Review of silviculture in forests of south-west Western Australia

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Executive Summary

The Western Australian Forest Management Plan (FMP) 2004-2013 contains an action to review silvicultural practices in various south-west forest types prior to the development of the next FMP. Consistent with this action, the Department of Environment and Conservation (DEC) through the Director of Sustainable Forest Management established a 'Silvicultural Review Expert Panel' (the Panel) to review the role of silviculture in delivering ecologically sustainable forest management (ESFM) in Western Australia.

There exists a comprehensive documentation of silvicultural policies, principles, guidelines and manuals prepared by DEC, which, based on the evidence available to the Panel, and given appropriate staff training and compliance, appears to adequately accommodate the conservation of biodiversity and other environmental values at the local forest scale. This observation is further supported by recent research and data gathered as part of FORESTCHECK, a biodiversity monitoring and evaluation framework and protocol that, in the Panel's view, is current best practice and a credit to forest management in WA. As an integral part of adaptive management, the Panel is unaware of any similar program elsewhere in the world. In summary, the Panel identified a number of relatively minor issues of potential concern (see below) regarding biodiversity conservation and silvicultural prescriptions that require attention, but overall, existing and proposed practices should sustain biodiversity and forest productivity at the local forest scale.

It is the Panel's view that forest management to achieve a better water balance in a drying climate is a most critical issue facing forest managers now and in the future. As a consequence of a drying and warming trend since the 1970s, and a legacy of predominantly heavily stocked regrowth forests, these ecosystems are experiencing acute water stress. Groundwater is disconnecting from stream flow, reducing streamflow and causing many once-permanent streams to become ephemeral and ephemeral streams to become dry. Wetter parts of the landscape including winter wetlands, peat swamps, riparian zones and other more mesic habitats embedded in the forest complex are drying. This is having acute impacts on the stream and riparian zone biota as well as predisposing them to damaging bushfires. If this issue is not addressed as a matter of priority, then the consequences will be undesirable, probably irreversible, and will likely compromise efforts to achieve ESFM. Silviculture has a pivotal role in addressing this issue. As far as is feasible given capacity constraints, the focus of timber production from jarrah forests in particular should be to increase environmental water availability through reduction of standing basal area and leaf area index. While all jarrah forest ecosystems will probably benefit from silvicultural measures that reduce water stress, management should focus in the higher rainfall zones, as achieving significant improvement in water yield is most likely in these areas.

Summary of Recommendations

Recommendation 1: As a response to climate change and to improve forest water balance, large scale operational trials should be carried out in an adaptive management framework to determine the feasibility, risks and benefits of sustained reduction of basal area and leaf area index (LAI) in heavily stocked regrowth jarrah forests in the high rainfall zone. The effects of these trials on biodiversity and ecosystem health should be monitored and evaluated using the established FORESTCHECK protocol.

Recommendation 2: Maintain and ensure adequate staff training and compliance with existing and proposed silvicultural standards, principles and guidelines to protect and conserve legacy habitat elements.

Recommendation 3: The value of fauna habitat zones as refugia and sources of recolonisation post logging should be assessed either by a separate study, or as part of the FORESTCHECK monitoring protocol, particularly given a range of proposed silvicultural changes to further a) retain legacy habitat elements and b) improve connectivity.

Recommendation 4: Monitoring and evaluation is fundamental to adaptive management and ESFM. FORESTCHECK, which represents current best practice forest biodiversity monitoring, should be maintained as an integral component of forest management.

Recommendation 5: The FORESTCHECK PROTOCOL should be reviewed in light of proposed silvicultural changes so that the effects of these changes on biodiversity can be monitored and properly evaluated.

Recommendation 6: The practice of mechanical scarification to create additional soil disturbance in order to improve the stocking of regeneration should be minimised. Physical or chemical removal of the mid-storey shrubs and small tree species (such as Persoonia spp., Banksia spp. and Allocasuarina fraseriana) in jarrah forest should cease except where it is deemed essential for the establishment and survival of regeneration of overstorey tree species.

Recommendation 7: Review the current specifications for regeneration surveys in jarrah.

Recommendation 8: Phytophthora dieback management guidelines should be updated to address other Phytophthora species and to reflect changes in Phytophthora activity likely with changes in the seasonality and intensity of rainfall.

Recommendation 9: Annual aerial surveillance of the whole forest estate be strengthened to capture changes in forest health and to better identify threatening processes that can be considered in adaptive management of the forests. This should be integrated with landscape and stand level assessments.

Recommendation 10: Establish guidelines for the management of pests and diseases of significance to all forest trees and forest ecosystems. Research should be undertaken where knowledge gaps are insufficient to inform management decisions.

Recommendation 11: Due to reduced rainfall and lower groundwater levels associated with climate change, and consequent reduced salinity risk, phased harvesting in lower rainfall areas of the jarrah and karri forest in the Swan and South-West DEC administrative regions

is not warranted. However, ongoing monitoring of groundwater should continue so that management can respond should there be a return to a wetter climate.

Recommendation 12: Undertake investigations into a) the loss of CWD habitat and b) effects on understorey regeneration, diversity and development resulting from windrowing / heaping and burning of logging slash in karri forest coupes. Where practical to do so, exclude large old logs in advanced stages of decay from rough heaping operations. Investigate smoke management systems that will facilitate the application of broad scale post-harvest burns, alleviating the need for windrowing and excess soil disturbance.

Recommendation 13: Consider extending FORESTCHECK to karri forest available for timber harvesting to monitor the efficacy of silvicultural practices designed to conserve legacy habitat elements and associated dependent biota.

Recommendation 14: To maintain genetic fitness, investigate the aerial application of seed to regenerate coupes following clearfelling and burning in two-tiered karri forests.

Recommendation 15: Ensure adequate training and compliance with the existing soil management guidelines throughout the harvesting and regeneration process (i.e. including burning) in the two-tiered karri forests.

Recommendation 16: Revise the specifications for retention of individual habitat trees on clearfelled karri coupes to reflect a preference for retention of small clumps of trees where possible.

Recommendation 17: To reduce soil and root disturbance, and the potential for stem damage during stump removal operations for Armillaria control, this practice should be discontinued unless forest health benefits can be clearly demonstrated.

Recommendation 18: Consider extending FORESTCHECK to wandoo forest available for timber harvesting to monitor the efficacy of silvicultural practices designed to conserve legacy habitat elements and associated dependent biota.

Recommendation 19: Avoid the use of mechanical soil scarification / scalping for seedbed preparation and removal / reduction of competition (other native plant species) when regenerating wandoo forest following harvesting.

1. Introduction

In accordance with the *Conservation and Land Management Act 1984* (CALM Act), management of south-west forests vested in the Conservation Commission of Western Australia is guided by the *Forest Management Plan 2004-2013* (Conservation Commission 2004). Consistent with adaptive management, there are specific actions in the plan to revise and review policies and guidelines during the life of the plan. This includes a requirement to review silvicultural practices, and to this end, Action 34.1.4 states:

"The Department and the Conservation Commission will initiate an independent expert review of silvicultural practices and their impacts on biodiversity during the second half of the life of the plan. The review will have regard to the results of FORESTCHECK and other research and monitoring, audits and adaptive management trials of these practices".

In response to this requirement, a review was initiated by the Director of the Sustainable Forest Management Division of the Department of Environment and Conservation (DEC), who appointed a Silvicultural Review Expert Panel (the Panel), being the authors of this report, to:

1. Obtain a sound understanding of the key elements of current and proposed silvicultural guidance documents and practices applied in jarrah, karri and wandoo forests.
2. Provide advice regarding the strengths and weaknesses of the guidance documents and practices, and the adequacy of the provisions of Ecologically Sustainable Forest Management (ESFM).
3. Provide advice as to any options for refinement of the guidelines and / or practices that should be considered during the development of the next forest management plan, based on the results of FORESTCHECK and other relevant research, monitoring, audits and trials.
4. Provide advice regarding any inherent 'trade-offs' between ESFM objectives that may accompany these refinements.

Although Action 34.1.4 of the FMP specifically requires revision of the silvicultural practices in relation to biodiversity impacts, the review Panel was instructed to consider ESFM more broadly, encompassing the (modified) Montreal Criteria for ESFM that are most acutely influenced by silvicultural practices at the local forest scale, being:

- Conservation of biodiversity
- Maintenance of productive capacity
- Maintenance of ecosystem health and vitality
- Conservation and maintenance of soil and water

Maintenance of forests contribution to the global carbon cycle, of heritage and of socio-economic values are important criteria for ESFM but are not considered in any detail in this report because they are not significantly influenced by local forest scale silvicultural practices alone. With regard to maintenance of forests contribution to global carbon cycles, whole-of-forest management actions that maintain or increase forest biomass will contribute to the maintenance of global carbon cycles. In this regard, further understanding of the impact of changing forest water balance on carbon stores and sequestration is desirable.

As components of these criteria, and in its deliberations, the Panel was also required to "*have regard"* for relevant contemporary issues including:

- Climate change and forest ecosystem resilience;
- Silvicultural practices and their impacts on biodiversity;
- Potential for increased utilization of wood biomass;
- Environmental water availability;

- Modified salinity risk in light of lowered water tables in the low and intermediate rainfall zones; and
- Timber industry viability.

Further details regarding the scope and workings of the Panel are at Appendix 1.

This report is structured around each of the three broad forest types (jarrah, karri and wandoo) that are covered by the current Forest Management Plan and for each forest type, we assess the efficacy of current and proposed silvicultural practices against the four Montreal Criteria for ESFM listed above. Some processes, such as climate change and soil disturbance for example, will inevitably impact on more than one of the ESFM Criteria in more than one forest type, resulting in some repetition throughout the document.

Consistent with climate change models, the south-west forest region has experienced a significant reduction in mean annual rainfall since the 1970s (Bates *et al*. 2008). Coupled with a legacy of an altered forest structure resulting from more than 100 years of timber harvesting, future silviculture will need to consider the water balance of forest ecosystems, which will impact most, if not all, of the criteria for ESFM including biodiversity conservation. Managing the water balance in forests under a drying climate is viewed by the Panel as the single most important issue of future forest management. Reduced rainfall together with high water use in heavily stocked regrowth forests is resulting in little or no runoff, significantly reduced environmental water and increasing incidence of drought deaths. More than 100 years of timber harvesting has altered the forest structure such that today there is a higher density of trees in the smaller size classes over a larger area. There is some evidence that older, relatively even-aged regrowth stands use more water than the old growth forests they replaced (Schofield *et al*. 1989: Macfarlane *et al*. 2010). Defining 'heavily' stocked regrowth stands is complex because of the natural variability in climatic and edaphic factors that fundamentally regulates stand density potential. Beyond recognizing that as a result of timber harvesting, significantly more of the modern forest is comprised of younger and smaller tress than was the case prior to European settlement, it is beyond the scope of this Panel to attempt to quantify what constitutes 'heavily' stocked regrowth stands in the variety of biophysical contexts of the south-west forest region.

As soil profiles dry and with the lowering of water tables, reduced tree growth and productivity is inevitable. Although not well documented, increased warming and drying is likely to have irreversible adverse ecosystem health and biodiversity impacts, especially in more mesic parts of the landscape. This issue is not limited to forests currently available for timber harvesting, but applies more broadly (Maher *et al*. 2010). Because of the high importance of water management in a drier climate, and its broad impact, we have dedicated the following section of this report to this critical issue.

2. Responding to climate change

Most of the south-west Australian forest region has experienced decreasing annual rainfall and increasing temperatures since the mid-1970s, consistent with climate change predictions (e.g., Bates *et al*. 2008; Maher *et al*. 2010). Since the mid 1970s, mean annual temperature has increased at a rate of about 0.15^{o}C per decade, there has been a reduction in early winter rainfall, mean annual rainfall over the last 40 years has decreased by ~14% (50-100 mm) compared with the period from 1900s to 1974, groundwater levels have dropped alarmingly, streamflow has reduced and rivers and streams flow less often (CSIRO 2009; Barron *et al*. 2010; Petrone *et al*. 2010). As well as a continuing trend of warming and drying, levels of atmospheric CO_2 are likely to continue to increase. Climate change is having, and will continue to have, a profound impact on a range of forest values including productivity, biodiversity and water yield (e.g. see Maher *et al*. 2010). This section considers

(a) the main elements of climate change, (b) the likely impacts of climate change on the south-west forests and (c) key management strategies to lessen climate change impacts on forest ecosystems.

2.1 Elements of climate change

Major common elements of climate change projections are that the overall water balance will change with drier conditions mainly through a reduction in rainfall, temperatures will increase, combined with an increased frequency of both extreme conditions (frosts and heat waves) and there will likely be an increase in the frequency of extreme fire weather events. Table I summarises trends observed in south-west Western Australia since the 1970s and the likely scenario to 2030.

Table 1 Observed and 2030 climate change scenario for south-west WA (adapted from Kauhanen et al. 2011).

Component	What has happed since 1970s	What is likely to happen by 2030
Temperature	Has increased by 0.4-0.8^{o} C over the last 40 years.	Mean temperature will increase by 0.5 – 2.0^{o}C compared to 1960-1990 baseline.
Rainfall	Has reduced by 50-100 mm per annum over the last 40 years. Seasonality has changed with less rain in autumn and early winter and slightly more rain in summer	Rainfall will reduce by 2-14% (median 8%), compared to 1975-2007 baseline. South west is predicted to experience some of the largest reductions in rainfall across Australia
Groundwater	Groundwater levels across Gnangara Mound have declined by up to 6 m during 1975-2005, with up to 4 m related to reduced rainfall Groundwater levels in the jarrah forest have fallen (by greater than 10 m in some catchments) from 1975 to 2007. Groundwater levels in high rainfall areas have now disconnected from many valley floors resulting in terrestrialising of valley flora.	
Streamflow	Average streamflow in southwest rivers from 1975 – 2010 was approximately 50% less than pre-1975 average. With groundwater levels disconnecting from valley floors there has been a much greater reduction in streamflow than just with rainfall decline.	Streamflow to reduce by 10-42% (median 25%), compared to 1975-2007 baseline.

There is a degree of uncertainty around these estimates (Table 1), both spatially and temporally. Similarly, the confidence in estimates for different elements of climate change varies. Current climate modelling develops estimates at a regional level, but estimates at the level of specific forest blocks are not possible at this stage. Another source of uncertainty comes with the future global emissions scenarios, which will in turn drive climate change. Future emissions growth will be driven by global economic growth and improvements in energy efficiency, and most future projections provide a range of possible scenarios.

2.2 Likely impacts of climate change

How will these elements of climate change affect the growth of the forest ecosystems of south-western Australia?

Water balance: A change in the water balance as a consequence of a) decreased rainfall, b) higher demand for water with increasing temperature and c) heavily stocked regrowth forest stands resulting from past logging and regeneration practices (e.g. see Figure 1), will result in a reduction in the amount of vegetation (and possibly other biota) that the forest can sustain. It is likely that, over time, the biomass of the forest will adjust to the new water balance, this occurring through plant competition, reduced biomass production and death of outcompeted species and of vegetation on sites with relatively low soil water storage capacity. The water storage capacity varies across the forest in relation to soils and geomorphology, so the pattern of impact will also vary (see Maher *et al.* 2010).

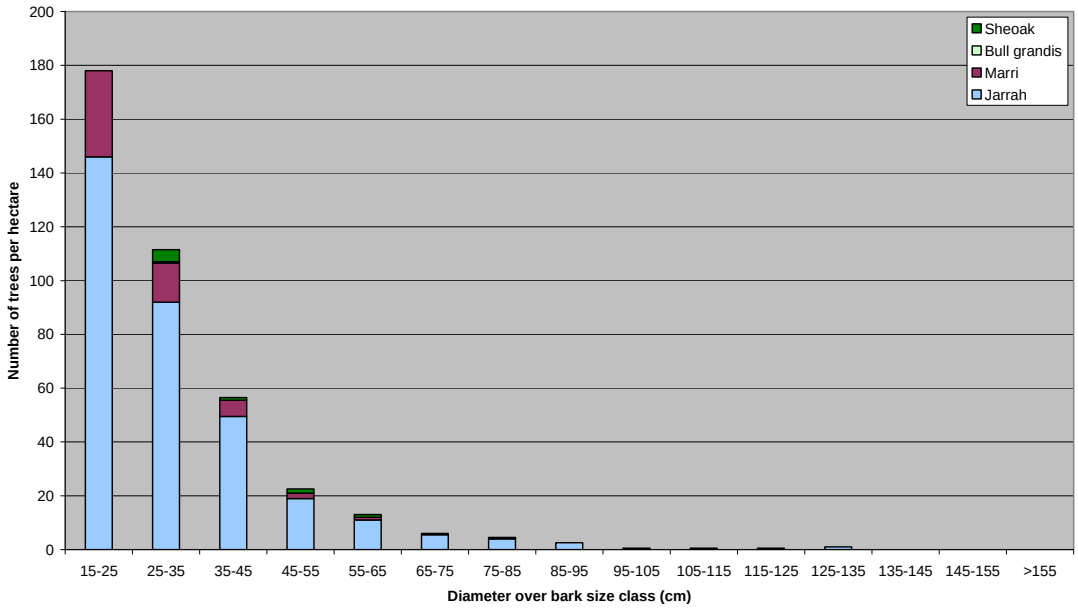

Figure 1: Average stem diameter size class distribution of trees (>15 cm) at the landscape-scale in high rainfall jarrah forests heavily cut-over prior to 1940. Note the high proportion of regrowth stems in the smaller size classes (source: Department of Environment and Conservation). There is likely to be an additional 250-300 stems per hectare of smaller trees (<15 cm) (Burrows 1987; Burrows et al. 2010)

The change in water balance will also influence forest hydrology, an effect that is already apparent (Petrone *et al.* 2010; Kinal and Stoneman 2011). This will be expressed in two major ways; a) a continued lowering of groundwater systems in the deep regolith and b) a consequent decline in stream flow as groundwater systems further disconnect from surface stream-lines. Perennial streams will become ephemeral and overall water yields will further decline (Petrone *et al.* 2010). The impact of these changes on stream and stream zone biodiversity are not clear, but are likely to be profound (Horwitz *et al*. 2008). An example of reduction in streamflow for a high rainfall zone catchment is shown in Figure 2. For this catchment, mean annual streamflow has reduced from 300 mm (based on limited pre-1975 data) to 134 mm (since 2001), a 55% reduction.

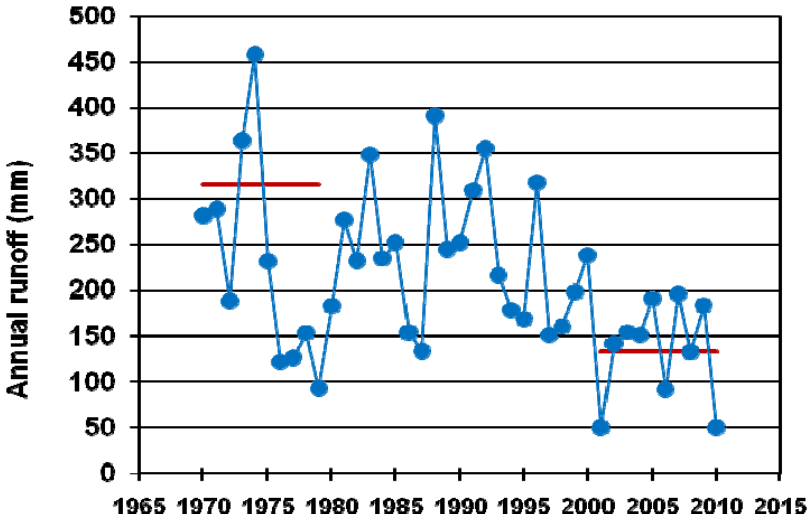

Figure 2: Example of declining streamflow – Harvey River (Dingo Road)

The reduced streamflow has implications not only for potable water supply but also for in-stream ecology, stream vegetation and forest wetlands or damplands. A 'do nothing' or 'business as usual' management response will likely give rise to undesirable ecological and economic consequences. Inaction is not a viable option given the hydrological and vegetation water stress observations as a consequence of climate change and the structure and stocking of much of the forest resulting from past timber harvesting activities. It has been demonstrated that streamflow and groundwater recharge can be increased by thinning jarrah forests in the high and intermediate rainfall zones (Stoneman and Schofield 1989; Stoneman 1993). The recommended response is to apply appropriate silviculture to manage the forest structure in order to improve ecosystem water balance including increasing streamflows. Implemented in an adaptive management framework, improving forest water balance will have multiple benefits. This management approach, which is discussed in more detail below, requires ongoing monitoring and evaluation to refine and adapt silvicultural treatments to meet challenges presented by a changing climate.

The Panel is of the view that focusing management on the high rainfall zone jarrah forests is likely to be most cost effective and will yield greatest gains in improved environmental water balance and water yield. The high rainfall zone is approximated by the area with an annual average rainfall >1100 mm (Figure 3) based on data for the period 1926-1979. Stoneman and Schofield (1989) suggest that thinning jarrah forest in both the high and intermediate rainfall zones, an area of approximately 100,000 ha, would significantly increase streamflow giving increases in the order of 11.5 % - 27.4% and providing an additional water volume of 127 x 10^6 m^3 (also Stoneman *et al*. 1989). They also conclude that thinning is significantly more cost effective than building new dams. The current Wungong Catchment Trial being undertaken by the Water Corporation is evaluating the full scale benefits and impacts of forest management to increase water yield. The key high rainfall zone water supply catchments with high rainfall areas are Wungong, North Dandalup, South Dandalup, and Serpentine. These catchments have potentially 42,000 ha available for treatment to improve water balance and forest health (Table 2) and could provide an additional 29.5 GL ± 8 GL. This could be achieved over a 10-15 year timeframe of treating 3,000 – 4,400 ha per year. This could return river flows to about 1975-2000 levels which are still 30-50% below pre 1975 levels.

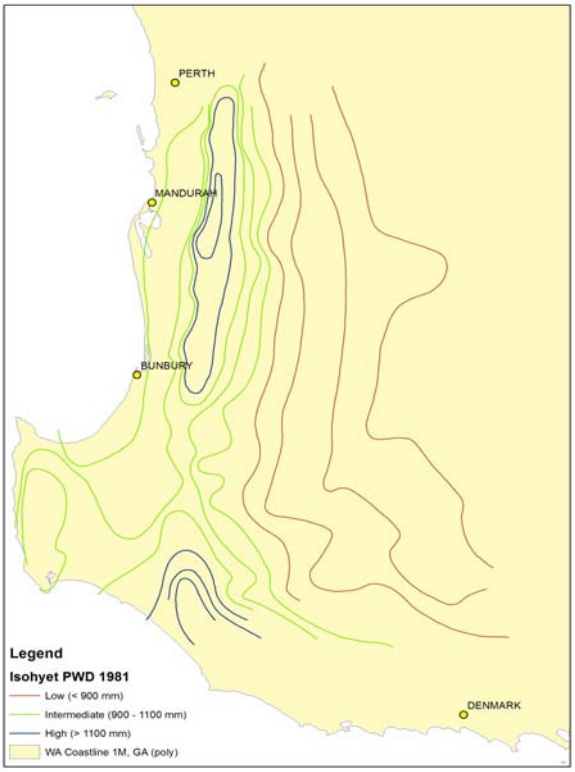

Figure 3: High, Intermediate and Low rainfall zones in the south-west forest region based on the *average annual rainfall for the period 1926-1979.*

Table 2: Potential area of intensive forest management and streamflow benefit in the high rainfall zone (HRZ)

Catchment	Area (km^2)	HRZ Area (km^2)	Management area (km^2)	Potential addition streamflow (GL)
Wungong	130	116	70	4.9
North Dandalup	153	153	92	6.4
South Dandalup	315	130	78	5.5
Serpentine	660	238	142	10.0
Canning	789	65	39	2.7
TOTAL	2047	733	421	29.5

The adaptive management of these high rainfall areas would have a focus on water production, forest health and biodiversity conservation in stream zones and jarrah forest winter wetlands. There is also the potential for the establishment of a new, small industry to utilize material from thinning operations, and a longer term benefit of enhanced sawlog production resulting from thinning.

Temperature: Extremes of temperatures include frosts and heat-waves. Frosts will result in the direct damage of some species whereas heat waves will not only cause direct damage to some species but also increase the level of fire-caused damage.

Interactions and surprises: There are several existing threatening processes in the forest, such as salinity, *Phytophthora* and various insect pests. The impact of climate change on

these processes is not clear. It can be inferred that a reduced water balance and drop in groundwater levels will reduce the impact of salinity. *Phytophthora* activity may be increased by wetter, warmer soil conditions in late spring / early summer and its spread may be increased by more intensive, out of season rainfall that induces overland flow. The impact of changed conditions on a range of pests and diseases is unknown and is likely to present surprises, such as seen with the mountain pine beetle in North America.

A drier, warmer climate will increase the conditions under which bushfires can spread and there is likely to be an increase in frequency of severe fire weather days. Importantly, parts of the landscape that have been historically buffered against frequent and intense fires because they stay wet for longer, will dry and be prone to more frequent fire. Of particular concern are habitats with organic substrates such as peat swamps and associated biota, which if destroyed by fire, could take centuries or millennia to recover if at all.

Atmospheric CO_2 will continue to increase, but the impact of this on forest growth and survival is less clear. Some overseas studies have suggested that there will be an increase in water use efficiency under increased carbon dioxide concentrations, however the applicability of this to the forests of south-western Australia is not clear.

Management options for the forest can be considered in terms of the likely impacts of climate change and the outcomes sought. Five options are:

- As discussed, appropriate silviculture is an important strategy for managing forest water balance in a drying climate. Basal area and leaf area index (LAI) reduction (including coppice control) of well stocked regrowth forests will be essential to increase water availability to maintain forest health, productivity and biodiversity. Changing the vegetation cover and LAI targets of minesite rehabilitation to improve water balance should also be considered. Water yield benefits will only be realized if basal area and LAI reductions can be maintained at or below threshold levels. This will be challenging as opening up the canopy will encourage the establishment of regeneration and the release of ground coppice and other advanced growth. The Panel understands that reducing tree basal area to ~10 m^2 /ha on some sites will improve water balance while discouraging regeneration.
- Translocation of species: Changes in temperature and water balance may result in species being unsuitable for the location in which they are currently growing. Whereas the selection of new species is possible in plantation forestry, this is less of an option in natural forest systems. One theoretical option is to consider re-establishing forest systems at distant locations, however how this could be achieved in practice is uncertain.
- Archiving of species.
- Research and adaptive management: This includes learning from extreme events, such as from the unprecedented death of trees following the 2010-2011 drought, monitoring pests and diseases and quickly identifying and suppressing new outbreaks of pests and diseases.
- Changing expectations: It may not be possible to preserve all species and forest ecosystems in the face of climate change. Another option may be to change expectations and be prepared for large-scale, potentially catastrophic change.

<u>Recommendation 1</u>: As a response to climate change and to improve forest water balance, large scale operational trials should be carried out in an adaptive management framework to determine the feasibility, risks and benefits of sustained reduction of basal area and leaf area index (LAI) in heavily stocked regrowth jarrah forests in the high rainfall zone. The effects of these trials on biodiversity and ecosystem health should be monitored and evaluated using the established FORESTCHECK protocol.

3. Silvicultural Practices and Montreal Criteria for ESFM

3.1. Jarrah Forest

3.1.1 Conservation of Biodiversity

Prior to European settlement, south-west forests and associated ecosystems comprised ~1.6% of Western Australia's mainland area and today, following settlement and associated land clearing for agriculture and urbanisation, forests now comprise ~1% of Western Australia. The south-west forests contribute to the globally recognised rich biodiversity of south-west Australia. Consistent with ESFM principles and in recognition of the uniqueness and importance of the biodiversity of south-west forests, the Forest Management Plan (FMP) places a strong emphasis on actions to protect and conserve biodiversity. Informed by on-going research and improved knowledge of the effects of timber harvesting on the biodiversity, the FMP requires a number of actions to be implemented at three scales:

- Whole of forest scale: All land categories that are subject to the FMP.
- Landscape scale: Where a landscape is defined as 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 or repeated across the whole area. It could be a (sub) catchment or, for convenience, an administrative management unit such as a forest block or aggregation of blocks. Landscape scale is usually tens of thousands to a few thousand hectares (Burrows *et al*. 2002a).
- Operational scale: A discrete area or patch of forest to which one or more operations have been or are planned to be applied.

Forest management strategies to achieve biodiversity conservation across these scales include the establishment of a formal comprehensive, adequate and representative (CAR) reserve system, an informal reserve system within forests available for resource development including timber production and mining, establishment of a network of fauna habitat zones, and a range of actions at the operational scale that aim to maintain diverse vegetation structures, protect threatened flora and fauna and protect and retain habitat elements.

This review focuses on the operational scale as silvicultural practices are most likely to impact on biodiversity values at these scales. It draws on a recent review prepared for the Panel by McCaw *et al*. (2011) and findings of the FORESTCHECK biodiversity monitoring program (Abbott and Williams *in press*).

Current silvicultural practices

Current silvicultural practice for the jarrah forest is detailed in "Silvicultural Practice in the Jarrah Forest – SFM Guideline No. 1 (DEC 2004a) and aligns with the requirements and intent of the FMP. (New guidelines and reference manuals are being prepared – Bradshaw 2010a; DEC 2011a). With regard to biodiversity conservation, this document (DEC 2004a) identifies silvicultural strategies to be implemented primarily at the operational scale that aim to protect and preserve biodiversity through the retention of legacy habitat elements that may not otherwise be adequately provided for in a young regrowth forest. Retaining legacy, or mature forest habitat elements within harvested coupes (operational scale) is important for ensuring that recently harvested patches retain a level of functionality for species that require habitat normally associated with mature forests. Legacy elements are often naturally limited, can be damaged or destroyed by disturbances such as logging and mining and can take decades or centuries to form. Their retention increases the likelihood of also retaining species that depend on these habitats. Retention of legacy habitat elements also facilitates

habitat connectivity, landscape permeability and ecosystem resilience, especially post-disturbance recovery.

The distribution and abundance of some forest-dependent or conservation-listed species may be constrained by the lack of suitable habitat in legacy elements. Under current silvicultural prescriptions, conserving legacy elements at the operational scale includes temporarily excluding strips or patches of forest from logging (Temporary Exclusion Areas - TEAs) until the adjoining logged forest has regenerated and developed (usually 20-25 years), retaining primary and secondary habitat trees, long-lived and keystone understorey elements, coarse woody debris (logs and stumps), cull trees and taking measures to protect threatened species habitat. "Silvicultural Practice in the Jarrah Forest – SFM Guideline No. 1" (DEC 2004b) and the draft "Jarrah Forest Silviculture Guideline" (DEC 2011a) provide the rationale and adequate instructions for retention of these legacy habitat elements.

Tree hollows, especially those used or required by larger fauna, are typical legacy habitats that take many decades to form and unless special provisions are made, could become limiting in forests harvested for timber or cleared for mining. McCaw *et al*. (2011), citing Abbott and Whitford (2002), report that some forty two vertebrate species use tree hollows in south-west forests. Of these, twenty nine are considered highly-dependent on hollows for breeding. In addition to habitat provided for at the landscape scale by the formal and informal reserve system and fauna habitat zones (FHZs), the current silvicultural prescription requires the retention of at least five primary habitat trees per ha^{-1} and 6 to 8 secondary habitat trees ha^{-1} if suitable trees exist. The desirable characteristics of primary and secondary habitat trees are adequately described in DEC (2004a and 2004b). Habitat tree characteristics and retention rates are based on a substantial body of research and modeling of the requirements of focal arboreal species such as the common brushtail possum (*Trichosurus vulpecula*) and the western ringtail possum (*Pseudocheirus occidentalis*) (see literature cited by McCaw *et al*. 2011).

The value of retaining primary habitat trees, in conjunction with temporary exclusion areas (TEAs) and other biodiversity conservation measures implemented under the current FMP, in mitigating the acute impacts of timber harvesting on brush tail possums (and other arboreal fauna) has been demonstrated through the Kingston Study (Morris *et al*. 2001; Abbott *et al*. 2003; Craig 2002 & 2004) and through FORESTCHECK monitoring (Abbott and Williams *in press*). Research and monitoring indicates that brushtail possum abundance is influenced by both the intensity and spatial scale of timber harvesting and that current silvicultural measures taken to mitigate this, including habitat retention and limiting the maximum size of gaps (<10 ha), are effective.

Broadscale baiting of introduced predators such as the European red fox under the auspices of Western Shield have proven to be highly beneficial for the conservation of many forest fauna species. Fox control (and possibly feral cats) is particularly important following disturbances such as fire and logging, which temporarily improves access for predators.

Long-lived secondary and understorey trees and shrubs provide important habitat (food, shelter, roost sites) for a variety of organisms. For example, balga (*Xanthorrhoea spp.*) are important refuge sites for the ringtail possum and many small reptiles, and *Banksia spp*. flowers are an important food source for a variety of mammals and birds (Wayne *et al*. 2001). Bark of some species is an important substrate for epiphytic ferns, lichens and mosses (McCaw 2006; McCaw *et. al* 2011; Abbott and Williams *in press*). DEC (2004a and b) provide the rationale and detailed prescriptions for retaining balga and secondary storey species.

Recommendation 2: *Maintain and ensure compliance of existing standards and prescriptions to protect and conserve legacy habitat elements.*

<u>Recommendation 3:</u> The value of fauna habitat zones as refugia and sources of recolonisation post logging should be assessed either by a separate study, or as part of the FORESTCHECK monitoring protocol, particularly given a range of proposed silvicultural changes to further a) retain legacy habitat elements and b) improve connectivity.

Coarse woody debris (CWD) on the forest floor, comprising large logs and stumps that remain following the death of large trees, makes an important contribution to the conservation of jarrah forest biodiversity (McCaw *et al.* 2011). CWD is very durable, even in the presence of fire, and can persist for many decades on the forest floor, sometimes ecologically connected to the soil surface. The FORESTCHECK program has revealed that about 50% of all cryptogams utilize woody debris and 40% were dependent upon it (Cranfield *et al.* in press). Woody debris has also been shown to provide substrates for a wide range of macrofungi (Robinson and Williams in press) and invertebrates (Farr *et al*. in press). Loss of large diameter logs in harvesting will also affect availability of hollows suited to ground dwelling vertebrates such as chuditch, numbat and a variety of reptiles.

While timber harvesting can add to the amount of woody debris on the forest floor, fire plays an important role in the quantity and condition of woody debris. The amount of coarse woody material consumed is proportional to the intensity of the fire (Hollis *et al*. 2011a) so it is important that the frequency of high intensity fires is minimised. Post-harvest burning often aims to consume a portion of the woody debris to reduce fuel loads, to stimulate understorey regeneration and to prepare a seedbed for tree seedling establishment (DEC 2011c). These burns are generally low to moderate intensity, and while there is some removal of woody debris a considerable amount (40-60%) is retained. Low intensity fires (<500 kW m^{-1}) typically consume between 40% and 60% of woody fuel >25 mm diameter, increasing to >80% consumption for intense fires (>10 000 kW m^{-1}). Woody fuel consumption is also affected by decay condition, fuel arrangement and seasonal conditions but the influence of these factors has proven difficult to quantify and appears of secondary importance to fire behaviour (Hollis *et al*. 2011b). Most silvicultural burning is of low to moderate intensity (<2500 kW m^{-1}) so is unlikely to remove a high proportion of CWD.

Current silvicultural guidelines require at least one suitable ground habitat log or stump to be retained per hectare and all 'natural' hollow logs with a pipe >10cm diameter and >3 m long. Characteristics of preferred logs are described in the guidelines. The Jarrah Silvicultural Burning Manual (DEC 2011c) provides guidelines for implementing low to moderate intensity burns, which should meet silvicultural objectives and minimize damage to legacy habitat elements including hollow logs and dead trees (stags).

Monitoring the effects of timber harvesting on biodiversity

The previous and the current forest management plans require the implementation of a forest monitoring program, primarily to monitor the response of the forest biota to the various silvicultural prescriptions applied to the jarrah forest. Consequently, FORESTCHECK was established in 2001 in response to a Ministerial Condition associated with the previous forest management plan (Burrows *et al*. 1994; Abbott and Burrows 2004; McCaw *et al*. in press). Rather than taking an indicators approach to monitoring disturbance and recovery, FORESTCHECK is comprehensive, sampling a significant proportion of the Plant, Animal and Fungi Kingdoms. As such, FORESTCHECK is unique and establishes current best practice in forest biodiversity monitoring and evaluation.

The first five years of data collected by FORESTCHECK are being prepared for publication. Abbbott and Williams (in press) and McCaw *et al*. (2011) provide a detailed synthesis of FORESTCHECK, so only a brief commentary is required here. The syntheses report few significant impacts of timber harvesting on biodiversity. Species richness and abundance across all taxonomic groups were generally similar between harvested and unharvested grids and generally, biodiversity recovered following harvesting. However, although not

statistically significant, there were slight differences in species composition. For example, unharvested grids had more species of small and medium shrubs, more macro-invertebrate morphospecies and more singletons (single species) compared with harvested grids. While the differences were not statistically significant, and provided this was not a sampling artifact, the ecological significance of this, if any, is unknown. The taxonomic group in which there were significant differences between harvested and unharvested grids was the cryptogams, the group most sensitive to timber harvesting and which took at least 10 years to recover. As to be expected, soil compaction / disturbance was also greater on the harvested grids (Whitford and Mellican in press). Compaction was greatest on log landings and primary and secondary extraction tracks. Reported levels of soil compaction are consistent with increases observed as a result of timber harvesting in a range of other forests, but what is not clear from the available literature, is the proportion of the coupe affected by compacted soils. Given that heavily compacted soils may take many decades, or centuries, to recover, the cumulative effects of timber harvesting on soils needs to be considered.

In recognition of the fundamental importance of soil condition to ESFM, the "*Soil and water Conservation Guidelines*" (DEC 2009) and the "*Manual of Procedures for the Management of Soils Associated with Timber Harvesting in Native Forests*" (DEC 2010) provide context, guidelines and thresholds for managing soil disturbance and damage. While soil disturbance limits and thresholds are specified, there is no specification of acceptable levels of soil compaction *per se*. Instead, a visual assessment of soil disturbance is used as a surrogate for compaction (Whitford 2009). Adequate training and compliance with these documents should minimise the risk of significant soil damage.

Aquatic invertebrates and water chemistry have been monitored at 51 sites throughout the south-west forests, including jarrah and karri forests, in order to detect broad changes or variations from historical ranges due to forest management practices (Pennifold and Pinder 2011). In summarizing these data, McCaw *et al*. (2011) conclude that there are no significant correlations between changes in biodiversity measures that can be attributed to forest management (harvesting and burning), suggesting that current measures to protect water quality and invertebrate biodiversity in forest streams are effective.

McCaw *et al*. (2011) note that bats are not monitored as part of FORESTCHECK, but they have been studied in jarrah forest by Webala *et al*. (2010; 2011). They reported that the southern forest bat (*Vespadelus regulus*) is highly reliant on hollows in large trees in mature forest. On the other hand, Gould's long-eared bat (*Nyctophilus gouldi*) uses a broader range of roost types with an apparent selective bias towards recently harvested sites (<25 years). Active and foraging bats use mature jarrah forest significantly more than regrowth forest (<30 y old), principally due to the more open under-canopy. These findings provide further support for the retention of mature trees within harvested areas, and for maintenance of landscape habitat connectivity (see below).

<u>Recommendation 4:</u> Monitoring and evaluation is fundamental to adaptive management and ESFM. FORESTCHECK, which represents current best practice forest biodiversity monitoring, should be maintained as an integral component of forest management.

Proposed changes to the Silvicultural Guideline

It has been brought to the Panel's attention, that a number of changes and additions to the Silvicultural Guideline are being proposed. These changes / additions include:

- Retaining a selection of standing dead trees in areas where sawlogs are to be salvaged (harvested).

Panel comment: The Panel supports this proposed change with the added proviso that retained trees do not pose a safety risk.

- Retaining a selection of large diameter logs (in addition to hollow logs).

Panel comment: The Panel supports this proposed change.

- Favouring habitat trees that include nests of threatened fauna where these have been identified.

Panel comment: The Panel supports this proposed change.

- Harvesting to achieve silvicultural objectives will be limited to no more than 300 ha to limit local impact. Temporary exclusion areas of at least 100 m in width to provide linkages to formal and informal reserves.

Panel comment: The Panel understands that the adoption of a 300 ha limit (above) is based on professional judgement informed by an examination of the topography of jarrah forest that could be subjected to intense harvesting. The Panel was advised that the 300 ha limit will result in better forest connectivity. Notwithstanding uncertainties surrounding the derivation of the 300 ha limit, the Panel supports the notion of reducing the intensity and scale of disturbance to benefit biodiversity. The Panel also supports the proposal to provide linkages to formal and informal reserves through strips temporarily excluded from timber harvesting.

- Temporary exclusion areas will be retained in silvicultural treatment operations that occur subsequent to mining or other disturbances whereby legacy elements are limited or no longer present in the disturbed area. The extent of mining and planned silvicultural treatment will be limited to a maximum of 60% of the local scale management unit. Gaps may be harvested in temporary exclusion areas once the regeneration forest reaches the mature forest development stage (~70 yrs). Areas requiring shelterwood treatment will be commenced after 45 yrs to allow 4-5 burns to be undertaken to promote seedlings and lignotubers before gap creation.

Panel comment: The intention of this proposal is to ensure the retention of legacy habitat elements in areas likely to be heavily disturbed by timber harvesting and mining. Beyond being a professional judgement, the ecological basis for the 60% maximum area disturbed is not clear, but the Panel supports actions that aim to restrict the scale and severity of disturbances and retain legacy habitat elements. Given the uncertainty, and consistent with adaptive management, this proposed action could be monitored and evaluated as part of the FORESTCHECK monitoring program.

- Where harvest intensification from increased residue utilization is likely over extensive areas, silvicultural treatment will be staged over time through the use of temporary exclusion areas to ensure that no more than 60% of a local scale management unit is reduced below a basal area of 10 m^2 ha^{-1} in any 10 year period.

Panel comment: While unsure of the basis for the metrics, the Panel supports the notion of lessening the temporal and spatial scales of impact.

- Mining rehabilitation areas and other extensive areas of even-aged regrowth, structural diversity may be introduced through varied rotation ages and the use of variable density thinning.

Panel comment: The Panel supports this proposed change, although clearer guidance on how to implement this will be required.

- Silvicultural burns will be planned where possible to ensure a mosaic of burnt and unburnt patches and persistence of a variety of understorey structures.

Panel comment: Provided that the key burn objective is being met, otherwise this could lead to conflicting objectives.

- Silvicultural treatments in forest isolated in agricultural landscapes will be staged over time to ensure the entire isolate is not subject to harvesting disturbance in any one cutting event. A maximum of 50% of each forest type that occurs in the isolate may be harvested at any one time. Where the isolated area is <400 ha it will be managed in two approximate halves, with subsequent harvesting permissible after 10 years.

Panel comment: Beyond being a professional judgement that takes into consideration that a 'reasonable' area is necessary for cost effective harvesting in low volume stands, the ecological basis for the metrics is unclear. However, the Panel supports the notion of reducing the intensity of disturbance in highly fragmented landscapes.

- Temporary exclusion areas will be established in areas of predominantly mature forest to provide linkages to the predominantly mature forest within the informal reserve network.

Panel comment: The Panel supports this proposed change.

- Landings will be preferentially seeded with endemic understorey seed sourced from within the same Landscape Conservation Unit or to conform to species specific seed collection maps where studies have identified alternative genetic zones for the purpose of defining local provenances.

Panel comment: The Panel supports this proposed change.

- Seed mixes developed for landing rehabilitation will only include plant species that occur in adjacent comparable vegetation types or complexes.

Panel comment: The Panel supports this proposed change.

Recommendation 5: That the FORESTCHECK *protocol be reviewed in light of proposed silvicultural changes so that the effects of the changes on biodiversity can be monitored and properly evaluated. Links to Recommendations 1and 3.*

3.1.2 Maintenance of productive capacity

The forests of south-western Western Australia have been producing timber for over 100 years. Nearly all of the forests now available for timber production have been harvested previously. Consequently, they usually comprise at least two, and often more, age classes. The production forests are dominated by either jarrah or karri, with only a small fraction of the annual timber production coming from wandoo forests. The focus of this section is on jarrah and karri forests as these support the large majority of wood production from Western Australia's forests.

The ecology, and in particular the natural regeneration strategies, of jarrah and karri are very different and this is reflected in their respective current forest structures and approaches to management.

In jarrah forests, regeneration establishes prolifically following most disturbances, and also establishes episodically over time. Jarrah seedlings can persist on the forest floor as lignotubers, which can take advantage of openings created through natural tree death, or disturbance from harvesting. Consequently jarrah forests often have an uneven-aged structure, but with cohorts of trees of a given age arising from past disturbances, such as fire or harvesting.

Jarrah forests are currently harvested using a range of partial harvesting techniques, which are applied on a patch basis and which recognises the multi-aged structure of the forest. Where the standing forest has abundant lignotubers present, most of the canopy may be removed (gap release). Where the forest is fully stocked with immature trees it can be thinned. Where the standing forest is not fully stocked and there is not abundant lignotubers present, a shelterwood harvest is prescribed where trees are retained to provide seed to establish a new cohort of regeneration. (It would seem 'shelterwood' is a misnomer in this case – it is more akin to seed tree retention). Selective harvests for sawlog are also applied. Regeneration can take some time to establish, but the evidence to date indicates that all these techniques are ultimately successful in creating well stocked stands.

In the past, the focus of attention on the silvicultural management of jarrah forest, beyond promoting regeneration or growth, was primarily on biodiversity conservation (not discounting

the importance of *Phytophthora* management), but the focus of this Panel's work is on the silviculture of these forests more broadly. In a drying climate, the emphasis has clearly shifted from a concern about waterlogging to a concern about drought and its ecological and economic impacts. Improving knowledge over the last 30 years and data from FORESTCHECK provide a high level of confidence to forest managers and the broader community that the management systems in place in these forests are adequate for the protection of biodiversity at all scales, although there will always be space for fine tuning and continuous improvement as knowledge improves. Formal reserves, informal reserves, fauna habitat zones, retention of legacy habitat elements, appropriate temporal and spatial scales of disturbance and management plans for rare and endangered species are all in place. DEC's Management Audit Branch audits systems and procedures and some of these findings are reported in DEC's Year Book (e.g., DEC 2011e). Based on these reports, the on-ground quality assurance and extent of compliance with these protocols and plans appears adequate. FORESTCHECK, which assesses how the biota is responding to some of these management actions, suggests the safeguards are functioning adequately (Abbott and Williams in press).

Clearly, and as outlined above, the greatest threat to the future health of these forests is the declining rainfall associated with a changing climate, and the consequent decline in the levels of groundwater and soil water storage generally. Many of the once perennial streams within the jarrah forest have stopped flowing, and groundwater levels have lowered dramatically. Inflows to dams within Perth's water catchments have declined to record low levels. Where concerns once focused on issues of salinity and *Phytophthora* infestation due to rising water tables, they have now shifted to the potential for ecosystem collapse, or more likely disappearance, as the water tables have disconnected from the streams, leaving riparian and aquatic communities waterless. There is a potable water need, a forest health and productivity need, and a biodiversity need to manage water balance in these forests.

Forests that have a high component of regrowth trees, or more specifically, a high sap wood area-to-basal area ratio, have a higher water demand than forests dominated by mature and over-mature trees with a lower sap wood area-to-basal area ratio (Macfarlane *et al*. 2010). As the jarrah forests have been cutover for more than 100 years, regrowth dominates and in terms of spatial extent, is probably at unprecedented, artificially high levels. At a time of declining rainfall, the higher water use may be exacerbating the issue of declining water yields. Reducing the density of the regrowth is the only way to manage the forest for higher water yield. Reducing the density of the forests below about 10 m^2 per hectare of basal area, and in the absence of on-going treatments, will result in a proliferation of regeneration, thus treatments will need to focus on maintaining the basal area at or somewhat above this level. Treatment should be focused within the high rainfall jarrah forest zone as a priority (See Recommendation 1).

Adequate thinning at a catchment or sub-catchment level should improve the water balance at these scales and provide benefit to the biota in vulnerable parts of the landscape (Stoneman and Schofield 1989; Stoneman 1993; Macfarlane *et al*. 2010). If 6,000 ha – 8,800 ha of the western zone of the northern jarrah forest were thinned each year over ~7 year cycle (or half this area over double the time frame – see Section 2.2) this should provide the multiple benefits of environmental water for ecosystem function and for water harvesting.

This is about the same level of harvesting activity that is currently undertaken within the entire jarrah forest estate, so a management decision will be required as to whether the current harvesting effort is concentrated into the water catchments, or whether new operations are commenced. This will require economic and environmental assessments and market evaluations and development but some operations should be shifted into the water catchments as soon as possible, as the indications are that even with average annual rainfalls or better it will take some years for the efforts to result in increased water yields.

The Wungong Catchment Trial, designed to evaluate thinning parts of the jarrah forest to improve streamflow and water yield in a drying climate (Terry *et al*. 2005), will provide valuable information about the efficacy of this management strategy and its impacts on the biota and other forest values. The Panel supports an adaptive management approach to better understanding complex and interacting processes such as climate change, forest hydrology, forest structure and biotic responses.

Mechanical soil scarification is applied in some circumstances to promote seedling regeneration. It is the Panel's assessment that the harvesting disturbance, burning of the harvesting slash, and/or subsequent fuel reduction burning, creates more than sufficient seedbed. The regeneration survey data provided to the Panel demonstrates that regeneration in these forests has been and continues to be adequate or better and we question the need to continue with this practice given potential adverse impacts on understorey vegetation (Burrows *et al*. 2002b) and other values. Similarly, the practice of pushing (by bulldozer or excavator) or 'notching' (by chemical injection) of the mid-storey shrubs and small tree species (such as *Persoonia spp*., *Banksia spp.* and *Allocasuarina fraseriana)* in jarrah forest, presumably to reduce competition, should also be discouraged - except where dense thickets of species jeopardize the establishment and survival of regeneration. Tall woody shrubs and understorey tree species are usually sparsely distributed through the jarrah forest, and have been shown to be important habitat for various elements of the biota. They are easily disturbed during harvesting and some take a long time to re-establish. The Panel notes that the potential adverse impacts of these operations are addressed in the current FMP.

Recommendation 6: The practice of mechanical scarification to create additional soil disturbance in order to improve the stocking of regeneration should be minimised. Physical or chemical removal of the mid-storey shrubs and small tree species (such as Persoonia spp., Banksia spp. and Allocasuarina fraseriana) in jarrah forest should cease except where it is deemed necessary for the establishment and survival of regeneration of overstorey tree species.

Panel comment on issues raised by recent past forest management review / audit processes

Issues raised in the Conservation Commission of Western Australia, Forest Management Plan 2004-2013, Mid-term audit of performance report (Conservation Commission 2008). Issues raised under Productive Capacity:

- a new grading system for sawlogs,
- raising the annual limit on karri other bole volume

- lower than forecast yield of jarrah sawlogs

All of these issues are presently under discussion. There are no issues of concern to the Panel.

'The conservation commission remains concerned with performance in the areas of regeneration, regrowth and thinning schedules and advises that it will consider undertaking future specific performance assessments during the remainder of the plans duration' (page 9 mid-term audit report).

This issue was raised in the EPA mid-term audit response report (EPA 2010) and is discussed further below.

The Environmental Protection Authority response to the Conservation Commission mid-term audit of the Forest Management Plan (FMP) (EPA 2010).

The EPA report 1362 (EPA 2010), a review of the DEC mid-term audit of the FMP presents no scientific or other evidence to support the opinions and considerations expressed in the document in relation to the productive capacity of the forest. It appears that the author(s) of this report are unfamiliar with the subject matter, and have not had an opportunity to read the extensive relevant literature in order to understand the fundamental processes and concepts that underpin forest management and the current FMP.

With respect to Productive Capacity, the EPA report makes the following remarks.

"The EPA considers that there is considerable doubt and increasing uncertainty about the maintenance of forest values in the low and medium rainfall zones. These zones have moved westward and southward since the 1970s. The Mid-term Audit of Performance Report has pointed to the declining timber yield from the northern jarrah forest. The EPA believes that it is most unlikely that the jarrah forest in the low and adjacent medium rainfall areas, particularly in the northern forest, can continue to contribute to the jarrah sustained yield and also be consistent with ecologically sustainable forest management (ESFM)".

Panel response:
The Panel is not aware of any evidence to support this claim. While growth rates in the northern and eastern jarrah forests are slow, the decline in the timber production from these forests is a consequence of a history of harvesting, and thus a reduction in the availability of sawlog, and the location of customers, who are predominantly located in the southern and western regions of the jarrah forest. Net productive capacity relies on production from the entire forest estate, and the current models accommodate low levels of production in some areas and higher levels of production in other areas. The Panel is of the view that jarrah forests in all rainfall zones have the potential to contribute to the jarrah sustained yield provided ecologically appropriate silvicultural and other management systems that support sustainable forest management are in place.

"The EPA notes the Conservation Commission's concern with performance in the areas of regeneration and regrowth and that the Commission will consider undertaking future specific performance assessments during the remainder of the plan's duration. The EPA expressed reservations in its report on the Proposed Forest Management Plan (EPA 2003) about the likely regeneration success from the current jarrah silviculture prescriptions, and therefore supports the Commission's intention to carry out performance assessments".

Panel response:
The performance assessments of regeneration in the eastern jarrah forests carried out by DEC on behalf of the Forest Products Commission (FPC) (Tables 3 and 4 below) clearly demonstrate that recruitment of regeneration in these forests is acceptable. Recruitment of jarrah seedlings extends over an extended period compared to some eucalypt forest types; for example in wet eucalypt forests in Tasmania recruitment has generally ceased altogether about three years after harvesting. In the jarrah forests, recruitment continues for many years, and seedlings take many years to establish. The silvicultural systems that are applied in the jarrah forests recognise this, and retain a canopy and hence a seed supply, wherever regeneration is lacking. Further, the current approach of surveying a sample of the harvested areas at appropriate intervals (e.g. five years) is supported, as it is clear that recruitment is rarely an issue, given that the appropriate silvicultural system is applied in the first instance.

Table 3. Summary of regeneration data from surveys in 2003 of 'shelterwood' cut areas in the eastern jarrah forest. (Source: DEC).

Silvicultural type	Number of sample points	Proportion by silvicultural type (%)	Average BA (m^2/ha)	Points stocked prior to harvest (%)	Points stocked after harvest (%)	Comments
Gap	11	3	4	100	100	Stocked with regeneration - recruitment not required
Potential gap	31	7	10	97	97	Stocked with regeneration - recruitment not required
Selective	0	0	0			0
Shelterwood	380	89	9	21	60	Recruitment occurring
Shelterwood-Selective	4	1	22	25	25	Recruitment not required
TOTAL	426	100	9.2	29	63	

Table 4. Summary of regeneration data from surveys in 2008 of 'shelterwood' cut areas in the eastern jarrah forest. (Source: DEC).

Silvicultural type	Number of sample points	Proportion by silvicultural type (%)	Average BA (m^2/ha)	Points stocked prior to harvest (%)	Points stocked after harvest (%)	Comments
Gap	115	6	4	94	97	Stocked with regeneration - recruitment not required
Potential gap	580	32	10	90	95	Stocked with regeneration - recruitment not required
Selective	65	4	21	94	97	Recruitment not required
Shelterwood	979	54	11	19	40	Recruitment occurring
Shelterwood-Selective	87	5	26	14	29	Recruitment not required
TOTAL	1826	100	12	49	63	

"The next FMP is due to be prepared and approved by January 2014. Work on this should commence as soon as possible. Matters that the EPA considers need to be addressed during preparation of the next FMP include:

• A review of silvicultural policies and practices within an ESFM framework that reflects current and reasonably foreseeable environmental conditions, including the practice of 'notching' of trees and aesthetic and conservation implications of different thinning regimes;
• The whole issue of the sustainable yield of jarrah, karri and other species in the forest. Many submissions argued that the levels should be reviewed immediately while others want current levels to be maintained during the life of this plan. Associated with this are growth rates of potential log trees and also the effectiveness of regeneration following treatment of State Forest areas;"
(Note: only items relevant to 'productive capacity' have been included in this section).

Panel response:
The current review is considering, amongst other things, the appropriateness of the silvicultural systems applied in the commercial forest of WA. On the information presented to the Panel, all of the points above are addressed comprehensively within the current FMP. The Panel notes that the sustained yield for the next FMP will be independently reviewed, but makes the observation that based on information provided to the Panel, the current level of harvest is being regulated to be within the sustained yield determined for the current FMP.

The Panel has expressed concern about notching and pushdown of understorey / lower storey trees and tall shrubs (see Recommendation 6 above). However, we understand that the practice of notching trees is undertaken in a very limited way. Jarrah seedlings and

saplings are remarkably persistent in the face of quite intensive competition, and suppressed trees survive for longer than is typical for *Eucalyptus spp*. Selectively reducing localised intraspecific competition to promote growth on crop trees, at the current extent of implementation, has no foreseeable harmful effects.

Response to Ministerial Condition 11: Panel report Part 1 (Burrows et al. (2001)

The key recommendations of the above with respect to Productive Capacity were:

1. Jarrah forest regeneration standards need to be refined to reflect the variability and capability of site types throughout the range of jarrah. The method for assessing regeneration appears adequate over the limited range of site types under which it has been evaluated, but further validation across a broader range of site types may be warranted.

2. The outcomes of recent research and monitoring provides bases for a number of changes to the silvicultural guidelines to further ensure that forest management is consistent with the principles of ecologically sustainable forest management. These relate to improving the provision of habitat for hollow-dependent and arboreal fauna, better protection of soil and enhancing the protection of understorey vegetation. Detailed recommendations are appended to this report.

Panel response:
The measures of regeneration success used throughout Australia were reviewed by Lutze *et al.* 2004. The triangular tessellation method used in Western Australia was found to provide an 'unbiased estimation of seedling density, regardless of spatial distribution', and to provide a similar amount of information as the quadrat-count method currently applied in Tasmania. Both methods were regarded as providing acceptably reliable estimates of seedling density. The stocking standards for eastern jarrah are slightly lower than those for the rest of the jarrah estate, reflecting the slower recruitment in the east.

If Silvicultural Guideline 4/97 is still current for regeneration standards then the implicit expectation that the regeneration will be established within 12 months after harvesting is clearly unrealistic and does not reflect the natural regeneration strategies in Jarrah forest, as discussed in the Burrows report Part 1 (Burrows *et al*. 2001). This guideline therefore needs to be reviewed to reflect the episode recruitment of jarrah over time.

<u>Recommendation 7:</u> Review the current specifications for regeneration surveys in jarrah.

Towards Ecologically Sustainable Forest Management in Western Australia; A review of draft jarrah silviculture guideline 1/02 (Burrows et al. 2002a).

This review identified that the term selective harvesting is inadequately defined. The review recommended, amongst other things, that the adequacy and timing of regeneration surveys needed to be reviewed, and that a better explanation was required of the stocking standards applied in the draft guideline.

3.1.3 Maintenance of ecosystem health and vitality

The Panel acknowledges that of the forest covered by the FMP, the areas where active management of stands and harvesting is permitted is a small part of the total, largely contiguous, forest area. Ideally there needs to be a whole of forest strategy for ensuring that forests are part of well-functioning ecosystems in the long-term. Because healthy ecosystems are resilient, they are better able to maintain biodiversity, and recover from disturbance where impacts are not extreme or stressing agents are not continuous in space and time.

Whilst the jarrah forest generally displays a level of resilience to climate change there are emerging areas of concern due to recent events. Climate change in combination with other predisposing factors appears to be pushing some jarrah forest communities to tipping points as evidenced by recent local-scale mortality of jarrah on shallow soils and drying of 15 out of 18 monitored perennial streams in 2010-2011. Furthermore, some recent modelling exercises, that extend rainfall projections into the next two to three decades, highlight the vulnerability of much of the high-rainfall northern jarrah forest in particular to climatic water stress.

There is increasing evidence that jarrah forest structure is contributing to the decline in groundwater. Leaf Area Index (LAI) maps, generated from satellite imagery taken in January 2010, reveal that more than 50% of some jarrah forest catchments have a LAI of 1.5 or greater, with reforested areas after bauxite mining being as high as LAI 3. Water lost by the more dense canopies places a high demand on water stored in forest regoliths, especially if the vegetation is dominated by regrowth or from reforestation (relatively high sap wood area). Estimates of jarrah forest water use suggest that mature trees transpire up to 50% less water than vigorous regrowth for the same LAI (Macfarlane *et al*. 2010). Due to the high proportion of forest area comprising of heavily stocked regrowth, the observed marked decline in the ground water in this region is likely therefore to be a consequence of a declining rainfall plus increased demand by the forest as it changes structurally over time. Based on a limited data set, up to 40% of the decline in groundwater level in parts of the jarrah forest may be attributed to relatively high water use by the forest (R. Silberstein pers. com.), the structures of which are largely a consequence of historical logging practices and infrequent follow-up silvicultural treatment. The inability of jarrah to self-thin in that time indicates that active management is essential to ensure ecosystem health and vitality.

There is also concern that the health of marri is deteriorating across the south-west. The next FMP will need to consider these and other aspects of ecosystem health. While attention was placed on the eastern jarrah forest in previous advice and reviews regarding ecosystem health and vitality, it is appropriate that the focus of concern should now move to the higher rainfall zone where ecosystem health is visibly declining at a local scale. Although collapse of riparian vegetation communities has not yet occurred, the loss of stream flow is likely to be having a significant impact on aquatic fauna, especially species that depend upon perennial riparian zones and other more mesic habitats in the forest complexes that are drying, thus predisposing them to damaging bushfires.

There is concern at the increasing risk of damage to the forest from pests and diseases. The key issues brought to the attention of the Panel were:

- New *Phytophthora* species that have been recently identified, especially *P. elongata* (Rea *et al*. 2010), which has the potential to severely damage vegetation during reforestation, and *P. multivora* (Scott *et al.* 2009), which has been isolated from plant roots in sandy soils.
- Canker in marri caused by *Quambalaria coryecup*, which is now spreading from periurban areas into the forested estate.

- Shoot and flower blight in marri caused by *Q. piterika*, which appears to have been introduced from eastern Australia and is likely to reduce nectar and seed production and negatively impact on birds (e.g. cockatoos) and honey production.
- *Phoracantha semipunctata*, a longhorned borer, which is present in large numbers in drought-stressed jarrah and on emergence of the adults could become a threat to healthy trees.
- Whether outbreaks of jarrah leaf miner (*Perthida glyphopa*) and the gum leaf skeletoniser moth (*Uraba lugens*) are likely to become more frequent if climate change increases water stress, carbon starvation in jarrah and allows multiple generations per year.

Panel comment on issues raised by recent forest management review/audit processes

The Panel agrees with the Conservation Commission's assessment (Conservation Commission 2008) that the nature and scale of threats to the forest appear to be increasing and the combining of some of these threats over time and in parts of the forest is placing considerable stress on the values of the forest. The Panel notes the EPA's concern expressed in the EPA's review of the FMP Mid-term Audit of Performance by the Conservation Commission (EPA 2010) regarding the potential of climate change to impact on the health of the jarrah forest and accepts the "*notion of a precautionary approach, based on monitoring and early adaptive management, including reviewing settings upon which management is based*" is an appropriate course of action for the next FMP.

The EPA (EPA 2010) raised a number of matters concerning ecosystem health that need to be addressed during preparation of the next FMP, including implications to the health of the forest ecosystems under changing conditions, including a drying climate, in the short to long term. Specifically, regarding Objective 21, the EPA questions whether management of the forest to promote higher stream flows for water supply is realistic and environmentally desirable under a drying climate. The Panel agrees that this is a critical area where agreement needs to be reached in time for the next FMP. However, the Panel is concerned that debate on promoting stream flow may fail to fully consider the vexing issue of environmental water in the context of sustainable water balances underpinning healthy forests. In this regard, the potential of silvicultural treatments to deliver environmental water benefits should be further canvassed and explained.

The Panel considers that "*the view of the Conservation Commission that the FMP's Objective 21 for water may be overly ambitious with regard to the desire to protect the ecological integrity and quality of streams, wetlands and their associated vegetation, and increase the flow of water in the context of a drying climate*" is overly pessimistic. There is a range of research catchment studies across the southwest forests that provide a robust set of data on stream flows and groundwater change upon which policy decisions can be made with some confidence. It is the Panel's view that thinning parts of the high rainfall jarrah forest catchments is desirable environmentally to improve forest structure, to enhance the water balance in favour of threatened habitats and to further protect biodiversity.

It is not within the Panel's scope to be prescriptive about how and where thinning should occur. However, the extent to which thinning can be advocated can be informed by data obtained from existing silvicultural trials (e.g. Stoneman 1993, the Inglehope thinning trials and others). There is considerable understanding of how the jarrah forest overstorey and understorey respond to different thinning intensities, and therefore the degree to which management intervention is required to maintain a particular stocking over time. The Panel recognises that more work needs to be done to identify those environmental water benefits that flow from active catchment management that can be easily identified by the wider community. Furthermore, the need remains for long-term catchment studies, such as the Wungong trial, to provide data sets for future adaptive management. The Panel agrees with

the EPA judgement that the Wungong trial objectives should more strongly align protection of biodiversity values with water production. The Panel is especially concerned about the vulnerability of riparian and other wetland ecosystems and their biota to reduced stream flow and declining groundwater in the future. See Recommendation 1.

The EPA (2010) recognises that "*Changing climate and ongoing management and use also affect the presence and spread of disease through the forest*" and ...."*strongly urges a more coordinated, integrated management of dieback throughout the State, not just in the forest regions*." The Panel notes that little progress appears to have been made over the past decade in this area, although a comprehensive dieback assessment has been completed. The Conservation Commission (2010) reported that, "*Despite the lack of guidelines outlining dieback risk assessment approaches to be adopted relevant to different situations, the Commission is satisfied that in areas of State forest that systems are in place, particularly with respect to forestry operations*".

Soil moisture and temperature regimes affect the level of activity and impact of soil-borne pathogens such as *Phytophthoras.* How climate change will alter the threat posed by these organisms is somewhat speculative. On the one hand, a drying climate may create soil conditions less favourable for the spread of the disease, but on the other hand, the possibility of increased episodes of heavy late spring and summer rainfall could increase the threat. Similarly, how silvicultural practices designed to improve water yield are likely to influence the spread of *Phytophthoras* is uncertain, but needs to be monitored.

Phytophthora dieback management guidelines used by DEC (and other agencies) are largely predicated on the detection and / or impact of a single species, *P. cinnamomi*. Recent examination of cultural collections held by DEC's Vegetation Health Service over four decades has revealed the presence of undescribed species. It is prudent therefore to update the current management guidelines and to include all *Phytophthora* species with potential to threaten biodiversity or other forest values. In particular, this will require changes to detection, diagnosis, demarcation and mapping of infested areas. Consideration will need to be given to whether infested areas should be defined at the *Phytophthora* species level. Furthermore, it is timely to review whether any guidelines should be amended as a result of changes in the seasonality and intensity of rainfall.

Recommendation 8: Phytophthora dieback management guidelines should be updated to address other Phytophthora species and to reflect changes in Phytophthora activity likely with changes in the seasonality and intensity of rainfall.
Recommendation 9: Annual aerial surveillance of the whole forest estate be strengthened to capture changes in forest health and to better identify threatening processes that can be considered in adaptive management of the forests. This should be integrated with landscape and stand level assessments.
Recommendation 10: Guidelines be established for the management of pests and diseases of significance to all forest trees and forest ecosystems. Research should be undertaken where knowledge is insufficient to inform management decisions.

It is not clear to the Panel why concern remains that logging in low and adjacent medium rainfall zones, especially in the northern forest, would not meet ESFM principles and objectives. Data from FORESTCHECK indicate that jarrah forest health is not being negatively impacted by logging (Abbott and Williams in press). This is discussed in more detail in the biodiversity section of this report.

Proposed changes to Silvicultural Guideline

- Identify and retain dieback resistant trees in areas of high disease impact.

- Individual trees or groups of trees that exhibit resistance to disease or the effects of insect outbreaks (Jarrah Leaf Miner or Gum Leaf Skeletoniser) should be marked and protected from damage during timber harvesting operations.

Panel comment: The Panel supports these proposed changes. The Panel would prefer to see provision for the inclusion of other pathogens and pests that threaten forest health, as circumstances arise. Attention should be given to the complexity in Phytophthora dieback where species other than P. cinnamomi *may be impacting on forest health.*

- Disease resistant jarrah seed or propagules may be used for rehabilitation/regeneration operations where this is considered likely to result in better long term regeneration.

Panel comment: The Panel supports this proposed change.

- In mining rehabilitation areas and other extensive areas of even-aged regrowth, structural diversity may be introduced through varied rotation ages and the use of variable density thinning.

Panel comment: The Panel supports this proposed change.

- Harvesting to salvage sawlogs in disease or pest killed stands may be approved by the Senior Silviculturalist on a case by case basis. Measures to maintain stand resilience must be included in any proposal.

Panel comment: The Panel supports this proposed change.

- Prohibit the removal of leaf and fine branch material (less than 150 mm diameter) as residue products from forest harvesting operations.

Panel comment: The Panel supports this proposed change. The nutrient content of this residue is an important driver for ecosystem health.

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

Panel comment: The Panel supports the overall thrust of the proposed change but recommends that guidelines be included for minimum stand densities and management of regrowth after thinning.

3.1.4 Conservation and maintenance of soils and water

Soil and water quality are important for maintaining forest productivity, biodiversity (terrestrial and aquatic) and water resources. The Forest Management Plan (FMP) objective of the soil management strategies is broadly to protect soil from damage. The FMP objective of water management strategies is to protect the ecological integrity and quality of streams, wetlands and their associated vegetation, and increase the flow of water to surface and groundwater reservoirs.

Soil

As discussed above (sections 3.1.1, 3.1.2 and 3.1.3), soil conservation is paramount to ESFM. Studies on the impact of timber harvesting on soil compaction have shown an increase, with the mean bulk density of undisturbed and disturbed soil being 0.71 g cm^{-3} and 0.85 g cm^{-3} respectively, with localized areas on harvested coupes being considerably more compacted. Burrows *et al*. (2002b) reported a reduction in diversity and abundance of some

understorey vegetation life forms following intensive soil scarification to promote regeneration of commercial tree species, however recent studies (Ward *et al* in press) found no statistically significant difference in mean species richness and abundance of understorey plants between harvested and unharvested sites. Recommendation 5 above addresses this issue.

Current silvicultural Strategies

- Rehabilitation of soil damaged on extraction tracks will be timed to occur prior to the post harvest burn for all shelterwood operations.
- When reducing rootstock competition to assist establishment of overstorey regeneration in shelterwood operations, limit soil treatments to a maximum of 50 per cent of the harvested area.

Panel Response

Increased soil disturbance is of concern despite the apparent lack of impact on understorey plant richness and abundance as reported by FORESTCHECK. The previous issues related to soil damage were:

- Non compliance
- Ineffective erosion control
- Exceeding soil disturbance limits

The extent of severity of soil disturbance associated with these issues related to timber harvesting in jarrah forests appears to have significantly reduced as a result of management responses to the problem. It is also noted that soil protection treatments such as cording, matting and brushing have been evaluated and may have merit in some circumstances. Although engineering solutions such as these can help, in most situations, good planning and management of machinery movement across the harvested area offer the most effective solutions for minimizing soil disturbance (Whitford 2009). There is a need to map where soil damage has occurred and to review rehabilitation and regeneration in these areas. Recommendation 6 above discourages the practice of soil disturbance / scarification to establish seedling regeneration or to reduce competition to commercial tree species.

Water

Current silvicultural Strategies

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

Protect water quality from salinity in high salt risk catchments through increased stream reserves, phasing harvesting within second order catchments and a minimum cutting cycle interval of 15 years.

Protect water quality from salinity in salt sensitive catchments through phasing harvesting within second order catchments and a minimum cutting cycle interval of 15 years.

Chemicals used and method of application in harnessed catchments will be selected to have low impact on both water quality and aquatic ecosystems. Chemical use will be minimised wherever possible.

Panel response
The need for phased harvesting as a protective measure against salinity was based on high soil salt storage and shallow groundwater levels in the Intermediate Rainfall Zone (IRZ – mean annual rainfall greater than 1100 mm). However mean annual rainfall observed over the last 35 years is significantly less, groundwater levels are much lower as a result, and there are indications that forest density, as measured remotely by LANDSAT, is also increasing in undisturbed areas of forest. This means that the requirement for phased harvesting for salinity protection is not as critical (see Kinal 2011).

Ongoing monitoring of key groundwater bores and an assessment of cumulative rainfall will need to be maintained to assess whether there is a return to much higher average rainfall or with land use change there is increased groundwater levels. However the major concern is with continued drying climate and increased jarrah forest vegetation density there has been observed a significant decline in streamflow volumes, reduced time when watercourses are flowing, increased duration of 'summer drought' given the delay in onset of winter rainfall patterns, and increased temperatures. The climate change scenarios as outlined in Table 1 emphasise or increase the intensity of these already observed impacts. As mentioned above, there have also been jarrah tree deaths in some parts of the forest with shallow soils.

From a water quality perspective the current prescriptions are acceptable as they relate to chemical use and water source protection. There is however potential for a review of the buffer zones for water quality protection. A more evidence-based risk management approach, which is balanced against water quantity and biodiversity / ecosystem health objectives is considered necessary. For example, utilising all available information in a risk management framework, or a graphical probability model such as a Bayesian Network, could be worthwhile approach to rational decision making regarding buffer zones.

<u>Recommendation 11:</u> Due to reduced rainfall and lower groundwater levels associated with climate change, and consequent reduced salinity risk, phased harvesting in lower rainfall areas of the jarrah and karri forest in the Swan and South-West DEC administrative regions is not warranted. However, ongoing monitoring of groundwater should continue so that management can respond should there be a return to a wetter climate.

3.2 Karri Forest

3.2.1 Conservation of Biodiversity
It is estimated that 82% of the original (pre-European settlement) area of karri forest remains (Conservation Commission 2004). Most of this occurs on public land. As discussed above, measures to protect the environment and to conserve biodiversity occur at various scales. At the whole of forest scale, some 53% of the existing karri forest is in the formal reserve system (national parks, conservation parks, nature reserves) and are excluded from timber harvesting. At the landscape scale, a further 13% is in the informal reserve system including stream and road reserves, patches of old growth forest, diverse ecosystems, fauna habitat zones, etc. About 34% is available for timber production and of this, ~1,600 ha per annum are harvested in some way for timber (Bradshaw 2010b; DEC 2011e). Silvicultural practices aim to align with ESFM principles, which includes conservation of biodiversity, but there are and will be trade-offs at various temporal and spatial scales. The underlying principle is that biodiversity should be conserved at the whole of forest and landscape scales, and at the coupe or patch scale, and forest management should ensure the capacity for biodiversity to be retained or to recover between harvesting cycles. Maintaining ecosystem resilience, or the capacity for ecosystems to recover from disturbances such as timber harvesting and fire without permanent loss of ecosystem function, biological diversity and productivity, is fundamentally important to achieving ESFM.

Silviculture applied to a karri forest patch available for timber production varies depending on the size / age class structure of the stand, which in turn is a function of disturbance (fire and logging) history. Various documents including Silvicultural Practice in the Karri Forest (DEC 2005), Karri Forest Silviculture Reference Manual (draft) (Bradshaw 2010b) and Karri Forest Silviculture Guideline (draft) (DEC 2011b) provide good descriptions of the karri forest and of the rationale and science underpinning karri silvicultural. The following discussion is based on a paper prepared for the Panel by McCaw *et al*. (2011).

Disturbances such as fire and timber harvesting promote the development of regenerating or new growth forest structures at various scales. In forest ecosystems, overstorey tree species are keystone species, and unlike understorey species, which can regenerate and mature relatively quickly following disturbance, overstorey species can take many decades or even centuries to reach maturity. Studies have demonstrated that many karri forest species associated with the understorey are able to persist, or quickly recolonise new growth forest following disturbance (see Bradshaw 2010b). However, as with most forests prone to relatively frequent disturbance, the potentially sensitive components of the biota are organisms that depend upon specific habitat characteristics only associated with mature, large or 'old' overstorey trees or other legacy elements such as large, decaying logs on the forest floor. The spatial and temporal arrangement and availability of habitat is important to their persistence. Examples of mature forest dependent species include tree and log hollow dependent birds and mammals (see Bradshaw 2010b; McCaw *et al*. 2011).

Unlike the situation in the jarrah forest, there is no routine monitoring of a broad spectrum of biodiversity associated with timber harvesting in karri forest. Current silvicultural prescriptions are designed to align with ESFM principles and with regard to biodiversity conservation, are based on knowledge gained from research and experience, and on first principles. Bird populations continue to be monitored in karri forest at Gray forest block following clearfelling and regeneration burning in 1984/85 (Abbott *et al*. 2009). After 21 years, species richness and total abundance of birds remained greater in the unlogged mature forest than in the regenerated forest but as expected, the recovery of the bird population is continuing as the regenerated forest matures.

Silvicultural guidelines specify the selection and retention of primary and / or secondary habitat trees, depending on the stand composition and structure (DEC 2005; Bradshaw 2010a; Bradshaw 2010b). Primary habitat trees, or hollow-bearing trees are not routinely retained on karri stands that are clearfelled largely because to do so would adversely impact on regeneration development (Rotheram 1983), especially as coupes are relatively small, and there is concern that retention of large trees presents safety issues to forest operations (McCaw *et. al* 2011). In these circumstances, absence of habitat trees is off-set by retention of secondary habitat trees (younger trees that will fulfill this role in time), of mature forest along streams and roads, of old growth patches, Fauna Habitat Zones and the very high formal reservation levels in the karri forest. The lack of a market for marri in recent times has resulted in increased retention of mature marri, a proportion of which are likely to be hollow-bearing (McCaw *et. al* 2011). In the absence of a monitoring and evaluation program, the efficacy of these measures is uncertain, although an adaptive management trial of habitat tree retention during karri forest harvesting has recently been undertaken at Chanybearup forest block (McCaw *et. al* 2011). While some hollow-dependent species may not be present in patches of regrowth forest, measures taken at the whole of forest and landscape scales (see above) should ensure retention of viable populations of these species as well as providing sources for recolonisation as forests grow and mature.

Silviculture guidelines specify selection and retention of both primary and secondary habitat trees in clearfelled mixed karri/jarrah stands at rates of 5 and 2 per hectare respectively (except where marri has been retained). While the basis for these retention rates is unclear to the Panel, given whole of forest and landscape scale measures to retain legacy habitat

elements, it is unlikely that these prescriptions will pose a threat to biodiversity dependent on large hollow trees for habitat.

Possible changes to the Silvicultural Guideline

- Retain a selection of remnant mature trees where they exist in stands to be thinned.
- Retain patches of standing dead trees (where it is safe to do so) in areas where sawlogs are to be salvaged.
- Retain senescent trees with secondary crowns and visible hollows in clearfell coupes where it is considered safe. (Note: Criteria as to whether a senescent tree is considered 'safe' to retain may need to be developed).
- Strategies to maintain species (compositional) diversity of the overstorey.
- Strategies to use knowledge of the scale of natural disturbance regimes to guide the scale of silvicultural practices.
- Establishment of TEAs in mature forest to improve connectivity with the formal and informal reserve system.
- Use of seed from local endemic species for regeneration and rehabilitation.

Panel comment:
While knowledge of the temporal and spatial scales of 'natural' disturbance regimes is limited, the Panel supports the concept of ecological forestry and use of limited available knowledge in an adaptive management framework. The Panel commends and supports proposed changes to the karri silvicultural guideline.

Large old logs lying on the forest floor (coarse woody debris – CWD) provide specialized habitat for some elements of the biota but are also sensitive to disturbances such as fire and timber harvesting. McCaw (2006) has shown that in regrowth forests, retention of large, old decaying logs and stumps and associated moss beds are important habitat for species such as *Asplenium* fern (Priority 4) in regrowth karri forest. Some mammals such as mardo are known to utilise hollow logs as do some reptiles. In order to reduce the risk of smoke affecting adjoining land uses, such as grape growing, the current practice following harvesting in two-tiered karri forests is to windrow / heap and burn logging slash at a time when grapes are less vulnerable to smoke taint. Aside from being a costly exercise, this practice is likely to result in greater removal and clumping of CWD and of ashbeds. This practice could also adversely impact on the regeneration and growth of understorey species given the additional machine traffic over the soil and the spatial reduction of ashbed and soil heating compared with broadcast burning of debris. See also concerns about this practice raised in section 3.2.2. below.

A possible change to the silvicultural guideline is to retain scattered large logs. The Panel supports this proposed change (see Recommendations below).

<u>Recommendation 12:</u> Undertake investigations into a) the loss of CWD habitat and b) effects on understorey regeneration, diversity and development resulting from windrowing / heaping and burning of logging slash in clearfelled karri stands. Where practical to do so, exclude large old logs in advanced stages of decay from rough heaping operations. Investigate smoke management systems that will facilitate the application of broad scale high intensity burns, thus removing the imperative for windrowing and excess soil disturbance.
<u>Recommendation 13:</u> Consider extending FORESTCHECK to karri forest available for timber harvesting to monitor the efficacy of silvicultural practices designed to conserve legacy habitat elements and associated dependent biota.

3.2.2 Maintenance of productive capacity

Karri forests, like wet eucalypt forests in south-eastern Australia, regenerate naturally only following severe disturbance, usually wildfire, which initiates even-aged cohorts of

regeneration. Production karri forests are either two-aged, comprising scattered older trees over an even-aged cohort of regrowth arising from a previous harvest and follow-up regeneration treatment, or even-aged, arising from past clearfell, burn and sow / plant operations. Two-tiered stands are managed either though clearfelling or thinning, depending on the size and abundance of the lower storey of regrowth eucalypts. Even-aged regrowth stands are managed through thinning. The main issue arising from operations visited by the Panel during the July meeting is soil management.

Soil management

The '*Manual of Procedures for the Management of Soils Associated With Timber Harvesting in Native Forests*' (DEC 2010) describes the rules and procedures for managing soils and minimising disturbance and damage to soils. Soil damage is described in the manual as comprising three primary disturbances: soil compaction, soil mixing and soil removal, scalping or deposition. The report details a variety of visible or obvious types of disturbance, amongst which are removal of litter, mixing of soil layers, mounding or other deposition of soil and rutting.

Management observed by the Panel in the harvested two-tiered karri forest at compartment 3 of Channybearup forest was not consistent with the approach described in the above manual. While the timber harvesting was apparently conducted in accordance with the soil management guidelines, at the completion of harvesting the site was disturbed once by an intensive operation of windrowing and burning the slash. Then the site (soil especially) was intensively disturbed again when the remaining material in the windrows was spread, and then the entire site was deep ripped. The site was then planted with nursery raised seedlings. During this process the soil was physically disturbed repeatedly, at the end of which the litter layer had been entirely removed, the soil profile had been altered, and the topsoil and subsoil mixed. Coarse woody debris (CWD) on the site had been disturbed, the important soil-to-CWD contact had been broken, all the CWD had been charred, and much of it will have been broken up during the repeated disturbances.

It was explained to the Panel on site that it is necessary to windrow the harvesting slash in order to extend the window of opportunity for burning outside the grape ripening season as smoke taint of grapes is a serious issue. This is acknowledged, but smoke management systems are successfully applied in other states, and their application in this instance should be investigated. This practice is not in accordance with the approach espoused in the Soil Manual, and is inconsistent with the principles of ESFM in the view of the Panel. Recommendation 12 above addresses this issue.

Evidence from other studies (Britten 1955; Gilbert 1959; Ashton 1981; Griffin 2008) has clearly shown the importance of the natural selection cycle in establishment of eucalypts in wet forests. In natural systems, following a disturbance (usually wildfire), tens of thousands to millions of seedlings germinate on the site and then intense selection and competition thins out those that are self-fertilised progeny, and then selects the most vigorous (the genetically superior), of those that remain. In planting seedlings, much of this opportunity for selection of the 'fittest', or plus' trees is lost, and the risk is then run of gradually decreasing

the genetic quality of the standing trees. Seed collection for aerial sowing purposes is applied in other Australian States with great success.

Recommendation 14: To maintain genetic fitness, investigate the aerial application of seed to regenerate coupes following clearfelling and burning in two-tiered karri forests.

During harvesting of Channybearup forest compartment 3 referred to above, scattered habitat trees were retained as part of an adaptive management trial. Isolated and exposed trees left in coupes subjected to high-intensity burns, whether broad scale or windrow, are susceptible to scorch / injury / death from the burn, and to windthrow. They also present a potential safety hazard to people working in the coupe, especially if the trees have been killed or significantly damaged during the regeneration burn. Retained trees would also be an impediment to aerial sowing operations, should this be considered. It would be more practical and ecologically beneficial for a similar number of trees to be retained in aggregates or clumps of at least 1 ha or larger. Clumps are easier to protect during regeneration burning operations, are more windfirm, and retain a core of intact forest including understorey, thus providing both protection and better habitat for a range of species. These patches could also serve as a source of propagules for species to recolonise the harvested areas.

Recommendation 15: Ensure adequate training and compliance with the existing soil management guidelines throughout the harvesting and regeneration process (i.e. including burning) in the two-tiered karri forests.
*Recommendation 16: Revise the specifications for retention of habitat trees in order to provide for retention of small, aggregates or clumps of trees, where possible, as an alternative means of retaining habitat on site***.**

Karri – thinning
Thinning of even-aged karri is currently the largest proportion by area of the annual karri harvest. At the Warren Thinning trial in Compartment 1 of Warren forest, the Panel observed recent thinning operations. The practice of removing the stumps of the harvested trees, as a means of *Armillaria* control was discussed.

The Panel was advised that the stumps were removed in order to reduce the available habitat for the fungus. At the same time, we were informed that following extensive fuel reduction burning in such forests, in infested areas, there were *Armillaria* fruiting bodies everywhere, suggesting that the entire site was infested.

Recommendation 17: Given the levels of soil and root disturbance and the potential for stem damage during stump removal operations, and given the advice that infestations tend to be widespread, stump removal should be reconsidered. Unless there is a very clear and scientifically defensible benefit to be gained from the practice, it should be discontinued.

3.2.3 Maintenance of ecosystem health and vitality

Unlike the jarrah and wandoo forests, the vulnerability of the karri forest to climate change is lower. This is because the area of karri forest predicted to fall below the threshold of 900 mm annual rainfall from climate models for 2030 ranges from 70 to 7,160 ha, depending on the climate scenarios used (Maher *et. al* 2010). Given the level of uncertainty in these

projections, it is appropriate that the next FMP consider consequences of a drying climate on ecosystem health especially in the Strachan Cattaminup and Northern karri landscapes.

Panel comment on issues raised by recent forest management review/audit processes

The EPA (2010) stated that the following should be considered in preparation of the next FMP:
"The full impacts and management of forest diseases, including….armillaria in karri forest, and other pests."

The Panel agrees with this assessment and reiterates the need for annual health surveillance of the whole forest estate (See Recommendation 9) and for the need for guidelines for the management of pests and diseases (See Recommendation 10).

Proposed changes to the Silvicultural Guideline

- Selectively remove stumps in thinning areas where the incidence of Armillaria is above 25 per cent of crop trees.

Panel comment: The Panel supports the intent of this proposed change but is concerned at impact from machines and whether the treatment is cost effective (see above recommendation). Research should be undertaken to address whether Armillaria damage to karri will increase on sites where water deficit may become an issue with climate change.

- Monitor the occurrence of Armillaria in thinned stands.

Panel comment: The Panel supports this proposed change.

- Harvesting to salvage sawlogs in disease or pest killed stands may be approved by the Senior Silviculturalist on a case by case basis. Measures to maintain stand resilience must be included in any proposal.

Panel comment: The Panel supports this proposed change.

- Prohibit the removal of leaf and fine branch material (less than 150 mm diameter) as residue products from forest harvesting operations.

Panel comment: The Panel supports this proposed change. The nutrient content of this residue is an important driver for ecosystem health.

- Individual trees or groups of trees that exhibit resistance to disease or the effects of insect outbreaks should be marked and protected from damage during timber harvesting operations.

Panel comment: The Panel supports these proposed changes.

- Adaptive management trials to investigate the rehabilitation of sites with significant tree deaths may be approved by the Senior Silviculturalist.

Panel comment: The Panel supports these proposed changes provided that the cause(s) of death are determined to inform adaptive management.

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

Panel comment: The Panel supports the overall thrust of the proposed change but recommends that "excessive" be defined and that environmental water values are emphasised.

3.2.4 Conservation and maintenance of soils and water

Soil - silvicultural strategies

- Compacted soils will be ripped prior to the planting of seedlings.
- Steep sites (greater than 20 degrees) will be excluded from harvesting.
- Moderately steep slopes (14 – 20 degrees) must be harvested under dry soil conditions.
- Preference for the removal of culls will be by felling rather than pushing, to limit soil disturbance.

Panel response
The application of ripping seems to be more widespread than indicated in the silvicultural guidelines (see discussion above). The need for ripping as a standard practice should be reviewed to better define circumstances under which ripping is necessary for remediation of soil damage.

Water - Silvicultural Strategies

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

Panel response
There are concerns with declining streamflow in karri forest streams similar to jarrah forest catchments. However given the limited water supply development in karri forest catchments the focus is much more on the impact on the aquatic biodiversity and other mesic habitats such as winter wetlands and peat swamps. Streams becoming ephemeral, streams having much longer periods of no flow, and in more drier areas no flow over years is likely to lead to significant changes to the stream ecology and groundwater dependent ecosystems.

3.3 Wandoo Forest

3.3.1 Biodiversity conservation

Of the present extent of wandoo-dominant forest on land managed by DEC (~145,000 ha) about 75% is in formal and informal reserves with about 25% (~36,470 ha) available for timber harvesting. Of this, very little is actually harvested each year. Over the period 2004-2010 only 400 ha was cut over and during the 10 year life of the previous FMP, only 340 ha was cut over.

The draft Wandoo Forest Silvicultural Guideline (DEC 2011d) includes guiding principles for silviculture in wandoo forest, including for the conservation of biodiversity. These principles are similar to those for other forest types and include retention of legacy habitat elements, maintaining connectivity, appropriate fire management and ensuring the maintenance of mixed species stands. The document 'Silvicultural Practices in Wandoo Forest and Woodland' (DEC 2004c) provides details about the retention of legacy habitat elements including habitat trees, balga (*Xanthorrhoea* spp.) and significant lower tree or mid-canopy

species such as *Allocasuraina* spp., *Hakea* spp. and the Christmas tree (*Nuytsia floribunda*), coarse woody debris (including hollow logs and stumps).

To the Panel's knowledge, there has been little or no research into the effects of timber harvesting and associated activities on wandoo forest, and the biodiversity monitoring protocol FORESTCHECK does not extend to wandoo forest. The guiding principles and measures outlined in the cited documents appear to be based on lessons and experience from jarrah forest and are probably appropriate for the wandoo forest.

Recommendation 18: Consider extending FORESTCHECK to wandoo forest available for timber harvesting to monitor the efficacy of silvicultural practices designed to conserve legacy habitat elements and associated dependent biota.

3.3.2 Maintenance of ecosystem health and vitality

The wandoo forest across its range has experienced significant crown decline and dieback over the past decade (Wandoo Recovery Group 2006). The cause of the decline has not been established, though decreased rainfall, salinity and boring insects have all been implicated (Hooper 2009; Hooper *et al*. 2010). However, in the past few years, crown condition has begun to improve.

Panel comment on issues raised by recent forest management review/audit processes
No specific issues were raised regarding wandoo silviculture that concern ecosystem health. Recommendations 8, 9 and 10 (above) apply across the whole forest estate, including the wandoo forest.

Possible changes to Wandoo Silvicultural Guideline

- Rehabilitation in mixed jarrah/wandoo forest may incorporate the use of *Phytophthora cinnamomi* resistant seedlings to improve site resilience.

Panel comment: The Panel supports this proposed change.

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

Panel comment: The Panel supports this proposed change.

- Water availability in harnessed catchments may be maintained to current levels by periodically thinning juvenile, immature stands either commercially or non-commercially. A detailed catchment management plan is required to ensure that protection of all catchment values has been adequately addressed.

Panel comment: The Panel supports the intent of this proposed change but questions whether "current levels" is appropriate given the large year to year variation being experienced over the past decade.

- Water availability for aquatic ecosystems may be increased by periodically thinning either commercially or non-commercially to conserve significant biodiversity values. Thinning regimes in wandoo stands may be altered to favour water yield in the short-term without adversely affecting the timber yield in the longer-term.

Panel comment: The Panel supports the intent of this proposed change, agrees with the first sentence but prefers the term "environmental water" to "water yield" in the second sentence. The Panel would prefer all forest values to be considered not just sustainable timber yield as there may be a need for trade-off to sustain ecosystem health in exceptional circumstances.

3.3.3 Conservation and maintenance of soil and water

Soil

The woodland occurs in the broad valleys on sandy loams over clay. These soils are low in nutrients and are more fragile than the surrounding jarrah forest soils, due to their higher clay content. The Wandoo Forest Silviculture Guideline draft (DEC 2011d), identifies a number of strategies to comply with Guiding Principle 16 – Timber harvesting activities and silvicultural treatments will be planned to minimize damage to soils. There is the potential for some of these strategies to be inconsistent with Principle 16. For example, using machines to '…*scalp off the understorey to expose mineral earth, or cultivate the soil surface to reduce understorey and grass competition…* etc., and "…*reducing rootstock competition to assist establishment of wandoo or jarrah / wandoo overstorey regeneration*…etc." Burrows *et al*. (1990) report that good regeneration and establishment of wandoo seedlings can be achieved by proper ashbed preparation through broadcast burning without the need for additional mechanical disturbance of the soil and potential damage to other native vegetation.

Recommendation 19: Minimise the use of mechanical soil scarification / scalping for seedbed preparation and removal / reduction of competition (other native plant species) when regenerating wandoo forest following harvesting. (Links with Recommendation 6).

Water

Reduction of crown cover through timber harvesting over extensive areas in salt sensitive catchments, can result in salt input into streams. However, the water table under many of the wandoo stands in the eastern part of the forest is highly saline, it is also very deep and harvesting when followed by regeneration (even intense harvesting over extensive areas) has not caused a sufficient rise in the water table to cause salinity discharge into streams. With the reduction in rainfall and a corresponding decline in the water table, these saline interactions with surface water are increasingly unlikely. See Recommendation 11 regarding phased logging.

4. General comments on silvicultural manuals / guidelines

Strengths of the current documents.

Clearly there is a wealth of knowledge about the forests of Western Australia accumulated over many decades of experience, research and monitoring. The document 'Silvicultural Practice in the Jarrah Forest, Silviculture Guideline for Jarrah Forest (DEC 2004a), is very comprehensive. As elsewhere in Australia, silvicultural systems have evolved over time as knowledge about the characteristics and ecology of the different forest types has been gained and this knowledge is clearly reflected in the current documentation.

The proposal to separate the existing documentation into a standard set of three different reports for each forest type is cautiously supported. The proposal, as the Panel understands, is that for each forest type - karri, jarrah and wandoo - there will be one document containing all the reference material, one containing the guidelines, aligned with the principles of ecologically sustainable forest management and articulating the philosophy and reasoning underlying the approach to forest management in that forest type, and a manual, describing how to undertake harvesting in that forest type.

The support for this process is cautious because the existing documentation demonstrates the ease with which information can be repeated, and because the “how-to” manual for jarrah has not yet been produced.

The Panel also reiterates the importance of training staff who are to implement the guidelines and the need for proper auditing and monitoring for compliance.

Weaknesses of the current documents

The variety of formats and versions of silviculture related documents was somewhat confusing. Draft documents need to be completed and all documentation rationalized, or published in a structured way for ease of interpretation. The silvicultural guidelines as written are very complex. ‘Silvicultural Practice in the Jarrah forest’ (draft) (DEC 2004), is 133 pages long and presents a wealth of information but at no point is there a clear and simple explanation of the different silvicultural systems that are currently applied in the jarrah forests and why. For field staff the basic information about the different approaches to harvesting is most useful. Appended are two pages from one of the Technical Bulletins currently in use in Tasmania, as a possible template that could be adopted in Western Australia. The Panel understands that a jarrah field manual is currently in preparation, so the Tasmanian model is offered for consideration.

The current manuals/guidelines suffer greatly from repetition and cross-referencing. For example in many places the reader is referred to a silvicultural specification, see specification 1/92?, 3/97?, 3/90? If the information in those specifications is relevant then it should be included in the manual. If it is more appropriate, the reader should simply be referred to that specification, and there should be no reiteration. There needs to be a checking for consistency of practice, alignment of purpose and consistency of language and definitions across the various documents, including manuals for post harvest treatment, silvicultural burning, soil and water conservation and regeneration survey procedures, as referred to in other reports and guidelines.

While comprehensive, perhaps turgid, the structure of the documents needs to be reconsidered. For example, the first section of Silvicultural Practice in the Jarrah Forest, SFM Guideline No 1 (DEC 2004b), is on regeneration surveys. Unless pre-harvest surveys are routinely undertaken to assess the most appropriate silvicultural treatment, surveys are usually carried out at the end of the harvesting and regeneration process, that is, when assessing the outcomes of a silvicultural treatment, not at the beginning. This is followed by a section on ‘integrated harvesting and regeneration plans’, which contributes little, then there is a section on tree marking. The critical issue, that being which silvicultural systems are applied in various jarrah forests, is not up-front. To find this, it is necessary to read most of the document, or to defer to the contents page and search through the document. As above, the Panel recommends that at the front of the document there is a single page for each of the silvicultural systems, that presents the key factors that determine the utility of that system, as presented in the attached example from Tasmania. The flow of information in each manual should progress in the order in which it will be considered by the planners and supervisors.

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Appendix 1
Terms of Reference - Review of silviculture in jarrah, karri and wandoo forests

Introduction

The commitment of the Conservation Commission and the Department of Environment and Conservation (DEC) to ensuring that management actions, policies and guidelines maintain their currency is reflected in the Forest Management Plan 2004-2013 (FMP). Consistent with this commitment, the FMP contains an action to review silviculture practice prior to the development of the next Forest Management Plan.

Action 34.1.4 of the FMP states:
The Department and the Conservation Commission will initiate an independent expert review of silvicultural practices and their impacts on biodiversity during the second half of the life of the plan. The review will have regard to the results from FORESTCHECK and other research monitoring, audits and adaptive management trials of these practices.

The purpose of this review is to fulfill the above requirement, and to facilitate the findings from the review being considered as part of the development of the next forest management plan. The scope of the review has been extended to all aspects of ecologically sustainable forest management (ESFM) to reflect the role that silviculture plays in the delivery of ESFM.

This review should be informed by earlier reviews and reports including:

- Burrows, N., Christensen, P., Hopper, S., Ruprecht, J. and Young, J. (2001). Ministerial Condition 11: Panel Report Part 1.
- Burrows, N., Christensen, P., Hopper, S., Ruprecht, J. and Young, J. (2002). Towards Ecologically Sustainable Forest Management in Western Australia: A Review of Draft Jarrah Silvicultural Guideline 1/02. Panel Report Part 2 for the Conservation Commission of Western Australia.
- Conservation Commission of Western Australia. (2008). Forest Management Plan 2004-2013: Mid-term audit of Performance Report.
- Environmental Protection Authority (2010). Forest Management Plan 2004-2013: Mid-term audit of Performance Report. Report and Recommendations of the Environmental Protection Authority. Environmental Protection Authority of Western Australia, Report 1362.

Objectives

The objectives of this review are for the Panel to:

1. Obtain a sound understanding of the key elements of current and proposed silvicultural guidance documents and practices applied in the jarrah, karri and wandoo forests;
2. Provide advice regarding the strengths and weaknesses of the guidance documents and practices, and the adequacy of the provisions for ESFM;
3. Provide advice as to any options for refinement of the guidelines and/or practices that should be considered during the development of the next Forest Management Plan, based on results from FORESTCHECK and other relevant research, monitoring, audits, and trials;

4. Provide advice regarding any inherent ‘trade-offs’ between ESFM objectives that may accompany these refinements.

Note: The Expert Panel is not required to attempt to reach an appropriate ‘balance’ where there may be conflicting aspects of ESFM, as this is most appropriately undertaken in the development of the next Forest Management Plan.

Scope

In providing its advice to DEC, the Panel should have regard to:

1. The modified Montreal Criteria for ESFM (see Definitions);
2. The principles of ESFM (see Definitions);
3. Specific issues raised in the Mid-term audit of the current FMP and in the subsequent EPA report;
4. Relevant contemporary issues including:
    - Climate change and forest ecosystem resilience;
    - Silvicultural practices and their impacts on biodiversity;
    - Potential for increased utilisation of wood biomass;
    - Environmental water availability;
    - Modified salinity risk in light of lowered water tables in the low and intermediate rainfall zones; and
    - Timber industry viability.

Geographic Extent – Location of Work

The review will apply to all State forests and timber reserves within DEC’s Swan, South West and Warren regions. This is the same area covered by the current FMP and expected to be covered by the next FMP.

Methodology

The Expert Panel will convene for 10 days in WA and subsequently work ‘out-of-session’ to:

1. review the existing and draft silviculture guidance documents to assess how the existing and proposed practices address the principles of ESFM;
2. inspect and review silvicultural practices;
3. prepare a draft report detailing its findings in relation to objectives 2-4;
4. deliver a presentation to key officers of the Conservation Commission and DEC based on the draft report; and
5. following DEC’s feedback on the draft paper, prepare a final written report to DEC.

DEC will:

1. provide existing and draft silvicultural guidance documents for jarrah, karri and wandoo;

2. provide a summary of proposed changes to guidelines and the rationale for these changes;
3. provide a summary of silviculture and related issues raised in the mid-term audit of the current FMP and the subsequent EPA report;
4. provide a summary of information on the impact of silvicultural practices on biodiversity in Western Australia that has become available since the FMP was approved in December 2003;
5. organise briefings by key DEC staff, and provide opportunity to question and discuss key issues with these staff;
6. arrange field trips to familiarise the Panel with silvicultural practices in the jarrah, karri and wandoo forest;
7. provide an executive officer to facilitate the work of the Panel, both during its period in WA and 'out-of session'; and
8. publish the final report as a DEC SFM Technical Report and make it available to the public on the DEC website.

Timeline

The Expert Panel will convene for 10 days in WA during June 2011 to familiarise themselves with guidance documents and field practices. An indicative breakdown of this period involves:

- 1 day introduction
- 4.5 days jarrah
- 2 days karri
- 0.5 day wandoo
- 2 days forest tours

Following the familiarisation and field inspection process in Western Australia, it is expected that the Panel will prepare its report 'out of session', with assistance and coordination as required from the Executive Officer.

The Panel will provide a draft report and deliver a presentation to key officers of the Conservation Commission and DEC by the end of August 2011.

The Panel will provide a final written report to the Director General of the DEC by the end of October 2011.

Members

Chair and forest ecologist	Dr Neil Burrows (DEC)
Ecology	Professor Bernie Dell (Murdoch University)
Silviculture	Dr Mark Neyland (Forestry Tasmania)
Hydrology	John Ruprecht (DAFWA)
Executive Officer	Tony Mennen (DEC)

Attachment 1 – Definitions

For the purposes of this review, the following definitions apply:

‘Biodiversity’ means 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.

‘Biodiversity components’ includes habitats, ecological communities, genes and ecological processes.

For the purposes of the review, ecologically sustainable forest management refers to the slightly modified Montreal Criteria of sustainability adopted as the framework within which to identify management actions in the Forest Management Plan 2004-13 (FMP).

The criteria are:

- Conservation of biodiversity
- Maintenance of productive capacity
- Maintenance of ecosystem health and vitality
- Conservation and maintenance of soil and water
- Maintenance of forests contribution to the global carbon cycle
- Maintenance of heritage
- Maintenance of socio- economic values

The principles of ESFM are as defined by Section 19(2) of the *Conservation and Land Management Act 1984*

Appendix 2
Examples of silvicultural prescriptions from Tasmania

1. Shelterwood retention

Appropriate forest stands: *E. delegatensis* forests with open understoreys that lack sufficient advance growth greater than 1.5 m in height. An adequate seedcrop should be present in the retained trees. If the seedcrop is inadequate it is acceptable to sow; however it is preferable when possible to reschedule harvesting until an adequate seedcrop is available.

Harvesting method: All trees are harvested other than those required to provide the shelterwood. Retained trees should have good crowns and be evenly distributed at a rate corresponding to 9 - 12 m^2/ha basal area on coupes where the rainfall is below 1000 mm. On coupes with higher rainfall the retained basal area can be up to 14 m^2/ha. The proportion of species present on the site prior to harvesting should be reflected in the retained trees.

Regeneration treatment:

Site preparation: Receptive seedbed must be created by low intensity broadcast burning, top disposal burning, excavator heaping, harvesting disturbance or additional mechanical disturbance. On grassy sites, deliberate additional mechanical disturbance may be required to create sufficient seedbed.

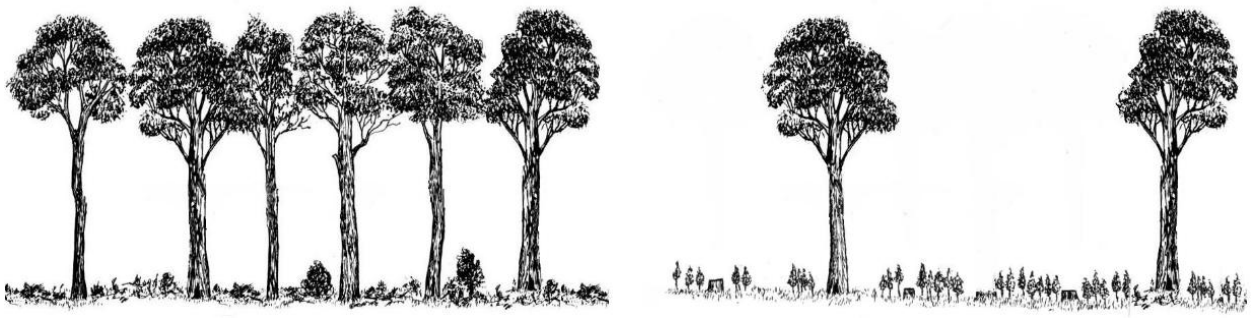
Source of regeneration: From seed shed during and after harvesting and from the release of advance growth (where present). If the seed supply is inadequate the coupe must be sown. If rapid grass invasion of the coupe is expected, supplementary sowing onto receptive seedbed should be undertaken.

Monitoring and protection: Indicator plots must be established to monitor germination and problems due to inadequate seedfall, lack of receptive seedbed or browsing damage, as prescribed in Technical Bulletin 12. As the plots are a measure of the success of the seedfall on the coupe, they should not be artificially sown.

Browsing damage: Browsing transects should be established and monitored, and control of browsing undertaken if required, as prescribed in Technical Bulletin 12.

Regeneration survey: A seedling regeneration survey must be carried out about two years after the regeneration treatment, as prescribed in Technical Bulletin No. 6. A multi-aged survey is the appropriate method where shelterwood retention occurs as a mosaic within patches treated by the advance growth or potential sawlog retention methods.

PRE-HARVEST **POST-HARVEST**



2. Advance growth retention

Appropriate forest types: Uneven-aged forests containing advance growth that has good potential for further growth. The cohorts of advance growth are often of different ages as they arise from different disturbances such as low intensity fires or previous harvesting events.

Harvesting method: Most mature and over-mature stems should be harvested. Regardless of the understorey type (grassy, sedgey, heathy or shrubby), the advance growth should be clearly taller than the competing understorey before the overstorey trees are removed.

Regeneration treatment:

Advance growth retention is only undertaken when the stand is stocked with advance growth. No additional regeneration should be required.

Regeneration survey: A multi-aged survey must be carried out within one year of the regeneration treatment, as prescribed in Technical Bulletin No. 6.

PRE-HARVEST **POST-HARVEST**