. Alternatively, there are tools available online that can help, such as:

- Forest & Wood Products Australia's Spotted Gum Productivity Assessment Tool (SPAT)
- The Forest Stewardship Council's Forest Carbon Monitoring Tool.

As these tools continue to improve, they help us to understand how carbon can be managed in forests and how effective forest management actions are in balancing carbon stocks over time.

## 8.2 How can forests be managed in a changing climate?

A difficult issue for forest managers is how forests will be affected by climate change. Occuring over longer time frames, climate change is difficult to distinguish from normal climate variations. It can be seen in the increase of severe weather events such as the drought and subsequent fires across south-eastern Australia in 2019–2020.

For forest managers, the likely greatest impact of climate change will be more frequent or intense wildfires. In Chapter 6, we discussed how changes to fire regimes can impact your forest and how you can manage risks. In general, thicker bark can improve a tree's ability to survive fire. You can increase bark thickness by rapidly increasing tree sizes with techniques such as thinning.

Rainfall and temperature changes related to climate change may impact the types of plants and animals found in your forest. Species which are only found in a small area or in specific conditions may be the most vulnerable. Be aware of the species in your forest and any changes over time, and speak to an expert if you have concerns. See Chapter 13 for techniques for ensuring tree regeneration.

# Water and soil management

# 09

## Effective forest management can have a positive influence on the quality and quantity of water on your property.

Water quality can be affected by any activities that disturb soil and encourage erosion, such as creek crossings and disturbance too close to waterways. Increased nutrients and light can lead to algal growth which also affects water quality.

Harvesting operations or wildfire that reduces canopy reduces evapotranspiration, which means increased stream flow and water yield. If the canopy is just burnt (but trees are not killed or removed completely), the effect will be very short term as regrowth will return leaf area and canopy quickly. To understand the impact of harvesting on water yield, consider changes in the basal area as a good indication of changes in the canopy, resulting in reduced evapotranspiration. Continuous cover harvesting techniques, such as single tree selection, can lessen these impacts.

During harvesting, soil is compacted, which can lead to increased runoff. Compacted soil is slower to soak up water, and has higher bulk density and less cavities and preferential pathways through it. Soil quickly gets saturated, resulting in increased overland water flow.

The increase in water yield after harvesting usually only lasts three to 10 years. Once a forest has regenerated it grows rapidly and rebuilds crown volume and leaf area. Evapotranspiration then increases and water yield returns to pre-harvest levels.

Changes in water yields after harvesting depend on site-specific variables including:

- Climate
- Location and spread of forestry operations within the catchment
- Distance from a river or stream
- Soil conditions
- Species composition
- Forest age
- Type and intensity of harvesting, including total basal area harvested.

Areas that receive a lot of rain will see the greatest increases in water yield after harvesting, sometimes experiencing a 25% increase in streamflow, which then gradually declines and returns to pre-harvest levels.

When planning forestry operations, you should consider how you can minimise the potential impacts of harvesting on water yield and flow. Under the PNF Codes, clear felling is not permitted. Under the PNF Codes, the retention of exclusion areas and trees mitigates the impact of harvesting on water yields.

The expected reduction in water yield during the regrowth phase can be improved to a minor extent through thinning.

You should minimise impacts on water quality by avoiding unnecessary disruptions of soil and plants next to waterways, minimising the number of crossings needed, and avoiding activities that cause erosion.

**PNF Codes:** Following the PNF Codes will help you effectively manage water in PNF areas. Protections for drainage features include riparian exclusion zones and conditions for the construction and maintenance of roads and crossings. Other key features include minimum harvesting standards, and the mandated retention of habitat trees, feed trees, rainforest, and old growth forest. The PNF Codes ensure that changes to hydrological flows and water yields are minimised. Consider conducting advanced management and planning to lessen soil compaction. You can do this through directional felling techniques and by minimising access tracks, snig tracks and log landings.

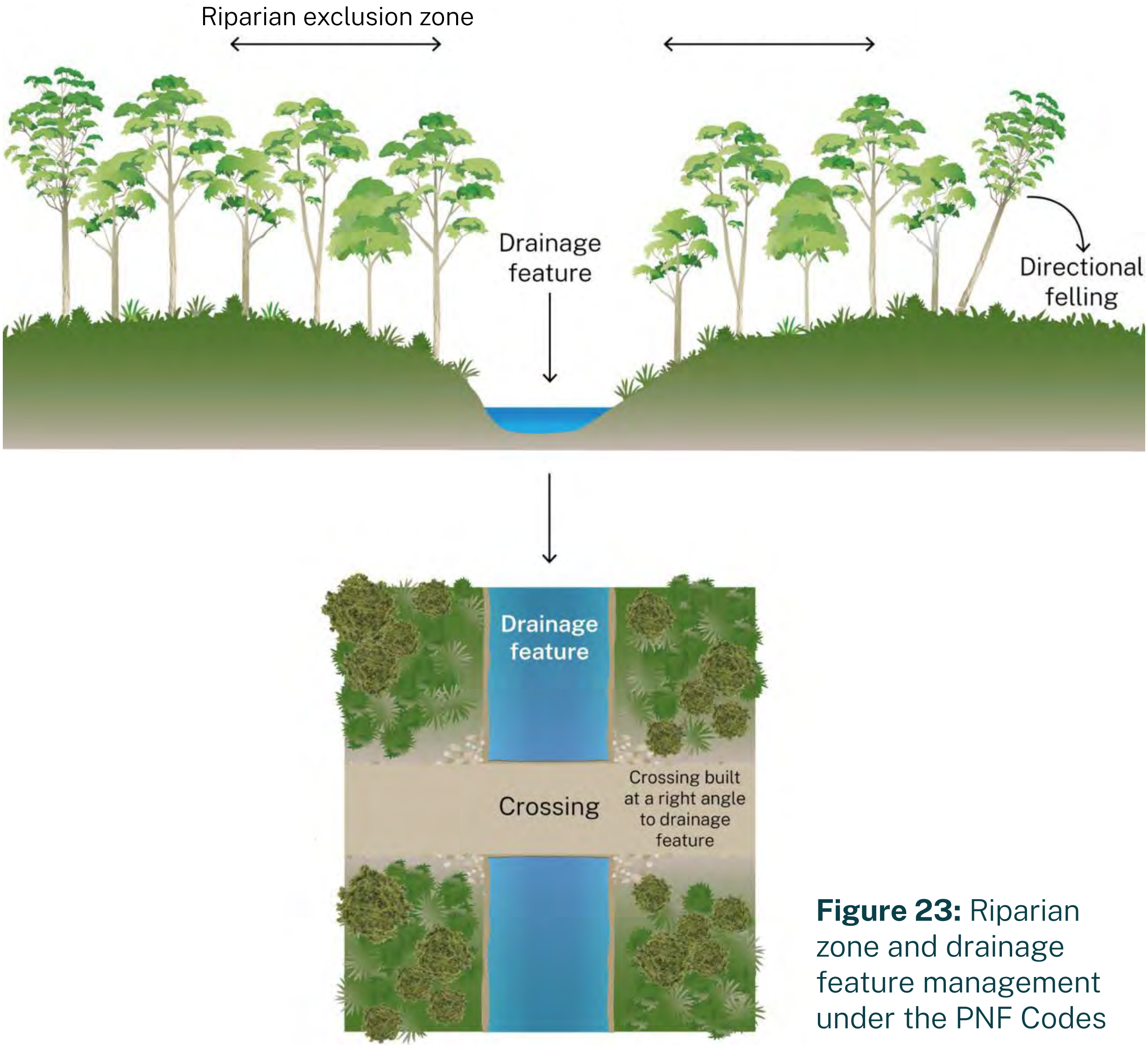



**Figure 23:** Riparian zone and drainage feature management under the PNF Codes

## 9.1 Catchment management

Across NSW, local councils include water catchments in their Local Environmental Plans (LEPs). Councils have a list of considerations for any forestry activities requiring development consent within drinking water catchment areas. Currently, the only declared catchment area in NSW is the Greater Sydney drinking water catchment. See WaterNSW for information on how to manage properties in the Sydney catchment area.

# Tree growth and development

# 10

## 10.1 Growth stages

There are four recognised growth stages of a tree: sapling, pole, mature and over-mature.

### Sapling

Once a seedling is established, a main stem develops quickly. During this phase of rapid height growth, the lower branches will continually shed, and the crown will remain small and compact.

### Pole

Height growth starts to slow down and continues at a slower pace than in the sapling stage. The lower branches stop shedding and grow longer, and this deepens and broadens the crown. The tree starts to rapidly grow in width.

### Mature

When it is nearly fully grown in height, the tree enters the mature stage. Smaller, lateral branches grow on the existing branches, expanding and filling in the crown for a more complex structure. The tree continues to grow in width, but hollows have not formed yet.

### Over-mature

After 80–100 years or more, depending on the species, fungus weakens the inside of the tree's trunk and branches, causing larger branches to fail. New branches may develop close to the trunk but they aren't as healthy or efficient as the branches of the crown. Branches may break and regenerate several times as the tree ages. Over-mature trees are known as as 'senescent' and may live many hundreds of years. Wildlife habitat hollows are found in these over-mature trees.

# 10.2 Stand development and resource competition

Trees compete for resources including light, nutrients, and water. As a forest stand develops and trees compete for space, some trees will grow faster and taller and begin to overshadow neighbouring trees. Some species are better suited to handle competition than others. Eucalypts are typically shade intolerant, meaning they may struggle to grow and regenerate when shadowed by forest canopies.

In silvicultural operations, spacing of trees must be planned to provide enough light and space for all trees to maximise growth potential.

## 10.2.1 Crown class

In a forest, competition for light is asymmetrical or uneven, as taller trees capture most of the light at the expense of smaller trees. In a shaded tree canopy, growth is limited by what light is available. Trees within a developing stand can be classified into crown classes, which reflect how much light the tree receives, its competitive position in the canopy, and its growth rate.

As some trees become taller and shade neighbours, competition for light will cause eucalypt trees in the stand to separate into crown classes (Figure 24). Crown classes also develop because eucalypts are crown shy; the tips of a eucalypt are sensitive to any sort of damage, such as where crowns touch each other in the wind. Crown shyness causes small trees to bend away from large trees, and overshadowed trees to not grow as high as they should. This is why overlapping or interlocking crowns are uncommon in eucalypt forests.

| Crown class | Crown competitive position |
|---|---|
| **Dominant** | Receives light from above and sides |
| **Codominant** | Receives light from above and some sides |
| **Subdominant** | Receives light only from above |
| **Suppressed** | Overtopped by other trees |

**Table 3:** Crown class definitions

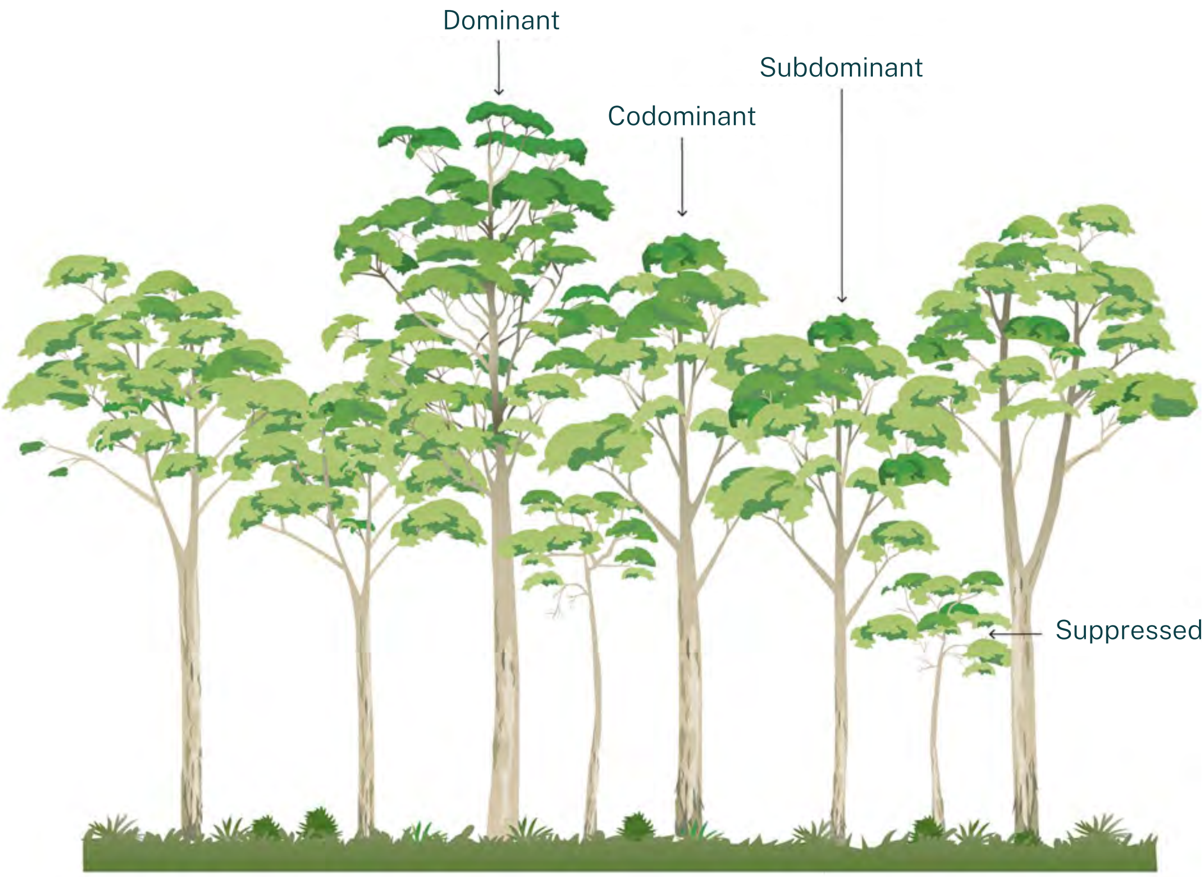



**Figure 24:** Diagram of crown classes

### 10.2.2 Growth restriction

The most intolerant eucalypt species can die when they become subdominant or suppressed. More tolerant eucalypts and tolerant non-eucalypt species may survive as suppressed stems with very small canopies and low growth. These suppressed trees are referred to as growth restricted (Figure 25).

Growth-restricted trees often have less foliage than expected for their height and width. As foliage drives growth, this can make it hard for these trees to grow even if they are no longer competing for light. It is possible for a small tree to be relatively old.

When planning silvicultural practice, you must remember that trees of the same size are not necessarily the same age or have the same growth potential. A tree's growth potential is best judged on crown characteristics. Large, dense crowns provide the basis for growth.

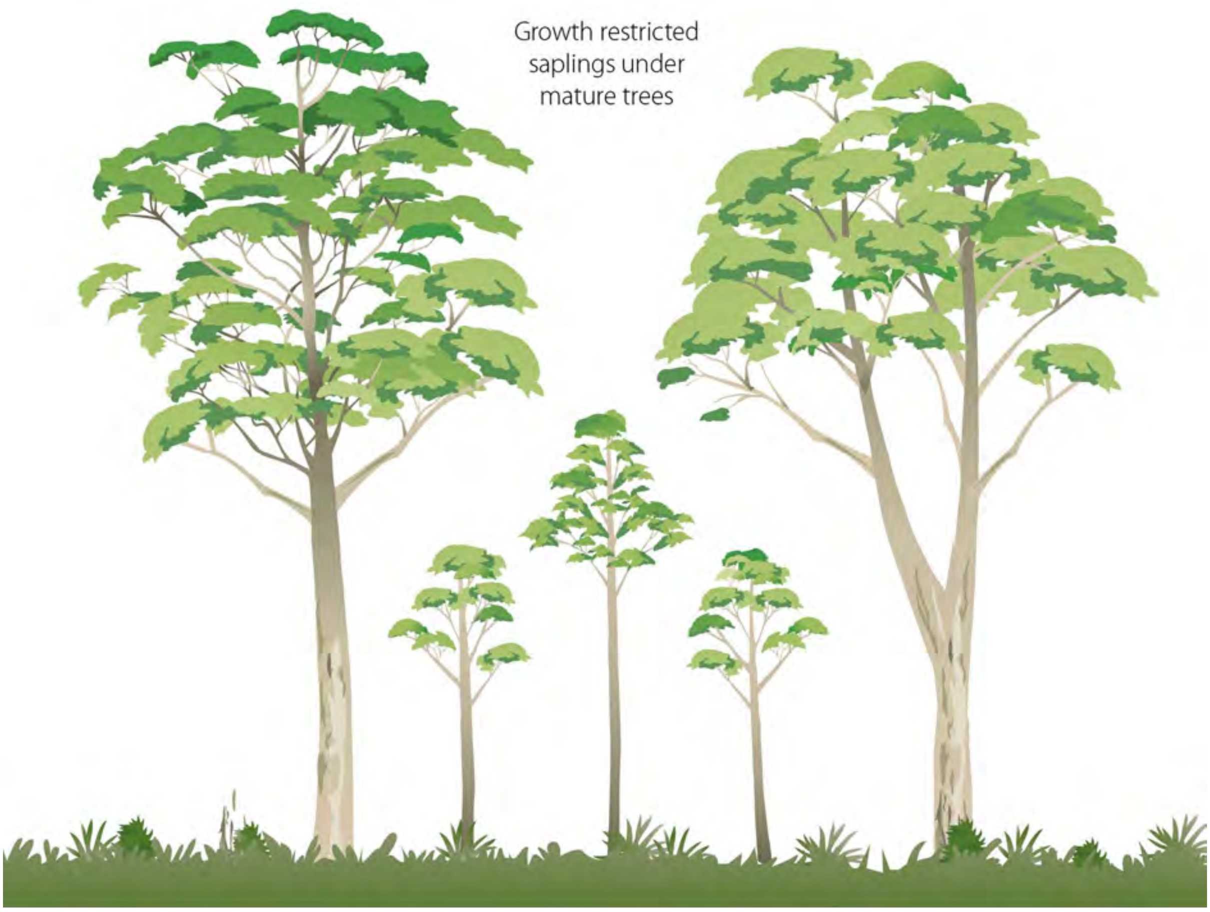



**Figure 25:** Growth-restricted saplings under mature trees

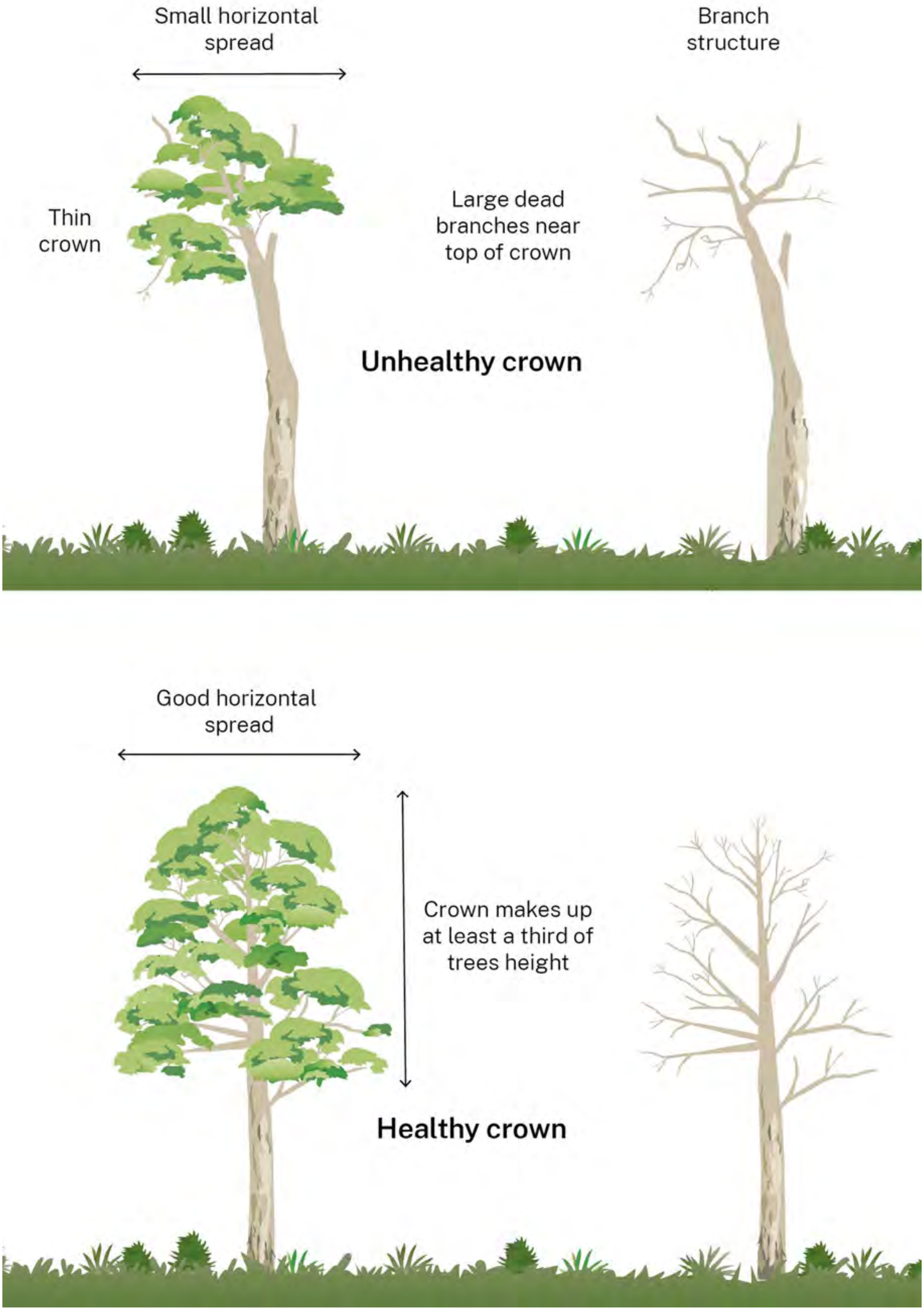



**Figure 26:** Healthy vs unhealthy crowns

### 10.2.3 Tolerance to competition in different species

Smaller trees compete with large trees for light, root-growing space, nutrients and water. How trees compete and progress through the growth stages depends on the physiological characteristics of the trees. Some tree species cannot survive under a canopy and will die, whereas other trees can survive and grow slowly. 'Tolerant' trees can withstand lower levels of resources. In productive forests where water and nutrients are not limited, species need to be tolerant of competition for light.

Eucalypts cannot grow under dense canopy and are therefore much less tolerant than rainforest trees. The tolerance levels of eucalypts differ from species to species. Some quickly die when their crown is shaded, while others are tolerant and can survive as subdominant or under a light canopy. Non-eucalypt species in wet sclerophyll forests are usually very tolerant, as is cypress pine. When planning forestry management, you'll need to think about the tolerance of your trees.

Table 4 indicates the tolerance level, general growth characteristics and management considerations of eucalypts and other important species.

The tolerance of the species in your forest should guide your silvicultural practice. If your forest has very intolerant and intolerant species, you will need large canopy openings to make sure seedlings can generate and grow through the development stages. Individual trees will respond well to a large growing space and will grow fastest away from the crown edges of neighbouring trees.

| Tolerance | Species | Growth characteristics | Silvicultural considerations |
|---|---|---|---|
| **Very intolerant** | Flooded gum | Rapid height growth when given access to a high level of light; can't develop in the shade of other trees. | Requires large canopy openings. |
| **Intolerant** | Blackbutt, alpine ash, silvertop ash, stringybark | Fast growing species, poor development under other trees. | Requires medium to large canopy openings. |
| **Intermediate** | Spotted gum, river red gum, brown barrel | Moderate growth rate where part of the overstorey may exist in growth-restricted form under other trees. | Requires medium canopy openings. |
| **Tolerant** | Tallowwood, white mahogany, red mahogany, grey gum, ironbarks | Slow to medium growing species, can exist in growth-restricted form under other trees. | Requires small canopy openings or can develop in small gaps in mixed species forest. |
| **Very tolerant** | Turpentine, brush box, cypress pine | Slow growing species, often exist in growth-restricted form under other trees. | Able to respond to very small openings in the canopy after the death or re-moval of individual trees. |

**Table 4:** Tolerance of forest trees and implications for management

## 10.3 How management shapes forest structure

A forest's structure – how its trees relate to each other spatially and in age – can range from simple to complex.

An even-aged forest that has regenerated from a large-scale event will have a simple structure (especially if there is only one species), with tree crowns all at about the same height. Depending on how quickly an even-aged forest is growing, trees will form crown classes, with dominant through to suppressed trees that may eventually die (known as self-thinning).

Complex forest structures include trees of different ages within a small area, such as patches created by individual tree falls. An uneven-aged forest containing tolerant species may have over-mature and mature trees overtopping and alongside regrowth saplings, and perhaps a rainforest understorey. A forest can be uneven in age at a larger scale, but trees within each age class can be grouped together, allowing trees within each group to dominate and develop rapidly through the growth stages.

If trees of several different ages or sizes aren't grouped together by their class, and are arranged without a defined pattern, many of the sapling and pole-sized trees will have to compete for resources and may be growth restricted and suppressed.

**PNF Codes:** Forests managed according to the PNF Codes can develop complex structures through tree retention requirements, the protection of old growth and rainforest, and strategic application of single tree selection and Australian Group Selection silvicultural techniques.

### 10.3.1 Practices that degrade forest structure

Poor or inappropriate silviculture practices can have negative consequences and degrade forest structure.

When harvesting a forest, canopy openings need to be created to allow regrowth to develop through the normal growth stages. If canopy openings aren't big enough, forest productivity can suffer. Larger canopy openings encourage and maintain dynamic growth.

High grading of forests, which harvests only the most valuable timber, can remove too many healthy trees and degrade the structure of the forest, leaving gradually worse quality trees.

As a forest declines in quality, so to does its potential for wood production and its value as wildlife habitat. There will be less structural diversity and, as tree crowns weaken, the amount of quality food resources and hollow-bearing trees for animals also decreases.

**Consequences of high grading on forest structure**

High grading was used for almost a century in many forests in NSW and Queensland, with lasting impacts on tree condition.

In Queensland, trees were historically selected for harvesting based on their size, without thinking about canopy openings. By the late 1990s, forests in the state had a low percentage of trees of sawlog quality and few smaller trees with the potential to become sawlogs. Forests were increasingly dominated by low quality stems.

In NSW, an assessment of the tree condition in part of Pine Creek State Forest showed that only 40% of the 3,200 trees assessed were in fair to good condition. Most of these were blackbutt and flooded gum in mature and pole classes. The other 60% were weak older trees and growth-restricted trees. Most of these were tolerant species, such as white mahogany, tallowwood, grey ironbark, grey gum, brush box and turpentine. A similar assessment of spotted gum forest in Bodalla State Forest showed only 30% of the trees had good trunks and crowns.

**PNF Codes:** The PNF Codes outline restrictions on the creation of canopy openings.

# Forest products and markets

# 11

Before you can effectively plan how you will manage and maintain a diverse, healthy and productive forest, you must understand the economics of forest management.

## 11.1 Economics of silviculture operations

The major economic factors of silviculture operations include:

- The sustainable yield of the forest
- The efficiency of harvesting operations including contractor management
- Market factors such as log products, prices, and distance to mills.

It can be tempting to use quick, cheaper practices, like clear felling, burning of debris and direct seeding over a large area. However, this approach won't meet sustainability and environmental objectives or regulations, and can mean delayed costs to fix shortcomings in the future.

Modern multipurpose silvicultural practice, including tree-marking and relatively low-impact harvesting, can be more expensive in the short term, but is needed to meet competing forest management objectives and the requirements of the PNF Codes. Multipurpose forest management can earn a profit while also enhancing the forest in multiple ways.

## 11.2 How much wood can a forest sustainably produce?

Rainfall, soil and temperature all impact a forest's productivity, or how much wood a forest can sustainably produce. For example, wetter forests with high-quality soil are the most productive. In NSW, productivity is lower in the west where there is less rainfall.

In order to plan for harvesting in a sustainable way, you need to assess the forest's health, productivity and sustainable yield.

Productivity is usually expressed as the number of cubic metres of timber that is produced per hectare each year. Sustainable yield is the production of timber that can be maintained over multiple growth cycles.

In any defined area of forest an individual harvest event may remove the sustainable production of many years of growth over a cycle of management. In the case of a gap, forest is effectively regrown. Therefore, sustainable yield only applies at larger scales and over long timeframes. The most important indicator of the sustainability of an individual harvest event is if the forest trees successfully regenerate to acceptable stocking levels and return to full productivity after a disturbance. If there are areas of forest that don't regenerate, many forest values will be impacted.

Practices such as high grading can severely reduce a forest's future productivity and sustainable management. High grading is where high-quality trees are repeatedly removed with no planning to ensure appropriate forest structure or regeneration. This degrades the forest and leaves behind a low proportion of saleable trees.

To make informed decisions when planning harvests, you must calculate the long-term potential productivity of the forest.

**PNF Codes:** Under the PNF Codes, you must assess and manage regeneration after every harvest.

### *Calculating sustainable yield*

Calculating the sustainable yield of a forest is an ongoing process of recording forest growth. Forest growth varies with the seasons and can be impacted by long-term trends like climate change. This can mean you need to revise yield forecasts.

To calculate yield, you'll need data on forest growth (expressed in cubic metres of wood per hectare per year) and the productive area (in hectares) where the trees will grow. You can then give an estimate of yield in cubic metres of timber per year for the forest area. The productive area of your forest will be measured while preparing your forest management plan, by excluding areas you can't harvest, like waterways and protected spaces.

You will need to use established methods to calculate the growth of your forest. Most methods use a system of fixed area plots where trees are measured repeatedly to understand growth rates. Two measures are needed to make an initial estimate of productivity. You will also need to consider the design of the system of growth plots. Technical guides to forest measurement are available, but you may want to consult a technical professional.

# 11.3 Forest products

## 11.3.1 Non-wood forest products

While the focus of a healthy, productive forest is usually on the wood products it provides for the landowner, non-wood products like seed, honey and recreation can also be valuable. Some of these products are compatible with timber production, while others are not. You should be aware of the relationship between non-wood forest products and timber production. If you plan to limit timber harvesting, non-wood products may become more important.

**PNF Codes:** If you plan to use non-wood forest products, you must meet any relevant regulatory requirements and approvals. Contact DPI if you have questions about what is required.

## 11.3.2 Timber products

In the past, the forest processing industry generally only accepted large, nearly perfect logs. Poorer quality trees were unsaleable and were therefore left in the forest. This process of high grading results in a gradual decline in the health and quality of the forest. Thankfully, we now use logs of a wide range of sizes and quality, allowing for better silviculture where we harvest trees of poorer quality or with limited potential for growth.

To be able to maximise the value of your forest, you need an understanding of the range of wood products that can be generated from each tree and how much they are worth (Table 5). When measuring forest growth, you can collect data on the value of log products in the forest. Species, size and defects are the main features that determine log value (Table 5, Figure 28). In general, the larger a log is and the fewer defects it has, the higher its value will be. Species that are easy to process, suitable for high value uses, highly durable and of a good appearance grade are more valuable. Large logs are worth more because they can be used for a greater range of things and require less handling and processing. Other factors like the distance to mills also influence the net profit of the forest harvest.

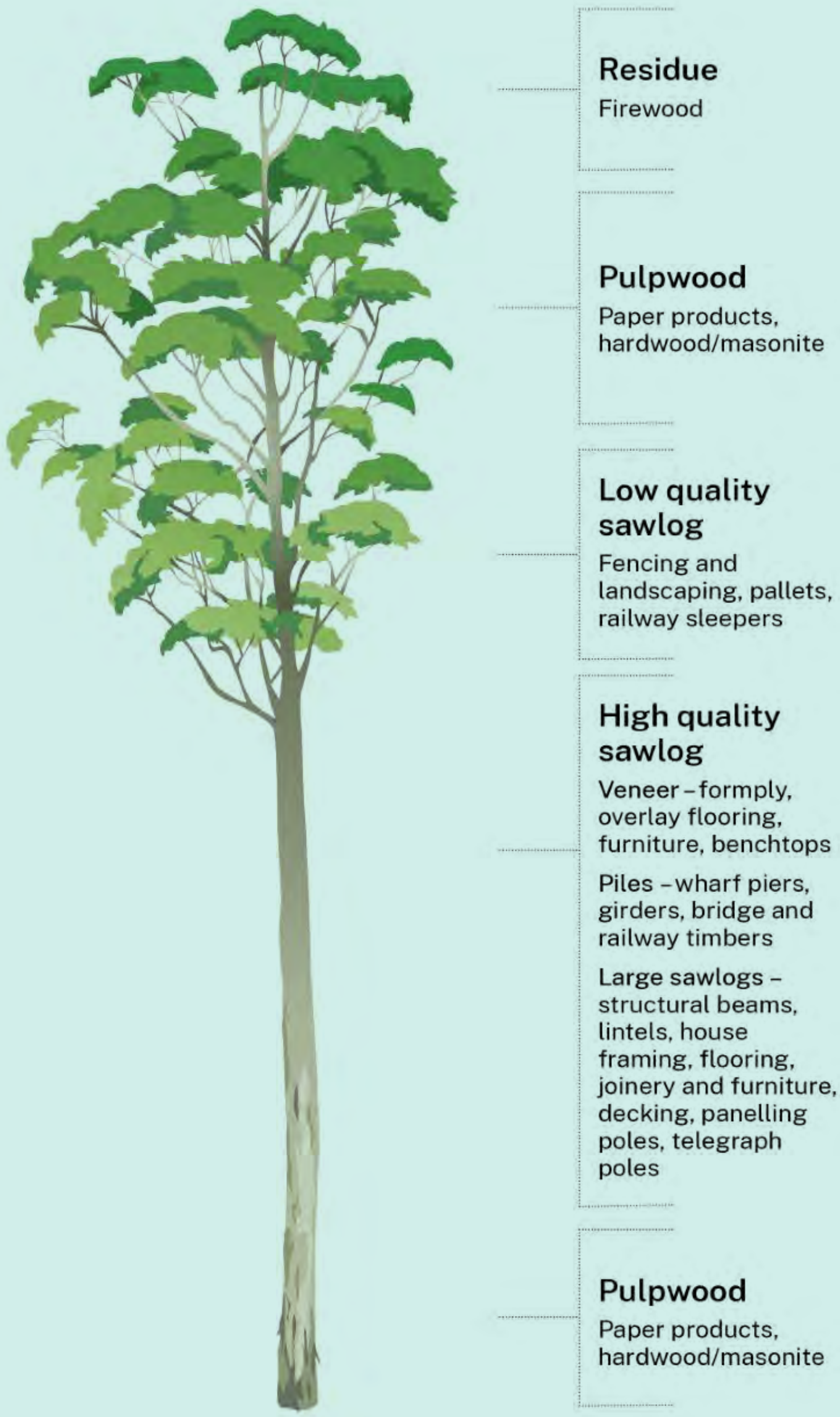



**Figure 27:** Log products within a tree

### *Estimating available log products*

There are usually several log products within each tree, decreasing in value from the tree base to the top. Logs of the highest value are identified first, then the next highest value and so on. Timber poles are generally the highest value product but there is specific criteria the wood needs to meet to be sold as a pole. If a tree does not meet the pole size and taper specifications, then it will be merchandised into veneer log, quota and woodchip. Further information on log grades is available from AgriFutures Australia.

| Product | Indicative value / $m^3$ | Description |
|---|---|---|
| **Pole (P)** | 1.5–2 x Q price | Minimal defects. Logs that are too large for P become V. |
| **Veneer log (V)** | 1.5–2 x Q price | |
| **Quota (Q)** | 2 x Z price | Some minor knot and pipe defects, too small for P. |
| **Salvage (Z)** | $20–60 | Low-quality sawlog, millable but has defect (knots, sweep, kinks, gum pockets). |
| **Thinning (T)** | $20–30 | Small Q or Z logs. |
| **Woodchip and fencing material (W)** | $10–20 | Not merchantable as a sawlog but suitable for chip mills, fencing, firewood, etc. |

**Notes:** Indicative value is based on prices at time of writing, but can be used to understand relative values. Higher quality logs are becoming less common.

**Table 5:** Types of timber products in order of decreasing value

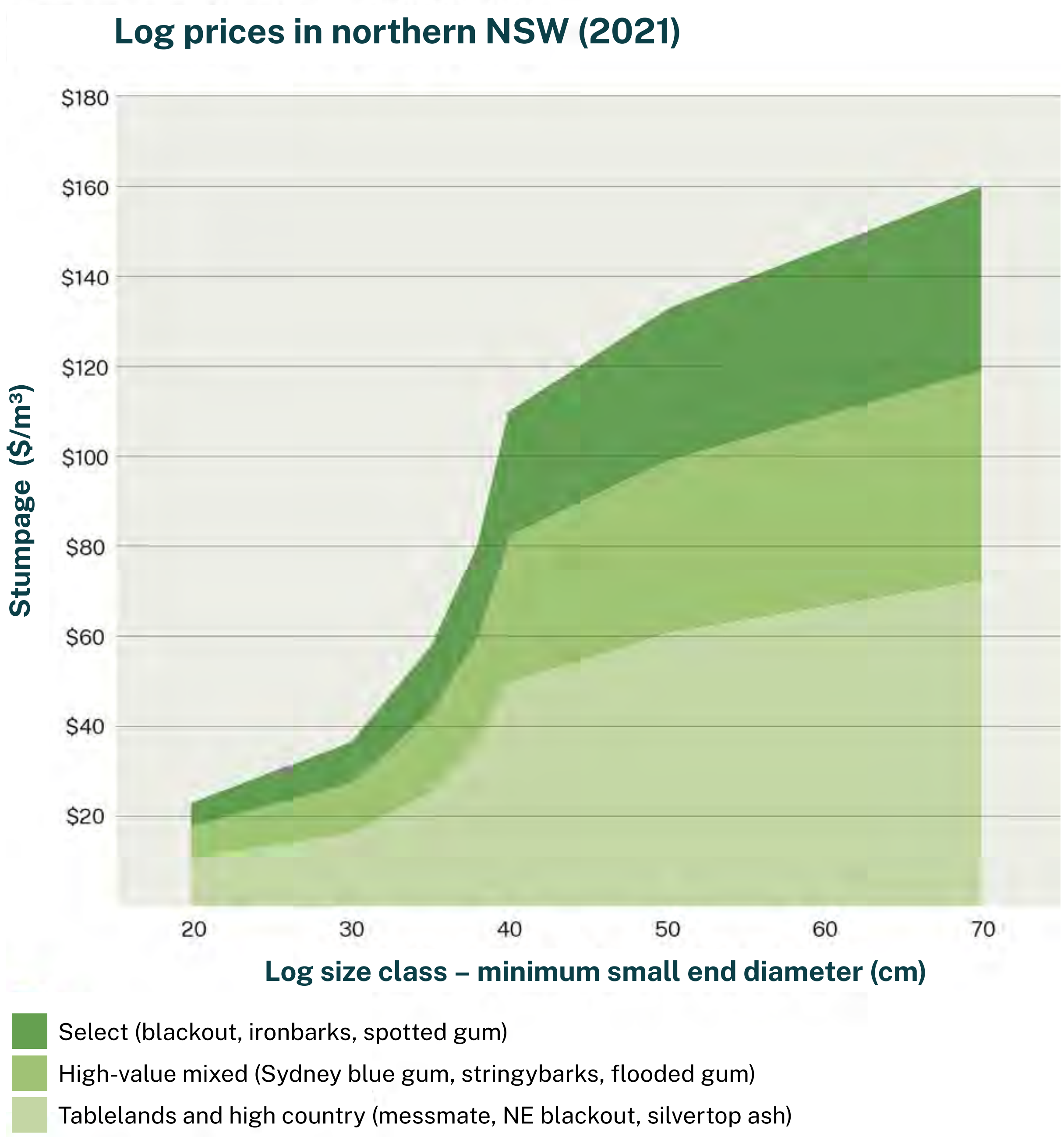



**Figure 28:** Log prices in northern NSW in 2021 demonstrates the effect of size and species

# 11.4 Selling Forest products

When planning to sell forest products you need to consider several factors, including:

- The range, volume and grades of log products available
- The costs of road construction, harvesting and log transport
- Potential profit
- Environmental constraints and the viability of the operation.

To determine your prospects for harvesting, you can seek advice from LLS, DPI, other forest owners, contractors and local timber processing industries. An experienced contractor will be able to maximise the value of commercial timber products from a harvest, which may mean using more than one timber mill in the area.

Understanding the range of products you can harvest provides flexibility when selecting harvest areas, reduces waste, and prevents the risk of high grading a forest. As the value of logs increases with size, knowing the value of larger timber products and the growth rate of a stand helps you make an informed decision on when, what and how to harvest.

# 11.5 Forest certification

Forest certification is an independent guarantee that timber production forestry is being managed in an ecologically sustainable manner. Certification for native forest management can improve community confidence in forestry activities and open up new market opportunities for certified timber products. There is growing demand for certified timber products in farm forestry, with more and more landholders interested in certification. There are two forest certification schemes in Australia, administered by Responsible Wood and the Forest Stewardship Council.

# Silviculture: Putting theory into practice

12

There is no single silvicultural process or practice that can be applied uniformly to all forests. This is because all private native forests in NSW are different in a number of ways, including:

- Composition
- Structure
- Productive condition
- Environmental values
- Management history
- Natural environment
- Responses to past events like grazing, harvesting, clearing and fire.

There is also a diverse range of management objectives that require certain silvicultural practices, and requirements in the PNF Codes for silvicultural actions that protect values of the forest. Over time, the use and combination of these processes will become a silvicultural regime.

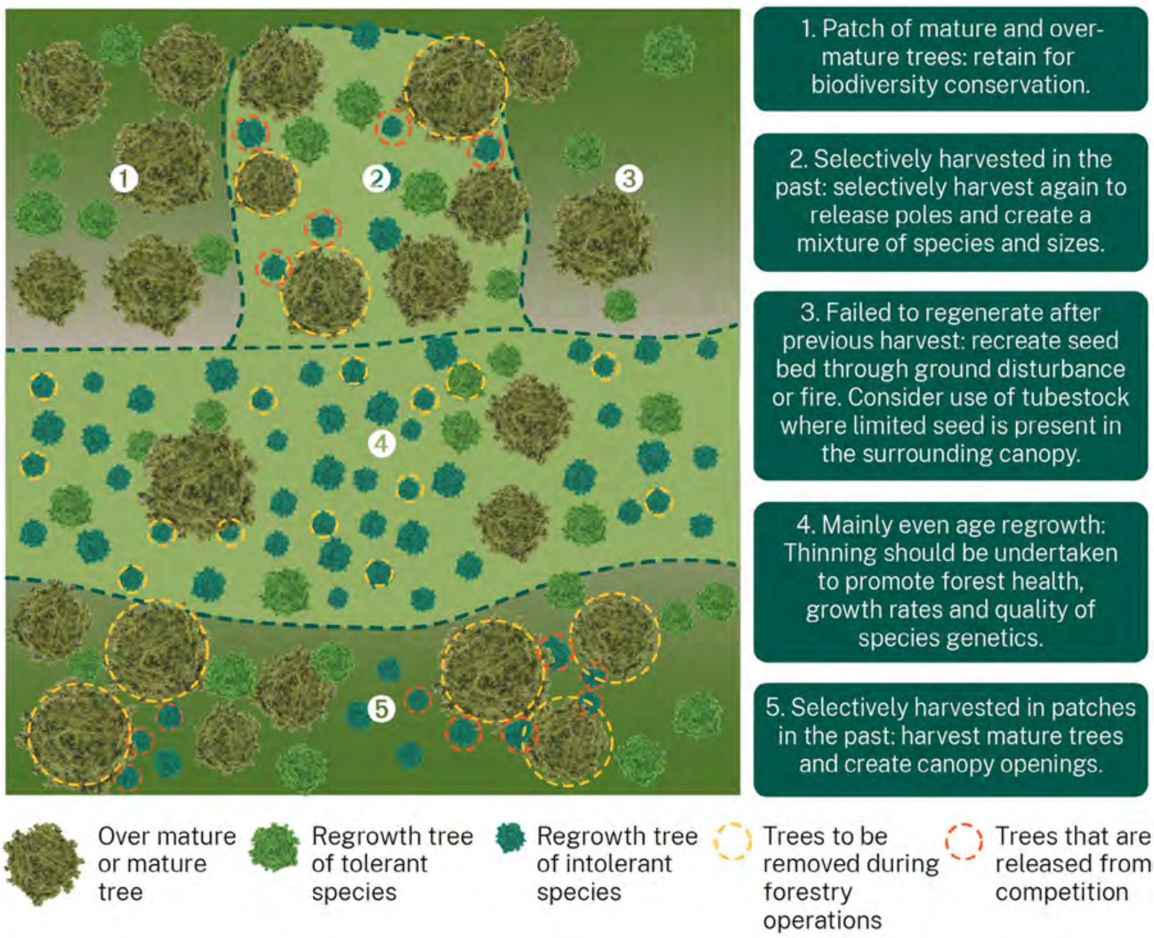



**Figure 29:** Various silviculture practices to suit forest management objectives

# 12.1 Understanding disturbance regimes in forest management

While we know a lot about the processes that naturally occur in native forests and the impacts of people, forests are extremely complex natural systems. So, determining the best management regime for a forest requires judgement, monitoring and active management.

A forest will adapt to the disturbance regime of its location, to be able to regenerate after severe disturbance events such as drought, fire and storms. A forest's type, species and ecology will adapt based on the frequency and intensity of disturbances.

Some forest disturbance regimes include:

- Small-scale, individual tree falls in rainforest
- Frequent, low-intensity burns in drier forest types
- Moderately frequent flooding events in river red gum forest
- Infrequent, high-intensity fires in wet sclerophyll eucalypt forests.

Natural disturbance regimes involve random events that can change species patterns over varying scales. In contrast, controlled silvicultural management must maintain natural species patterns, and can be used at smaller scales to manage species composition through what species are removed and what regenerates.

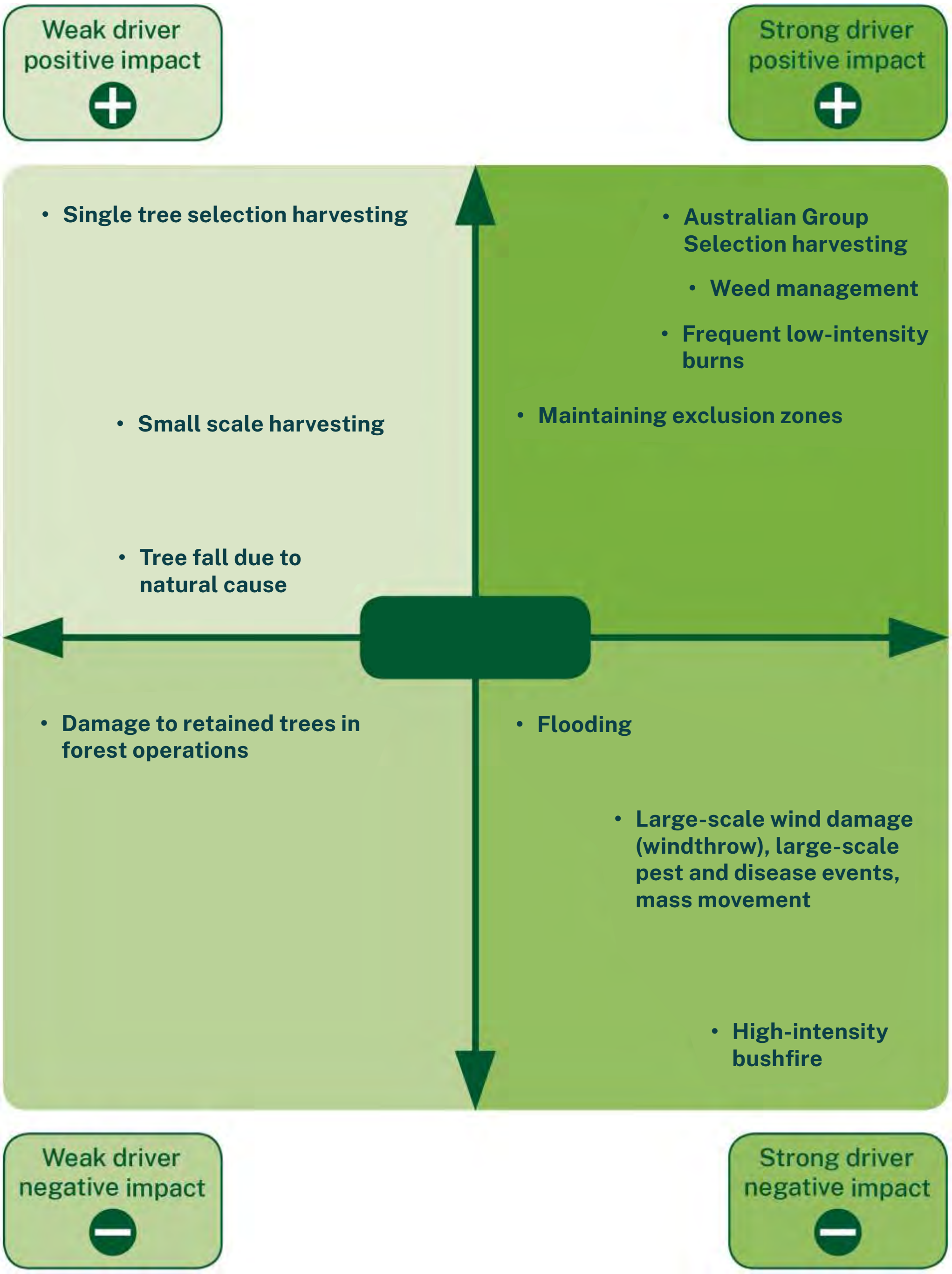



**Figure 30:** Common forest disturbances and scales of change

# 12.2 Silviculture and the PNF Codes

The PNF Codes set the standards for PNF operations in NSW. This includes the harvesting approaches, also known as silviculture methods, that can be used, such as small scale harvesting, single tree selection, thinning, and Australian Group Selection.

Some private native forests may not be in a good enough condition to support economic harvesting while also meeting the requirements of the PNF Codes. Forests with few merchantable trees, or understocked forests that need intensive site manipulation to meet the PNF Codes' regeneration requirements, present significant challenges.

**PNF Codes:** When you apply for a PNF Plan, LLS will consider whether it will be possible for you to adhere to the PNF Codes in the area. If it is deemed not possible, your PNF Plan may not be approved until you have restored the area through forest management actions.

# 12.3 Designing silvicultural harvesting systems

Most silvicultural harvesting techniques can be thought of as disturbance that varies in spatial pattern and intensity, depending on the forest management goal. Techniques range from removing individual trees in a regular pattern across the forest (known as thinning), to creating larger openings to help regeneration (like group selection).

Some of the main harvesting techniques suitable for private native forests are outlined below.

**PNF Codes:** Harvesting operations must be conducted within the limits of the PNF Codes.

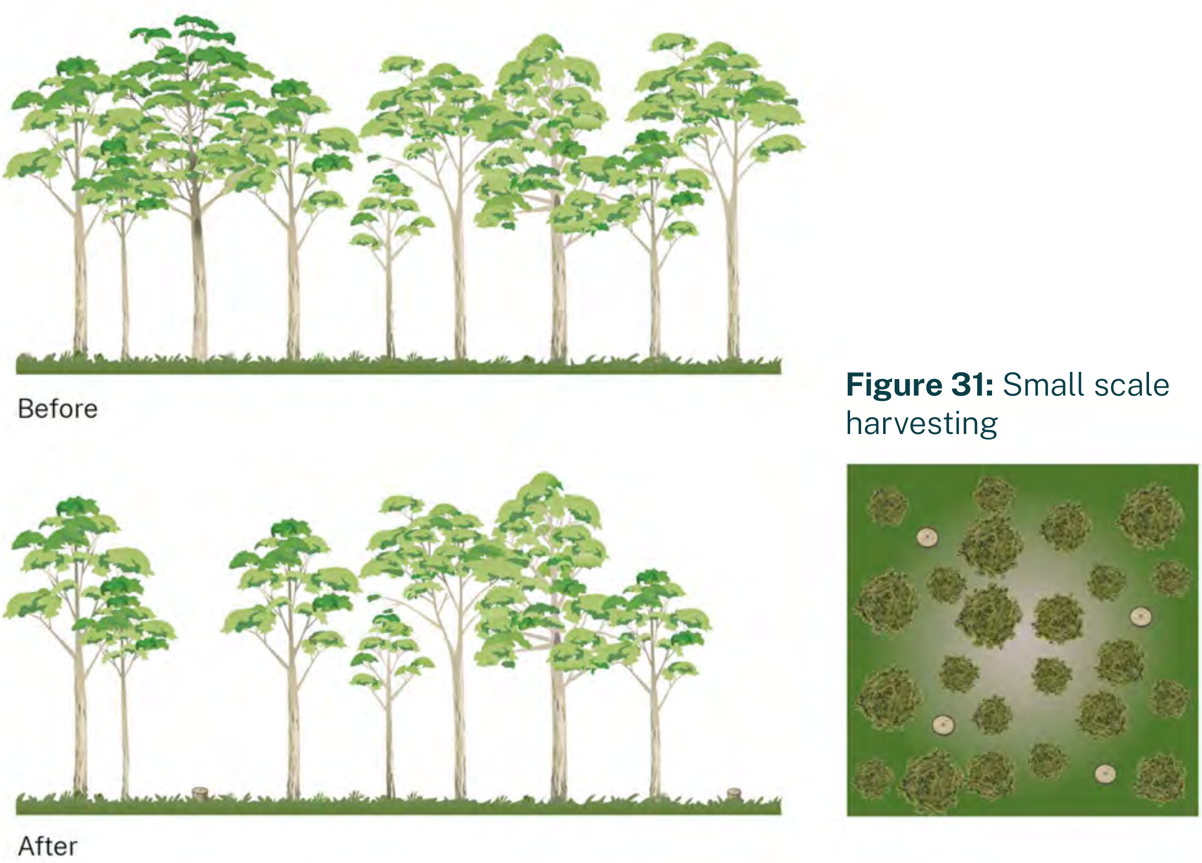



**Figure 31:** Small scale harvesting

## *Small scale harvesting*

Under the PNF Codes, small scale harvesting allows landholders to remove five trees per hectare (ha), either across no more than 5 ha or up to a total volume of 50 $m^3$ per year.

While this is not a traditional harvesting technique, it is included in the PNF Codes so landholders can remove a small number of trees without a full-scale harvesting operation.

Key considerations when selecting trees to remove using small scale harvesting include:

- Whether or not you want to sell the timber, and what type of timber is saleable in such a small quantity
- The effect of removal on the surrounding trees, such advanced growth or competing trees
- The removal of habitat, recruitment or feed trees could stop you from meeting the minimum standards for tree retention outlined in the PNF Codes
- Removing the best trees of only a small number of species (high grading), leads to a decline in forest quality, strength and possibly a change in species composition.

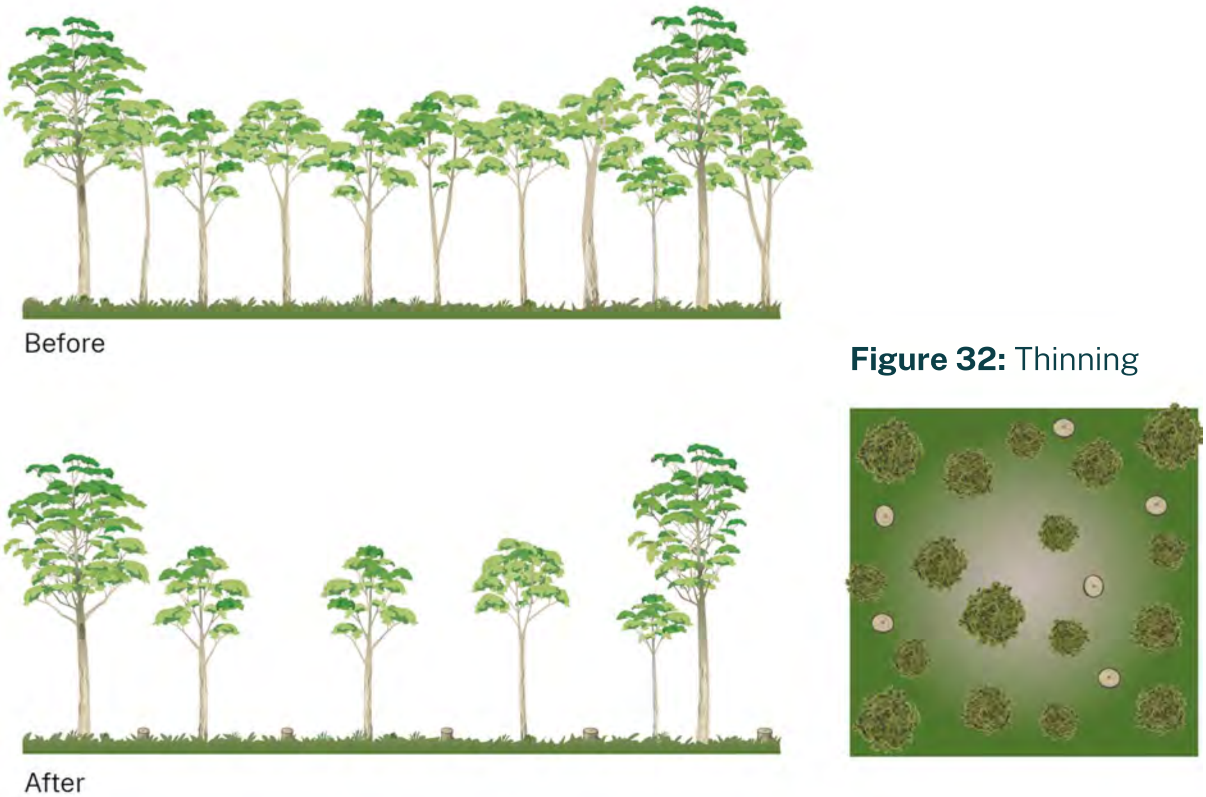



**Figure 32:** Thinning

## *Thinning*

Thinning involves selecting trees for removal to provide more growing space and increase the growth rates for retained trees. Thinning is similar to single tree selection but is used for different objectives. It is a forest management practice used to improve the overall health of the forest or growth rate of the remaining trees and is not designed for short-term commercial gain. Sometimes thinning to improve stand growth and quality doesn’t result in a product. However if there is a viable market for any timber harvested from thinning, it can be sold commercially. Self-thinning occurs naturally when the density of a forest stand causes tree death. Forest operations can manage and accelerate the thinning process and provide ecological, environmental and economic benefits.

Benefits of thinning include:

- Improving stand quality where there is a large proportion of low-value trees with defects
- Improving tree growth by providing retained trees greater accesses to resources, helping trees reach commercial size sooner
- For commercial operations, removing trees before they die allows you to market timber that would otherwise be lost and can also reduce fuel load
- Improving stand hygiene and removing potential sources of infestation, as stressed trees are more vulnerable to pest and disease outbreaks
- Increasing the amount of other native (non-tree) species.

There is a lot to consider when planning thinning for your forest operation. Thinning can target trees of a particular diameter range, or it can focus on crown classes by thinning from below or above. Thinning from below removes suppressed and sub-dominant trees and has little effect on the growth of retained trees. Thinning from above, removing some (usually defective) dominant and codominant trees, releases space and resources for retained trees to increase growth.

There are spacing requirements for thinning to ensure retained trees have access to the space that is created. If the distance between remaining trees is too large (thinning is too severe), the trees might not be able to use the space and may develop overly large branches. Severe thinning can also lead to regeneration, which can work against the objectives of thinning. If thinning is too light, there will be little improvement in the growth of retained trees.

Plan thinning to meet objectives such as final or intermediate stocking levels. An early thinning could remove defective trees and provide enough stems for an intermediate thinning and a final harvest. A final stocking level might be based on full site occupancy at tree size at final harvest.

### Thinning principles for even-aged forests

Eucalypt forests may be even-aged, or mostly even-aged, where in the past:

- A wildfire killed or weakened the overstorey trees, resulting in vigorous regeneration
- Much of the overstorey was harvested in a single operation (or several operations over a short period of time)
- Land had been cleared for primary production (agriculture, plantations, grazing) then regenerated to forest.

There may be some large over-mature trees in the forest, which can have a negative impact on the condition of the regrowth but may also make good habitat for wildlife.

Even-aged forests, or large areas of even-aged regrowth, can be highly productive. You can enhance that productivity by thinning from time to time. Do this at two stages: before regrowth has reached a commercial size (preferably at the sapling stage and before too much of the green crown has been lost through competition), and in the pole and early mature stages when commercial products are harvested.

Thinning is great for highly stocked forests of fast-growing eucalypts, such as blackbutt. These forests can rapidly peak in volume production. Non-commercial thinning in the rapid early growth phase can direct much of the total volume production to a smaller number of trees, accelerating their diameter growth, and reducing how long it takes to reach commercial size. As demonstrated in regrowth mountain ash in Victoria, a forest non-commercially thinned at five years and for pulpwood at 20 years would produce, at 50 years, almost as much sawlog volume as an unthinned forest produced at 80 years.

Inherently slow-growing species respond more slowly to thinning. Fast-growing species may also respond slowly if thinning has been delayed and all crowns (even those of the dominant trees) have been weakened by competition. In this case it takes extra time for crown volume and leaf area to regrow and for you to see the growth and health benefits of thinning.

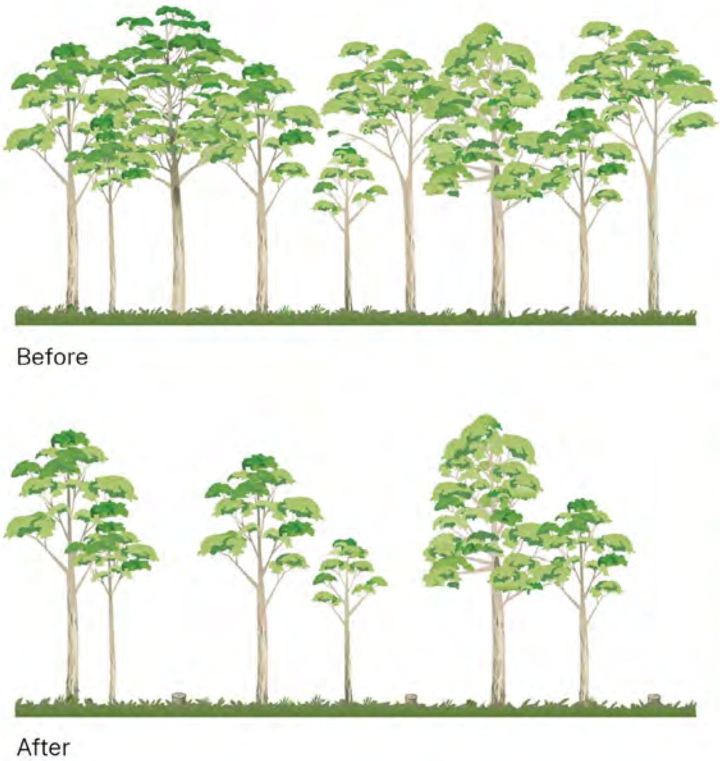
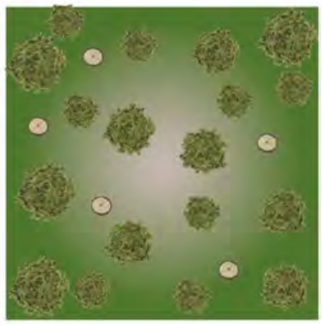



**Figure 33:** Single tree selection



## *Single tree selection*

Single tree selection involves harvesting either single trees or small groups of trees. Depending on the intensity of previous harvesting and the forest type, single tree selection is normally repeated at relatively short intervals, every 10 to 30 years. This method allows you to be flexible in selecting which trees will be harvested and retained, to achieve specific management objectives. For habitat preservation, you would retain hollow-bearing, recruitment and feed trees, and then retain smaller, younger trees to grow on for the next harvest without the competition of the trees which were harvested.

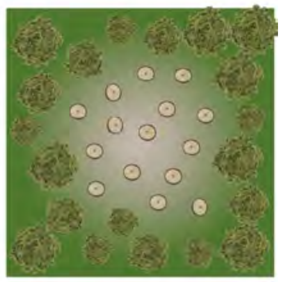
Single tree selection is generally low intensity. If the tree selection removes large enough patches of trees to produce even-aged stands within canopy openings, the PNF Codes considers the method to be Australian Group Selection.

Following single tree selection, trees will be distributed across the landscape, with less light reaching the ground than in an opening. This method also modifies humidity and the probability of frost. It shelters regeneration and helps more shade-tolerant species grow, including those that don't need bare earth. Mechanical disturbance can be used to create a seedbed, or you can use prescribed fire to remove the groundcover, prepare a seedbed, and promote seed fall.

When using single tree selection, in keeping with PNF Codes, be sure to carefully consider the structure of the forest. Single tree selection is well suited to uneven-aged and mixed-species forests, where many trees are not big enough to harvest.

**PNF Codes:** Under the PNF Codes, single tree selection must not create canopy openings. If you want to create canopy openings, you will need to use Australian Group Selection or variable retention.


**Figure 34:** Australian group selection



## *Australian Group Selection*

Australian Group Selection is designed to stimulate regeneration for shade-intolerant species (see Chapter 10.2.3) and create a mixture of differently aged trees across the landscape. It was developed for eucalypt forests in NSW and Queensland, where species can't regenerate under competition.

A group of trees are selected and removed to form a canopy opening that allows the seedlings to regenerate with minimal shading. The trees growing near the edge of the opening will always be somewhat restricted by shade, so larger openings will provide the greatest area of unrestricted growth. Under the PNF Codes, the maximum canopy opening size allowed is 0.5 ha.

To maximise regeneration, canopy openings should be planned, not created incidentally. These openings may release advance growth (from lignotuber type seedlings to stems up to half canopy height) or allow new seedling regeneration to establish and grow to maturity. Where sapling advance growth has been weakened by competition, it can be coppiced so new, more vigorous stems develop.

Plan canopy openings where:

- Harvesting will create openings big enough to ensure advance growth or new seedling regeneration can develop
- One or more additional trees of low productivity can be removed to create an effective canopy opening.

Through Australian Group Selection, irregularly shaped and well-positioned canopy openings can maximise light penetration to encourage forest regeneration and account for existing landscape features and significant habitat features.

After a harvest, regeneration must be closely monitored and managed. To protect young trees, the openings or gaps you create may need extra treatment such as weed control, fire management, feral species controls or stock exclusion.

**PNF Codes:** Check the PNF Codes for guidelines for the size, arrangement and extent of canopy openings.

# 12.4 PNF Code harvesting limits: Retained basal area

The PNF Codes use post-harvest basal area to describe disturbance thresholds – or how many trees need to be kept – for small scale harvesting, single tree selection and thinning operations. Basal area is widely used to control growing stock levels in full, even-aged forests and plantations. However, it is difficult to use in uneven-aged forests because the trees vary in size and arrangement.

The PNF Codes' minimum stand basal areas for single tree selection and thinning operations are not necessarily ideal for maximising timber yield in all forests. They are limits to how intense a disturbance can be, taking all forest values into account. When developing a silvicultural management approach, the focus should be on keeping all quality trees that are capable of more growth. While the basal area of available quality trees will vary a lot, it is useful to have some understanding of the optimum basal area for particular forest types (Table 6). For forests that have management challenges or have been modified by historic practices like high grading, some areas may have to be harvested below the ideal basal area range.

| Forest type | Optimum post-harvest basal area range ($m^2$/ha) |
|---|---|
| **Blackbutt, spotted gum (wet), moist coastal hardwoods, flooded gum, alpine ash** | 15–20 |
| **Spotted gum (dry), mixed hardwoods, silvertop ash/ stringybark, tablelands hardwoods** | 8–15 |
| **River red gum** | 12–15 |
| **Cypress pine and western hardwoods** | 6–8 |

**Table 6:** Optimum post-harvest basal areas by forest type (stand height greater than 25 m)

# 12.5 Tree marking

You can physically mark trees that are to be removed or retained, or a combination of both.

The LLS Forest Management Plan templates provide some guidance on the types of tree markings you can use.

Trees that should be marked include:

- Trees being retained for wildlife
- Trees with good productive capacity (those with a seed source with good genetics) to be retained for future harvest
- Trees to be harvested in the current operation.

If a forest is in good productive condition and near fully stocked, an experienced tree feller might be able to effectively judge which trees should be removed without them being marked beforehand. However, it is better to mark trees for removal before the harvest because the tree marker is likely to have a better understanding of the forest's layout. The tree marker should adjust the marking to meet the requirements of the PNF Codes and the long-term forest management goals.

*Steps in a tree-marking regime*

**Step 1:**

## Mark trees for wildlife

The PNF Codes require that habitat is kept for birds and mammals that live in trees.

Over-mature trees that are dying may have little impact on regrowth if retained for habitat. If the trees are still relatively healthy, their large crowns can significantly limit wood production. You need to balance productive regeneration and providing habitat trees for animals.

Wildlife values are enhanced in structurally diverse areas with a variety of food sources. One option is to leave some patches that include habitat trees, dense understorey, and a variety of tree species and size classes undisturbed.

**Step 2:**

## Mark trees with good productive potential to be retained for future harvest

**(optional but recommended)**

All trees with good productive potential should be marked and kept for future harvests. Look for trees with defect-free trunks and vigorous, well-balanced crowns. The size of trees you retain will depend on the forest type and the quality of the site. Some species (such as grey gum and grey box) develop defects earlier than others so it may not be a good idea to retain them beyond a certain size. Seek advice from local specialists on how different tree species grow.

**Step 3:**

# Mark trees for harvesting

**(optional but recommended)**

Trees not marked for retention are potentially available for harvest. Harvests should provide an economic benefit to the forest manager and improve the average productivity of the forest. As well as thinning in patches of pole and mature trees, harvesting should focus on older, commercially mature trees that are:

- Starting to slow in growth
- Already in decline
- In a growth-restricted condition.

To avoid high grading, harvest as many trees of marginal commercial quality as possible, making sure to still satisfy the PNF Codes' basal area requirements.

When marking trees to be removed, also mark the preferred felling direction to minimise risk of damage to trees marked for wildlife purposes and trees with future growth potential.

**Step 4:**

# Adjust to meet the PNF Codes and sustainable management goals

These tree marking guidelines represent a single tree selection approach to silviculture of considering each tree on its own merits. Look at the trees marked for harvest and consider the impact of their removal in terms of:

- Basal area and canopy opening limits in the PNF Codes
- The forest structure
- The balance between biodiversity, conservation and wood production.

Sometimes, no adjustments will need to be made. Otherwise, marked trees may need to be changed to follow the PNF Codes and meet your other management objectives.

# Regeneration

13

Regeneration is the forest growing back after a disturbance, like a harvest event or a natural process opening the forest canopy (wind throw, ageing, death, or fire).

Forest regeneration primarily comes from:

- Soil with seeds in it being disturbed, leading to seed and seedling production
- Resprouting from underground structures, such as lignotubers
- Resprouting from epicormic buds, such as coppicing.

Forest regeneration ensures the sustainability of farm forestry and is important for maintaining the forest's long-term ecological value for landholders and the community. The process often occurs naturally, but may need to be assisted for some species, site conditions and types of harvesting.

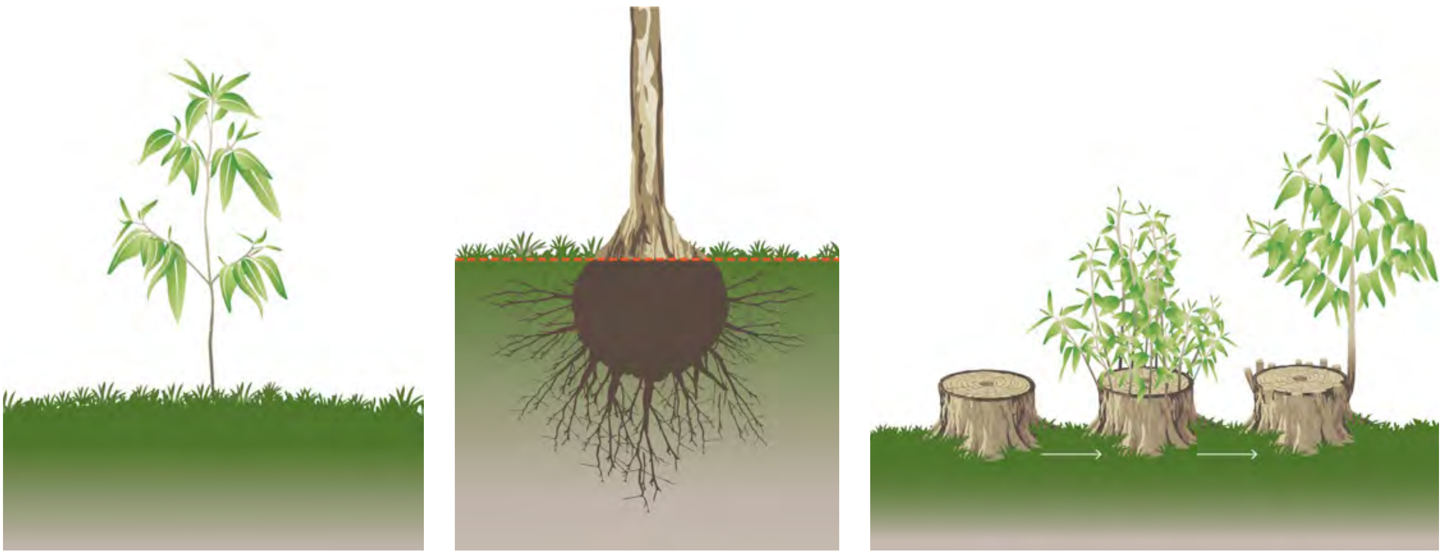


**Figure 35:** Seedling, lignotuber, and coppicing in eucalypt forest

# 13.1 Seedling regeneration

There is usually enough seed production in a native forest for regeneration after a disturbance. If there is not enough natural seed on site, direct seeding and planting may be required.

Seed production factors that influence how a forest will regenerate after harvesting:

- It can take two to five years for a new flower bud to mature into a capsule ready to release seed, depending on the species and environmental conditions.
- Capsules that are ready to release seed are normally located at the base of tufts of leaves at the end of the branch (Figure 36).
- Usually, only part of the seed crop sheds when the capsule reaches maturity. Seed continues to be shed during following years.
- Seeds are released as the capsule dries out, so more will shed at a dry time of the year. If fire scorches part of the crown, most seeds are shed within a few weeks.
- The amount of seed each year varies greatly in eucalypts. There may be a reasonable crop every two to four years, and a bumper crop at wide and irregular intervals. Most eucalypts set some seed each year and seed from any single crop is shed over two or more years, some seed will be available in most years.
- Most of the seed will be found in larger, more dominant trees. Suppressed and small trees give little to total seed supply.
- Eucalypt seed does not have wings, is not carried by birds, and does not float on the wind. How far seed spreads depends on the species, the size of the crop, and wind strength and direction. Eucalypt seed is dispersed to around 1–1.5 times the height of the parent tree. River red gum seed can be dispersed by flood waters.
- Once shed from the capsules, eucalypt seed only survives for a few months and, in most situations, will be quickly eaten by insects. Occasionally insects spread seed further from the tree without destroying it.

## 13.2 Seedling establishment

Only a small amount of the seed that reaches the forest floor will germinate and survive to become established seedlings. A lot of the seed is eaten by ants and other insects before it germinates. Other seed falls onto the litter layer and may germinate after rain. Moist conditions are required for seedlings to establish.

Seedlings are prone to damage from fungi or may not grow due to a lack of nutrients. Eucalypt roots form close connections with some fungi to improve growth and better absorb nutrients. Seedlings may struggle to survive if they fail to establish fungal associations (known as mycorrhizae).

Seedlings need a good suitable seedbed to establish. You can create a seedbed in one of three ways:

- Fire, which removes the litter layer and exposes mineral soil, destroys bad soil fungi, and releases soil and litter nutrients.
- Mechanical disturbance (intentional or from harvesting), which reduces competition by understorey species and exposes soil. While often not as successful for regeneration as fire, mechanical disturbance can be significant in eucalypt forests.
- Prolonged flooding, which can kill off herbaceous vegetation and create a moist seedbed for trees such as river red gum.

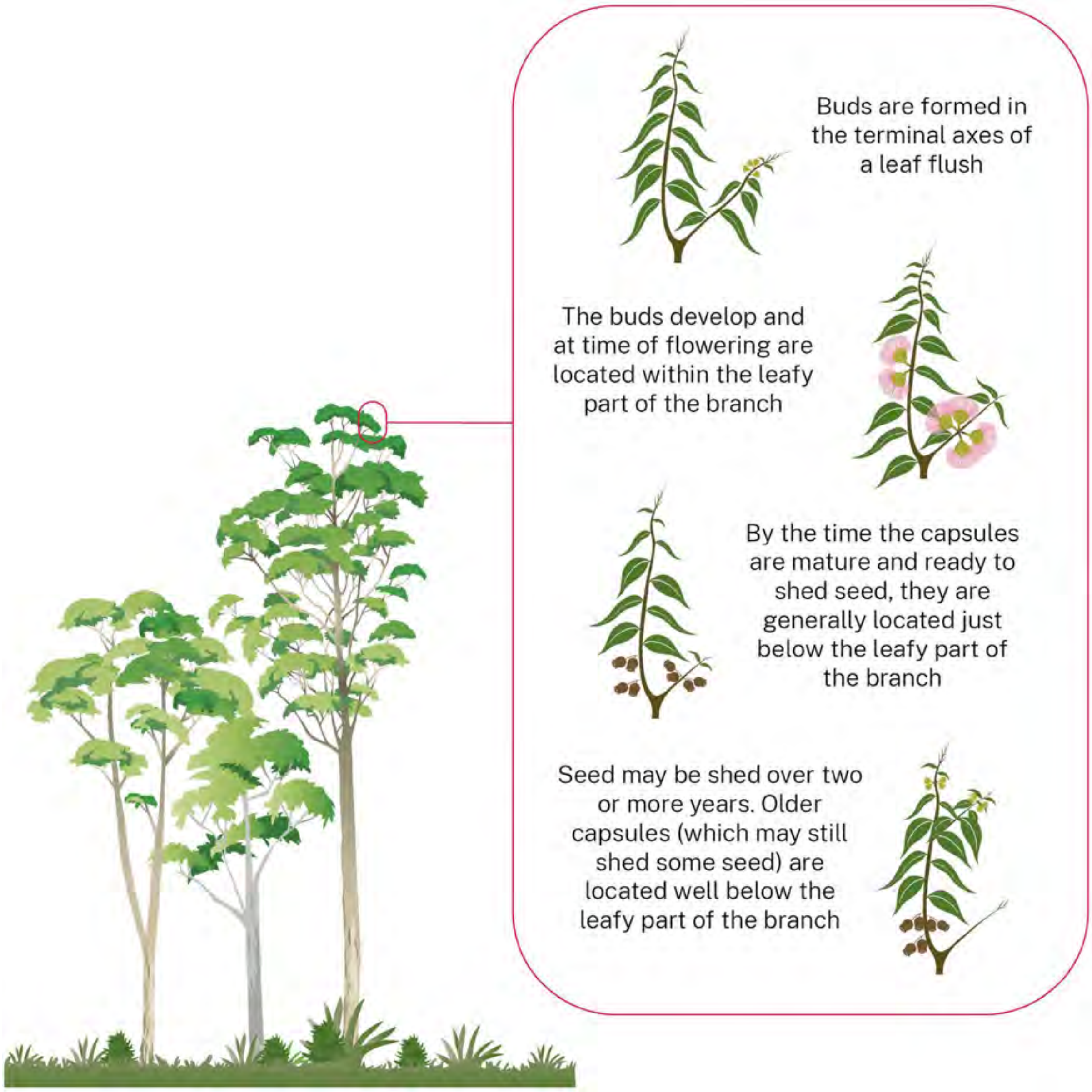



**Figure 36:** Typical development of seed capsules in the branch of a eucalypt

## 13.3 Resprouting from underground structures

In most eucalypt species, especially those that experience frequent disturbance events, seedlings form a lignotuber, which is a woody swelling or bulbous mass at the base of the stem. The lignotuber contains nutrient and starch reserves and has buds that form new shoots if the above ground parts of the seedling are damaged or destroyed. Seedlings with lignotubers are very hardy and may survive for many decades.

Lignotubers are helpful in stressful environments where frequent disturbances make regeneration by seed difficult, like in dry sclerophyll forests where new seedlings rarely establish and survive. Lignotuber seedlings don't survive well in wet sclerophyll forest, especially if there is a well-developed understorey of non-eucalypt species, so forest management must rely on new seedling regeneration.

Some species common to high-quality sites do not form lignotubers, including blackbutt, flooded gum, river red gum, brown barrel and shining gum.

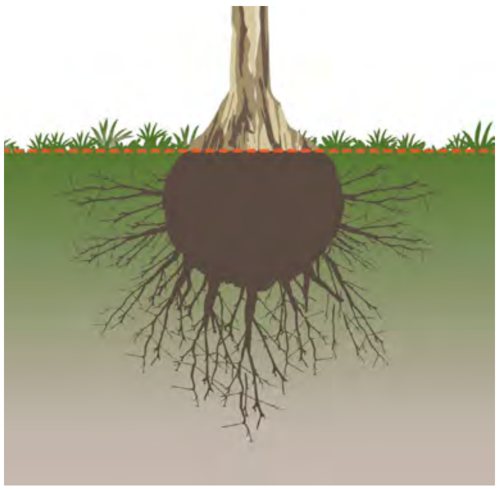


**Figure 37:** Lignotuber growth

# 13.4 Resprouting from epicormic buds

Most eucalypts have dormant buds beneath the bark around the stem. When the stem is cut or the tree is burnt, vigorous new shoots can develop from these buds, known as epicormic shoots.

Coppicing is a method of using shoots for regenerating trees after cutting or fire. Like advance growth, coppicing is more important in dry sclerophyll forests than wetter forest types.

**Figure 38:** Epicormic growth post fire

**Figure 39:** Coppicing

# 13.5 Ensuring adequate regeneration after harvesting

Successful regeneration after harvesting is the most important step in sustainable forest management. If regeneration is unsuccessful the forest can become seriously degraded, which is expensive to rehabilitate.

In most forest types and situations, regeneration will occur naturally. In others, you may need to intervene. Forests that are more likely to have difficulty regenerating include those with:

- Insufficient natural seed on site (species that rely on seed for regeneration)
- Competition from weeds
- A high chance that grazing will damage regenerating plants.

When selecting your silviculture methods, you must consider your regeneration objectives and requirements, and then monitor forest regeneration after harvesting. Techniques that promote regeneration include replanting (generally with tubestock), seeding, and managing weeds, fire and grazing.

## 13.5.1 Management to assist natural regeneration

Natural regeneration from on-site seed and trees is the preferred and most efficient form of regeneration and helps ensure that natural species patterns are maintained. There are management actions to assist natural new growth.

**Minimising grazing and browsing pressures:** Grazing by stock, kangaroos/wallabies or pest species can kill or impact the growth of new seedlings, resprouts and young trees. Consider grazing exclusion by fencing, using tree guards and rotational or tactical stock grazing. Managing pest species like deer, rabbits and goats can reduce browsing pressures (see Chapter 7.1 for more on pest management).

**Weed management:** Weeds compete for resources with native species. Forests can be particularly prone to weed invasion after a disturbance, including harvesting. Proactive weed control can help regeneration (see Chapter 7.1 for more on weed management).

**Fire management:** Fire can stimulate seed capsules in tree crowns to open, create a bare-earth seedbed and prompt the release of soil nutrients to promote seedling establishment. If species in your forest are fire dependent, fire management may be used as a regeneration tool (see Chapter 6).

**Mechanical disturbance:** Mechanically disturbing the soil and reducing understorey competition creates a good seedbed for regeneration. If you don't want to or can't use fire, mechanical disturbance can be a good option.

### 13.5.2 Direct seeding and planting

Direct seeding or planting can help when natural regeneration is unsuccessful or is unlikely to be successful because of weeds or a poor natural seed crop.

Use locally collected seed (for direct seeding or for growing seedlings for planting) to maintain genetic diversity. If forest is highly degraded and the best trees have been repeatedly removed, you may need to use seed from nearby high-quality trees to try and reverse the degradation of genetic stock on a site. Talk to your local commercial nursery and consider the use of stock that is genetically adapted to your local area. Never use genetically modified trees as seeding stock for regeneration.

The basics of direct seeding and planting are simple, but there are potential risks to new seedlings and plantings that must be managed, such as:

- Weeds
- Rabbits
- Browsing animals
- Frosts
- Use of nursery stock that is incompatible with the site.

Seek advice from people who have successfully established trees on similar sites.

#### Direct seeding guidelines

- Collect capsules with mature seed from the crowns of felled trees of all species.
- Extract seed from the capsules by drying it in the sun.
- Seed can be sown by hand or by machine.
- Sow seed onto burnt or mechanically disturbed ground, preferably just before rain and at a wetter time of the year.
- Use seed from a mixture of species that are appropriate for the site.

#### Planting guidelines

- Seedlings can be grown at home or bought from commercial nurseries.
- Where possible, plant seedlings of local provenance.
- Seedlings should be about 20–30 cm tall and hardened off before planting.
- Prepare the site for planting by burning or mechanical disturbance, using herbicides to delay weed competition as long as possible.
- Plant around 1100 seedlings per hectare (3 m by 3 m spacing).
- Plant during the wettest time of the year when there is good soil moisture and it is highly likely to rain immediately after planting.
- Fertilise seedlings after planting with a complete NPK (nitrogen, phosphate and potassium) fertiliser (around 100 g per tree).

### 13.5.3 Encouraging regeneration on difficult sites

#### *Wet sclerophyll forest*

In wet sclerophyll forests, or forests with grassy rather than shrubby understoreys, treatment of the soil surface to encourage new seedling regeneration is recommended.

Mechanically disturbing at least 60–70% of a canopy opening should stimulate enough seedling regeneration. Remove competition (such as ferns and shrubs) and expose the mineral soil surface using the blade on a harvesting machine or tractor. Lift the blade every few metres to avoid pushing topsoil too far and to reduce the potential for erosion. If weeds such as lantana are present, weed management might be needed. Seek advice from LLS.

You may choose to dry and burn harvesting debris in suitable weather conditions. The issues and risks of managing debris through burning include:

- Destruction of established seedlings
- Loss of seed in the crowns of felled trees
- Infrequency of weather conditions needed to sustain a fire that will create a good seedbed, but with minimal risk that the fire will spread to the surrounding forest
- Need for specialised fire fighting equipment and experience
- Possible stimulation of dense, competitive vegetation that responds to fire, such as wattles or lantana.

#### *Forest with a grassy floor*

Eucalypts do not regenerate as consistently or uniformly on forest sites with a grassy ground layer. In nature, regeneration may have developed primarily on localised seedbeds created where trees have fallen and burnt intensely. As grass responds rapidly to moderate intensity fire, it is recommended that you create seedbeds through mechanical disturbance such as blading off the grass and exposing the mineral soil.

# Glossary

# 14

| Term | Definition |
|---|---|
| **Australian Group Selection** | A silvicultural system in which groups (small patches or stands) of trees are har-vested, allowing for regeneration and leading to a forest with patches of differently aged trees. |
| **Basal area** | The sum of cross-sectional area of trees that are greater than 10 cm in diameter at breast height (DBH). Measured at breast height in square metres per hectare ($m^2$/ha). |
| **Biomass** | Organic matter that comes from plants. |
| **Crossing** | A structure designed to allow the crossing of a drainage feature and is either a track crossing or road crossing. |
| **Coarse woody debris** | Fallen dead timber (including a log or a head of a tree) of at least 3 m in length, where bark has been completely separated from the sapwood due to decay and the smallest end of the dead timber has a minimum diameter of 10 cm under bark. |
| **Directional felling** | The felling of a tree so it falls in a pre-determined direction. |
| **Drainage feature** | A drainage depression, drainage line, stream, river or watercourse. |
| **Drainage structure** | A structure designed to convey water away from a road, track or area of soil disturbance, such as cross drains, mitre drains or relief culverts. |
| **Epicormic** | Growth from a previously dormant bud, often prompted by a fire. |
| **Erosion** | Growth from a previously dormant bud, often prompted by a fire. |
| **Evapotranspiration** | The process by which water moves from land surface to the atmosphere; evaporation from surfaces such as land and water, and transpiration from the leaves of plants. |
| **Fire regime** | The pattern, frequency and intensity of fire in the landscape over time. |
| **Habitat tree** | A tree retained for habitat purposes. |

| Term | Definition |
|---|---|
| **Heathland** | Areas dominated by shrubs less than 2 m tall at maturity. |
| **Log landing** | An area (usually cleared) where timber products are assembled for processing and sorting before being loaded onto a truck. |
| **Old growth forests** | Ecologically mature forest where the effects of disturbance are now negligible. This includes an area of forest greater than 5 ha where:<br>• The overstorey is in late to over-mature growth stage, there are relatively large old trees with hollows and often dieback or dead branches in the crown<br>• The age (growth) structure of the stand (measured as relative crown cover) consists of less than 10% regeneration and advance growth and more than 10% late to over-mature growth.<br><br>Old growth woodlands west of the Great Dividing Range, while containing a characteristic canopy of late to over-mature trees (many with hollows), may have a woodland structure with less diverse or often shrubby understorey and a ground-cover of grasses and herbs. |
| **Pulp logs** | Logs cut and prepared primarily to produce wood pulp for the manufacture of reconstituted products including paper and panel board. |
| **Rainforest** | Tree-dominated vegetation where the tree stratum (over 3 m in height) which has the greatest crown cover has rainforest species making up 50% or more of the crown cover, except where non-rainforest emergent species (including brushbox and turpentine) occur and exceed 30% or more of the upper stratum crown cover.<br><br>Rainforest includes all areas of rainforest mappable at a 1:25000 scale. Rainforest also includes areas exceeding 0.5 ha occurring as isolated clumps or lineal strips of rainforest trees. |
| **Regeneration management actions** | Forest management techniques that promote forest regeneration after forestry operations including replanting, minimising or removing grazing pressure, seeding, weed management, fire management and mechanical soil disturbance. |

| Term | Definition |
|---|---|
| **Remnant forest** | Areas of forest containing native flora and fauna that have not been significantly disturbed; patches of native vegetation that remain. |
| **River red gum forests** | A forest dominated by Eucalyptus camaldulensis consistent with description of Forest Type 199 (River Red Gum) in State Forests of NSW, Research Note 17. |
| **Riparian exclusion zones** | Areas around drainage features where forestry operations are not permitted, as specified by the PNF Codes. |
| **Road** | Any route used for vehicular access to, and the transport of logs from, the point of loading (log landing) within the forest area. |
| **Rocky outcrops** | An area of at least 0.2 ha, where 70% or more of the surface has skeletal soils and exposed boulders of more than 60cm in diameter. |
| **Roost trees** | Trees with nests or roosts of bats or raptors. |
| **Saturated soil** | The physical condition of soil where no more moisture can be absorbed or accepted. |
| **Sawlog** | Log of a species suitable for processing through a sawmill into solid timber products. |
| **Seral communities** | Vegetation communities that occupy forested areas after a distrurbance and before re-establishment of a closed canopy. |
| **Silvicultural operations** | The activities associated with the management of trees within a forest for the purpose of meeting sustainable long-term productivity objectives, including thinning, single tree selection and creation of canopy openings. |
| **Single tree selection** | A harvesting operation where the trees harvested are either single trees or small groups of trees. Under the PNF Codes, single tree selection operations will not create canopy openings. |
| **Stand basal area** | The sum of the basal area of all trees within a stand expressed in square metres per hectare ($m^2$/ha). |

| Term | Definition |
|---|---|
| **Stand height** | Mean height of the dominant trees in the stand. Measurement of stand height must conform to methods described in approved guidelines. |
| **Stocking level** | The amount of tree stems capable of growing to canopy level. |
| **Thinning** | A silvicultural practice where some trees are removed in order to increase the growth rates of retained trees. |
| **Threatened species** | Species that are protected under legislation, and listed in the PNF Codes' Appendix A: Listed Species Ecological Prescriptions. |
| **Timber products** | Commercial timber products removed from or felled within the forest, including sawlogs, veneer logs, poles, girders, piles and pulp logs. |
| **Veneer log** | High-quality logs that are rotary peeled or sliced to produce sheets of veneer. |
| **Western hardwood forests** | A forest that is consistent with the description of any of the Forest Types 99, 103, 104, 124, 171–178, 180–185, 203–210 and 213 in State Forests of NSW Research Note 17. |
| **Wetland** | Includes any shallow body of water (such as a marsh, billabong, swamp or sedgeland) that is:<br>• Inundated cyclically, intermittently or permanently with water, and<br>• Vegetated with wetland plant communities |

Local Land Services – Private Native Forestry
Forest Management Guidelines