Silviculture Guideline for Wandoo Forest

Sustainable Forest Management Series

Department of Parks and Wildlife
FEM Guideline No. 2

Department of
Parks and Wildlife

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Reference details
The recommended reference for this publication is: Department of Parks and Wildlife 2014, *Wandoo Silviculture Guideline*. Sustainable Forest Management Series, FEM Guideline 2.

This Guideline supersedes:
SFM Guideline 2 (2004) - Silvicultural Practice in Wandoo Forest and Woodland

when applied in conjunction with:
Silvicultural Reference Material for Wandoo Forest (2014).
Silviculture Manual for Wandoo (2014).

Cover illustration: Developed by Clare Martin, Strategic Development and Corporate Affairs, Department of Parks and Wildlife

Deirdre Kaye Maher
20 June 1967 - 13 August 2011

Deirdre Kaye Maher was a wife, mother, friend, passionate forester and community member. Deidre began the consultation and development of these guidelines before her illness and contributed a great deal to these guidelines.

Deirdre's career with the Department of Conservation and Land Management (CALM), later the Department of Environment and Conservation (DEC), began in 1990 as a junior officer at Manjimup at a time when women were a rarity in forestry, and District field operations in particular. Deirdre soon became familiar with what was required and quickly gained the respect of contractors and crews by never trying to be "one of the boys", but by being proud to be a woman in a predominantly male workplace.

It was during the early years of her career that Deirdre developed her love of silviculture, especially the intricacy of jarrah forest management. In 2007 Deirdre was appointed Senior Silviculturalist with DEC and worked out of the Bunbury Office for over three years. Her experience and attention to detail earned her great respect and staff soon found out that work completed to Deirdre's satisfaction would stand up to any scrutiny inside or outside the Department.

Deirdre was much loved by her husband Tony, and their children Leah and Michael. Deirdre passed away too young, with so much more to contribute to the science of forest silviculture, a knowledge and skill that will become increasingly important for sound management of the forests of the south-west Western Australia in the face of changes in climate and community expectations.

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1. 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 wandoo forest that are subject to timber harvesting. Guidelines are generally not prescriptive, but provide the intent and guidance for forest managers.

Scope

This guideline deals with the management of the wandoo forest available for timber harvesting and applies to State forests and timber reserves, and freehold land that contains indigenous vegetation and which is held in the name of the Conservation and Land Management (CALM) Act Executive body. The guideline contains some strategies which may not be strictly silviculture, but are integrals to and/or managed as part of the silvicultural system. The guideline does not cover the identification of informal reserves or other areas from which timber harvesting is excluded, as this process occurs prior to the application of silviculture and is referred to in this document as the coupe or harvest planning process.

Context

This guideline provides the framework for operational practices which meets those goals and operations of the *Forest Management Plan 2014-2023* (FMP) that are implemented through silvicultural practice. Legislative requirements are detailed in Appendix 1. Measures to protect soil, including suitable times to conduct timber harvesting operations, are addressed in Sustainable Forest Management Series (SFM) Guideline 5, *Soil and water conservation guideline (Department of Environment and Conservation 2009c)* and subsidiary documents. Current versions of all SFM guidance documents are available at http://www.dpaw.wa.gov.au/management/forests.

This guideline provides guiding principles, rationale and strategies, whereas supporting manuals are intended to provide detail regarding operation practices (Fig 1).

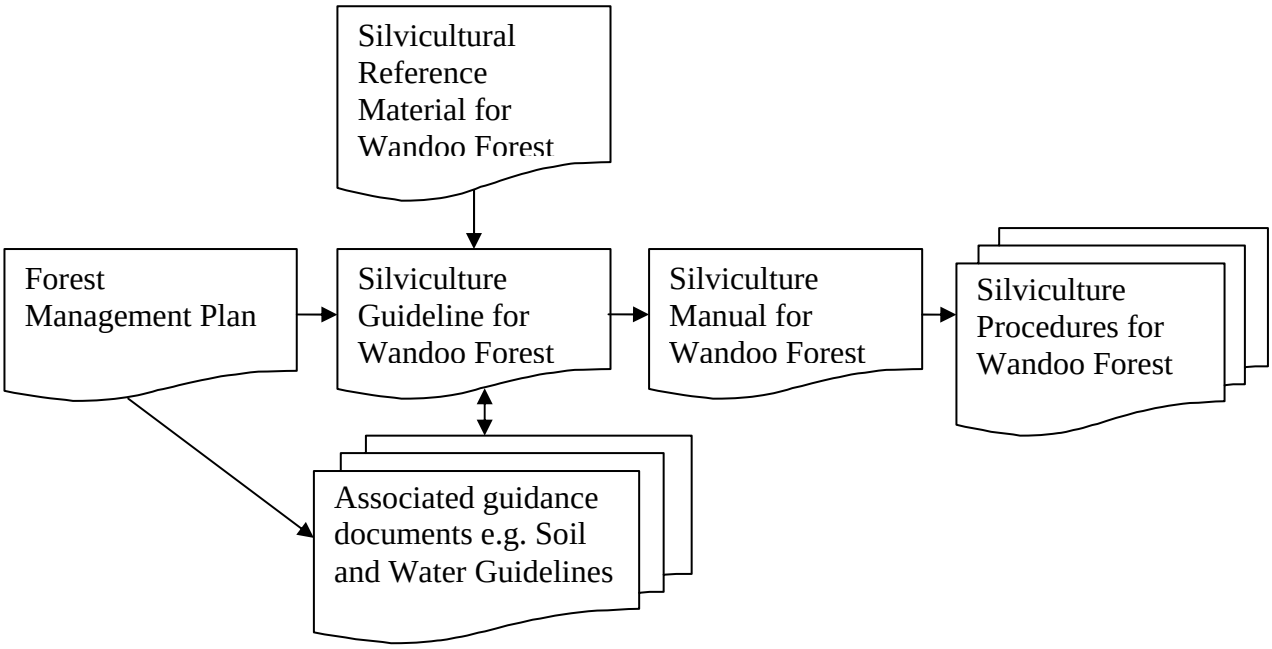

Figure 1. Diagrammatic representation of the hierarchy of documents for guiding the application of silviculture in the wandoo forest.

Separate guidelines apply to the jarrah forest and to the karri forest.

The manuals and procedures which support the application of this guideline provide instruction on applying silviculture in the wandoo forest. It is important that forest officers have sufficient training and experience to be competent in applying the most appropriate silviculture in the wandoo forest, and to facilitate this, training is provided.

Custodianship and management of this guideline

This guideline is a controlled document. The custodian is the Manager, Ecosystem Health Branch of the Forests and Ecosystems Management (FEM) Division of Department of Parks and Wildlife (DPaW).

Application and scale of silviculture

What is silviculture?

Silviculture is the theory and practice of growing and tending forests to achieve management objectives. Historically more associated with timber production, contemporary silviculture encompasses economic, environmental and social objectives to achieve ecologically sustainable forest management. It is applied to achieve a wide variety of outcomes including soil and water protection, wood production, catchment management, habitat for wildlife, maintenance of aesthetics, and provision for recreation.

Objectives may be complementary to, or to some extent, in competition with one another. The silvicultural method(s) applied are therefore designed to achieve a balance between objectives, and those objectives may differ at the local and landscape scale in order to achieve the desired balance of objectives for the whole of forest.

Wandoo most frequently occurs as uneven aged forest in open woodlands characterised by clumps of regrowth, groups of mature trees and large gaps. The lack of secondary storey and the low scrub understorey enhance its open nature. The wandoo forest is valuable for many purposes (recreation, catchment protection, timber production,

conservation of flora and fauna and honey production) and State forest management practices must support all values.

The clumped distribution of wandoo trees reflects their dependence upon ashbed for regeneration and possibly the limited site capacity. The importance of linking several steps (seed, ashbed, burning and long-term protection) to achieve regeneration after timber harvesting is demonstrated by the scarcity of regrowth in some cutover stands, and the successful restocking of areas where correct procedures are followed.

The broad objective of these guidelines is to manage the wandoo forest and woodland through selective cutting and regenerate stands so that they will contain a mixed size/age structure with a capacity for continued growth and productivity.

Towards the end of the FMP (2004-2013) a review of current silvicultural practice was undertaken (Burrows *et al.* 2011) and a series of recommendations were made for changes. The primary recommendation was to implement forest management to achieve a better water balance in a drying climate. Concern was raised over the impacts of human induced climate change, particularly decreased water availability and its effect on forest health and the health of associated ecosystems, especially aquatic ecosystems. This has been addressed within the current guidelines in Guiding principle 10 – *Promote ecosystem health and vitality through silvicultural management*. The purpose of Guiding principle 10 is to apply silvicultural management to protect threatened ecological values potentially at risk because of human induced climate change. The review recommended the practice of mechanical scarification and scalping be minimised and care taken to preserve the diversity of understorey. These recommendations are incorporated in strategies 64, 65 and 87 and Guiding principle 5 – *Compositional diversity will be maintained in silviculturally managed forest*.

Scales of management

The management of silviculture considers three scales which are as follows:

- *Whole of forest* – all wandoo forest land categories that are subject to the FMP.
- *Landscape – a* mosaic where the mix of local ecosystems and landforms is repeated in a similar form over a kilometre-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 management could span a few thousand to many tens of thousands of hectares. In this guideline, reference is sometimes made to landscape management units (LMUs), which are based on mapping of vegetation complexes (see (Mattiske *et al*. 2002).
- *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. As a guide, for the purposes of this document, local scale is the average area of the forest blocks in the vicinity subject to, or potentially subject to harvesting in the three year harvest plan.

Silviculture is usually applied at the patch level with a silvicultural method selected appropriate to the condition of the stand. However, silviculture is also guided by the condition of the forest at the local landscape scale and seeks to provide for ecologically 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 wandoo forest. A guiding principle is a statement that communicates a basis for management decisions. This guideline has been prepared to accompany the FMP and is consistent with the settings adopted for the final FMP.

2. Summary of guiding principles for silviculture in wandoo forest

Guiding principles for biological diversity	
1.	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.
2.	Silvicultural practices will contribute to maintenance of connectivity.
3.	Key structural features will be retained as legacy elements in silviculturally managed forests.
4.	Natural regeneration will be used wherever possible.
5.	Compositional diversity will be maintained in silviculturally managed forest.

Guiding principles for ecosystem health and vitality	
6.	Promote resilient stands on sites with high levels of overstorey mortality or stress through silvicultural management.
7.	Promote resilient ecosystems through silvicultural management of sites affected by disease.
8.	Prescribed fire will be used to promote regeneration, protect fire sensitive regeneration and reduce high fuel loads that may result from silvicultural practices.
9.	Silvicultural management will be used to maintain nutrient cycling processes.
10.	Promote ecosystem health and vitality through silvicultural management.
11.	Maintain resilience by reducing the impact of weeds on natural ecosystems.

Guiding principles for soil and water	
12.	The extent and severity of harvesting disturbance on soil values will be minimised and damaged soil remediated.
13.	Water quality will not decline as a result of silvicultural treatment.

Guiding principles for climate change and carbon cycles	
14.	Forests will be managed to maintain forest carbon stocks, provide forest products and contribute to the mitigation of climate change.

Guiding principles for productive capacity	
15.	The most appropriate silvicultural method will be applied to each stand to support short and long term productivity.
16.	Regeneration and tree growth will be enhanced through actions to alleviate competition on regeneration and selected trees.
17.	Where the canopy is removed to establish regeneration the forest will be regenerated effectively and in a timely manner.
18.	Trees to be retained will be marked and protected from damage.
19.	Forest areas that are killed or damaged by fire or other agents may be restored or salvaged.

Guiding principles for heritage	
20.	Harvest disturbance will be managed to avoid adversely affecting Aboriginal cultural heritage values and sites.
21.	Harvest disturbance will be managed to avoid adversely affecting Australian cultural and natural heritage values and places.

Guiding principles for socio-economic benefits	
22.	The capacity of forest areas will contribute to the social and economic sustainability of regional communities.
23.	Visual landscape management will be used to manage potential impacts of silvicultural treatments on visual amenity.
24.	Minimise the disturbance associated with the extraction of basic raw materials.

3. Guiding principles for biological diversity

Overall objective

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

Within the area covered by the FMP, biological diversity is supported through formal reserves, selected to be comprehensive, adequate and representative, the multiple use forest area, informal reserves, temporary exclusion areas (TEAS) and fauna habitat zones (FHZ), which together, represent a significant continuous area of forest cover. Habitat elements are retained in harvested areas through the application of silvicultural guidance. The small proportion subject to harvesting disturbance operations in any one year can re-establish from propagules existing on site, and/or be re-established using seed or seedlings selected for the site. To assist re-establishment, structural complexity and heterogeneity of the forest are maintained at multiple spatial scales, facilitating the movement of genetic material and individuals. Disturbance supports biodiversity so long as the scale and intensity of disturbance are appropriate.

Guiding principle 1

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 wandoo forest generally occurs as a multi-aged forest with stands of different regeneration age occurring throughout. Even-aged stands are generally relatively small. Providing a mix of structural types across the landscape can encourage a wide variety of habitats and plant and animal communities.

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 mature stands to the establishment development stage, with very little structural complexity and no legacy elements. There is potential for the impact of mining on the wandoo forest to increase significantly as the mining for bauxite and other minerals (including gold) moves further eastward.

Timber harvesting for regeneration establishment also impacts on forest structure where the mature forest structure is converted to establishment forest. However the impact of disturbance from timber harvesting is mitigated by the application of a number of strategies to ensure structural complexity is maintained – as outlined in Guiding principle 3.

Forest structure can also be modified by intense bushfire that kills trees, and death is more likely in stands of immature wandoo, which are fire sensitive. The appropriate periodicity, intensity and seasonality of fire regimes are essential for both the health and regeneration of wandoo, but also the health and biodiversity of the ecosystem.

The absence of disturbance, or large or repeated stand replacing disturbance 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 intensity and size of disturbances and their separation in space and time are important consideration in managing biodiversity at a landscape scale.

Strategies

General forest area:

1. During treemarking 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 also contribute to Guiding principle 2).

2. When applying silvicultural treatments in forest isolated in agricultural landscapes, stage operations over time. Where the isolated area is less than 400 hectares, it will be managed in two approximate halves, with subsequent harvesting permissible after 10 years.

3. During treemarking, ensure the existing heterogeneity of forest structures are maintained through the application of a range of silvicultural methods. Application of a single silvicultural method to a continuous area representing greater than 60 per cent of the local scale should be avoided. The exception is thinning, where variable density thinning should be applied to create heterogeneous structure. This also contributes to Guiding principle 2).

Additional strategies for forest subject to mining:

4. During the mine planning process, consider the retention of legacy elements, or ideally patches of retained forest within the mined area (This also contributes to Guiding principle 3).

5. During harvest planning avoid greater than 40 per cent of the landscape scale area being in the establishment to immature developmental stages at any one time.

6. Treemarking will endeavour to manage the local scale management unit to retain the structural complexity (see Guiding principle 3). This includes giving consideration to marking additional legacy elements in areas immediately adjacent to mining rehabilitation, to increase their retention rate at the local scale.

7. During harvest planning, schedule thinning of the non-mined forest to coincide with periods of high water use in the mine rehabilitation.

8. During thinning of rehabilitated mine sites, apply variable density thinning to increase structural complexity and reduce water use.

Guiding principle 2

Silvicultural practices will contribute to maintenance of landscape connectivity.

Rationale

Connectivity is the degree to which the landscape facilitates or impedes movement of individuals or genetic material. 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 re-colonisation by those species displaced following disturbance. Connectivity is particularly important in light of 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. Informal reserves (such as stream zones), and other areas temporarily excluded from operations, such as fauna habitat zones, provide areas of forest within which silvicultural treatment are not applied. 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 1).

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 persistence and re-colonisation of species in treated forest (for example, the retention of habitat trees, logs, understorey and overstorey elements see Guiding principle 3). Retention of these elements provides habitat for species which may have limited dispersal, such as endemic saproxylic communities occupying large diameter logs.

A risk to connectivity in the multiple use forest area is open cut mining, which has long lasting effects on the structure and function of the soil profile and forest. Connectivity can be supported by managing the forest surrounding mined areas to offer a means of dispersal around and re-colonisation of the disturbance, until connectivity is re-established. Connectivity is maintained by the strategic location of retained forest within the mining envelope to retain structural complexity and heterogeneity at the local scale.

Strategies

9. During harvest planning, the application of TEAS will provide structural complexity locally and heterogeneity within the landscape. TEAS may act as both a refuge and source of individuals or genetic material for re-colonisation of mined areas (this strategy also contributes to Guiding principle 1).

10. During treemarking, legacy elements will be retained in harvested coupes to provide structural complexity and provide connectivity for species which require legacy elements for their life cycle (this strategy also contributes to Guiding principle 3).

11. In larger areas (>50 ha) of even-aged forest where thinning is an appropriate

silvicultural treatment to apply, variable retention thinning may be used to increase structural complexity.

Guiding principle 3

Key structural features will be retained as legacy elements in silviculturally managed forests.

Rationale

The occurrence of late structural stage or long-lived structural elements of the forest such as over-mature trees, shrubs; thickets and large coarse woody debris (CWD) can be reduced in areas of wandoo forest subject to timber harvest. These elements, referred to as legacy elements, are important contributors to complexity, connectivity and heterogeneity at the local scale.

Over-mature trees with hollows provide nesting and roosting sites for a wide range of hollow dependent species. To retain a supply of hollow bearing trees some 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 cryptogams. All are important to maintain the species richness of the forest.

After tree fall, the hollows formed while the tree was standing will be used by ground dwelling fauna. Wandoo tend to exclude under-storey species through competition for moisture, creating an open forest and so it is thought that ground habitat, in particular woody debris is particularly important to provide shelter and protection from predators. To retain a supply of hollow-bearing trees and ground habitat, both current and future sources of CWD must be retained. Prior to each harvest operation retention strategies require marking of:

- mature trees with the potential to supply tree hollows in the future
- currently over-mature trees with a high probability of providing hollows
- large diameter and hollow logs

Retained mature and over-mature trees will become the large diameter and hollow logs of the future as they senesce and fall (hollows are formed in standing trees). Bringing trees through to maturity is already part of standard silvicultural practice for timber production.

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. At the same time, harvesting provides disturbance which favours other suites of species reliant on early seral stages.

The fauna distribution information system (FDIS) is used prior to harvesting to identify the likely presence of species in the harvest area and may recommend additional management actions for some species. For example, FDIS recommends the retention of additional ground habitat where numbats are present. Recommendations from FDIS may require modifications to silviculture such as marking of additional legacy elements.

Strategies

12. Silvicultural treatments will have regard for requirements outlined in FDIS where the presence of species vulnerable to timber harvesting and/or silvicultural burning is

identified.

13. During treemarking, select trees to retain which have a moderate to high probability of bearing hollows (Whitford et al. 2001). Aim to retain both individual trees and groups of trees.

14. During treemarking, retain some large logs (non-sawlog) and logs with pipe or hollows suitable for habitat where they are available.

15. During treemarking, protect underground cavities suitable as fauna refuges, where they are identified.

16. During treemarking and preparation for harvest, give preference for habitat marking to trees that include signs of significant use by, or nests of, threatened fauna species, where these have been identified during pre-harvest checks or observed by the tree-marker or other staff on-site.

17. In those LMUs in the wandoo forest where large marri are relatively low in abundance (Eastern Dissection, Eastern Murray, Monadnocks Uplands Valleys and Northern Sandy Depression), retain all marri 50-70cm dbhob with a healthy crown (potential for good seed production) and marri > 70cm dbhob, where practicable.

18. During harvesting operations, retain some large standing dead trees if they provide habitat value and it is safe to do so.

19. In salvage operations following natural disturbance, retain patches of standing dead or damaged trees where they provide habitat value and it is considered safe to do so.

Guiding principle 4

Natural regeneration will be used wherever possible.

Rationale

Natural regeneration is the preferred method of regeneration in the wandoo 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 harvesting disturbance.

Traditionally, regeneration operations requiring the use of supplementary seed or seedlings have strived to use 'local' seed. Where knowledge of the population genetic structure of a species exists or can be reasonably inferred, this should guide seed collection areas. 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 (Millar *et al.* 2007).

Seed collected for regeneration is usually collected from the same LMU as the area to be regenerated. Flexibility is 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

20. Fire will be used to stimulate seed fall, encourage the germination of soil-stored seed and prepare a receptive seedbed.

21. Use natural regeneration where reasonable and practical. Where natural regeneration is not reasonable and practical, use only species endemic to the area being regenerated.

22. In areas to be regenerated, stool coppice will be used in preference to the use of artificial seeding or planting, wherever the stocking of wandoo regeneration is marginal.

23. Where there is knowledge of population genetic structure or it can be reasonably inferred, use this to guide seed collection areas.

24. 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.

25. Seed collection for rehabilitation should prioritise the matching of climatic, edaphic and other environmental variables from the seed collection with the area to be rehabilitated.

26. Seed collection for highly disturbed sites, or sites subject to pest, disease or changed climatic conditions, should target resistant phenotypes or genotypes were they exist. Alternatively choose from a wide genetic base to facilitate adaptation.

Guiding principle 5

Compositional diversity will be maintained in silviculturally managed forests.

Rationale

Diversity in overstorey composition can be observed throughout the wandoo forest. Wandoo forest can occur as both a forest and woodland and may occur in mixtures with other species. *E. wandoo* occurs in mixtures with jarrah (*E. marginata*), marri (*C. calophylla*), flooded gum (*E. rudis*), yate (*E. cornuta*) and powderbark wandoo (*E. accedens*). Where mixed stands have or still occur, regeneration to a single species is inappropriate, as it would lead to simplification of species composition and impair forest ecosystem resilience.

The silvicultural methods developed for wandoo favour the use natural seed fall or artificial seeding on ashbeds as the preferred regeneration technique. Regeneration can also be successfully achieved using mechanical disturbance to vegetation and soil to reduce

competition and enable wandoo seedlings to establish. These disturbances can have short term impacts on understorey species richness and abundance. Achieving the necessary level of disturbance to the soil and the understorey helps to ensure a balance between achieving regeneration of the overstorey and the impact on other vegetation.

Appropriate fire regimes in wandoo will benefit overstorey and understorey regeneration and favour the development of a diverse understorey. Thinning may also favour understorey development by reducing competition for moisture and light from the highly competitive overstorey.

Where artificial regeneration methods such as the planting or seeding are used, it is important to ensure that all components of the stand composition are represented in the regenerating stand.

Strategies

27. In regeneration operations, reflect the composition of the previous stand and consider the relative competitive ability of each species in the regeneration species mix.

28. During burn planning consider the importance of fire regimes to regeneration, forest health and diversity.

29. During treemarking, apply thinning to over-stocked wandoo stands to allow understorey development.

30. When applying silvicultural treatments, aim for overstorey species composition in similar proportions as the original stand.

31. During post-harvest treatment, when reducing rootstock competition to assist establishment of overstorey regeneration, limit the area treated or disturbed 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.

32. During post-harvest silvicultural treatments, use ashbeds to facilitate regeneration of wandoo in mixed wandoo / jarrah stands rather than soil disturbance treatments which can remove jarrah advanced growth or lignotubers.

4. 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 6

Promote resilient stands on sites with high levels of overstorey mortality or stress.

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 upper slopes, 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 can improve health and vigour and may reduce the potential risk of drought related deaths, and reduce vulnerability to pest insect and disease attack (Barry *et al.* 2011). 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 there are individuals that 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

33. Individual trees or groups of trees that exhibit resistance to disease, insect attack or the effects of wandoo crown decline should be marked for retention and protected from damage during timber harvesting operations.

34. Reduce stand density in stands subject to water stress to assist with adaption to a drier climate.

35. Adaptive management trials to investigate the rehabilitation of sites with significant tree deaths may be approved by the Manager, Ecosystem Health Branch.

36. Establish adaptive management trials to investigate the effect of silvicultural treatments on the effects of frost damage to determine the most appropriate management on identified frost prone sites.

Guiding principle 7

Promote resilient ecosystems on sites affected by disease.

Rationale

Wandoo is susceptible to *Armillaria luteobubalina*, a naturally occurring fungus, with the capacity to affect regeneration and growth of trees and understorey species in the wandoo forest. Where severe *Armillaria* infestations occur it is possible that it will be difficult to establish regeneration of wandoo or marri (*Corymbia calophylla*).

Phytophthora dieback is a disease that can affect large areas of the wandoo and mixed jarrah / wandoo forest. Wandoo is not particularly susceptible to *Phytophthora* dieback, but many of the other species in the ecosystem are susceptible and minimising spread or intensification of the disease through forest hygiene is a management requirement. Timber harvesting that removes a large proportion of the overstorey may reduce water demand and can lead to increased availability of soil water. This change in water availability coupled with higher soil temperatures from reduced canopy cover may increase *Phytophthora* lesion growth in infected trees.

Wandoo crown decline is a syndrome affecting wandoo and occasionally other eucalypts. Its exact cause is unknown, but may be related to changed hydrological conditions (decline in water availability), changed fire regimes or the activities of wood boring insects and fungal pathogens. Thinning in areas experiencing crown decline should reduce stress and susceptibility to insect and disease attack (except in the presence of *Phytophthora* dieback) on retained trees.

On sites where the current impact of the *Phytophthora* dieback is high with substantial overstorey killed, site resilience is likely to be lower than in healthy 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.

Strategies

37. The occurrence of Armillaria is to be recorded on the hygiene management plans and considered in subsequent silvicultural and management decisions.

38. The occurrence of Armillaria is to be incorporated into silvicultural monitoring in the wandoo and mixed wandoo forests.

39. On sites expressing high disease impact, manage access for harvesting and extraction patterns to promote resilience and assist site recovery by protecting regeneration, and individuals and species demonstrating field resistance to Phytophthora dieback.

40. During treemarking, the preference for selecting trees to retain in high disease impact on un-protectable forest areas, will be for healthy trees, tree species that are not susceptible to Phytophthora dieback, or individual trees that appear to be resistant to Phytophthora dieback.

41. Do not cull trees where the impact of Phytophthora or dieback or Armillaria is predicted to be high.

42. Where possible, encourage and protect natural regeneration on high impact disease sites and / or use dieback-resistant jarrah for regeneration.

43. Establish adaptive management trials to determine the effect of harvesting disturbance on, and most appropriate management of sites exhibiting a high disease impact.

Guiding principle 8

Prescribed fire will be used to promote regeneration, protect fire sensitive regeneration and reduce high fuel loads that may result from silvicultural practices.

Rationale

The management of tops from harvesting is critical in wandoo. Wandoo regeneration is heavily dependent on the creation of ashbeds which significantly improve the survival and development of wandoo regeneration(Bradshaw 1987). To assist with the development of ashbeds, crowns are bunched together and the material cut or crushed so that the crown lies relatively flat to facilitate complete burning of the wood. Ashbeds must be located away from retained trees, as the crowns of wandoo are sensitive to fire damage and bole damage provides an entry point for fungi and termites.

While fire is critical for wandoo regeneration, once regenerated the early growth and development stages are susceptible to fire and fire should be excluded from stands at this stage. Removal of high fuel loads in the regeneration burn is key to reducing fire risk during early development stages. Fire is likely to kill above ground shoots until the bark thickness of saplings is sufficient to withstand mild fire and the leading shoot tall enough to escape damage. Wandoo lignotubers will re-sprout and continue to develop after all but very high intensity fire, however any growth achieved prior to the burn will be lost. The period of fire sensitivity for regrowth is variable however it is usually not less than 10 years and may be as long as 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.

The clumped nature of the wandoo cohorts leads to an uneven distribution of litter fuel, with heavy litter beneath the clumps and a much lower fuel load of grass or low shrubs away from the clumps. When planning prescribed fire it is important to plan for the differential in burn intensity between more open areas of the wandoo forest and wandoo clumps with high fuel loads.

In managing prescribed fire, the primary objective is reducing potential for bushfire, after which consideration is given to biodiversity conservation, forest silviculture, research and any other land management objectives. Prescribed burning objectives for silviculture include promoting regeneration, protecting growing stock, maintaining biodiversity values, nutrient cycling and achieving a mosaic of burnt and unburnt patches.

Strategies

44. During burn planning, include an assessment of the stocking of saplings that will withstand mild fire and/or the significance and sensitivity of regeneration where multiple objectives exist. This assessment will include assessment of sapling height and diameter to gauge their fire sensitivity.

45. During burn planning, if there is a low risk of escape, aim to reduce fuel loads in areas adjacent to fire sensitive regeneration in order to reduce the likelihood of bushfire during the fire sensitive period.

46. Post-harvest prescribed burning will manage fuel to protect retained trees, and facilitate the creation of ashbeds for good regeneration.

47. After the initial fuel reduction burn, prescribed low intensity fire will be used in wandoo stands as soon as possible after the fire sensitive period for regeneration has passed.

48. Silviculture burns will provide for a mosaic of burnt and unburnt patches.

Guiding principle 9

Maintain forest nutrient cycling processes.

Rationale

The soils of the wandoo forest are generally infertile and growth of the forest is often nutrient limited. 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. Fire also triggers 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.

High intensity fires affecting large areas of the forest expose bare soil and can result in losses of nutrient from the forest system due to wind and water erosion of the nutrient rich surface soil. Prescribed burning can be used to reduce the likelihood of high intensity fires and so the risk of soil erosion.

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

Strategies

49. Avoid excessive removal of leaf and fine branch material from forest harvesting operations.

50. During burn planning, aim to manage fire regimes to minimise the extent of intense bushfires, which can result in large losses of nutrients from the ecosystem and accelerated soil erosion.

51. Minimise the potential of soil erosion by limiting soil disturbance during harvesting.

52. After harvesting, where possible or practicable, silvicultural burns should be planned to allow sufficient time for leaching of nutrients from the leaf litter produced by the harvest.

Guiding principle 10

Promote ecosystem health and vitality through silvicultural treatment.

Rationale

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

A key finding of the *Review of Silviculture in Forests of South-west Western Australia* (Burrows *et al.* 2011) was the opportunity that silviculture provides to assist forests to adapt to climate change. In summary, the report found that "*declining rainfall has significantly impacted water availability in the FMP area and predicted future climate change is likely to lead to further impacts. Further declines in streamflow and impacts on aquatic environments are likely. The impact of climate change needs to be closely, monitored with adaptive management strategies*." The purpose of 'silviculture for ecosystem health' is to enhance ecosystem health and function, and biodiversity, through enhanced water availability. Enhanced water availability is achieved by reducing the density of vegetation in the stand (and thus lowering transpiration demand).

Changes to groundwater and flow days may result in gradual changes to the health and distribution of ecosystems. More immediate, but localised effects may occur as a result of extreme weather events such as storms and heatwaves, with higher maximum temperatures, more hot days and more intense precipitation events considered very likely as a result of climate change (Arthrington *et al.* 2003).

Mitigating the effects of reduced rainfall and higher temperatures on the forest and associated communities will require adaptive action to help to align density and structure of the forest with current and future climate. Targeted action may protect susceptible ecosystems, retain water availability in some parts of the forest, improve the health of forest and associated ecosystems, reduce susceptibility to high intensity fire and allow for the persistence of ground and surface water dependent ecosystems.

A reduction in stand density reduces competition for water and has positive effects on vegetation health and vitality, increasing resilience to pest and diseases. A sufficient reduction in stand density increases the amount of water moving through the soil profile to groundwater and into streams. 'Silviculture for ecosystem health' aims to reduce the impact of declining rainfall on the forest and associated ecosystems. Declines in ecosystem health are associated with:

- loss of free water in the environment
- potential impact on forest health associated with water stress
- reduction in site carrying capacity
- loss of or reduction in riparian and aquatic ecosystems
- increased frequency and intensity of bushfire.

The strategies associated with this principle incorporate a number of management tools able to reduce inter-tree competition, move forests to a more appropriate carrying capacity, slow the loss of and/or maintain current riparian ecosystems and reduce fire intensity.

Areas that could be targeted for treatment are:

- areas with a high stand density that are subject to damage by insects or disease (except dieback) and where a reduction in stand density is likely to promote recovery from and/or reduce susceptibility to damage by insects or disease.

- catchments where a reduction in stand density is likely to maintain groundwater levels and streamflow so that these catchments can act as refuges from the hydrologic impacts of climate change.
- granite outcrops from the impacts of high intensity bushfire through stand density management and prescribed burning of surrounding areas.

Strategies

53. Identify ecological values or communities where the effects of climate change will escalate the threat to the value or community.

54. Prioritise ecological values or communities in relation to the potential risk associated with the:
    - likelihood and degree to which soil moisture, ground and surface water availability will decline in the areas in which the value or community occurs.
    - likely impact on the value or community of declining soil moisture, ground and surface water availability.
    - feasibility of conducting silvicultural treatment to reduce the potential for soil moisture, ground and surface water decline.
    - potential impact on other values of conducting silvicultural treatment to arrest soil moisture, ground and stream water decline.

55. Consider relevant species management plans, species recovery plans or catchment management plans to guide the application of 'silviculture for ecosystem health' treatments, depending on the value being addressed and the scale of the work proposed.

56. Introduce or modify burn plans to improve the health of and/or reduce the threat to identified values or communities.

The following strategies are existing practices, or modifications to existing practices, which may be used to enhance water availability.

57. Use an adaptive management approach to residual stand density to:
    - arrest or improve groundwater and/or streamflow to threatened communities or ecosystems
    - improve the health and vigour of the overstorey
    - reduce water use by reducing basal area (and consequently leaf area)
    - allow retained trees to develop to maturity at which time they are less water demanding per unit of leaf area
    - promote the recovery of trees following severe damage from disease or insect attack.

Guiding principle 11

Maintain resilience by reducing the impact of weeds on natural ecosystems.

Rationale

Weeds have the potential to significantly increase the competition for limited water and nutrient resources in the wandoo forests. Some weeds are so competitive they can

displace and exclude native flora, altering the vegetation structure. Altered vegetation structure affects the habitat and food resources for native fauna and changes the effects of both bushfire and prescribed fire. Silvicultural activities involving the use of heavy earthmoving equipment or other machinery should therefore be subject to weed hygiene measures.

There are a number of species which have been used for plantations, in timber production trial plots or in rehabilitation that have the potential to become weeds. It is intended that these species are identified and actions taken to remove them and replace them with native tree species as well as limit their spread.

Strategies

58. During forest management activities, provide a system of recording, monitoring and providing treatment options for weeds.

59. During silvicultural operations, incorporate hygiene measures to minimise the potential for the introduction of weeds into the hygiene management requirements for the machinery.

60. During harvest operations, preferentially remove exotic tree species.

61. During post-harvest surveys, monitor the occurrence and density of pest plants in the wandoo forest and develop management strategies to address these as required.

5. 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. Harvesting disturbance, particularly roading, can be detrimental to soil and water values. Management controls on these operations should limit potential harm.

Guiding principle 12

The extent and severity of harvesting disturbance on soil values will be minimised and where practicable remediated.

Rationale

Maintaining soil values is one of the most important elements of sustainability since soil health underpins the health of the ecosystem. Potential risks to soil health associated with harvest disturbance activities include:

- changes to soil structure; and
- loss of topsoil (soil erosion).

Soil structure can be adversely affected by soil compaction during timber harvesting and forest management activities, and by the mixing of soil profiles particularly when the soil is moist. These types of damage can reduce seed germination, seedling survival and plant growth. Profile mixing or topsoil removal cannot be remediated. The effects of compaction and mixing of soil profiles are controlled by restricting machine activity during moist soil conditions (Rab *et al.* 2005; Whitford *et al.* 2012). Compaction can be alleviated by shallow ripping or scarification for surface compaction, and deep ripping for compaction of the lower horizons.

The success of establishing regeneration is dependent on having a receptive seedbed to facilitate germination of seedlings, and some soil disturbance contributes to a receptive seedbed. However, 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, remediation works need to occur under the correct soil conditions to be effective. For example, ripping to alleviate compaction is of no value unless the soil moisture levels are such that ripping shatters compacted soils and may be detrimental if carried out under moist soil conditions.

Pushing of cull trees can result in soil disturbance where clay is brought to the surface with the root ball of the tree. Where there are a significant number of cull trees to be removed, this method can result in an unacceptable level of soil disturbance and should be avoided.

High intensity bushfire can lead to a loss of nutrients from the system, particularly in erosion events. Prescribed burning should seek to prevent high intensity bushfire.

Salvage harvesting operations after bushfire disturbance may require the use of erosion control structures.

Strategies

62. Timber harvesting activities will be managed in accordance with the Soil and Water Conservation Guidelines, SFM Series Guideline No 5, (Department of Environment and Conservation 2009c).

63. During harvesting operations, use a combination of harvest timing, extraction pattern design and surface water management structures (Manual for the management of surface water SFM Series Manual No. 3, Department of Environment and Conservation 2009b) to limit erosion and compaction.

64. When reducing rootstock competition to assist establishment of overstorey regeneration, limit soil treatments to a maximum of 50 per cent of the harvested area.

65. During post-harvest silvicultural treatments the technique of scalping to expose mineral earth will not be used.

66. After harvesting is complete, carry out timely remediation of compacted soils, landings, roads and tracks, to allow seed-fall onto a receptive seedbed.

67. During burn planning, aim to ensure burn cycles support nutrient cycling within the forest and prevent high intensity bushfire.

68. During salvage operations post-fire, incorporate erosion control structures.

Guiding principle 13

Water quality will not decline as a result of silvicultural treatment.

Rationale

Historically the main potential risk to water quality has been from groundwater rise dissolving and transporting salt stored in the unsaturated zone of the soil profile. The potential of silvicultural treatment of forested areas leading to a rise in groundwater is not a potential risk in the Wandoo forest.

All operations conducted during silvicultural treatment must be in accordance with *Soil and Water Conservation Guideline* SFM Series, Guideline No 5 (Department of Environment and Conservation 2009c) which guides all aspects of operations associated with silvicultural treatments to avoid or minimise potential effects on water quality.

A number of measures are implemented to control potential impacts on water quality from silvicultural treatments and the operations that accompany them. River and stream zones are excluded from harvesting disturbance as specified in *Guidelines for protection of the values of Informal Reserves and Fauna Habitat Zones* SFM Series, Guideline No 4 (Department of Environment and Conservation 2009a). The width of stream zones is dependent upon the stream order and ranges from 60 m for stream order 1-3 up to 400m for stream orders 5 and greater. River and stream zones provide protection from erosion and sedimentation. Additional guidelines around river and stream zones can be found in *Guidelines for protection of the values of Informal Reserves and Fauna Habitat Zones* SFM Series, Guideline No 4 (Department of Environment and Conservation 2009a).

Water quality can also be affected by contamination from chemicals (e.g. herbicides and fuel oils) if they are used incorrectly or spilled in the catchment.

Strategies

69. During silvicultural treatments, all operations must comply with SFM Series, Guideline No 5, Soil and Water Conservation Guideline (Department of Environment and Conservation 2009c).

70. Prior to silvicultural treatment, river and stream informal reserves must be demarcated and subsequently protected as specified in Guidelines for the Protection of the Values of Informal Reserves and Fauna Habitat Zones SFM Series, Guideline No 4 (Department of Environment and Conservation 2009a).

71. If using chemicals during silvicultural treatments, use good practices as guided by regulations and the Code of Practice for the use of agricultural and veterinary chemicals in Western Australia (Department of Agriculture and Food Western Australia 2007).

72. If using herbicides in water catchment areas, use must also be in accordance with the Use of Herbicides in Water Catchment Areas (Department of Health 2007).

73. Pesticides will only be used where there is, in the view of the Department, no practicable alternative.

6. Guiding principles for climate change and carbon cycles

Overall objective

Within the constraints of a changing climate and the achievement of other goals of management, seek to adapt forest management to climate change and sustain the contribution of the forest to global carbon cycles.

Native forests contribute to climate change mitigation through storage of carbon in forests. Storage of carbon in forest products harvested from sustainably managed forests and use of those forest products contributes further to mitigation of climate change.

Silvicultural management of the forest to retain its productive capacity in the face of climate change requires addressing potential damage agents such as weeds, pests and diseases, protecting forest soils and adapting silviculture to address changes in water availability. These issues are addressed in Guiding principle for ecosystem health and vitality and Guiding principles for soil and water.

Guiding principle 14

Forests will be managed to maintain forest carbon stocks, provide forest products and contribute to the mitigation of climate change.

Rationale

Forests and forest products have an important role in global carbon cycles, predominantly as sinks. 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 carbon cycles. 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 products that 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. The aim of forest management practices 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. The potential for well managed forests to contribute to climate change mitigation is acknowledged by the Intergovernmental Panel on Climate Change, which states: *In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stock, while producing an annual sustained yield or timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit* (Nabuurs *et al.* 2007).

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. In native forests subject to harvest and subsequent regeneration, the impact of practices implemented at a stand scale relate to:

- *Quantity and timing of timber harvests*: the extent to which carbon stocks are modified at a point in time through harvesting practices is related to the proportion of area harvested, proportion of trees removed and the harvest interval. Effective regeneration and replanting mean that the area of forest available to store carbon is not reduced, and subsequent regeneration restores site carbon stores over time.
- *Low-impact practices*: reducing the harvesting disturbance of soil and remaining vegetation will help conserve soil carbon and the productive capacity and sequestration potential of the site. Soil carbon is mostly held in organic matter and measures to protect soils from disturbance are covered in the guiding principles for soil and water (Guiding principle 11, Guiding principle 12 and Guiding principle 13). However in terms of carbon stocks, as noted Australia's 'State of the Forests Report 2008' (Montreal Process Implementation Group for Australia 2008), in native forests subject to cycles of harvest and subsequent regeneration, change in soil carbon is believed to be insignificant since emissions caused by disturbance of soils during harvesting: are balanced in a given inventory period by re-accumulation through tree growth. This reasoning is also used in accounting rules set out by the United Nations Framework Convention on Climate Change.

Strategies

74. Protect forest soils during harvesting operations by following the Soil and Water Conservation Guideline SFM Series, Guideline No 5 (Department of Environment and Conservation 2009c).

75. Use silvicultural treatments to encourage the sustainable production of forest products with a long service life, and those that replace fossil fuels and high-embodied energy alternatives.

76. Ensure effective regeneration and where practicable, carry out rehabilitation of the forest, to maintain productive capacity, maintain the forest area and sustain the pool of carbon stored in the forest.

77. In post-harvest silvicultural treatments, limit culling of trees to a level required to maintain a healthy and productive forest that is actively sequestering carbon.

78. Aim for timely completion of all silvicultural burns, which will also help reduce the risk and frequency of large-scale, high-intensity bushfires.

7. 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 15

Ensure the most appropriate silvicultural method is applied to each stand to support short and long term productivity.

Rationale

Silvicultural practice in the wandoo forest is essentially a single tree selection system. In selecting trees for harvest, the aim is to maintain a stand with three major cohorts, regeneration, intermediate and mature or senescent trees. Even aged stands will be thinned until they are mature and eventually require regeneration. Given the fire sensitivity of wandoo in early growth stages, it is very difficult to manage for multiple small stands of varied ages. Each stand or group of stands at the local scale must be large enough to manage for a single silvicultural objective.

Strategies

79. For harvest planning, maintain maps of forest structure and use pre-harvest regeneration surveys to assist in the selection of the most appropriate silvicultural method and group size.

80. Prior to treemarking, carry out an advanced burn where practicable to facilitate the identification of regeneration stage and numbers.

81. During treemarking when selecting trees to provide seed, select the most vigorous trees, of good form with mature characteristics (dbhob>30 cm) and spreading crowns to provide sufficient and quality seed for regeneration.

82. Areas planned for a regeneration establishment burn should have a formal capsule and seed crop survey completed, to ensure that an adequate seed crop is available, prior to the burn being undertaken.

Guiding principle 16

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

Rationale

The open nature of wandoo forest is a function of competition for moisture in a water limited environment. Wandoo suppresses understorey (through competition for moisture) to about three times its own crown area, and the influence on developing regrowth is likely to extend further than this.

In some circumstances, where the understorey has a significant component of species that re-sprout from rootstocks, mechanical soil scarification may be applied to promote seedling establishment. In most circumstances the harvesting disturbance, burning of the harvesting slash, and/or subsequent fuel reduction burning, will create sufficient seedbed. It is intended that the use of mechanical soil scarification will be restricted to limit potential adverse impacts on the soil, understorey vegetation and other values.

Competition for water and nutrients impacts on the survival and growth rate of established trees and therefore affects the quantity of wood that can produced from a stand. Silvicultural thinning reduces stand density usually to keep the trees actively growing and prevent severe competition and tree decline. The juvenile stand experiences significant competition from the time of crown closure, and this continues throughout the life of the stand. When the stand experiences severe competition, growth rates decline and trees suffer stress and some die. This natural thinning process occurs at a slow rate. Silvicultural thinning aims to redistribute growth from the site onto selected stems without reducing total stand growth. In addition silvicultural thinning shortens the time taken for the trees to reach sawlog size, accelerates the development of mature forest characteristics that people find appealing, and that provide for the habitat requirements of birds and animals.

Regeneration patch size and shape influences the level competition experienced by individuals within the patch. Small gaps experience the highest level of influence from edges with competition reducing as patch size increases. If competition from retained trees is too great, areas may not regenerate. Similarly, retained legacy elements in the form of mature and over-mature trees are in competition with adjacent trees and this is can influence the health and endurance of these legacy elements.

Strategies

83. During treemarking, retain habitat trees in groups where required to reduce the suppression of regeneration.

84. During treemarking endeavour to create a patch diameter in regeneration release areas at least four times tree height, to minimise edge competition on regeneration.

85. During treemarking aim to promote growth on retained trees by implementing silvicultural thinning regimes that maximise sawlog development within other constraints.

86. During treemarking aim to maintain stand density near the optimum for tree growth, consistent with changes in water availability.

87. During post-harvest silvicultural treatment, competition from understorey, may be

reduced, but only to prevent suppression of the regeneration.

88. Where resources allow, apply silvicultural thinning to relieve competition between trees in the absence of commercial timber harvesting, where appropriate.

Guiding principle 17

Where the canopy is removed to establish regeneration the forest will be regenerated in an effective and timely manner.

Rationale

Where regeneration establishment operations are applied, timely regeneration is important for,

- sustained yield
- carbon storage and sequestration
- ongoing provision of habitat for overstorey forest dwelling species
- visual amenity

Timely regeneration is dependent upon the coordination of harvesting, post-harvest treatments, site preparation, seed crop and silvicultural burns. Scheduling of operations is complex and subject to the availability of resources and suitable weather conditions. This complexity can lead to delays in regeneration.

Where regeneration is not achieved in a timely or effective way, the reasons behind this should be recorded. Where possible the information recorded should be used address delays or failure in regeneration to improve regeneration outcomes in the future.

Strategies

89. Post-harvest silvicultural treatments should be completed adequately and within a timely manner to achieve regeneration as soon as possible after timber harvesting is finished.

90. Post-harvest silvicultural treatments will be conducted prior to burning where possible.

91. After regeneration, monitor stocking to determine if and where remedial action is required.

92. Where regeneration is delayed or remedial action is required, document where known the reasons for delay or regeneration failure.

Guiding principle 18

Trees to be retained will be marked and protected from damage.

Rationale

Silvicultural practices in the wandoo 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, as cover to protect water values, or for other reasons.

Harvesting operations have the potential to damage retained trees, from harvest machinery coming into contact with retained trees and from the impact of falling trees. Both can result in damage to the bark and cambium, broken limbs and potentially the toppling of the trees marked for retention.

While some damage may be unavoidable, levels of damage should be minimised. Some damage to the bark and cambium or broken limbs is acceptable in retained habitat trees, as it can add to the habitat value over time. However, damage that kills or destabilises a habitat tree should be avoided.

Avoiding damage to crop trees, especially in thinning, requires care as the trees may be closely spaced and machine operators have limited area to manoeuvre. However, damage to the bark or cambium of crop trees can cause wood degrade. Therefore, avoiding damage to crop trees is important if the value of the crop is to be maintained.

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

93. Treemarking is to be undertaken in advance of harvesting operations and trees are to be marked for retention in accordance with the silviculture 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.

94. During harvesting operations, monitor the level of damage to retained trees to help ensure it does not exceed the allowable level.

95. During harvesting operations, ensure debris is removed from trees selected for retention when the combination and arrangement of fuels is such they would otherwise be potential for damage to wood or other values during post-harvest burns.

Guiding principle 19

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

Rationale

Bushfire of moderate to high intensity will kill healthy wandoo saplings and small poles. Even if saplings and poles are not killed the bole or the growing tip may be damaged. 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.

It is predicted that climate change will lead to more frequent extreme fire weather conditions. Unplanned 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, and quality, of sawlogs (and other logs) available. While fire deaths and degrade may reduce yields, this may be partially offset where salvage harvesting occurs.

If sizeable patches of forest are killed or degraded, there is often significant benefit to a range of values by regenerating or rehabilitating affected areas. Salvage harvesting of these sites allows for useable wood to be recovered and provides an opportunity to commence the process for regeneration or rehabilitation. However, as the wood of dead trees degrades quite quickly, achieving this requires that the usual assessment, planning and approval processes be undertaken in a timely fashion.

Strategies

96. All stands that are burnt with moderate to high intensity fire, should be assessed for damage.

97. After natural disturbance events which result in tree death or damage, harvesting may be used to salvage forest products and facilitate regeneration and/or rehabilitation of the disturbed areas. Facilitate salvage harvesting as soon as possible after the disturbance event to reduce log degrade and promote regeneration.

98. Harvesting to facilitate salvage forest products may be approved by the Director Sustainable Forest Management, on a case-by-case basis.

99. During salvage operations, retain legacy elements where they exist (see Guiding principle 3).

100. After natural disturbance events and salvage operations, regenerate and/or rehabilitate areas left understocked.

8. Guiding principles for heritage

Overall objective

Protect and maintain Aboriginal and other Australian cultural heritage.

Cultural heritage is a generic term which refers to the qualities and attributes that are present at places which have aesthetic, historic, scientific or social significance for past, present or future generations. These qualities or attributes may be seen in the physical features at a place (such as travel routes, buildings or relics), or can be associated with the intangible qualities such as the association with or feelings for a place by a community. Identifying intangible qualities will require consultation with the people or communities who hold these feelings or associations. The identification and protection of cultural heritage sites is primarily addressed during the harvest planning and approval process.

Section 56 of the CALM Act, prescribes the management objectives for each category of land to which the CALM Act applies, and management plans for lands managed by the Department may enable management activities to conserve, protect, preserve, maintain or restore cultural heritage. The CALM Act requires that the management of lands and waters include the objective to protect and conserve the value of the land to the culture and heritage of Aboriginal persons.

In relation to other Australian heritage, the *Heritage of Western Australia Act 1990* provides the legislative guidance. The crucial factor in applying the requirements of this Act is that there must have been human activity associated with the place.

Heritage issues are addressed in the harvest planning and approvals process, and the strategies listed below are complementary to this.

Guiding principle 20

Harvest disturbance will be managed to avoid adversely affecting Aboriginal cultural heritage values and sites.

Rationale

The wandoo forest was traditionally occupied by the Noongar people, who are the original custodians of the land. A large number of Aboriginal sites have been recorded within the plan area. These are places of importance and significance to Noongar people and to the cultural heritage of Western Australia. They are significant because they link Noongar cultural tradition to place, land and people over time. Noongar people have a rich and intimate connection with the country within the plan area, which includes knowledge of, rights to, and responsibility for these sites and for protecting the culture and heritage values of these sites.

Scarred or modified trees that mark trails or other sites of significance to Noongar people occur throughout the forest. The locations of the trees that exist today are not all known or registered. Staff conducting silvicultural operations should be aware of the need to conserve cultural heritage and be trained to 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

101. During treemarking, look for and report items that may be evidence of Aboriginal use of a site such as scarred or modified trees, and prevent damage to them until they can be assessed.

102. During rehabilitation planning, consider use of seed from endemic "bush tucker" plants as part of the seed or seedling mix.

Guiding principle 21

Harvest disturbance will be managed to avoid adversely affecting Australian cultural and natural heritage values and places.

Rationale

Throughout the forest there are places providing examples of early settlement and harvesting activity 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 that may be 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 harvesting 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

103. During treemarking, ensure the curtilage of registered heritage places is demarcated or the silvicultural method is adapted to conserve heritage values.

104. During treemarking, mark for retention and ensure sufficient protection of trees of cultural significance, and significant trees. Candidate and nominated significant trees should remain undisturbed until they can be formally assessed for registration.

105. Ensure that any proposal to disturb a blazed location reference tree is approved by the Department prior to the disturbance taking place.

9. 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 wandoo 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 produce, basic raw materials, nature based recreation and tourism, apiculture and wildflowers and seeds. Silvicultural treatments within the wandoo 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 22

Maintain the capacity of multiple use forest areas to contribute to social and economic sustainability of regional communities.

Rationale

The wandoo forest forms part of a larger forest matrix that is important to regional communities and industry in Western Australia. Silvicultural management of the forest seeks to provide for employment and other benefits of the native forest timber industry with the ongoing provision of environmental values (Guiding principles for biodiversity, Guiding principles for ecosystem health and vitality, Guiding principles for Soil and Water, Guiding principles for climate change and carbon cycles), tourism and recreation, and other values. Silvicultural methods that are designed to provide for non-timber objectives are often at an economic and/or efficiency cost to the native forest timber industry. The design of silvicultural practices should seek to balance the achievement of environmental outcomes with economic and social outcomes.

Silvicultural management can also be applied to benefit environmental and social values outside the scope of the timber industry. For example the application of silvicultural principles can be used to rehabilitate cleared or degraded forest, mitigate potential fire risk while maintaining biodiversity, manage water catchments for water and environmental values and manage the impact of infrastructure projects such as power lines on forest values.

Strategies

106. Liaise with companies involved in large scale mining and infrastructure projects to ensure that regeneration strategies, and species mixes, are able to provide for both natural values and commercial opportunities.

107. When applying an adaptive management approach, balance the delivery of social, economic, and environmental values by evaluating the likely merits of changes to silvicultural methods.

108. Where possible, preference will be given to achieving silvicultural objective through commercial rather than non-commercial means.

Guiding principle 23

Visual landscape management will be used to manage potential impacts of silvicultural treatments on visual amenity.

Rationale

Priorities for management of visual amenity in forest areas are based on the mapping of visual resource values and visitation and/or road usage patterns. 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 thinning intensity, felling cycle, rotation length and treatment method.

Strategies

109. During harvest planning, manage the visual amenity from major roads and recreation sites by applying the requirements appropriate for the allocated visual management zone.

110. During harvest planning, extend rotation length, where necessary, to allow mature forest characteristic to develop to maintain visual amenity from major travel routes.

111. During harvest planning, extend the cutting cycle adjacent to major travel routes, where necessary, to allow the scenic quality to recover from harvesting disturbance.

112. When conducting post-harvest treatment adjacent to major travel routes, do not create standing dead trees that would reduce the visual quality of the view-shed and that may pose a potential risk to passing traffic in storm or fire events.

Guiding principle 24

Minimise disturbance associated with the extraction of basic raw materials in the wandoo forest.

Rationale

Basic raw materials (BRM) including clay, gravel, sand and stone, are used for road building and other industrial uses. The FPC and DPaW regularly establish BRM pits on DPaW-managed estate to provide for these purposes. The conditions associated with the removal of BRM are outlined in SFM Series, Guideline - *Guidelines for the Management and Rehabilitation of Basic Raw Material Pits* (Department of Environment and Conservation 2008), which is applicable to all users. The removal of BRM by FPC is covered by draft SFM Series, Advisory Note No. 7 - *Use of Basic Raw Materials for the Construction and Maintenance of Harvesting Roads (Department of Parks and Wildlife 2013)*.

It is intended that the area of wandoo forest that is mined for BRM is minimised and that all areas including any legacy areas that are not successfully rehabilitated will be rehabilitated to an appropriate standard using seedlings and seed mixes that are appropriate to the area.

Strategies

113. Minimise the loss of productive forest from mining of basic raw materials in association with silvicultural activities.

114. Rehabilitate areas used for basic raw material extraction, where this is associated with silvicultural activities.

115. Use wandoo seed or seedlings and understorey seed from the local area in rehabilitation of basic raw material pits.

10. Appendix

Appendix 1: 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 relevant 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 and protect Aboriginal heritage sites and ensure that sites are protected. This Act is also relevant under section 24 of the Mining Act, the Minister for Mines may consent to mining, including exploration activities, subject to conditions that may be intended to protect environmental and cultural heritage.	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. 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 Western Australia 2007).	Department of Agriculture and Food WA
Bush Fires Act 1954	Provides regulation of the control of bushfire and the use of prescribed fire.	Department of Fire and Emergency Services
Biosecurity and Agriculture Management Act 2007 **(BAM Act)**	Prescribes certain statutory obligations to the Department concerning biosecurity matters generally, and particularly with respect to the management of pathogens that cause forest diseases, through the CALM Act. The management and control of weeds in Western Australia is guided by the BAM Act and the *Agriculture and Related Resources Protection Act 1976* (it is intended that the BAM Act will replace the Agriculture and Related Resources Protection Act and some other Acts in the near future, which may bring some changes to management requirements).	Department of Agriculture and Food WA
Conservation and Land Management Act *(CALM Act)*	Establishes the Conservation Commission as an independent controlling body and provides for the functions of the Conservation Commission including: to have State forest, timber reserves and conservation reserves vested in it; and to prepare management plans for those lands as prescribed in Part V of the CALM Act, according to certain purposes and objectives. It also provides for the Department to manage land vested in the Conservation Commission according to available resources and management plans.	Department of Parks and Wildlife

Title of Act or Regulation	Relevance of legislation	Responsible agency
Country Areas Water Supply (CAWS) ***Act 1947***	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
Emergency Services Act 2005	Sets out the emergency management arrangements for the State and requires that a number of emergency response plans be maintained. The response plan for bushfire is Westplan Bushfire, which sets out the Department's role in bushfire suppression operations as a 'Controlling Agency'.	Department of Fire and Emergency Services
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)	Contains provisions relating to the protection of nationally-listed threatened species and ecological communities. In that part of the plan area covered by the Regional Forest Agreement (RFA), the Commonwealth and State governments have agreed that the CAR reserve system and the forest management system, meet the requirements of that Act for the protection of threatened flora and fauna and ecological communities (RFA clause 56). Therefore, the provisions of the EPBC Act for environmental assessment are not triggered for forestry operations.	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth)
Environmental Protection Act 1986 *(EP 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 Parks and Wildlife and Environmental Protection Authority
Forest Products Act 2000 *(FP Act)*	Provides for Forest Products Commission with the responsibility for the harvesting and regeneration of native forest and plantations in State forests and timber reserves, and for the sale of forest products (a subset of CALM Act forest produce) and some associated industry development matters.	Forests Products Commission
Health Act 1911	Applicable to pesticide use within a public drinking water source area. The conditions for pesticide use in these areas are specified in the Department of Health *Public Service Circular 88 Use of herbicides in catchment areas*, and also relevant to this is the Department of Water *Statewide Policy 2 Pesticide Use in public drinking water source areas*.	Department of Health
Heritage of Western Australia Act 1990	Provides for the registration and protection of places of historic interest on lands as 'heritage places'. This Act is also relevant under section 24 of the Mining Act, the Minister for Mines may consent to mining, including exploration activities, subject to conditions that may be intended to protect environmental and cultural heritage.	Heritage Council of Western Australia

Title of Act or Regulation	Relevance of legislation	Responsible agency
Metropolitan Water Supply, Sewerage and Drainage Act 1909 (MWSSD Act)	With 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 be in accordance with *Statewide Policy No.2 Pesticide use in PDWSA*.	Department of Water
Rights in Water and Irrigation Act 1914	This Act covers the use of water in the plan area, and permits (related to the disturbance of beds and banks) and licences (for the taking and use of water) are required within proclaimed areas.	Department of Water
Soil and Land Conservation Act 1945	This Act provides for the conservation of soil and land resources and provides mechanisms for the mitigation of the effects of erosion, salinity and flooding. This Act covers crown land.	Department of Agriculture and Food
Wildlife Conservation Act 1950	This Act provides for the conservation of native flora and fauna throughout the State.	Department of Parks and Wildlife

11. Acronyms

Acronym	Definition
CALM	**Conservation and Land Management**
CWD	**Coarse woody debris.**
Dbhob	**Diameter at breast height over bark.**
DEC	**WA Department of Environment and Conservation (now DPaW)**
DPaW	**WA Department of Parks and Wildlife**
FDIS	**Fauna Distribution Information System**
FHZ	**Fauna Habitat Zone**
FMP	**Forest Management Plan 2014-2023.**
LMU	**Landscape management unit**
TEAS	**Temporary exclusion area.**

12. Glossary

Term	Definition
Advance growth	A term used to describe the established regeneration stages of jarrah, including established seedlings, coppice, saplings and poles.
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.
Clearfell	A silvicultural method in which all, or nearly all trees in a defined area are removed at one time to allow regeneration to establish and develop (note legacy elements are marked for retention, and some non-commercial trees may still remain on site).
Coarse woody debris	Dead woody material such as boles and branches on the ground or in streams.
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.

Term	Definition
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.
Dbhob	Stem diameter measured at breast height over bark.
Department, or the Department	The Western Australian Department of Parks and Wildlife.
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).
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.
Evapotranspiration	Loss of water from an area of land through the transpiration of plants and evaporation from the soil.
Even-aged stand	A forest stand dominated by trees of a similar age. In native forests, this includes stands where the non-dominant age classes comprise less than 15 per cent crown cover.
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.

Term	Definition
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.
Fauna Distribution Information System	Departmental database of taxonomy, conservation status of fauna species and advice on management practices.
Fauna Habitat Zone	FHZs are patches of forest systematically distributed across the landscape which are temporarily excluded from timber harvesting.
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.
Floristic	Of or relating to flowers, a flora, or the biogeographical study of plants

Term	Definition
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: trees or parts of trees; timber, sawdust or chips; charcoal, gum, resin, kino or sap; and firewood, located on public land or sharefarmed land.
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.
Formal reserve	See 'Reserve – Formal'
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, the size of the gap must be large enough to create a suitable microclimate for regeneration and/or growth of younger trees, and allow for later felling without causing undue damage to surrounding trees.
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.

Term	Definition
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.
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.
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.
Legacy elements Also Legacy habitat elements	Refers to existing key habitat features, such as hollow bearing trees and logs which may take many decades to replace and which are retained after harvesting or remain after natural disturbance, which provide refugia and enrich the structural complexity of the new stand.
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. For the purposes of this guideline – the average area of a forest blocks in the vicinity.

Term	Definition
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.
Natural regeneration	Regeneration through lignotubers or seed produced on site as opposed to planting or applying seed from collections.
Overstorey	Species comprising the upper canopy layer of the forest. Common overstorey species include *Eucalyptus marginata, Corymbia calophylla, E. wandoo, E. patens and E. diversicolor.*
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.
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, vegetation 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.

Term	Definition
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.
Salvage harvest	The removal of forest produce and/or forest products following an unplanned disturbance event to recover economic value that would otherwise be lost. Salvage operations require approval by the Department. By their nature, salvage harvest areas may not appear on the three or one year harvest plan(s) that pre-date operation.
Saproxylic	Saproxylic organisms are those which are dependent on dead or decaying wood (or dependent on other organisms that are themselves dependent on dead wood). They may be dependent on dead or decaying wood for part of or the entirety of their life cycle.
Second-storey	The structural layer between the shrub and herb storey and the overstorey (canopy). In the wandoo forest, the second storey is usually absent.
Seed tree	A tree left standing for the purpose of providing seed for the regeneration.
Senescent crown (for selecting trees bearing hollows)	The development stage that follows the mature tree stage and precedes natural death, usually involving a decreased ability to repair damage and degradation. Characterised by a dominance of dead branches in the tree crown together with the formation of new branches from epicormic buds. Senescent crowns in large trees are likely to bear usable hollows for large hollow dependent fauna. They are found in trees 50 – 70cm, but more often ≥ 70 cm, dbhob, with a crown senescence rating greater ≥ 4 (Whitford *et al.* 2001), and with highest likelihood at a crown senescence rating of 7. Likelihood of bearing usable hollows is reasonable with higher dead branch order scores (≥ 4 and increases with a dead branch order 7 to 9; (Whitford *et al.* 2001)), and crowns with evidence of hollow entrances (smallest entry dimension >10cm in diameter) into low order branches (orders 1, 2 & 3 - branches leading to, or close to the bole).

Term	Definition
Senescent stand	The development stage that follows the mature stand and precedes natural death, usually involving a decreased ability to repair damage and degradation. Characterised by a dominance of dead branches in the tree crown, together with the formation of new branches from dormant buds.
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 application of silvicultural management to protect threatened ecological values or communities where the effects of climate change will escalate the threat to the value or community.
Silviculture for water production	The application of silvicultural management to increase the flow of water to surface and groundwater reservoirs which will support aquatic ecosystems, but also be available for consumptive purposes.
Site productivity	The inherent capacity of forest land to grow woody biomass of a particular species
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.
Structure	When applied to a forest, is the horizontal and vertical distribution of the alive and dead vegetation.
Stool coppice	A growth stage where shoots have developed from a stump cut off at ground level.
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.

Term	Definition
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, karri and wandoo 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.
Understorey	Herb and shrub layer. This vegetation layers occurs beneath both the overstorey and second-storey.
Variable density thinning	Type of thinning used to introduce structural complexity into even-aged regrowth stands by for example, leaving un-thinned patches, retaining older trees and understorey, 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.
Vegetation complex	A combination of distinct site vegetation types, usually associated with a particular geomorphic, climatic, floristic and vegetation structural association.
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 approved Forest Management 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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