Draft Silviculture Guideline for Jarrah Forest

Sustainable Forest Management Series

Department of Environment and Conservation

Draft SFM Guideline No. 1

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Department of
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Our environment, our future

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2. Framework for this guideline

Purpose

The purpose of this document is to provide guidance on the application of silvicultural practices in those parts of the jarrah forest that are subject to timber harvesting. Guidelines are not prescriptive, but provide the intent and guidance for forest managers.

Scope

This guideline deals with the management of the forest available for timber harvesting and applies to State forest, timber reserve and freehold land that contains indigenous vegetation and which is held in the name of the CALM Act Executive body. The guideline does not cover the identification of informal reserves or other areas from which timber harvesting is excluded, this process occurs prior to the application of silviculture and is referred to in this document as the coupe planning process.

Context

This guideline provides the framework for operational practices which meets those goals of the *Forest Management Plan* (FMP) that are implemented through silvicultural practice. Measures to protect soil, including suitable times to conduct timber harvesting operations, are addressed in SFM Guideline 5, *Soil and water conservation guideline* and subsidiary documents. Detailed guidance on the application of fire to meet silvicultural objectives to promote regeneration and protect established growing stock from damaging bushfires can be found in the *Jarrah Silvicultural Burning Manual* – SFM Manual 4.

The purpose of this document is to provide guidance on the application of silvicultural practices in those parts of the jarrah forest that are subject to timber harvesting. This guideline provides guiding principles, rationale and strategies, and supporting manuals are intended to provide detail regarding operational practices.

Separate guidelines apply to the karri forest and to the wandoo forest. Silvicultural practices for mixed jarrah / karri / marri forest are covered in the karri guideline.

Custodianship and management of this guideline

This guideline is a controlled document. The custodian is the Manager of the Forest Policy and Practices Branch of the Sustainable Forest Management (SFM) Division of DEC.

Scale and application of silviculture

As in the FMP, this guideline recognises three scales of management which are as follows:

- Whole of forest – all land categories that are subject to the plan.
- Landscape – A mosaic where the mix of local ecosystems and landforms is repeated in a similar form over a kilometres-wide area. Several attributes including geology, soil types, vegetation types, local flora and fauna, climate and natural disturbance regimes tend to be similar and repeated across the whole area. It could be a (sub) catchment or, for convenience, an administrative management unit such as a forest block or an aggregation of forest blocks. Landscape scale could span a few thousand to more than many tens of thousands of hectares..
- Local – a discrete area of land to which one or more operations have been or are planned to be applied. It could span tens of hectares to perhaps a few thousand hectares.

Silviculture is usually applied at the local scale with a silvicultural objective selected appropriate to the condition of the local forest. However, silviculture is also guided by the condition of the forest at the landscape scale and seeks to provide for sustainable forest management at the whole of the forest scale.

This document includes twenty four guiding principles that provide the framework of silvicultural practice in the jarrah forest. A guiding principle is a statement that communicates a basis for management decisions. This guideline will be finalised in parallel with the finalisation of the Forest Management Plan 2014-2023 and will be consistent with the settings adopted for the final Forest Management Plan 2014-2023.

3. Legislative requirements

The legislative controls in relation to silviculture in Western Australia are found in the relevant State and Commonwealth Acts and regulations. The following table summarises the State government legislation.

Title of Act or Regulation	Relevance of legislation	Responsible agency
Aboriginal Heritage Act 1972	Under this Act the Department is required to report Aboriginal heritage sites and ensure that sites are protected.	Department of Indigenous Affairs
Agricultural and Veterinary Chemicals (Western Australia) Act 1995	Covers the use and control of pesticides, including the requirement to use pesticides in accordance with label requirements or "off label" permits for unregistered pesticide. Regulations related to pesticide application will be covered through compliance with the *Code of Practice for the use of agricultural and veterinary chemicals in Western Australia.*	Department of Agriculture and Food
Bush Fires Act 1954	Regulates the control of bushfires and the use of prescribed fire	Fire and Emergency Services Authority
Conservation and Land Management Act *(CALM Act)*	DEC's activities are exempt from requiring a clearing permit where the management is in accordance with the CALM Act. This exemption applies to all land within the FMP area that is managed in accordance with an approved management plan.	Department of Environment and Conservation
Country Areas Water Supply (CAWS) ***Act 1947***	This act governs the construction, maintenance and administration of reticulated supplies of water to country areas, to safeguard water supplies, and influences the Department's activities in gazetted catchments.	Department of Water
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)	Provides for the protection of the environment, particularly those aspects considered to be of national environmental significance (NES matters). Seeks to promote ecologically sustainable development through conservation and ecologically sustainable use of resources. Promotes conservation of biodiversity. The Act exempts RFA forestry operations from environmental approvals under Part 3 of the Act dealing with actions that will or are likely to have a significant impact on NES matters, e.g. listed threatened species, when done in accordance with a Regional Forest Agreement.	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth)
Environmental Protection Act 1986 *(EP Act)*	This act provides for the protection of the environment across the State. Relates to the prevention, control and abatement of pollution and environmental harm. It is to ensure the conservation, preservation, protection, enhancement and management of the environment, and may relate to any contamination caused by hydrocarbons from machinery and pesticides.	Department of Environment and Conservation and Environmental Protection Authority

Title of Act or Regulation	Relevance of legislation	Responsible agency
Forest Products Act 2000 *(FP Act)*	Clearing of vegetation maintained, or established and maintained, under the FP Act, or native forest harvested under a production contract or road contract, is exempt from the EP Act clearing permit requirements.	Forests Products Commission
Health Act 1911	Applicable to any pesticides used by the crown within a PDWSA. The restrictions on pesticide use are specified in Public Sector Circular 88 (PSC 88).	Department of Health
Heritage of Western Australia Act 1990	This Act provides for the registration and protection of places of historic interest on lands as 'heritage places'.	Heritage Council of Western Australia
Metropolitan Water Supply, Sewerage and Drainage Act 1909 (MWSSD Act)	This Act and the CAWS Act (above) and their associated by-laws are used to proclaim Public Drinking Water Source Areas (PDWSA). These may be referred to as water reserves, catchment areas or underground water pollution control areas. There are also requirements that relate to the use of pesticides in PDWSA (see *Health Act*, above). All operations in PDWSA are required to comply with *Statewide Policy No.2 Pesticide use in PDWSA*.	Department of Water
Rights in Water and Irrigation Act 1914	This act relating to rights in water resources, to make provision for the regulation, management, use and protection of water resources, and influences the Department's activities in relation to the taking and storage of water.	Department of Water
Soil and Land Conservation Act 1945	Provides for the conservation of soil and land resources. It includes the mitigation of the effects of erosion, salinity and flooding. This Act covers crown land. The Commissioner may advise a Government department or public authority in regard to the care or use of Crown lands which have lead to land degradation.	Department of Agriculture and Food
Wildlife Conservation Act 1950	Relates to the conservation and protection of indigenous flora and fauna on all lands and waters within the state. Provides for protection of threatened species.	Department of Environment and Conservation

4. Summary of guiding principles for silviculture in the jarrah forest

Guiding principles for biological diversity	
1.	Key structural features that provide biological legacies will be retained in silviculturally managed forests.
2.	Knowledge of natural disturbance regimes will be used to guide the size and intensity of silvicultural practices to ensure they contribute to the maintenance of landscape heterogeneity.
3.	Silvicultural practices will contribute to maintenance of landscape connectivity.

Guiding principles for ecosystem health and vitality	
4.	Promote resilient stands on sites with high levels of overstorey mortality.
5.	Promote resilient ecosystems on sites infested with *Phytopthora cinnamomi*.
6.	Fire will be used to reduce high fuel loads that may occur as a result of silvicultural practice.
7.	Maintain forest nutrient cycling processes.
8.	Promote ecosystem health and vitality through silvicultural treatment.

Guiding principles for soil and water	
9.	Water and quality and availability will be maintained or enhanced by silviculture treatment.
10.	Soil values will be maintained and protected in silviculturally managed forests.

Guiding principles for climate change and carbon cycles	
11.	Forests will be managed to ensure that local actions will contribute to global carbon cycles.

Guiding principles for productive capacity	
12.	Ensure the most appropriate silvicultural objective is selected for each stand.
13.	Regeneration and tree growth will be enhanced through actions to alleviate competition on regeneration and selected trees.
14.	Endemic regeneration will be used wherever possible.
15.	Silvicultural methods will reflect the site potential and developmental stage of the forest.
16.	Where the canopy is removed in gaps the forest will be regenerated in a timely manner.
17.	A grouped forest structure will be perpetuated at the local scale.
18.	Trees to be retained will be marked and protected from damage.
19.	Fire sensitive regeneration will be protected from fire.
20.	Forest areas that are killed or damaged by fire or other vectors may be restored or salvaged where necessary.

Guiding principles for heritage	
21.	Minimise disturbance to Aboriginal cultural heritage sites.
22.	Minimise disturbance to other Australian cultural and natural heritage sites.

Guiding principles for socio-economic benefits	
23.	Visual landscape management will be used to reduce the impact of silvicultural treatments on visual amenity.
24.	Post-harvest treatments will be prioritised according to the benefits likely to be realised.

5. Guiding principles for biological diversity

Overall objective

Conserve biodiversity and self–sustaining populations of native species and communities, and facilitate the recovery of biodiversity form disturbance operations.

Within the area covered by the FMP, biological diversity is supported through formal reserves, selected to be comprehensive, adequate and representative of communities, the multiple use forest area and informal reserves and fauna habitat zones. Together these areas represent a significant continuous area of forest cover. The small proportion subject to annual disturbance operations can be readily colonised from surrounding forest through the maintenance of the structural complexity and heterogeneity of the forest at multiple spatial scales, which facilitates the movement of genetic material and individuals.

Guiding principle 1

Key structural features that provide biological legacies will be retained in silviculturally managed forests.

Rationale

The occurrence of late structural stage or long-lived structural elements of the forest such as over-mature trees (over-storey trees which have begun to senesce and are likely to contain or develop hollows), mid-storey trees and shrubs; and large coarse woody debris can be reduced in areas subject to timber harvest. Attention is required to ensure the retention of these important elements of forests. These elements, referred to as legacy elements, are important contributors to structural diversity, connectivity and heterogeneity at the local scale.

Over-mature trees with hollows provide perching, nesting and roosting sites for a wide range of hollow dependent species. To retain a supply of hollow bearing trees, mature trees beginning to senesce must also be retained to supply tree hollows when the current cohort of over-mature trees collapse. This creates a cycle with collapsed trees providing ground hollows, habitat for fauna and substrate for saproxylic communities and cryptograms. All are important in maintaining the species richness of the forest.

Retention of legacy elements can mitigate the impact of the application of silviculture, by supplying a continuity of mature habitat across the landscape and reducing the recovery time following harvesting for fauna and flora populations reliant on these elements. Retention of these elements requires that they are clearly identified so that they can be protected both during harvesting and in post-harvest silvicultural treatments. Significant physical damage to retained elements could reduce hollow numbers or threaten tree survival. Conversely, some damage to the crown of potential habitat trees may increase the likelihood of trees developing hollows.

Mid-storey trees and shrubs contribute to food resources and habitat for fauna and contribute to structural diversity. The silvicultural methods developed for jarrah often involve mechanical disturbance to vegetation and soil to reduce competition with jarrah advance growth, or to enable jarrah seedlings to establish. These disturbances can have short term impacts on understorey species richness and abundance. Avoiding unnecessary disturbance to the soil and the understorey helps to ensure a balance between achieving regeneration of the overstorey and the impact on other vegetation.

Strategies

- Retain a selection of trees that have a moderate to high probability of bearing hollows ensuring that the pattern of marking includes a variety of arrangements.
- Retain selected trees that have a low to moderate probability of bearing hollows at the time of treemarking, but provide for the sustained availability of hollows through time in areas where regeneration is released by creating a gap.
- Retain a selection of large standing dead trees where they do not pose a safety risk.
- Retain patches of standing dead trees in areas where sawlogs are to be salvaged.
- Retain a selection of hollow logs and large diameter logs.
- Retain large balga (*Xanthorhoea preisii*) where present and exclude balga thickets from silvicultural treatments.
- Physical or chemical removal of the mid-storey shrubs and small tree species (such as Persoonia *spp., Banksia spp. and Allocasuarina fraseriana*) will only be undertaken where it is important for the establishment and survival of regeneration of overstorey tree species or for the continued growth of crop trees.
- Identify and protect selected underground cavities suitable as fauna refuges.
- Remove debris away from habitat elements when the combination and arrangement of fuels are such that the risk of damage threatens their long term survival.
- Preference to habitat treemarking will be given to trees that include nests of threatened fauna species where these have been identified during pre-harvest checks or observed by the tree marker on-site.
- Retain large marri (> 70 cm diameter with a senescent crown) additional to other requirements for habitat tree retention. In areas of the jarrah forest where large marri are relatively low in abundance, retain marri 50-70 centimetre diameter with a healthy crown and marri > 70 cm diameter, where practicable.

Guiding principle 2

Knowledge of natural disturbance regimes will be used to guide the size and intensity of silvicultural practices to ensure they contribute to the maintenance of landscape heterogeneity

Rationale

The natural or virgin jarrah forest occurs as a multi-aged forest with stands or individuals of different regeneration age generally occurring as a fine mosaic. Even-aged stands are usually relatively small in area, however there are exceptions. Past silvicultural practices and/or large scale disturbances such as bushfires have created some large areas of even-aged regrowth. For the most part, natural disturbances have helped to create diversity in forest structure at a range of spatial and temporal scales. Today, most of the forest consists of a mosaic of stands at different structural stages, resulting from previous natural and human disturbances. This complex diversity of structures across the landscape contributes to the biological diversity of the forest, with some species favoured by the habitat of early development structures, others by the later stages and others by a combination of two or more. Providing a mix of structural types across the landscape can encourage a wide variety of habitats and plant and animal communities, and thus, enhance ecosystem resilience.

Natural disturbances leading to changes in stand structures include stand replacing bushfire, storm damage, frost, drought, insect attack, and tree deaths in senescent stands. Adaptations to these natural disturbances enable the forest to respond and recover. Where canopy openings are

sufficiently large, the forest regenerates and progresses to later developmental stages until the cycle starts over again.

The highest intensity disturbance in the forest is mining, converting the existing mosaic to a single development stage, with very little structural diversity. Harvesting gaps to release regeneration also impacts on forest structure where the mature forest structure is converted to the establishment stage. However, the disturbance from timber harvesting is mitigated by the application of a number of strategies to ensure structural diversity is maintained - as outlined in Guiding Principle 1. No disturbance or large or repeated stand replacing disturbances may reduce ecosystem resilience by simplifying the landscape. Silvicultural management strategies ensure that the forest landscape continues to provide a mosaic of development stages to maintain biological diversity. The size of disturbances and combined extent and interval between disturbances are considered.

Use of temporary exclusion areas (TEAS) together with the formal, informal and fauna habitat zone reserve systems ensures that mature refuges are available. Once the forest has developed sufficiently to allow species to re-occupy the regenerating forest, then structure modifying disturbance in the TEAS can occur.

There are currently limited markets for non-sawlog logs that can arise as a consequence of harvesting sawlogs. There is a possibility that some markets may become available and as a result, harvesting disturbances could intensify. TEAS can be used to ensure that the local impact of more intensive harvesting is reduced to an acceptable level.

Strategies

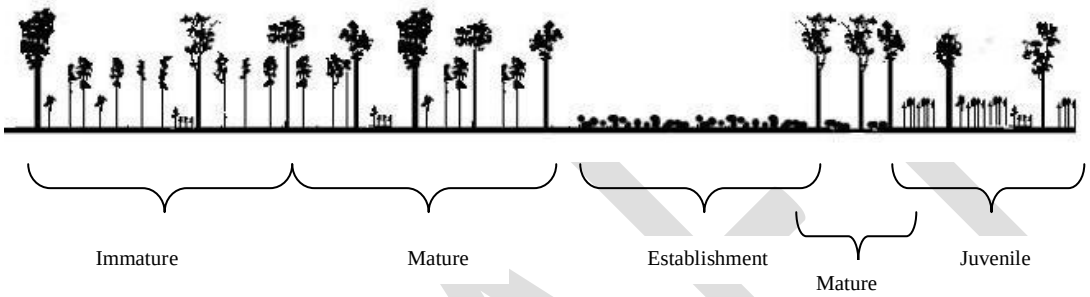
General forest area

- Existing heterogeneity, structural diversity and connectivity of the jarrah forest will be maintained through the application of a range of silvicultural methods. Silvicultural objectives will be selected for each stand based on the structural development stage, regeneration status, existing impact of disease and practicality of management (this will also contribute to maintaining an uneven-aged structure at the local scale and will contribute to Guiding Principle 2 & 3).
- Gaps will be limited in size to no more than 10 hectares (this strategy also contributes to Guiding Principle 2 & 3). In areas of forest where the predominant silvicultural objective applied was shelterwood (regeneration establishment) and where regeneration could be released across wide areas, structural diversity will be provided by TEAS to limit gap size. Harvesting of TEAS may occur once the regeneration is at least 10 years old depending on the visual landscape classification.
- Where harvest intensification from increased utilisation of non-sawlog material is likely over extensive areas, silvicultural treatment can be staged over time through the use of TEAS to ensure that no more than 60 per cent of a local scale management unit is reduced below the thresholds in Appendix 1, in any 10 year period.
- Reduction of competition from the mid-storey and small trees is only to take place where it is required to release overstorey regeneration and where this is undertaken, mid-storey and small trees may be reduced in numbers, but they must be retained as a component of the stand.
- When reducing rootstock competition to assist establishment of overstorey regeneration, limit soil treatments to a maximum of 50 per cent of the harvested area, to ensure re-sprouting species are maintained as part of the flora composition of the stand.
- Where possible, silviculture burns will be planned to create a mosaic of burnt and unburnt patches and persistence of a diversity of understorey structures.
- Retain advance growth of varying ages in areas of gap creation.
- Silvicultural treatments in forest isolated in agricultural landscapes will be staged over time to ensure the entire isolate is not subject to harvesting disturbance in any one harvesting event. A maximum of 50 per cent of each forest type that occurs in the isolate may be harvested at any

one time. Where the isolated area is less than 400 ha, it will be managed in two approximate halves, with subsequent harvesting permissible after 10 years.

Additional strategies for forest subject to mining

- The timing of silvicultural treatments will be managed to prevent greater than 40 per cent of the landscape scale area being in the establishment to immature developmental stages at any one time.
- Schedule thinning of the non-mined forest to reduce water use during times when more than 20 per cent of the landscape scale area is in establishment and juvenile stages during the mined site rehabilitation process.
- Manage the local scale management unit to retain the structural indicators of biodiversity (see Guiding Principle 1).
- Carry out variable density thinning on rehabilitated mine sites to increase structural diversity and reduce water use.



Note: the developmental stage is the predominant age in that stand, for example there may be mature trees present, but if the predominant age of trees in the stand is juvenile, then the areas is classified as juvenile and vice versa.

Guiding principle 3

Silvicultural practices will contribute to maintenance of landscape connectivity

Rationale

Landscape connectivity is the degree to which the landscape facilitates or impedes movement among resource patches. Connectivity is achieved by creating functional or structural linkage of habitats, communities and ecological processes. The exchange of individuals or genes among populations in different habitat patches influences both dispersal and genetic diversity and is an important consideration for persistence and resilience of populations, as well as for recolonisation following disturbance. Connectivity is particularly important in light of human induced climate change, as species or communities may need to reposition themselves in the landscape. Connectivity can be supported in the multiple use forest area through maintaining habitat at multiple spatial scales. Patches of forest to which silvicultural treatments are not applied are retained in the form of informal reserves such as stream zones, fauna habitat zones and other areas excluded from operations. Heterogeneity at the landscape scale avoids the creation of barriers to biological and ecosystem processes, including the physical movement of species or their propagules within the landscape. Connectivity is also maintained through the imposition of limits to the application of silvicultural treatments. Some species have a preference for particular structural elements, so large areas of a single structure within the forest should be avoided. Therefore, silvicultural practices seek to mimic the size and intensity of natural disturbances to which native flora and fauna have evolved to withstand (see strategies listed against Guiding Principle 2).

The scale and intensity of disturbance that would represent a barrier to biological and ecosystem processes varies from species to species, and the degree to which the disturbance alters the structure of the forest at the local scale. At the local scale, silvicultural treatments retain structural complexity to encourage the persistence and recolonisation of treated forest (for example, the retention of habitat trees, logs, understorey and overstorey elements see Guiding Principle 1). The retention of these elements provides habitat for species which may have limited dispersal, such as endemic saproxylic communities occupying large diameter logs.

A significant risk to connectivity in the multiple use forest area is mining, which significantly alters the structure and function of the forest for many decades. Connectivity can be supported by managing the forest surrounding mined areas to offer a means of dispersal around the disturbance, until connectivity is re-established. The strategic location of TEAS can ensure opportunities to retain structural diversity and heterogeneity at the local scale, supporting connectivity.

Strategies

- TEAS will be established to provide structural diversity and heterogeneity within the landscape. They may act as both a refuge and source of individuals or genetic material for recolonisation of treatment areas (this strategy also contributes to Guiding Principle 2).
- Habitat elements will be retained in harvested coupes to provide structural diversity and provide connectivity for species which require legacy elements for their life cycle (this strategy also contributes to Guiding Principle 1).
- Where thinning is an appropriate silvicultural treatment to apply to large areas of even-aged forest, variable retention thinning may be used to increase heterogeneity and structural complexity.
- Shelterwood or dieback selective cut may only be applied to a maximum of 60 per cent of the local scale area.

6. Guiding principles for ecosystem health and vitality

Overall objective

Use silvicultural treatment to mitigate the impacts of abiotic, biotic and anthropogenic stressors on the health and vitality of the forest.

Threats to the health and vitality of the forest will be identified and prioritised. Where possible, threats or damage from stressors will be avoided or mitigated through silvicultural treatment.

Guiding principle 4

Promote resilient stands on sites with high levels of overstorey mortality

Rationale

Climate change has the potential to impact on forest health. Competition for water may lead to drought related deaths of trees and other vegetation, particularly on shallower soils and others with low water holding capacity. The predicted increased incidence of extreme weather events may also lead to an increase in tree deaths from bushfire, storm and frost. Disease and insect attack may also have detrimental impacts on forest health. Water stress may predispose trees to insect attack and compromise their ability to recover from damage. Thinning stands subject to water stress increases the resources available to the retained trees and associated vegetation. This improves health and vigour and may reduce the risk of drought related deaths, and help enhance the trees natural defences in the face of insect and disease attack. Should myrtle rust enter Western Australia, both the increased vigour of trees due to thinning and the effect that a more open canopy has on relative humidity may reduce the incidence or intensity of infections.

Within any population are individuals who display resistance or resilience to stressors. Silvicultural treatments should identify and retain these individuals to improve representation of resistant genes in the overall population.

Strategies

- Individual trees or groups of trees that exhibit resistance to disease or the effects of insect outbreaks (such as Jarrah Leaf Miner or Gumleaf Skeletoniser) should be marked and protected from damage during timber harvesting operations.
- Select seed trees based on their form and vigour, together with their capacity to provide a crop of seed.
- Reduce stand density in stands subject to water stress to assist with adaption to a drier climate.
- Adaptive management trials to investigate the rehabilitation of sites with significant tree deaths may be approved by the Senior Silviculturist.

Guiding principle 5

Promote resilient stands on sites infested with *Phytopthora cinnamomi*

Rationale

Timber harvesting that removes a proportion of the overstorey trees reduces site water demand and may lead to increased availability of soil water. It is hypothesised that this change in water availability, coupled with higher soil temperatures from reduced canopy cover, may increase *Phytophthora cinnamomi* lesion growth in infected trees. *Phytophthora cinnamomi* impacts on the forest vegetation differently depending on a number of factors, including the abundance of susceptible plant species present, soil characteristics, drainage and climate. These factors can be used to predict the likely impact of the pathogen in different vegetation types should it become established. The predictions of impact are classified as either low, moderate or high. Low impact sites are those where few susceptible species are present and if the pathogen was introduced, it would be evident as a few scattered deaths in the understorey. Moderate impact sites are those where deaths are predicted in most susceptible understorey species and up to 10 per cent of the overstorey. High impact sites are those with a major component of susceptible species, where deaths are predicted to occur in most susceptible understorey and more than 10 per cent of the overstorey trees.

It is thought that less intensive disturbance on potential high impact sites may reduce the likelihood of generating conditions favourable to the activity of the pathogen and contribute to resilience.

On sites where the current impact of the pathogen is high, the ability of the site to recover from disturbance is likely to be lower than in healthier areas of forest. Disturbance in these areas needs to be carefully planned and should be directed to ensuring that the site is rehabilitated with resistant species or genotypes.

Strategies

- On sites expressing high disease impact, restrict harvesting and vehicle access to exclude areas where the live basal area is less than 18 m2/ha.
- Where site characteristics predict high disease impact on un-protectable forest areas, a basal area of at least 15 m2 of live trees will be retained. Retention preference will be for healthy trees, tree species that are not susceptible to Phytophthora cinnamomi, or individual trees that appear to be resistant to Phytophthora cinnamomi.
- Do not cull trees where the impact of dieback is predicted to be high.
- Where possible, encourage and protect natural regeneration on high impact disease sites and/or use dieback-resistant jarrah for regeneration.
- Adaptive management trials to investigate the rehabilitation of high impact sites may be approved by the Senior Silviculturist.

Guiding principle 6

Fire will be used to reduce high fuel loads that may occur as a result of silvicultural practices

Rationale

The quantity of combustible material on the forest floor after timber harvesting and silvicultural treatments is often increased above the range normally experienced through natural leaf litter and woody debris accumulation. Timber harvesting removes tree boles in the form of logs; however the tree crowns and other un-saleable material remain on the forest floor. The increased fuel load increases the risk of high intensity fire, which may be detrimental to biological diversity and other values.

Silvicultural practice in the jarrah forest involves fire exclusion and protection of developmental stages which are fire sensitive. The period of fire sensitivity for regenerating jarrah is variable and depends on the intensity of the fire. For a low intensity burn (< 120 kW/m), the regeneration should have reached the sapling stage and be at least 15 cm in diameter. This typically equates to a fire exclusion period of between 10 and 20 years. At the conclusion of this period, fuel loads are usually high and the canopy height is low, resulting in an increased risk of high intensity fire.

Strategies

- Tree felling to achieve silvicultural objectives will be followed by prescribed fire to reduce fuel loads. When cutting to gap or shelterwood fire should be introduced as soon as possible after harvesting ceases.
- Prescribed low intensity fire will be reintroduced into jarrah stands as soon as possible after the fire sensitive period for regrowth has passed i.e. at least 125 stems per hectare have developed sufficient height and bark thickness to tolerate fire.

Guiding principle 7

Maintain nutrient cycling processes

Rationale

The soils of the jarrah forest are generally infertile and growth of the forest is often limited by nutrients. Nutrient cycling within the forest conserves and recycles nutrients and prevents their loss from the system. Nutrient release from the breakdown of leaf litter occurs at a slow rate. Fire plays a positive role in the nutrient cycling, although some nutrient (mainly nitrogen) is lost to the atmosphere by the burning of litter and understorey. However, fire releases organically-bound nutrients in the litter into available inorganic form and promotes the regeneration of nitrogen fixing understorey, which not only fix nitrogen from the atmosphere but also increase the rate of decomposition and mineralisation of the litter. The removal of nutrients in sawlogs constitutes only minor losses to the system, relative to the stores of readily extractable nutrients in the soil. However, excessive removal of biomass from forest stands has the potential to impact on soil organic matter levels and may impact nutrient cycling. Proposals that include the removal of bark

and leaf material have greater potential to impact on soil nutrient and organic matter levels than those only removing bole material.

Strategies

- Planned fire will be used to manage fire regimes so as to minimise the extent of intense bushfires, which can result in large loses of nutrients from the ecosystem and accelerated soil erosion.
- Undertake silvicultural burns at a time after harvesting that allows leaf litter produced by the harvest to decompose prior to burning.
- Undertake prescribed burning operations in regeneration areas once the fire sensitive period has passed.
- Prevent the removal of leaf and fine branch material as residue products from forest harvesting operations.
- Prevent soil erosion by limiting soil disturbance and prevention of high intensity fire.

Guiding principle 8

Promote ecosystem health and vitality through silvicultural treatment

Rationale

This guiding principle is also referred to as 'silviculture for ecosystem health'.

Jarrah is a long lived species and the jarrah forest that occurs today is the product of past climatic conditions, natural events and past management. Over the last forty years, a marked drying trend is evident with average temperature increases of 0.8 ^{0}C and average annual rainfall reduced by around 15 per cent. Jarrah has evolved to be competitive for water and accesses water deep in the soil profile to survive the long dry period that occurs in summer and autumn each year. Therefore, on sites with a deep soil profile, the survival of jarrah is unlikely to be an early indicator of climate change.

Mitigating the effects of reduced rainfall and higher temperatures on the jarrah forest and associated ecosystems will require adaptive action. Water availability within the forest is one of the key drivers of vegetation patterns and the types and abundance of fauna. Groundwater monitoring shows that water tables in the northern jarrah forest fell by around 0.2 metres per year over the 35 years to 2011, and stream flow reduced by 12 to 50 per cent in the period 2004 – 2009 relative to 1975-2003 period. As a result, many permanent streams have become ephemeral and most ephemeral streams now rarely flow.

Both temperature and water availability are directly linked to the provision of refugia in the landscape. Action to align forest density with current and future climate is a practical way to assist forest ecosystems to adapt to climate change. Targeted action may retain water availability in some parts of the forest and allow for the persistence of ground and surface water dependent ecosystems in these areas.

A reduction in stand density has the potential to mitigate other risks associated with climate change. Reduced inter-tree competition improves tree vigour and reduces tree susceptibility to pest attack. Concurrently, a reduction in stand density also makes more water available for the understorey and therefore assists the broader ecosystem to adapt to climate change.

The juvenile and immature development stages of jarrah may have greater water use than older growth stages. At a catchment scale another option to increase water availability is to limit the amount of forest in the juvenile and immature development stages.

The strategies below are not proposed to be applied to the forest as a whole, but provide an option where it identified there is the potential and resources to protect an ecosystem or high value asset at risk. For example, thinning to reduce fire risk and prescribed burning could be used to help protect granite outcrops. Water dependent refugia could be identified and protected through targeted reductions in stand density to maintain or restore groundwater level or streamflow. Local areas subject to disease or insect attack could be thinned to help promote recovery.

Strategies

- Identify refugia, threatened flora communities and ecological communities at high risk of adverse impact from climate change and undertake 'silviculture for ecosystem health' in the surrounding area to protect and support their persistence, value and/or recovery.
- Identify catchments or Land Management Units (LMU) at high risk of adverse impact from climate change and undertake 'silviculture for ecosystem health' to protect and support these areas.
- Reduce stand density on mid and lower slopes of catchments with water dependent ecosystems which are subject stress from declining groundwater level or streamflow.
- In young stands with a high stand density, undertake early age thinning from below to promote tree development to more quickly attain characteristics of mature forest and a water balance in line with current and predicted future climate.
- Reduce stand density, if necessary with high levels of culling, in selective cut areas with a high stand density.
- Reduce stand density to promote recovery in high density stands that are subject to insect and disease damage (except dieback).

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7. Guiding principles for soil and water

Overall objective

Protect soil and water resources in order to sustain the foundation for diverse, productive and healthy forest ecosystems, and to provide water for consumptive uses.

The effect of forest cover on soils and water quality is positive. By regenerating forests after harvesting, soils are stabilised, water and wind erosion is prevented and nutrient cycles are maintained. Water quality is maintained and water flow moderated. Disturbance, particularly roading, can be detrimental to soil and water values. Management controls on these operations should limit potential harm.

Guiding principle 9

Water quality and availability will be maintained or enhanced by silviculture treatment

Rationale

A drying climate affects water availability for both human needs and for natural ecosystems. It may become necessary or desirable to actively manage the water use of forested catchments in order to maintain water supply both for consumptive use, and for surface and groundwater dependent ecosystems of particular conservation value. Water use by vegetation can be moderated by reducing the density of overstorey trees and understorey vegetation, and limiting the proportion of the catchment in young development stages, which typically have higher water use.

Reducing stand density provides for an increase in water availability by reducing water use for a period. In juvenile and immature stands, thinning is followed by increased growth of the retained trees and crown expansion, so the reduction in water use is temporary, but can be up to 25 years. The juvenile and immature stages of development may have higher water use than older growth stages. Where a large proportion of a catchment is in the juvenile and immature stages (i.e. approximately 9-120 years), higher water use may result in reduced surface and ground water availability for both biota and human needs. Active catchment management, through limiting the area of the catchment in juvenile and immature stages and/or thinning trees in these stages, can be used to reduce water use and increase water availability.

Some forested catchments are sensitive to salinity and special measures need to be taken in these areas to protect water quality. Limiting the extent of timber harvesting in these catchments reduces the risk of subsequent stream salinity. Water quality can also be affected by contamination from chemicals (herbicides and fuel oils) if they are used incorrectly or spilled in the catchment. Care needs to be taken to ensure that chemicals are used in accordance with best practice.

Strategies

- Water availability may be managed in forested catchments by either thinning juvenile or immature stands and/or by limiting the proportion of the catchment in the juvenile and immature stages of development. Catchment management plans will be required where any proposal seeks to reduce stand density below that provided for in this guideline or where it is

considered that an excessive proportion of the catchment will be in the juvenile and immature stages of development. Catchment management plans will address all forest values.
- Protect water quality from salinity in high salt risk catchments through increased stream reserves, phased harvesting within second order catchments and a minimum cutting cycle interval of 15 years.
- Protect water quality from salinity in salt sensitive catchments through, phased harvesting within second order catchments and a minimum cutting cycle interval of 15 years.
- Use best practice when using or applying chemicals as guided by regulations and the Code of Practice for the use of agricultural and veterinary chemicals in Western Australia.
- Pesticides will only be used where there is, in the view of the Department, no practicable alternative.

Guiding principle 10

Soil values will be maintained and protected in silviculturally managed forests

Rationale

The success of shelterwood operations is dependent on having a viable seedbed to facilitate the germination of seedlings. Soil damage not rehabilitated after timber harvesting can reduce seedbed quality and reduce regeneration. Soil treatments such as scarification and/or ripping with a machine can be used to rehabilitate damaged soils and improve the area of receptive seedbed available for regeneration. However, care needs to be taken to ensure the rehabilitation operations do not cause adverse impacts on soil values.

Strategies

- Rehabilitation of soil damaged on extraction tracks will be timed to occur prior to the post-harvest burn for all shelterwood operations.
- When reducing rootstock competition to assist establishment of overstorey regeneration in shelterwood operations, limit soil treatments to a maximum of 50 per cent of the harvested area.
- Refer to the Soil and Water Conservation Guideline for further strategies for management of soil and water values.

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8. Guiding principles for climate change and carbon cycles

Overall objective

Within the constraints of a changing climate, forests available for timber harvesting will be managed to sustain the contribution to global carbon cycles.

Wood production from native forests provides an opportunity to contribute to climate change mitigation through storage of carbon in forests, storage of carbon in forest products, replacement of fossil fuels and replacement of high-embodied energy alternatives.

Guiding principle 11

Forests will be managed to ensure that local actions will contribute to global carbon cycles.

Rationale

Forests have an important role in global carbon cycles, predominantly as sinks, but also as sources of carbon. Carbon stocks in forests include biomass (litter, woody debris, stumps, roots, dry standing stems) and soil carbon pools.

Forest products are also part of global forest cycles as both a source and sink for carbon. Forest products may reduce carbon emissions if they displace the use of materials which are more carbon intensive to produce, such as the use of timber rather than steel, concrete or aluminium in construction, or the use of non-sawlog material to replace fossil fuels to produce energy. Forest products store carbon, although the storage time of carbon in forest products varies, and is greatest in higher value timber products that typically have a long 'in-service' or 'end-use' life.

Natural disturbances affect the carbon cycle and these disturbances are a major cause of carbon fluxes in forests. Bushfire and damage from insects, diseases and storms may play a large role in the carbon cycling in forests. Forest management practices may increase or decrease these effects, however the aim is to ensure that forests continue to be carbon sinks, sequestering at least as much carbon as they emit at the whole of forest scale. Under the United Nations Framework Convention on Climate Change, harvested forests are considered carbon neutral as long as the area is maintained and regenerated.

The cumulative impact of practices implemented at a stand scale contributes to both the rate of accumulation of carbon in forests and the quantity of carbon emitted. Regeneration and rehabilitation ensure that the area of forest available to store carbon is not reduced and the preferential use of low impact forest harvesting practices can reduce the quantity of carbon emitted. There are situations however, where high carbon emitting practices are undertaken at the local scale. Forest management limits these practices to where they are necessary to achieve other forest management objectives.

Strategies

- Encourage the production of forest products with a long service life, and those that replace fossil fuels and high-embodied energy alternatives, from logs sourced from silviculturally treated forest.

- Sustain the pool of carbon stored in the forest by maintaining the area of forest, and regenerating areas that have been harvested and rehabilitating areas of soil damage, to maintain productive capacity.
- Culling trees by notching is the preferred method for post-harvest treatment in the jarrah forest. Felling will only be conducted in high value view sheds, where public safety concerns take precedence or there is a market for the material.
- Culling of non-merchantable trees will not occur in those stands where achievement of the silviculture objective would require culling of $12m^2$/ha basal area or greater of trees, unless there is an over-riding consideration. Follow up silvicultural treatment may be undertaken where there is a market for the material that would have been culled. Where culling of less than $12m^2$/ha basal area of trees is required to achieve the silviculture objective, this will be undertaken.
- Plan prescribed fire regimes to reduce the risk and frequency of high intensity bushfires.

9. Guiding principles for productive capacity

Overall objective

Silvicultural management will be used to support the capacity of the forest to sustain a supply of goods and services in the long run.

Maintenance of productive capacity provides for the sustainability of the flow of some of the benefits from forests to society. Productive capacity includes both wood and non-wood resources. Maintaining productive capacity of forests available for timber harvesting involves maintaining the area of State forest and timber reserves and the area within State forest and timber reserves where harvest is permitted, and providing for harvesting on a sustained yield basis.

Guiding principle 12

Ensure the most appropriate silvicultural objective is selected for each stand

Rationale

Jarrah forest is essentially uneven-aged, with relatively small patch sizes. Application of a single silvicultural method is not usually appropriate to the condition of the forest, so a systematic process is used to guide decisions as to which silvicultural method to apply. Study and observation enabled the development of jarrah forest silvicultural methods, based on how the forest regenerates naturally after disturbance and how the trees grow and interact with each other and their surroundings. There are three key silvicultural methods which can be applied at different developmental stages; being thinning, gap and shelterwood.

Thinning can be applied to juvenile or immature stands, but first requires correct assessment of the developmental stage. If immature stands are identified as mature, trees may be felled when only part of their bole is of sawlog size and the full timber potential of the trees will not be realised.

Gaps are applied to mature stands where there is sufficient advance growth present to develop into a fully stocked regrowth stand. Where insufficient advance growth is present, shelterwood is applied to assist its establishment. Application of the correct silvicultural method is first dependent upon the identification of regeneration status.

Strategies

- Carry out advance burning prior to harvesting to facilitate the identification of regeneration stage and numbers.
- Maintain maps of forest structure and use pre-harvest regeneration surveys to assist in the selection of the most appropriate silvicultural method.
- Mark vigorous trees, of good form with mature characteristics (dbhob>50 cm) and sufficiently spreading crowns to provide seed in shelterwood areas.
- Monitor treemarking against standards before harvesting to ensure that the most appropriate silvicultural method is selected.

Guiding principle 13

Regeneration and tree growth will be enhanced through actions to alleviate competition on regeneration and selected trees

Rationale

Competition for water, nutrients and light impacts on the survival and growth of all development stages of the forest and the quantity of forest products that can be produced. Silvicultural methods for the jarrah forest have been developed to alleviate competition at various development stages, to maximise tree vigour and sawlog production.

To establish regeneration using the shelterwood method, stand density and sometimes understorey density is reduced to increase the chance of seedling survival, particularly in the first summer. Seedlings that develop under a canopy become part of the pool of lignotuberous advance growth and do not proceed through later development stages until a gap is formed in the canopy, either from death or decline, or by removal of the trees during silvicultural treatment and/or harvesting. Release of regeneration by cutting a gap in the overstorey should not be carried out until a sufficient number of ground coppice or later advance growth forms of regeneration are present. Because of competition effects, the size of the gap must be sufficiently large to allow regeneration to progress to maturity.

Silvicultural thinning reduces stand density, usually to avoid stand stagnation and aims to keep trees actively growing and prevent severe competition or stand 'lock-up'. The juvenile stand experiences significant competition from the time of crown closure, at about 8 years after release, and this continues throughout the life of the stand. When the stand experiences severe competition, growth rates decline and many trees cease to grow, some die. This natural thinning process occurs at a slow rate. Silvicultural thinning hastens the natural thinning process to improve growth of the retained trees and reduces the time taken for retained trees to reach maturity and sawlog size. Thinning in uneven-aged stands may require variable density thinning practices to be adopted, to ensure that each tree has sufficient space to develop.

Regeneration patch size and shape influences the level of competition experienced by individuals within the patch. Small gaps experience the highest level of influence from edges, so competition reduces as patch size increases. Similarly, retained legacy elements compete with adjacent trees and regeneration and this is influenced by the density and pattern of these legacy elements. The footprint of competition is greatest from wide spaced individual trees, compared with trees with a clumped distribution, for a given density of legacy elements.

Strategies

- Undertake post-harvest treatment in areas cut to gap, targeting a reduction in the overstorey to less than 20 per cent crown cover.
- Retained habitat trees should be marked in groups wherever possible, so as to reduce the suppression of regeneration.
- The diameter of gaps should be at least four times tree height to reduce edge competition. The absolute minimum diameter is two tree heights, but this should not be commonly used.
- Where necessary, reduce competition from understorey, midstorey and overstorey to prevent suppression of overstorey regeneration.
- Promote growth on retained trees by thinning. Variable density thinning will be applied to uneven-aged stands to ensure that each tree is released from competition.

Guiding principle 14

Endemic regeneration will be used wherever possible

Rationale

Natural regeneration is the preferred method of regeneration in the jarrah forest. Silvicultural management encourages the production of seed crops *in situ* and promotes the growth of existing seedling, lignotuberous seedlings and ground coppice where they exist. Where natural regeneration is not possible or natural regeneration requires supplementation, endemic species are seeded or planted. Regeneration aims to restore the area to a self sustaining ecosystem, with a similar species composition to that which existed prior to disturbance.

Traditionally, regeneration operations requiring the use of supplementary seed or seedlings have strived to use 'local' seed. More recently, guidelines for seed collection for regeneration (and rehabilitation) have moved away from the requirement for only using 'local' material, as the scientific basis for this has been increasingly questioned, and additional considerations for optimal regeneration outcomes are now recognised. Factors considered to be important for any seed collection strategy include: matching topographic and edaphic features; allowing for expected changes in climatic conditions between seed collection sites and regeneration sites; and the need to use good quality seed with sufficient genetic variability to help enhance the resilience of regeneration.

Seed collected for regeneration is usually collected from the same landscape management unit (LMU) as the area to be regenerated. However, flexibility may be required to facilitate desired outcomes – for example where disease is present, or rainfall has declined, it may be appropriate to consider the use of disease, and/or drought, resistant varieties of those same species. In this case, the best source of seed or seedlings may be from another area. Alternatively, if disease or drought resistant varieties are unavailable or unknown, then using mixed seed sources to maximise genetic diversity might be an appropriate alternative strategy. This would provide a broader source of variation, allowing for greater potential to adapt to new perturbations such as disease or environmental change.

Strategies

- Use natural regeneration where reasonable and practical.
- Where natural regeneration is not reasonable and practical, use only species endemic to the area being regenerated.
- Fire will be used in gap creation operations to prepare a receptive seedbed and encourage the germination of soil stored seed.
- Stool coppice will be used in preference to the use of artificial seeding or planting, wherever the stocking of jarrah regeneration is marginal.
- Where there is knowledge of population genetic structure or it can be inferred from life history traits, use this to guide seed collection areas.
- Where population genetic structure is unknown and cannot be inferred, use seed collected from the same LMU (or neighbouring LMU) as the area being regenerated.
- Where a broader seed collection is required for successful regeneration, this will be based on criteria agreed between the Department and the Conservation Commission.

Guiding principle 15

Silvicultural methods will reflect the site potential and developmental stage of the forest

Rationale

Site potential refers to the maximum density of forest that can be supported before it becomes limited by nutrients and water. Areas of high site potential exist where rainfall is high, soils are deep and relatively fertile and evaporation is low. Lower site potential is found in areas with lower rainfall, shallower soils or soils with lower nutritional value, and where evaporation is high. The jarrah forest occurs over a geographically large area and site potential varies across its distribution, particularly from west to east, reflecting changes in the soil type and available water. Changes in site potential are often reflected in changes in vegetation. Broad scale structure mapping of the jarrah forest has provided height categories which can be used to infer the site potential.

The degree to which site potential is utilised depends on stand age. Young stands have less access to available water than mature stands, because root systems are not fully developed. The total biomass is limited during the younger development stages and increases as the stand matures (i.e. a uniform juvenile stand consisting of trees at the sapling stage would be expected to support less biomass than a fully stocked uniform stand consisting of pole sized trees). Thinning schedules take stand development stage into account and target density will vary between stages.

Strategies

- Regeneration stocking schedules will recognise that the forest has areas of high, moderate and low site potential (Appendix 2).
- Use historical maps of stand top height to indicate site potential for the application of relevant thinning schedules.
- Thinning schedules for even-aged regrowth and retained densities in shelterwood will recognise that the total biomass that can be supported increases as the stand progresses from one development stage to the next (Appendix 3).
- Periodically review classification of site potential in light of forest inventory to ensure the correct stocking and thinning schedules are applied.

Guiding principle 16

Where the canopy is removed in gaps, the forest will be regenerated in a timely manner

Rationale

Where the gap silvicultural method is applied, timely regeneration is required to ensure that productive capacity is maintained.

Time delays between harvesting and regeneration extend the time to reach stand maturity, reduce the ability to achieve prescribed burn outcomes and may lead to reduced yields. Ensuring that areas are regenerated adequately and within target timeframes contributes to the provision of a range of forest values.

Strategies

- Post-harvest regeneration treatments should be completed as soon as practicable after the cessation of forest harvesting in that coupe.
- Post-harvest silvicultural treatments will be conducted prior to burning where possible.
- Regeneration stocking rates will be monitored to determine regeneration success (see Appendix 2 for stocking rates).

Guiding principle 17

A grouped forest structure will be perpetuated at the local scale

Rationale

Sustainable wood production is facilitated by a forest structure that protects or reduces the incidence of damage to regrowth in successive harvest operations. Mature overstorey trees have large spreading crowns; which when felled can damage other trees and vegetation in their path. Where regrowth stands are small, trees within the stand are likely to become damaged when adjacent trees are fallen.

Harvesting damage may range from complete removal of the above ground portion of the regrowth, to the damage to the crown or cambium layer. Where saplings are snapped off at the base, all growth achieved in the interval between cutting cycles will be lost, increasing time to reach maturity. Damage to the crown of young sapling or poles may impact on growth and form, downgrading timber values. Managing areas of forest at a very fine mosaic poses safety risks to forest workers. When mature trees are fallen into stands of regrowth or other trees, there is increased risk of branches or debris striking and injuring the faller.

Strategies

- Maintain a grouped forest structure with a minimum patch diameter of at least four times tree height and a maximum of ten hectares (this strategy also contributes to Guiding Principle 2).

Guiding principle 18

Trees to be retained will be marked and protected from damage

Rationale

Silvicultural practices in the jarrah forest involve the retention of trees for various purposes depending on the silvicultural method that is selected. Trees may be retained to grow on for future timber values, provide hollows for habitat, as a seed source or cover to protect water values.

Harvesting operations which remove mature trees have the potential to damage retained trees, both directly and indirectly. Direct mechanical damage to the cambium of a tree can result in wounds which facilitate the entry of borers and rot, degrading the timber value of the tree. Damage to retained trees may also occur during post-harvest burns. The radiant heat generated by the

combustion of fine fuel from tree crowns in combination with larger debris has potential to damage or kill trees. The likelihood of damage varies with the amount of heat exposure, the length of time the tree is exposed to the heat and the bark thickness of the tree.

Strategies

- Treemarking is to be undertaken in advance of harvesting operations and trees are to be marked for retention in accordance with the treemarking manual.
- In first thinning of regrowth stands, consideration may be given to the use of trained machine operators to identify trees for retention without prior marking.
- Monitor the level of damage to retained trees to ensure it does not exceed the allowable level.
- Remove debris away from the base of marked trees when the combination and arrangement of fuels are such that they risk damage to timber and other values during post-harvest burns.

Guiding principle 19

Fire sensitive regeneration will be protected from fire

Rationale

Regeneration in the jarrah forest is fire sensitive during its early development stages. During the establishment and juvenile development stages, until the bark thickness of saplings is sufficient to withstand mild fire and the leading shoot tall enough to escape damage, fire is likely to kill above-ground shoots. Lignotuberous seedlings, seedling coppice and ground coppice will resprout and continue to develop after fire. Ground coppice will resprout after all but very high intensity fire, however any growth achieved prior to the burn will be lost. The nominal rotation age will be extended as the burn effectively restarts the development cycle.

Strategies

- Fire will be excluded from regeneration during its early developmental stages for a nominal period of 10 years.
- The planning process for prescribed burns in juvenile stands will include an assessment of the stocking of saplings that will withstand mild fire. This assessment will include measurement of sapling height and diameter to gauge their fire sensitivity.
- Forest areas adjacent to fire sensitive regeneration will be burnt where possible to reduce the likelihood of high intensity bushfire in regrowth stands.
- The significance and sensitivity of regeneration will be used to prescribe fire in areas where multiple objectives exist.

Guiding principle 20

Forest areas that are killed or damaged by fire or other vectors may be restored or salvaged where necessary

Rationale

While it is unlikely that bushfire will kill healthy jarrah saplings or small poles, it may cause damage to the bole or the growing tip. Damage of this nature can seriously reduce the value of the tree for sawlog production in the future. Fire damaged trees are pre-disposed to insect, fungal and termite attack, which can also lead to mechanical failure in the tree, constituting a safety concern. The value of the damaged regrowth can be improved through coppicing the stems and allowing them to regrow. Alternatively, the yield calculations for the area can be amended with a reduced quality expectation to reflect the damage.

It is predicted that climate change will lead to more frequent instances of extreme fire weather conditions. Fires that occur during extreme weather conditions can result in the death of mature trees. Provision of forest products may be adversely impacted, both by increasing time to stand maturity where stand replacing fires occur and where fire damage reduces the volume of sawlogs available. Death and degrade may reduce sustained yields where they occur on State forest, but can be partially offset where salvage harvesting occurs.

Disease or insect attack may also affect sustained yield; however salvage is not as straight forward when there are underlying forest health issues. Care needs to be taken when considering salvage of these stands to ensure that the harvesting operation does not further reduce the resilience of the stand.

Strategies

- Fire damaged regrowth areas should be coppiced and managed to ensure that at least 125 stems per hectare will be available for future sawlog production.
- Harvesting may be used to salvage sawlogs in fire killed or drought killed stands.
- Harvesting to salvage sawlogs in disease or pest killed stands may be approved by the Senior Silviculturist on a case by case basis. Measures to maintain stand resilience must be included in any proposal.
- Regenerate areas left understocked after fire or salvage harvesting.

10. Guiding principles for heritage

Overall objective

Protect and maintain Aboriginal and other Australian cultural heritage.

The value of heritage places relates to their historic, aesthetic, scientific or social significance. Heritage values can be threatened by inappropriate fire regimes, theft, vandalism, disturbance activities, structural decay, erosion, and failure to have proper procedures for their protection or failure to enforce those procedures.

Guiding principle 21

Minimise disturbance to Aboriginal cultural heritage values and sites

Rationale

The jarrah forest was traditionally occupied by the Noongar people, who are the original custodians of the land. In the Noongar dreamtime creation story, the responsibility of caring for everything was given to people. All of the other spirits of the dreamtime agreed to this so long as the people ensured that all the different elements of ecosystem were not used until nothing was left. Sustainability of the forest and all elements of biodiversity are therefore still very important to the Noongar people.

Scarred or modified trees that mark trails or other sites of significance to Aboriginal people occur throughout the forest. The locations of the trees that exist today are not all known or registered. Therefore, an important part of protecting heritage values and sites is to ensure adequate training of staff and contractors working in the forest, so that they are able to recognise sites and follow procedures for protecting and registering them. Staff conducting silvicultural operations should be able to recognise potential cultural heritage sites, report them and take action to avoid disturbing them until they have been assessed. Trees or sites encountered during silvicultural operations that have potential heritage value need to remain undisturbed until their suitability for registration can be formally determined.

Strategies

- Ensure staff and contractors receive adequate training in how to recognise, protect and register Aboriginal cultural heritage values and sites.
- Identify and protect all scarred or modified trees where they exist in areas of silviculture treatment.
    - Identify and protect all sites of significance in accordance with Department of Indigenous Affairs, Cultural Heritage Due Diligence Guidelines www.dia.wa.gov.au
- Consider use of seed from “bush tucker” plants in landing and track rehabilitation operations.
- Ensure that regeneration is established where gaps are cut (this strategy also contributes to Guiding Principle 16).

Guiding principle 22

Minimise disturbance to other Australian cultural and natural heritage values

Rationale

Throughout the forest there are places providing examples of early settlement and harvesting practices such as remnant tramways, cuttings, old bridges and loading ramps. Pre-harvesting checks of databases are conducted to conserve known cultural heritage sites. However, not all places with other Australian heritage value are currently known and staff conducting silvicultural operations should be able to recognise potential cultural heritage places, report them and take action to avoid disturbing them until they have been assessed. It is important to protect places of significant value when encountered in harvesting operations.

The Department maintains a Significant Trees Register. Listed trees can be identified through pre-harvest checks to ensure they are located and protected from disturbance. Trees encountered during silvicultural operations that have characteristics of significant trees need to remain undisturbed until their suitability for registration can be formally determined.

Strategies

- Retain trees of cultural significance in areas of silvicultural treatment. Vary silvicultural treatment within the curtilage of registered heritage places to protect heritage values.
- Identify and protect significant trees in areas of silvicultural treatment.
- Ensure potential significant trees remain undisturbed in areas of silvicultural treatment until they can be formally assessed for registration.

11. Guiding principles for socio-economic values

Overall objective

Sustain social and economic benefits, through the provision of a range of goods and services valued by the community

The jarrah forest provides a range of goods and services including clean and moderated flows of water, clean air, carbon sequestration (in the forest and forest products), minerals and petroleum, wood and non-wood forest products, nature based recreation and tourism, apiculture and wildflowers and seeds. Silvicultural treatments within the jarrah forest available for timber harvesting are designed to contribute to the provision of a range of goods and services valued by the community.

Guiding principle 23

Visual landscape management will be used to reduce the impact of silvicultural management on visual amenity.

Rationale

Priorities for management of visual amenity in forest areas are based on the mapping of visual resource values and visitation or road usage. Where a landscape has both high visual quality and high visitation, it is assigned a high priority for visual landscape management, and modified practices are used. Higher levels of landscape alteration are permitted where there are reduced visual resource values and lower usage patterns.

Silvicultural treatments can alter the landscape in terms of visual amenity. Well planned silvicultural practice can reduce visual impact by introducing variations of gap size, thinning intensity, felling cycle, rotation length and treatment method.

Strategies

- Visual amenity from major roads and recreation sites will be mapped and allocated a visual management zone.
- Where necessary, limit gap size, or design gap shape to reduce the visual impact of harvesting.
- Where necessary, extend rotation length to allow mature forest characteristic to develop to enhance visual amenity from major travel routes.
- Where necessary, extend the cutting cycle adjacent to major travel routes to allow the scenic quality to recover from previous disturbances.
- Limit gap size to no more than 10 hectares in all visual management zones.
- When conducting post-harvest treatment adjacent to major travel routes, do not create standing dead trees that would reduce the visual quality of the viewshed.

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Guiding principle 24

Post-harvest treatments will be prioritised according to the benefits likely to be realised

Rationale

Timber harvesting has occurred in the jarrah forest since 1870, however past practices did not always involve the use of follow-up treatments to promote the grouped structure that is advocated in current silvicultural practice. As a consequence, there are areas of forest which contain few trees with the potential to produce sawlogs. The royalties collected from log sales that are used for regeneration, post-harvest treatment and fire protection operations is finite, and is currently not sufficient to treat areas with poor outcomes from past management. Priorities therefore need to be set to ensure the best return on investment of available funds.

Mining leases cover much of the northern jarrah forest. Mining involves the clearing of the forest and subsequent rehabilitation. Where timber harvesting occurs ahead of mining, there is potential for post-harvest treatments to use funds to regenerate or reduce competition in stands where the benefits of the work will not be realised, because the area is cleared for mining before the benefits eventuate.

Strategies

- When using culling to achieve thinning for a wood production objective, only release those trees of crop tree quality.
- Do not conduct regeneration or cull treatments in areas identified to be mined within 10 years of timber harvesting.
- The priority for follow–up treatments will be for those areas where the silvicultural objective can be achieved (i.e. gap, shelterwood and thinning) and where future mining or clearing for infrastructure development or dieback will not prevent the return on that investment.
- Use site productivity and knowledge of future infrastructure or mining operations to assist in prioritising follow up treatments.

12. Appendices

Appendix 1: Jarrah harvest intensity thresholds

Development stage	Mean dbhob of crop trees/ha	High and moderate site potential jarrah	Low site potential jarrah
		Nominal stand density *	
		(m^2/ha)	
	(cm)		
Juvenile	<15	5	4
Immature	16 – 25	9	5
	26 - 35	11	6
	36 – 45	14	11
Mature	> 45	18	14

* Note – this includes habitat trees but does not include other species. Rules regarding retention of other species are as per other silvicultural treatments (see Guiding Principle 1).

Appendix 2: Jarrah regeneration targets

In areas where the crown cover has been reduced below 20 per cent or a basal area of approximately 10m^2/ha. Regeneration surveys are required at to be completed on a 20m x 50m grid.

generation stage	Acceptable stocking	
	High and moderate site potential jarrah forest	Low site potential jarrah forest
Seedlings	5000	2500
Lignotuberous seedling		
Seedling coppice		
Ground coppice	1000	350
Sapling	500	200
Stool Coppice		

In the western jarrah forest 65 per cent of sample points must be stocked to an acceptable level for the regeneration to be considered successful.

In the eastern jarrah forest 60 per cent of sample points must be stocked to an acceptable level for the regeneration to be considered successful.

Appendix 3: Jarrah thinning schedules

High and moderate site potential jarrah forest

Development stage	Mean dbhob of crop trees/ha (cm)	Target stocking (stems/ha)	Nominal stand density * (m^2/ha)	Spacing guide (m)	Comments
Juvenile	<15	600	7	4	Thin from below, non-commercial thinning
Immature	16 – 25	350	11	4.5	Thin from below, non-commercial thinning.
	26 - 35	250	13	6	Thin from above and below, commercial and non-commercial thinning.
	36 – 45	125	16	9	Thin from above, where sufficient crop trees occur, commercial thinning.
Mature	> 45	125	20	9	Thin from above, where sufficient crop trees occur, commercial thinning.

* = Includes habitat trees

Low site potential jarrah forest

Development stage	Mean dbhob of crop trees/ha (cm)	Target stocking (stems/ha)	Nominal stand density * (m^2/ha)	Spacing guide (m)	Comments
Juvenile	<15	350	5	4.5	Thin from below, non-commercial thinning
Immature	16 – 25	200	6	6	Thin from below, non-commercial thinning.
	26 - 35	100	7	10	Thin from below, non-commercial thinning.
	36 – 45	100	13	10	Thin from above, where sufficient crop trees occur, commercial thinning.
Mature	> 45	100	16	10	Thin from above, where sufficient crop trees occur, commercial thinning.

* = Includes habitat trees

High site quality jarrah forest thinning guide for multi aged stands

Tree Diameter (cm)	Spacing guide (m)
15	4
20	5
25	5
30	6
35	6
40	9
45	9
50	9

Low site quality jarrah forest thinning guide for multi aged stands

Tree Diameter (cm)	Spacing guide (m)
15	5
20	7
25	7
30	7
35	10
40	10
45	10
50	10

13. Glossary

Advance growth	A general term to describe tree regeneration that has developed beneath an existing canopy.
Adaptive management	A process of responding positively to change. The term adaptive management is used to describe an approach to managing complex natural systems that builds on common sense and learning from experience, experimenting, monitoring, and adjusting practices based on what was learned.
Basal area	The sum of the cross-sectional areas of trees in a given stand measured at 1.3 metres above the ground. It is usually expressed as square metres per hectare.
Biological diversity (Biodiversity) **(described in CALM Act)**	The variability among living biological entities and the ecosystems and ecological complexes of which those entities are a part and includes: (a) diversity within native species and between native species; (b) diversity of ecosystems; and (c) diversity of other biodiversity components.
Biological diversity component **(described in CALM Act)**	Includes habitats, ecological communities, genes and ecological processes.
Bole	The tree trunk from the ground to the crown break. The bole does not include the major branches supporting the crown.
Catchment	The land area drained by a single stream, river, or drainage network.
Coppice (noun)	A shoot (or shoots) arising from adventitious buds at the base of a woody plant that has been cut near the ground or burnt back.
Coppice (verb)	The act of cutting near the ground or burning back a woody plant to encourage a shoot (or shoots) to arise from dormant buds at the base of the plant. Often completed to encourage the development of a new vigorous coppice stem.
Coupe	An area of forest that is planned for timber harvesting as a single unit. It may contain more than one silvicultural objective, such as a number of discrete gaps and areas of thinning.
Crop tree	A tree selected to retain during a harvest operation, to be grown on for many years to become a component of a future commercial harvest
Culling	The reduction in the density of unwanted vegetation, usually to reduce competition to retained crop trees or for establishing or releasing regeneration.
Current FMP	The Forest Management Plan 2004–2013 currently in force.
Dbhob	Stem diameter measured at breast height over bark.

Department, or the Department	The Western Australian Department of Environment and Conservation.
Dieback **(Phytophthora dieback)**	In the south-west of Western Australia a disease of plants caused by infection by the soil-borne organisms of the genus Phytophthora, of which P. cinnamomi is the most widespread.
Disturbance	Any relatively discrete event in time that disrupts ecosystems, communities, or population structure and changes resource availability or the physical environment. Disturbance may be natural (e.g. lightning caused fire) or human induced (e.g. timber harvesting).
Draft FMP, or **Draft plan**	means the Draft Forest Management Plan 2014-2023 as released by the Conservation Commission for public consultation.
Ecologically sustainable forest management	Forest management and use consistent with the principles described in section 19(2) of the CALM Act.
Ecosystem	A community or an assemblage of communities of organisms, interacting with one another and the environment in which they live.
Endemic	Flora or fauna that is confined in its natural occurrence to a particular region.
Exotic species	Any species growing or living outside its natural range of occurrence. Normally this refers to species purposely or accidentally introduced into countries or regions where they do not historically occur.
Fauna	The animals inhabiting an area; including mammals, birds, reptiles, amphibians and invertebrates. Usually restricted to animals occurring naturally and excluding feral or introduced animals. With respect to the Wildlife Conservation Act(Section 6), fauna is: (a) any animal indigenous to any State or Territory of the Commonwealth or the territorial waters of the Commonwealth; (b) any animal that periodically migrates to and lives in any State or Territory of the Commonwealth or the territorial waters of the Commonwealth; and (c) any animal declared as fauna pursuant to subsection (2), and includes in relation to any such animal – (d) any class or individual member thereof; (e) the eggs, larvae or semen; (f) the carcass, skin, plumage or fur thereof, but does not include any prescribed animal or prescribed class of animal.

First and second grade sawlog jarrah	A log cut from the bole of a jarrah tree that is a minimum of 2.1 metres in length, has a minimum under bark diameter of 200 mm and has a minimum of 30 per cent millable timber on the worst end face.
Fire regime	The history of fire use in a particular vegetation type or area including the frequency, intensity, season and scale of burning over a period of time. It may also refer to proposals for use of fire.
Flora	The plants growing in an area; including flowering and non-flowering plants, ferns, mosses, lichens, algae and fungi. Usually restricted to species occurring naturally and excluding weeds. With respect to the Wildlife Conservation Act (Section 6), flora is any plant (including any wildflower, palm, shrub, tree, fern, creeper or vine) which is: (a) native to the State or (b) declared to be flora pursuant to subsection (4), and includes any part of flora and all seeds and spores thereof.
Forest	An area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding two metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20 per cent.
Forest block	A named administrative subdivision of the forest, varying in size from about 3,000 to 8,000 hectares.
Forest ecosystem	An indigenous ecosystem with an overstorey of trees of more than 20 per cent crown cover. These ecosystems should normally be discriminated at a resolution requiring a map-standard scale of 1:100,000. Preferably these units should be defined in terms of floristic composition in combination with substrate and position within the landscape.
Forest products	As for the purposes of both the CALM Act and the Forest Products Act: (1) Subject to subsection (2) trees or parts of trees; timber, sawdust or chips; charcoal, gum, resin, kino or sap; and firewood. If they are located on public land or sharefarmed land. (2) When something referred to in subsection (1) has been removed under contract or arrangement entered into by the Commission, any residues that remain are not forest products for the purposes of this (FP Act) Act.
Forest regeneration	The renewal of a forest arising from planting or from seed or the young plants on a site. The process by which a forest is renewed.
Gap (regeneration establishment	A discrete opening in the overstorey canopy that reduces competition and allows seedlings to become established and or develop.
Global carbon cycles	The carbon cycle is the biogeochemical cycle by which carbon is exchanged among the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of the Earth.
Ground coppice	A growth stage where the lignotuber and root system have grown to the point that if surrounding competition is sufficiently reduced, the plant is capable of dynamic growth into a sapling. In jarrah, the lignotuber may be between five and 10 centimetres in diameter and the plant may take 20 years to reach this development stage under native forest conditions.

Group selection	The removal or retention of trees in relatively small groups with the object of creating a gap or retaining a group of younger trees to grow on. While there is no specific size of the group, it is generally considered to be of a size below which the edge effects dominate
Guideline	A document type that guides and directs actions for achieving consistency and required standards. Guidelines permit some flexibility in their application.
Habitat	A component of an ecosystem providing food and shelter to a particular organism.
Habitat tree	A tree selected to be retained in a coupe because it has features attractive to wildlife particularly for hollow nesting birds and animals.
Heritage	Something inherited from a past generation that is valued.
Hybrid	The progeny produced from a cross between two genetically different plants, usually different species.
High salt risk	Refers to certain river systems within the historic intermediate rainfall zone (based on data up to 1978) that are least disturbed and as such, are presumed to have the most intact aquatic ecosystems and consequently are the most environmentally sensitive to rises in saline groundwater.
Immature stand	The stand development stage beginning with the main lateral spread of tree crowns and finishing with the start of a mature stand.
Impact - dieback	The effect on vegetation from the presence of Phytophthora species, referred to as either predicted or current impact.
Indicator	A measure (measurement) of an aspect of a criterion. A quantitative or qualitative variable that can be measured or described and that, when observed periodically, may demonstrate trends.
Informal Reserve	See 'Reserve – Informal'.
Land category	Section 5 of the CALM Act specifies the categories of land to which the Act applies and section 6 defines those land categories. For the purposes of the plan the land categories are; State forest, timber reserves, national parks, conservation parks, nature reserves, any other land reserved under the Land Act 1933 and vested by order under that Act in the Conservation Commission and any other land other than excluded waters, reserved under Part 4 of the Land Administration Act 1997, the care control and management of which are placed by order under that Part with the Conservation Commission.
Landform	All the physical, recognisable, naturally formed features of land having a characteristic shape. Includes major forms such as a plain, mountain or plateau, and minor forms such as a hill, valley or alluvial fan.
Landscape Management Unit	An agglomeration of vegetation complexes and ecological vegetation systems, as defined and mapped by Mattiske and Havel (2002), to form more compact management units that recognise the underlying ecological characteristics.

Landscape scale	A mosaic where the mix of local ecosystems and landforms is repeated in a similar form over a kilometres-wide area. Several attributes including geology, soil types, vegetation types, local flora and fauna, climate and natural disturbance regimes tend to be similar and repeated across the whole area. It could be a (sub) catchment or, for convenience, an administrative management unit such as a forest block or an aggregation of forest blocks. Landscape scale is usually tens of thousands to a few thousand hectares.
Lignotuber	A woody swelling formed at the base of some eucalypts that has the ability to produce new shoots when the existing ones are destroyed.
Local scale	A discrete area of land to which one or more operations have been or are planned to be applied.
Mature stand	The stand development stage beginning with the formation of large persistent branches forming the outline of the crown as the crown reaches its maximum size, and finishing with the commencement of a senescent stand.
Monitoring	A process of repeated measurement or observation, for specified purposes of one or more elements, usually according to prearranged schedules in space and time, using comparable data collection methods. Often used to assess a management program, condition of the environment and/or resources being managed, to help determine if desired activities, processes, outputs and outcomes are being achieved.
Next FMP (2014–2023), **or next FMP**	Means the Forest Management Plan approved by the Minister for Environment to begin operation on 1 January 2014 for a period of 10 years (2014-2023).
Patch	A group of trees resulting from a natural regeneration event or a past management activity such as gap creation and regeneration. May also refer to a particular, relatively small area of forest and/or other vegetation type(s).
Pest	Troublesome or destructive animals including insects, either introduced or native.
Pesticides	Includes herbicides, insecticides, fungicides and related products registered for use in pest control.
Phytophthora cinnamomi, or P. cinnamomi	Water mould. The pathogen that causes most Phytophthora dieback disease.
Policy	A document containing principles and rules that outline an organisation's position and which guides decisions and actions taken in the conduct of its activities.
Prescribed burning	The controlled application of fire under specified environmental conditions to a predetermined area and at the time, intensity and rate of spread required to attain planned resource management objectives.
Proposed FMP	The Forest Management Plan 2014-2023 as forwarded to the EPA for assessment following modification (of the Draft FMP) as a result of the public consultation process.

Regrowth forest	Native forest which is dominated by similar aged stems that have not reached the mature growth stage, originating from previous harvest events, such as gap creation, or other disturbances, such as bushfire.
Rehabilitation	The process necessary to return disturbed land to a predetermined surface, vegetational cover, land-use or productivity.
Reserve – conservation	An area set aside primarily for the conservation of natural ecosystems but which may allow a level of recreation consistent with the proper maintenance and restoration of the natural environment.
Reserve – formal	One of the land category categories of national park, nature reserve, conservation park, or CALM Act sections 5(1)(g) or 5(1)(h) reserves for the purpose of conservation.
Reserve – informal	An area set aside for conservation under an approved management plan; has had opportunity for the public to comment on changes to reserve boundaries; able to be accurately defined on a map; and is of an area and design sufficient to sustain the values it seeks to protect.
Resilience	the capacity of an ecosystem to withstand external pressures and, over time, return to its prior condition, including its ability to maintain its essential characteristics such as taxonomic composition, structural forms, ecosystem functions and processes (adapted from Thompson et al., 2009, who cite Holling, 1973).
Riparian	Pertaining to the banks of streams, rivers or lakes.
Rotation	The period between regeneration establishment and the final harvest.
Shelterwood (regeneration establishment)	A jarrah silvicultural treatment that involves a partial reduction in the density of overstorey trees and action to establish regeneration under the remaining mature trees.
Silviculture	The theory and practice (silvicultural practices) of managing the establishment, composition, health, quality and growth of forests and woodlands to achieve specified management objectives.
Silviculture for ecosystem health	The development and application of silvicultural practices to provide for ecosystem health.
Silviculture for water production	The development and application of silvicultural practices to provide for water production.
Site potential	The density of forest that can be supported before it becomes limited by nutrients and moisture. Site potential depends on site conditions such as climate, slope, landform, soils and geology Site potential is also influenced by stand age in that young stands reach maximum density, and undergo suppression and mortality at a lower density than older stands. Young stands exploit a smaller volume of soil and access less soil moisture than older stands.
Stand	A group of trees or patch of forest that can be distinguished from other groups on the basis of size, age, species composition, structural condition or other attribute.

Stand structure	The horizontal and vertical distribution of the components of a forest stand including the height, diameter, crown layers and stems of the trees, shrubs, herbaceous understorey, stags and down woody debris.
Stool coppice	A growth stage where shoots have developed from a stump cut off at ground level.
Subsequent FMP	means the Forest Management Plan 2024 – 2033.
Suppression	The process whereby a tree or other vegetation loses vigour and may die when growing space is not sufficient to provide photosynthate or moisture to support adequate growth
Sustained yield, or Sustained timber yield	For the purpose of this plan, the first and second grade sawlog yield that a forest can produce for an extended period (to at least the year 2070) at a given intensity of management.
Taxa (taxon)	A defined unit (for example, species or genus) in the classification of plants and animals.
Temporary exclusion area (TEAS)	An area that is excluded from timber harvesting for a particular period of time.
Thinning	A felling made to reduce the density of trees within a stand. Usually undertaken to improve the growth of trees that remain by reducing competition, without either permanently breaking the canopy or encouraging regeneration. May also be undertaken to enhance forest health, water production or achieve another objective.
Threatening process	Those processes which may result in the long-term reduction of biodiversity. Examples include predation and habitat change by introduced animals; competition and displacement by introduced plants and destruction and modification of habitat.
Timber	Sawn or other products derived from first and second grade jarrah and karri sawlogs.
Timber harvesting	The cutting, felling, and gathering of forest products undertaken as part of a planned sequence of silvicultural activities including the regeneration of the forest.
Treemarking	The procedure in which trees are marked for retention (or removal) prior to timber harvesting or other operations in a forest.
Vegetation complex	A combination of distinct site vegetation types, usually associated with a particular geomorphic, climatic, floristic and vegetation structural association.
Variable density thinning	Type of thinning used to introduce structural complexity into even-aged regrowth stands by for example, leaving unthinned patches, retaining older trees and understorey elements, creating small gaps and varying the spacing of trees in thinned areas. In stands containing a range of size classes it can also be used to vary the spacing of trees and the retained basal area in response to variations in

	trees sizes.
Weed	A plant, often a self-sown exotic, growing where it is not wanted.
Weed – environmental	A naturalised non-indigenous plant species outside the agricultural context that adversely affects the health, survival or regeneration of indigenous species in natural vegetation communities.
Whole of forest scale	All land categories that are subject to the plan.
Wood	The material produced in the stems and branches of trees and other woody plants.
Wood products	All timber and other wood products, inclusive of sawlogs, firewood, chiplogs and other log products supplied to the wood products industry.
Yield	The amount of product produced from the forest by a particular management strategy.

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