Calculating Sustained Yield for the Forest Management Plan (2004-2013) STAGE 3 Report

Report for the Conservation Commission of Western Australia by the Independent Panel

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EXECUTIVE SUMMARY

1. Introduction

The terms of reference for this Stage 3* review require that

> "The Panel will provide a written report to the Conservation Commission, based on the data, assumptions, methods and Interim Proposed Forest Management Plan as at a date specified by the Commission, that confirms whether:

The sustained yield levels calculated for defined forest types are consistent with:

1. Findings of the Stage 1 report and outcomes of the recommendations
2. The area of forest that is proposed to be available for timber harvesting
3. The practices that are to be used to provide timber harvesting for ecologically sustainable forest management, as set out in the draft Forest Management Plan, and
4. The data, assumptions and methods used, and
5. The calculations have been carried out objectively and in an operationally realistic manner."

2. Forest areas and maps

The stratification of the jarrah forest has been revised and most of the karri forest has a new stratification from large scale aerial photos. The Geographic Information System is excellent. The Panel conducted spot checks of its capacity to accurately reflect the areas of the various strata and is satisfied that it is very accurate. The Panel is satisfied that the stratification and mapping systems are sufficiently accurate and robust for the calculation of sustained yield. Well developed protocols exist for checking and correcting apparent errors in species or structural typing. Appropriate small allowances are made in calculating the sustained yield for the impact of these errors based on the historical experience of corrections. In summary, such errors have no significant effect on the overall capacity of the system to properly and accurately calculate the sustained yield.

3. Inventory

The Panel considers that the design of the jarrah inventory system represents Australian best practice, and that with the adjustments described later, provide inventory estimates at an appropriate level of precision and confidence for strategic yield scheduling. However, during the course of the life of the Plan, new field sampling will be required to update it. In addition, more attention needs to be given to monitoring the predicted and actual values from harvesting forest. The Panel therefore recommends that during the life of the Plan, greater emphasis is placed on increasing the sampling framework for monitoring, and extending the analysis of monitoring data to separate any inventory bias from the utilisation factor. Given the expected changes to utilisation that will evolve with the re-structure of the industry and the time required to accumulate sufficient sampling we do not consider that adjustment to the yield is likely to be required before the next revision of the Plan.

The Panel has been advised that the largest source of difference between the estimate and sawlog acceptance is in trees that are made available for harvest but are left standing, rather than the full utilisation of felled trees. This suggests that more attention is required to ensure that potentially suitable sawlog trees (albeit marginal) are felled and utilised.

A new karri inventory system is in place using the same design as in the jarrah forest and therefore also represents Australian best practice. Current allowances for relating predicted to actual volumes are adequate, pending the likely progressive shift in utilisation standards as more regrowth is logged, while recognising that they are likely to be conservative. A greater emphasis on monitoring predicted against actual volumes is essential during the life of the Plan in the light of changing log sizes and grades. However, it is likely that karri will present fewer problems than jarrah with respect to the felling and utilisation of potentially suitable sawlog trees.

In summary, the inventory base is very good and the residual risk posed by possible mismatching of predicted and actual volumes is now small. The jarrah inventory is nearing the end of its useful life but its

* This report is the third produced by this Panel following the Stage 1 report completed in April 2001 (Ferguson et al., 2001a) and the progress report produced in September 2001 (Ferguson et al., 2001b).

use without updating for growth in two-tiered and irregular stands subsequent to 1990 introduces a significant element of conservatism.

Recommendation 1

In refining the inventory during the life of the Plan, greater emphasis should be placed by the Department of Conservation and Land Management on increasing the sampling framework for monitoring, and extending the analysis of monitoring data to separate inventory bias from the utilisation factor, in addition to updating the field sampling.

4. Growth

The Panel believes that the growth estimates that have been used are robust and appropriate for the estimation of sustained yield in this plan.

The precision of the output from the JARSIM model can be improved over time in several ways:

- Utilising more data as they become available from younger stands over a greater range of sites, as a basis for initialising the model;
- Improving the estimates of stand condition following thinning as a result of post thinning monitoring;
- Improving the understanding of forest dynamics by further research on the response to multiple thinnings;
- Reviewing the existing framework of growth plots and establishing new plots in stands that more closely represent the structure of future stands.

Significant improvement in the available data cannot be achieved for at least a decade and there is little value in further development of the growth model until that is available.

The Panel is of the view that growth and future condition of the karri forest has been estimated at a precision appropriate for sustained yield calculation and that the process is robust. The precision of the model will progressively improve as more data become available over time.

The predicted future stand condition before and following the simulated harvest are recorded for each simulation run, providing satisfactory transparency of the assumptions made.

Recommendation 2

In refining the growth models over the life of the Plan, the Department of Conservation and Land Management should adopt a strategic approach and seek to obtain data from a broader range of ages and conditions as those opportunities become available. Major refinement of the growth models is therefore unlikely to be feasible until towards the end of the Plan period.

5. Forest Health

The Forest Management Branch within the Department of Conservation and Land Management has made extra-ordinary progress in collating data on and in analysing the rate of dieback spread. Hence the recommendations of the expert working group established to design a trial of the protocol for dieback management may require further review.

The new information on impacts of dieback on jarrah sustained yield demonstrates the importance of minimising disease spread into potential moderate impact areas of forest.

The maps of projected spread of *Phytopthora cinnamomi* will assist decision making in a range of policy and management areas with respect to future impacts of dieback, not only on wood flows, but also biodiversity and ecosystem health and vitality. The methods developed have great potential in the definition of "protectable areas" and the setting of priorities for management in a range of ecosystems, regardless of tenure. The Panel identified a need for further commitments on dieback management, and hence the mapping of infections, within the conservation estate.

The new simulation and mapping system also has the potential to be a powerful tool in demonstrating the effects of random infections on areas currently free of disease. This should be encouraged as it would be a useful way of demonstrating the consequence of poor hygiene on future spread. Best practice with regard to minimising dieback impacts is dependent on the use of this simulation and mapping system and its further refinement over time.

An earlier recommendation of the Environmental Protection Authority was that results of past monitoring of dieback spread and occurrence should be collated and made public. The Department of Conservation and Land Management now have material in a form that can be finalised for distribution.

The findings and predictions of the Department of Conservation and Land Management research project should be used to assist in the implementation of a number of the recommendations stemming from

Environmental Protection Authority Bulletin 1010 and related reviews. While much has been done in developing these for the management of the productive forest, they merit revision in the light of this new information. In addition, the Panel is especially concerned that little appears to have been done in developing management prescriptions specific to the conservation reserves concerned. In the light of this recent research, this represents a significant risk to biodiversity.

Recommendation 3

Department of Conservation and Land Management resources should ensure that disease status of 'uninfested' areas in both production and conservation areas is monitored adequately and reported separately for the production forest and reserves, with amendment of Key Performance Indicator 14 in the Interim Proposed Forest Management Plan accordingly.

The results of research relating to the spread and impact on jarrah growth of dieback should be

(i) promulgated in an appropriate form to the Western Australian community by the Department of Conservation and Land Management.

(ii) used to assist the implementation of Environmental Protection Authority and related recommendations on the management of the productive forest and especially on the management of conservation reserves.

The Department of Conservation and Land Management should ensure that the new dieback spread and impact models are further developed, especially to model the effects of random or new infections in areas of differing potential impact, and that Objective 13 of the Interim Proposed Forest Management Plan be amended accordingly to incorporate the action.

6. Selecting and applying silvicultural treatments

The Panel noted that the predicted versus actual outcomes of silvicultural treatments are to be closely monitored for the period of the plan and recorded in the silvicultural information system, SILREC. Consistent and significant differences between assumed and the implemented silviculture could have long term consequences to the projection of sustained yield and hence future adjustments may be required resulting from such monitoring.

Balanced Silviculture

The Panel is in agreement with Burrows et al. (2002) that the silvicultural system has to be designed within a broad ecological base to deliver ecologically sustainable forest management. Silvicultural guidelines need to be able to cater for non-wood values to enable appropriate silvicultural decisions to be made. Silvicultural decisions and practices can greatly change the forest structural and floral composition spatially and through time resulting in differential supply streams of ecosystem services and products (including water and biodiversity). It is important that the Plan contain clearer forest ecosystem objectives and guidelines that inform silvicultural decisions. Ecologically sustainable forest management is fundamentally about protecting the ecological integrity (biodiversity, health and productivity) of forest ecosystems while sustaining a supply of products and services to the community (Burrows et al. 2002).

The Panel believes that the current Interim Proposed Plan still lacks (see Stage 1 Recommendation 4.1) clear objectives that enable trade-off decisions to be made in the context of forests at a whole-of-forest, landscape, forest patch (block) and coupe scales through appropriate modifications to rule sets. Such objectives are required for looking at consequential impacts on wood and non-wood values and potential effects on sustained yield during the period of the plan. Hence the Panel recommends that the Conservation Commission provide explicit whole-of-forest and landscape objectives and targets that address these trade-offs.

Fauna habitat zones and structural goals

The Plan needs to clearly articulate the objectives, role and purpose of Fauna Habitat Zones as they are currently unclear in the Interim Proposed Plan. The Panel understands that the purpose of the zones is to assist species to recolonise adjacent regrowth forest as well as maintaining throughout the forest fauna that depend on forest habitat characteristics that may be adversely affected by forest operations. Hence Zones have a quite complementary purpose to forest set aside in formal and informal reserves.

These Zones may be placed on longer rotations or subjected to conservative logging with the objective of

managing primarily for faunal habitat characteristics while allowing the removal of sawlog as a secondary objective. With appropriate training of Department of Conservation and Land Management and Forest Products Commission staff and clear specification of objectives, these forests could be managed for both fauna habitat and/or understorey flora and sawlogs, so fulfilling Objective 7 of the Interim Proposed Plan.

Silvicultural prescriptions

The Panel concluded that there has been a thorough review of the Jarrah Silvicultural Guidelines giving appropriate attention to regeneration adequacy, the maintenance of flora diversity and fauna habitat.

With regard to measures to ensure that the levels of tree removal do not result in increased salinity in streams emanating in the intermediate rainfall zone the conclusion of the Burrows Panel is endorsed by the Panel. They found "no basis by way of new evidence for changing" the measures that have been current during the last decade but noted that new data may become available from a major current catchment study under-way in the northern jarrah forest.

The Panel is aware that there has been considerable discussion of water quality issues during plan development based on a report from the Waters and Rivers Commission (2001). A number of guidelines for the management and maintenance of the stream-zone informal reserves will be reviewed during the first half of the plan. A program for any change will be reported in the mid-term review of the Plan. The Panel was satisfied with this approach and considered that this flexibility did not present a risk to sustained yield based on the current allowances. Major increases of stream zone informal reserves are not envisaged.

The Karri, Jarrah and Wandoo Silvicultural Guidelines to be used have recently been reviewed and the residual risk to sustained yield of further changes being required is low.

The risk to sustained yield through marri being retained due to a future lack of markets has been directly incorporated into the woodflow scheduling.

Recommendation 4

The Conservation Commission should

(a) provide explicit whole-of-forest and landscape objectives and targets to help address the trade-offs between wood and non-wood values at the various planning scales.

(b) clearly articulate the objectives and targets of Fauna Habitat Zones in the Forest Management Plan.

(c) review the selection criteria for the Fauna Habitat Zones in the light of the above.

7. Providing for risks

The Panel examined a number of factors that posed potential hazards to the calculation of sustained yield and on ecologically sustainable forest management. These included:

- Fire
- Fungal disease (*Armillaria, P. cinnamomi*)
- Insect attack
- Immediate climate (frost, drought and waterlogging)
- Longer term climate change
- Salinity
- Forest area loss and conversion
- Management practice and implementation
- Data uncertainty

The Panel concluded that, with the exception of two matters that are the subject of recommendations to reduce risks, the residual risks posed by these hazards were low and well catered for by the systematic conservatism inherent in the calculation of sustained yield and ongoing monitoring.

Recommendation 5.

Further refinement of the expected scheduling of jarrah regrowth thinning should be undertaken during the period of the Plan by the Department of Conservation and Land Management.

Any proposals for significant changes in zoning or operational guidelines that affect harvestable areas must be accompanied by a re-estimation of sustained yield by the Department of Conservation and Land Management to allow evaluation of impacts on ecologically sustainable forest management values.

8. Scheduling and management of logging

The Panel believes that the systems employed to simulate long-term woodflows (FORSCHED and its supporting systems) are appropriate and robust for the purposes of long term yield projection of jarrah and karri forests. The Panel has also investigated the operation of the systems and reviewed the derivation of the conversion factors. It is satisfied that the system produces adequate estimates of utilisable yield for the planning period.

The Panel is concerned that consideration is being given to letting contracts in which the annual cut is solely Grade 1 sawlog. There are concerns that some associated Grade 2 sawlog might be left on the forest floor. To the extent that this may occur, it constitutes a risk to the sustained yield in that monitoring of the actual cut for the period of the Plan could be inaccurate, relative to its definition. In short, more Grade 1 and 2 sawlog may effectively be being cut than would be apparent from records of sales.

The Panel believes that it may be preferable that all sawlog contracts be allocated and monitored on the basis of the volume to 200 mm top diameter combining Grade 1 and Grade 2 for the purposes of yield regulation and providing for all sawlog harvesting to be based on 'run-of-bush' i.e. harvesting all sawlog products from the forest in whatever ratio it occurs. Differential prices could still be applied for different log sizes and grades within that definition if required, but this change would remove an otherwise unrecognisable source of error in the regulatory system and assist transparency.

The Panel notes that there are many factors involved in ensuring that all utilisable yield is recovered from logging coupes. Waste at the coupe level could lead to pressure to extend harvesting areas to meet volume commitments, reducing long term sustainable yield. Forest Products Commission staff and the harvesting operatives play a key role. Ongoing development of the procedures and processes used to monitor utilisation and the effective conversion level is needed by Department of Conservation and Land Management and the Forest Products Commission to ensure waste is minimised. Comparison with pre-harvest forecasts of available volumes for an individual coupe can provide only a guide because these are generated from stratum wide data and cannot reflect the specific circumstances of each coupe. However, periodic data collected at the annual or three year level should be monitored by the Department of Conservation and Land Management and Conservation Commission as a basis for management and review.

Recommendation 6

Contracts let by the Forest Products Commission for the supply of sawlogs should be based on the volume to a 200mm top diameter, using current specifications to the lower limit of Grade 2. This will improve consistency and transparency of the level of removals against sustained yield calculations.

Within three years the Department of Conservation and Land Management should develop systems to monitor and report on differences between predicted yields and actual harvest volumes. These should be reported on annually.

9. Calculating sustained yields

The Panel used the scenario outlined in Appendix 15 of the Interim Proposed Forest Management Plan (which has come to be referred to as Scenario D) as the basic reference for the calculation of sustained yield (see Appendix 1 for detail).

The Panel examined the processes used in modelling and simulating sustained yield and concluded that they were robust. Provided the settings prescribed are appropriate to ecologically sustainable forest management, the Panel is confident that the calculation of sustained yield will be appropriate and sufficiently conservative for the purpose, given ongoing monitoring of conditions.

The Panel noted that the initial estimates of sustained yield for Scenario D had not been able to include the newly developed research and modelling of dieback spread and impact. The Panel regards this work as fundamental and would not be willing to confirm that any option would meet the criteria for ecologically sustainable forest management if it omitted this use of this modelling.

The Panel therefore examined a number of other options. These included an alternative definition of Fauna Habitat Zones, a variation to the proposed reservations that would provide access to regrowth and two-tiered forest within newly proposed reserves, the effect of shorter rotations, and delaying early thinning of jarrah regrowth. The Table which follows summarises the outcomes.

The Panel favours a scenario incorporating a combination of these options. Yield loss from dieback must

be incorporated. The Panel believes that much of the thinning of jarrah will be delayed unless the Government is prepared to subsidise it and hence the majority of this impact will be felt whatever other modifications are selected. Shorter rotations should be confined to the more productive jarrah forest (i.e. other than eastern jarrah). Only that regrowth and two-tiered forest in Dalgarup and parts of other newly proposed reserves that are readily accessible and of low conservation value should be included.

Local expertise is required to define this option in detail, so we cannot confirm the sustained yield for it. Nevertheless, it clearly represents a balance that meets almost all of the major underlying concerns and values. Almost every interest group will claim that it does not achieve its particular goals but the Panel would argue that, in aggregate, it is likely to achieve a higher level of social net benefit than any one of the preceding options or of those most favoured by individual interest groups. That is the essence of trade-offs at the whole-of-forest level.

The Panel is satisfied that ample marri resource exists to support a substantial cut of residual wood, if markets are available, and to supply current sawlog demands.

Table 9.1. Sustained yields for scenarios and detailed options.

Scenario / Option	Sustained yield (m3/y)	
	Jarrah	**Karri**
Scenario D*: Reference scenario		
D (a) No allowance for dieback spread	135,000	50,000
D (b) Allowing for dieback spread	116,000	50,000
D(c) Allowing for dieback spread, delayed thinnings	111,000	50,000
D (d) Allowing for dieback spread, shorter rotations	126,000	53,000
Panel Option 1:Alternative fauna habitat zones		
1(a) Allowing for dieback spread	126,000	52,000
1(b) Allowing for dieback spread, delayed thinnings	124,000	52,000
1(c) Allowing for dieback spread, shorter rotations	138,000	56,000
Panel Option 2: Access to regrowth/two-tiered areas		
2(a) Allowing for dieback spread	139,000	74,000
2(b) Allowing for dieback spread, delayed thinnings	133,000	74,000
2(c) Allowing for dieback spread, shorter rotations	151,000	78,000

* Scenario D is defined in the Interim Proposed Forest Management Plan Appendix 15 and provided to the Panel as the basis for assessment.

The Panel re-iterates that it is confident that the table setting out the levels of sustained yield for various options is robust and the values are conservative. It is also confident of the system's flexibility and capacity to accommodate appropriately most major variations to those settings.

Each of the scenarios and options evaluated provide different levels of contribution to socio-economic values and biological conservation. The Panel is of the view that a combination of options 1 and 2 will meet both the biological and other components of ecologically sustainable forest management to a satisfactory level.

10. Other matters

Improving transparency

The Panel notes the considerable effort put in to improving transparency during the period of the period of development of the 2004-2013 Forest Management Plan and these are commended.

The Panel notes a strong emphasis on the reporting of audit results and other compliance measures and the objectives for a mid-term review and consequent reporting. Effective communication with the broader community is also needed on more general forestry performance in relation to progress toward achievement of Ecologically Sustainable Forest Management.

The Panel urges that new resources be found to support public education and dissemination (including peer-reviewed publication) programmes.

Relationship to Regional Forest Agreement

The Panel is concerned about how the Regional Forest Agreement relates to the Forest Management Plan given the establishment of the *Regional Forest Agreements Act 2002* and the consequential obligations resulting from the Western Australian Regional Forest Agreement. This concern results from how commitments made in the Regional Forest Agreement flow from international obligations through the Commonwealth legislation (*Environment Protection and Biodiversity Conservation Act 1999; Regional Forest Agreements Act 2002*) and national policy (National Forest Policy Statement) to the State's Forest Management System and in particular the Management Plan.

Western Australia agreed in the Regional Forest Agreement "to produce and publish a Forest Management Plan to implement the commitments of this Agreement" (Clause 43). The Commonwealth or other stakeholders may have concerns that the resource base for which sustained yield is calculated is not consistent with the resource base commitments of the Regional Forest Agreement, or that Western Australian forest policy is not consistent with the policy settings and commitments agreed to in the Regional Forest Agreement. This raises issues concerning the possibility of legally enforceable rights and obligations that are outside the expertise of the Panel.

Future determination of sustained yield

In the calculations of the sustained yield by the Department of Conservation and Land Management, the assumption is made that non-declining yield is pivotal to the long term sustainability of the forest. However, reliance on the control of sustained yield of sawlogs alone is a simplistic device when the intention is to sustain all values. There is no pre-emptive priority for wood over non-wood values or vice versa. There may need to be an initial array of varying and independent priorities set for all values in the form of individual structural goals. If a feasible and near-optimal solution cannot be found that satisfies all these initial structural goals then the nature of the subsequent trade-offs required between goals must become transparent. The present process obfuscates these trade-offs but cannot ultimately avoid them, as the present report shows. New approaches based on setting and managing toward structural goals and ecological management can be developed. The effect of this approach in forestry is to shift the emphasis to the sustainability of forest and landscape structure and values, and away from a reliance on non-declining yield of sawlogs as the primary regulator of sustainability.

The Panel is of the view that this new approach to the determination of sustained yield could result in greater benefits to both conservation and socio-economic values than does the rigid application of the current mechanisms. At the same time it would provide improved transparency of the mechanisms employed to achieve ecologically sustainable forest management.

The Panel recognises that such an approach would require more rigorous whole-of-forest and landscape level analyses, which would depend on data sets and approaches that need to be refined and expanded. This will take some time. Sufficient data are not likely to be available until prior to the next revision of the Forest Management Plan in 2014. Extensive consultation would also be necessary to build consensus to support the approach.

Recommendation 7

The Panel recommends that alternative approaches be developed to determine the sustainable yields of a range of forest values while maintaining critical elements of ecosystem function. This should incorporate direct approaches to maintain target forest structures, and should be investigated and subjected to thorough analysis during the life of the plan.

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1 INTRODUCTION

1.1 Background

This review had its origins in commitments contained in the report by Mr Mike Codd of January 1999 and the Regional Forest Agreement (RFA) of May 1999. The report by Mr Codd included the following statement:

> *"it is acknowledged that the RFA process will establish an expert panel to provide independent scientific advice on the provisional sustained yield figure consistent with the principles of ecologically sustainable forest management, and with appropriate provision for potential improvements in utilisation; with such a panel expected to take some 12 months to report"*

Clause 50 of the Regional Forest Agreement of May 1999 stated:

> *"The Commonwealth accredits the process described in An Appraisal of Methods and Data used by Department of Conservation and Land Management to Estimate Wood Resource Yields for the South-West RFA Region of Western Australia (Turner B.J., Department of Forestry, Australian National University, December 1997) and being used by Department of Conservation and Land Management in the calculation of Sustained Yield of wood products from the public native Forest and plantation estate on the understanding that the improvements recommended in that report will be addressed prior to the development of the next Forest Management Plan. Western Australia agrees that the methods and data to be used in the calculation of the Sustained Yield of wood products from the public native Forest and the Sustained Yield figures to be included in the Forest Management Plans will be reviewed by a panel of suitably qualified independent experts as part of the development of each Forest Management Plan under the Conservation and Land Management Act and improvements incorporated during the Forest Management Planning process. Western Australia confirms that its current standard of inventory will be maintained and yield and planning databases and systems, as amended by this Agreement, will be enhanced."*

The purpose of the so-called Stage 1 review completed in April 2001 (Ferguson et al., 2001a) was to fulfil the above requirements and to facilitate the development of the next Forest Management Plan.

A brief Stage 2 progress report (Ferguson et al., 2001b) dealt with progress relating to the calculation of sustained yield to September 2001. The Panel could not complete its terms of reference because a number of critical matters concerning areas of reserves and silvicultural guidelines had not been completed.

1.2 Terms of reference of current review

The terms of reference for this Stage 3[*] review require that

"The Panel will provide a written report to the Conservation Commission, based on the data, assumptions, methods and Interim Proposed Forest Management Plan as at a date specified by the Commission, that confirms whether:

The sustained yield levels calculated for defined forest types are consistent with:

1. Findings of the Stage 1 report and outcomes of the recommendations
2. The area of forest that is proposed to be available for timber harvesting
3. The practices that are to be used to provide timber harvesting for ecologically sustainable forest management, as set out in the draft Forest Management Plan, and
4. The data, assumptions and methods used, and
5. The calculations have been carried out objectively and in an operationally realistic manner."

[*] This report is the third produced by this Panel following the Stage 1 report completed in April 2001 (Ferguson et al., 2001a) and the progress report produced in September 2001 (Ferguson et al., 2001b).

1.3 Underpinning principles

As noted in the Stage 1 report (Ferguson et al. 2001a), the agreed principles of Ecologically Sustainable Forest Management set out in the Terms of Reference of the review are:

- *planning and management of forests should maintain the suite of forest values for present and future generations:*
- *maintain and enhance long-term multiple socio-economic benefits to meet the needs of societies;*
- *protect and maintain biological diversity;*
- *protect and maintain natural and cultural heritage;*
- *maintain the productive capacity and sustainability of forest ecosystems;*
- *maintain forest ecosystem health and vitality;*
- *protect soil and water resources;*
- *maintain forests' contribution to global carbon cycles; and*

(b) *planning and management of forests should be guided by the precautionary principle;* (Regional Forest Agreement: Attachment 5)

A discussion of these principles may be found in the Ecologically Sustainable Forest Management report of the Regional Forest Agreement. The precautionary principle is defined thus:

> "Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by
>
> I. careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment;
>
> II. an assessment of the risk-weighted consequences of various options."

The principles of Ecologically Sustainable Forest Management state that planning and management should maintain the full suite of forest values for future and present generations through a set of principles relating to the management of various of those values. Sustainability for future generations is clearly a key factor that addresses the equity of resource use between generations. Mention of the long-term multiple socio-economic benefits makes it clear that the review is not confined to commercial net benefits. All values or uses have to be considered in addressing both the equity and efficiency of sustainable resource use.

The role of the Panel is to try to ensure that management practices maintain or enhance particular forest values listed in the set of principles for Ecologically Sustainable Forest Management, so that the Conservation Commission and Government can then choose outcomes that make the totality of the social net benefits across the entire forest as high as possible. As is well-known, neither the available data nor analytical techniques are equal to solving this task analytically, and hence the use of a panel of experts, supplementing these endeavours with public input to identify areas of concern and possibly needing further action or change.

Sustainability has been defined as the capacity for continued productivity where the primary requirement is for site and soil protection and for adequate regeneration and protection and sustainable yield as the capacity to maintain relatively consistent levels of production or products over an extended period. In the case of Western Australia, the Conservation and Land Management Act 1984 refers to 'sustained yield' in exactly the same context as sustainable yield, and the Panel therefore uses the term 'sustained yield' to be consistent with the legislation and terms of reference, but noting that it regards its definition as being identical to that for sustainable yield.

The Conservation and Land Management Act 1984 explicitly states several goals for forest management in Western Australia that are broadly compatible with the principles of Ecologically Sustainable Forest Management. In its Stage 1 report, the Panel attempted to ensure that:

1. Goals and indicators for principles of Ecologically Sustainable Forest Management should be set for the 'whole of forest' (spatial scale).
2. Consideration of 'Sustainability' should involve a time frame longer than that covered by a Forest Management Plan (temporal scale). Some goals will not be achievable within that term but there will be indicators that can be used to assess progress towards those goals.
3. Setting of goals and indicators should recognise the precautionary principle.

1.4 Outcomes of previous reviews

This review builds on the earlier Stage 1 and Stage 2 progress reports (Ferguson et al., 2001a and b) and a review of maps and data (Ferguson, 2002), together with a number of other reviews carried out as part of the Regional Forest Agreement (Turner,1998) and development of the Forest Management Plan. Further reference to remaining issues will be made in the course of this review but suffice it to say for now that a great deal of progress has been made in addressing the recommendations arising from previous reviews.

The review also draws on comments received in public submissions on the Draft Forest Management Plan (Conservation Commission, 2002b). The number of submissions received (circa 5,700) suggests that forest issues continue to a high priority for many stakeholders.

1.5 Risk assessment and management

In considering application of the precautionary principle, the Panel paid particular attention to forest management processes and practices dealing with 'risk assessment' and 'risk management' to minimise environmental impacts and avoid serious or irreversible damage to the environment.

As noted in the Stage 1 report (Ferguson et al., 2001a) the guiding methodology for risk assessment and management was based on the Standards Australia and Standards New Zealand publication AS/NZS 4360:1999 *Risk Management.* This provides a well-established and systematic approach that is compatible with the Environmental Management System adopted in the Regional Forest Agreement process, having been developed "with the objectives of providing a generic framework for identification, analysis, assessment, treatment and monitoring of risk".

Some of the key terms are defined as follows:

Hazard: a source of potential harm or a situation with a potential to cause a loss.
Likelihood: used as a quantitative description of probability and frequency.
Risk: the chance of something happening that will have an impact on objectives.
Residual risk: the remaining levels of risk after treatment measures have been taken.

2 FOREST AREAS AND MAPS

2.1 Introduction

The area of forest available for timber production is clearly a critical component for any calculation of sustained yield. For the purposes of establishing this area, it is useful to distinguish between two categories of land which are no longer available for timber production - new or proposed 'formal reserves' and 'informal reserves'.

2.2 Formal reserves

The Government has determined that a number of areas are to be added to the formal reserves for conservation or other purposes that specifically exclude timber production. In addition, the Conservation Commission is recommending that certain other areas be placed in formal reserves because they have high conservation value or are valued for other reasons by local communities (Map 1 attached). The Government has not yet taken decisions on the latter. Although decisions have not yet been finalised on all of these proposals, all of the reserves indicated on Map 1 have been taken as the basis for determining the areas available for timber production under the proposal outlined in Appendix 15 of the Interim Proposed Forest Management Plan (known as Scenario D) and referred to for the options examined in this report.

2.3 Informal reserves

There are other informal reserves imbedded in the areas of forest outside the formal reserve system. These include specified travel routes, river and stream buffers and patches of old-growth forest outside formal reserves.

Informal reserves can generally be identified accurately on maps and taken into account in the identification of the areas available for timber production. The matter of differences between prescribed and field boundaries is taken up in a later section, but this issue is minor relative to the base area involved. Informal reserves have been recognised in the scheduling carried out in developing the various options in this report.

Scenario D of the Interim Proposed Forest Management Plan also includes a series of fauna habitat zones which although not designated as informal reserves, they have been excluded from the area available for timber production for period of the analysis.

The distribution of these reserves in shown for a part of the forest estate at a larger scale in Map 2 attached.

2.4 Stratification and maps

The area of forest available for timber production is mapped into various classes of vegetative cover using aerial photography and field assessment. The intention is to separate out types that are reasonably uniform in species, structure, silvicultural status and productivity class but different, one class from the other. The labels given to the classes are descriptive of the principal species, structural and productivity classes and this has given rise to some misunderstanding. The resultant mapping is not and cannot be perfectly accurate in terms of species or structures or productivity class. While resolution is continually improving, it is difficult to envisage that there will be the resources available to map attributes at increasingly fine scales and there will therefore always be some uncertainty at the scale of metres and hectares.

It would matter little if the strata were given non-descriptive and arbitrary labels such as A, B and C. They are a broad-scale planning device to improve the efficiency of the subsequent field sampling and to facilitate prescription of silvicultural treatment appropriate to the type. Provided the later sampling is objective, the mean estimates will reflect faithfully the average composition of the stratum in terms of species, and hence the differences between strata.

Errors in the labelling of particular areas of strata may therefore occur due to the effects of fire or pest attack on crown imagery or due to errors in historical records of previous harvests, or in the difficulties of interpreting particular characteristics from aerial photos. It is important to recognise that many of the categories are separated by ‘soft’ boundaries (for example some forest types) and that precise boundary identification is neither possible nor sensible. Where errors are discovered in the course of field work, changes are made to the official database under a well-established protocol and the dependent area data

are recalculated at the next revision of the database. The database is also revised prior to each run of the sustained yield model. Thus each current set of estimates is based on the best available set of data at the time.

The area of greatest sensitivity in the concerns expressed by the public is the incorrect labelling of some 'old-growth' patches of forest. This would mean that the area concerned is not shown as 'old-growth' and might therefore be denied the protection which the policy introduced by the present Government seeks to implement - namely to set aside from timber harvesting all areas of old-growth on land vested in the Conservation Commission.

This issue highlights the distinction between planning at a strategic level, which is the basis of the calculation of sustained yield, and operational planning and management on the ground. Operational planning requires tree-markers to note and implement Government policy relating to such patches, so they would be identified in the field regardless of the stratum label, and would be reserved from logging. There is, however, a contingent issue relating to the area of forest available for timber production because the patch of 'old-growth' forest missed in typing from photos now forms part of the productive area, whereas it should not. But there are also patches typed as 'old-growth' that are not old-growth and that need similarly to be corrected after due process from field checking. These errors tend to cancel and the issue is what the net effect is and what allowance is made for the net effect on sustained yield, matters which are taken up in a later section

The present stratification of the forest provides for a total of 263 strata defined by species, forest structure, harvest and silvicultural history, incorporating 39 geographical areas (Supply Cells) across the forest. They are confined to the net area of forest that is available for harvest. The stratification used for this review of sustained yield has been revised from that used in previous analyses. The current stratification places greater emphasis on geographical subdivision, recent silvicultural status and ensures that each strata is large enough to contain a reasonable number of inventory plots to improve the precision of estimate in each strata.

The pre-1980 regrowth karri forest has been re-stratified incorporating a new and improved estimation of site productivity and of stocking. The two-tiered karri forest available for timber production was re-stratified as part of the new inventory.

The Panel has conducted simple random checks on the capacity of the geographic information system (FMIS) to accurately reflect the areas of the various strata. Subject to the limitations imposed by the minimum size of approx 0.5 ha pixel and the shape of cell that can be identified by the system, the Panel is satisfied that the area estimation is accurate. (It is necessary to recognise that the source data for the GIS system may have been captured at a greater or lesser resolution that 0.5 hectares, depending on the attribute). The stratification is also sufficiently accurate and robust for calculating sustained yield and later reference is made to relevant allowances for errors. These errors are quite small in aggregate net effect. The risks associated with stratification and area estimation are very low, and the residual risks even lower.

Conclusions

The Panel noted the substantial number of concerns expressed about the stratification and mapping. It concludes that these reflect a widespread misconception of the basis and nature of the system. Corrections or queries about strata from stakeholders are to be welcomed and will be checked and amended, if appropriate. However, they have no significant effect on overall capacity of the system to properly and to accurately calculate sustained yield.

3 INVENTORY

3.1 Jarrah

The underlying inventory of standing volume that supports the determination of yield is based on a systematic sample of 12,248 photo plots that estimates species composition, stand density and height, from which an estimate of gross bole volume is derived. A systematic subset of 1227 plots is measured on the ground to provide detailed descriptions of each tree that can be used through a program known as IRIS to estimate product volumes. The relationships between the two sets of plots provide for improved sampling error.

The current jarrah inventory (photo and ground plots) was established in about 1990. Given that spatially explicit adjustments have been made for areas that have been harvested or removed from the net area available for this plan, the ten year old inventory represents a conservative approach but the Panel does not consider that this represents a significant source of error in the determination of sustained yield. Nevertheless, consideration will need to be given to the most appropriate form of inventory update for the next revision of the plan.

Stratum volume for each of the 210 jarrah strata is derived from the plots that fall within each of the strata. In estimating the yield that could be expected from these strata if they were harvested to different prescriptions, individual ground plot data are imported into the simulator SILVIA and the results of individual plot analysis is averaged, providing a more realistic simulation than that which would result from assuming a average stand structure for each stratum.

The result of the ground plot analysis is then adjusted according to the relationship that exists between the gross bole volume of the ground plots and the photo plots.

The final stage of the inventory is the adjustment that needs to be made to allow for the difference that may exist between the estimated product volume and the product volume that actually exists (the inventory bias), and the difference that exists between the actual product volume made available and the volume that is recovered in harvesting (the utilisation factor). The combination may be additive or compensatory. The level of the former is not necessarily important provided it is known and repeatable. The level of the latter indicates both normal and expected operational loss in realisation and in some cases, the potential for increased yield by improved recovery.

This stage of the inventory is based on the re-measurement of ground plots after the plot has been harvested. Because relatively few plots are harvested each year, it requires some years to acquire a sufficient sample on which to make reliable estimates. Sufficient data is now available to allow comparisons to be made with a reasonable degree of confidence. The present estimate is based on an analysis of 3319 trees from 123 plots harvested and remeasured since 1993. These data indicate that there was an overall difference between the inventory estimates and the operational recovery of sawlogs of minus 33%.(i.e. combined total of inventory bias and utilisation factor). This conversion factor is applied to the inventory based estimate to give an estimate of final sawlog yield outputs which is then used in the scheduling process. As noted above these data were derived during the period from 1993 to 2002 and capture operational experience over that time period. It is considered to be a conservative estimate considering the improvements to utilisation that are expected with a re-structured industry.

For future yields predicted from the growth model, downward adjustments of 30-70% have been made according to tree size and age and the type of operation. These are also likely to be conservative in the longer term as repeated thinnings improve the overall quality of the trees remaining, and technological changes are expected to improve the utilisation of smaller logs.

However it is also apparent that a single adjustment figure is unlikely to be equally applicable to all strata and tree size, nor will it continue to be appropriate with changing standards of utilisation.

Conclusions

The Panel considers that the design of the inventory system represents Australian best practice, and that with the adjustments described above, provide inventory estimates at an appropriate level of precision and confidence for strategic yield scheduling.

The Panel has been advised that the largest source of difference between the estimate and sawlog acceptance is in trees that are made available for harvest but are left standing, rather than the full utilisation of felled trees. This suggests that more attention is required to ensure that potentially suitable sawlog trees (albeit marginal) are felled and utilised.

The Panel also recommends that during the life of the Plan, greater emphasis is placed on increasing the

sampling framework for monitoring, and to extend the analysis to separate inventory bias from the utilisation factor. Given the expected changes to utilisation that will evolve with the re-structure of the industry and the time required to accumulate sufficient sampling we do not consider that adjustment to the yield is likely to be required before the next revision of the plan.

3.2 Karri

Since the Panel's Stage 1 report, the two-tiered karri forest available for harvesting has been re-mapped and stratified with up-to-date colour aerial photography into approximately 10 strata together with a further 30 regrowth strata. More than fifty ground plots in patches of forest over 5 ha in size were measured with full tree descriptions for analysis in IRIS, the system previously developed for the jarrah inventory system. Small areas unavailable for harvesting for operational reasons have been excluded from the net area, reducing the total volume estimated to be operationally available for harvesting.

Comparison of estimated volume and utilisable volume in mature karri forest under a clearfelling regime has been relatively straightforward since most trees are felled and utilised for one product or the other, and for areas where reliable comparisons were possible, sawlog removed were 34% less than estimated availability. This adjustment has been applied to the new estimates. Future adjustment for utilisation of sawlog from two-tiered forest will be done using utilisation monitoring plots established for the purpose.

Product volumes in regrowth stands are based on a ratio of the tree bole volume and are explicitly specified in KARSIM. The ratio is varied principally on the basis of size, with specific allowance made for defect such as butt damage due to Armillaria or excessive branching etc. An overall conversion factor of - 30% has been applied to the modelled estimates of sawlog with higher allowance made for younger stands and lower amounts for later operations.

Experience with the use of regrowth trees for a range of sawlog products that is envisaged under the re-structured industry is limited. A monitoring system that provides feed back on the utilisation of sawlogs from different sized regrowth trees with varying defect needs to be developed to inform the decision on adjustments to expected yield. This is likely to be very dynamic over the life of the plan as the new industry and new markets develop.

Conclusions

The Panel endorses the inventory system that is in place, and until more data is available, the Panel has no basis for suggesting variation to the current allowances while recognising that they are likely to be conservative.

3.3 Recommendation

Recommendation 1

In refining the inventory during the life of the Plan, greater emphasis should be placed by the Department of Conservation and Land Management on increasing the sampling framework for monitoring, and extending the analysis of monitoring data to separate inventory bias from the utilisation factor, in addition to updating the field sampling.

4 GROWTH

4.1 Jarrah

In its Stage 1 report the Panel recommended that research and development of a new growth model that reflected a wider array of silviculture and sites should be initiated during the next plan period. Considerable progress has already been made in this respect with the development of the growth model JARSIM.

Dieback-affected forest

The area of forest to which the dieback prescription is applied is initially based on known dieback occurrence and the assumed impact associated with Vegetation Complexes. For future harvesting different proportions of a stratum are assigned to a dieback prescription according to the proportion of the strata expected to be impacted by dieback at the estimated rate of spread at different times in the future. This varies the timing and nature of subsequent operations modelled by the FORSCHED scheduler because different growth rate estimates or prescriptions are assigned to areas according to predictions of dieback spread and impact.

Regrowth forest

For the purposes of calculating sustained yield, growth is allowed for on existing or future regrowth stands based on estimates derived from JARSIM. JARSIM represents a forest stand as a list of trees described in terms of species, diameter and bole height. The initial input lists of trees are based on inventory of more than 1000 plots covering the range of sites available. These individual trees are 'grown' on the basis of algorithms in the model. The 'grown-on' tree list can be input into the simulation model, SILVIA, where the appropriate silvicultural treatment is applied and resultant 'grown-on' tree list provides the base for the next simulation period. Different growth rates are applied according to a range of factors that include site, stand age, stocking, species mix, relative size of the 'tree', timing and intensity of thinning. Where appropriate, the final outcomes from the results are derived as the mean output of a range of plot conditions within a strata which is more realistic basis for estimate than assuming an average 'stand'.

Growth applied to regrowth stands is therefore derived from the growth model rather than by direct application of growth from permanent sample plots (growth plots), although data from those plots as well as from a range of thinning and inventory plots have been used in the development of the model. This approach makes it possible to estimate growth, or rather future stand condition, without the need for permanent growth plots that fully replicate those conditions . Total predicted growth is constrained to ensure that realistic levels of stand density are not exceeded. This limit to density is derived for a range of sites from an analysis of jarrah inventory plots. The model also provides for the influence on growth of retained habitat trees. This enabled the change in prescription from 4 to 6 retained habitat trees per hectare to be taken into account in a robust and appropriate manner.

Gross checks

To arrive at a level of confidence that might be placed on the growth estimates that have been used for the calculation of sustained yield the Mean Annual Increment (MAI) of the total volume production predicted from JARSIM over a 200 year 'rotation 'was compared with the Periodic Annual Increment (PAI) of total volume derived from 68 growth plots established across the jarrah forest at three levels of site quality. While acknowledging that this comparison has limitations it is nevertheless the best that is available. The MAI that was used for each of the site qualities in the regimes used in JARSIM varied from 55% to 85% of the mean PAI of the growth plots in those site qualities. In the Panel's view this level of conservatism is appropriate until more data is available.

A further check on the influence of growth estimates on the level of sustained yield was made by running a sensitivity analysis of varying growth rate. These were based on increasing both the variability of growth and by considering an increase or decrease in mean annual growth by up to 50%. This indicated that the impact on the yield of a regrowth stand over the whole rotation was somewhat less than the percentage change in growth rate i.e. a change of ± 25% in growth rate might result in a ± 20% change in volume yield. However because these regrowth stands will not make a significant contribution to sawlog yield for many years, the impact on wood flow would not be felt for at least 50 years and have little impact on the non-declining yield.

No growth is assumed on the existing two-tiered forest. The proportion of growth in the future standing volume of these stands before the anticipated time of harvest varies from relatively small compared to

estimates of standing volume to quite substantial in the case of strata not scheduled for logging until 50 years hence. This represents a very conservative approach and merits checking during the period of the Plan.

Conclusions

The Panel is therefore of the view that the growth estimates that have been used are appropriate for the estimation of sustained yield in this plan.
The precision of the output from the JARSIM model can be improved over time in several ways:

- As more data becomes available from younger stands over a greater range of sites as a basis for initialising the model;
- Improving the estimates of stand condition following thinning as a result of post thinning monitoring;
- Improving the understanding of forest dynamics by further research on the response to multiple thinnings;
- Reviewing the existing framework of growth plots and establishing new plots in stands that more closely represent the structure of future stands.

Significant improvement in the available data cannot be achieved for at least a decade and there is little value in further development of the growth model until that is available.

4.2 Karri

The approach used in the estimation of growth in the karri forest is similar to that in jarrah i.e. no growth is assumed for two tiered stands, and regrowth stands are assumed to grow and develop according to a growth model, KARSIM (Rayner, 1992).

KARSIM has been developed using data from a series of 214 even-aged plots across the range of sites in the karri forest ranging in age from 2 to 135 years old. Future stand condition predicted by the model is responsive to site quality, stocking, density, tree size and stand age.

Since the Panel's Stage 1 report, considerable progress has been made in the base data used to initialise the growth model. Almost all existing regrowth stands regenerated before about 1980 have been stratified according to site quality and stand density using a combination of aerial photography and ground plots. Different growth rates are applied on the basis of these strata. Younger regrowth will be stratified as they reach an age when site quality is reliably expressed (about 20 years of age). Until that time stands are estimated to fall into one of three site qualities.

Where full tree descriptors are available, future stand condition could be input to the simulation model, SILVIA, which predicts a thinning yield and provides an estimate of the tree size distribution for input back into KARSIM to be 'grown on'. Post-thinning stand density sampling contributes to the validation of these assumptions.

Conclusions

The Panel is of the view that growth and future stand condition has been estimated at a precision appropriate for sustained yield calculation with the expectation that the precision of the model will progressively improve as more data becomes available over time.

The predicted future stand condition and the expected condition following the simulated harvest are recorded for each simulation run providing satisfactory transparency of the assumptions made.

4.3 Recommendation

Recommendation 2

In refining the growth models over the life of the Plan, the Department of Conservation and Land Management should adopt a strategic approach and seek to obtain data from a broader range of ages and conditions as those opportunities become available. Major refinement of the growth models is therefore unlikely to be feasible until towards the end of the Plan period.

5 FOREST HEALTH

5.1 Introduction

In the Stage 1 report (Ferguson et al. 2001a) the Panel considered and made recommendations concerning the possible impact of various pests and diseases, which have subsequently been pursued or are in train. Of these, dieback was by far the most important.

5.2 Dieback disease

Dieback disease represents the most important hazard to future growth, the calculation of sustained yield, and biodiversity for the jarrah forest. With regard to the dieback hazard, the Panel made two recommendations :

(1) *Recommendation 4.3 Dieback from Ferguson et al. (2001a).* The key points of the Environmental Protection Authority advice on the Protocol for the identification and prioritisation for the management of *Phytophthora cinnamomi* "protectable areas" endorsed by the Minister should be implemented as soon as possible. (EPA 2001 Bulletin 1010)

(2) The impact of future infection should be taken into account by sensitivity testing in the simulation models, assuming variously (a) no spread and (b) the apparent past spread over the last decade for the various strata.

Partly as a response to Recommendation 4.3 (2), detailed research has been carried out by the Department of Conservation and Land Management staff (Strelein et al. in prep). They estimated rates of spread and intensity of the impact on growth. Data on the rate of autonomous spread were collected from some 50 existing disease boundaries selected from about 260 initial sample sites. The selected sites were restricted to those in which autonomous spread could be confidently and precisely identified over periods of 5 to 17 years. Records and ground truthing enabled mean annual rates of spread for 4 zones and for differing slope conditions within them to be measured. Data were analysed and a predictive algorithm for FMIS developed. These estimates have been used to model spread within impact classes throughout the South-west forests.

New maps of current and projected distribution of dieback (see Figure 5.1) presented to the Panel demonstrate the enormity of the problem and the hazard it presents to the critical values of the forest and associated ecosystems in both production forest and reserves. The work done in relation to the assessment of future impacts of the disease on sustained yield is a major advance with many important implications.

The work has resulted in a significant revision of the sustained yield calculations for the plan. The maps produced illustrate the large area where *P. cinnamomi* has, and will continue to impact on biodiversity and productivity.

Effects of dieback on sustained yield.

Allowances for the effects of dieback on yields have now been made based on projected future dieback spread and impact. Different categories of forest have been defined on the current or predicted disease status. The disease status changes according to the predictions of spread and impact over time and spatially.

- Infected or "unprotectable high impact" forest may be logged but a basal area of 15 m^2/ha of standing live trees (preferably resistant species) must be retained where possible. No future yield is projected off such areas.

- Infected areas where disease impact is moderate can be logged according to the standard jarrah harvesting prescriptions but future yields are discounted by 60%.

- For infected areas suffering only low impact, standard jarrah prescriptions may be applied with no provision for reductions to future yield.

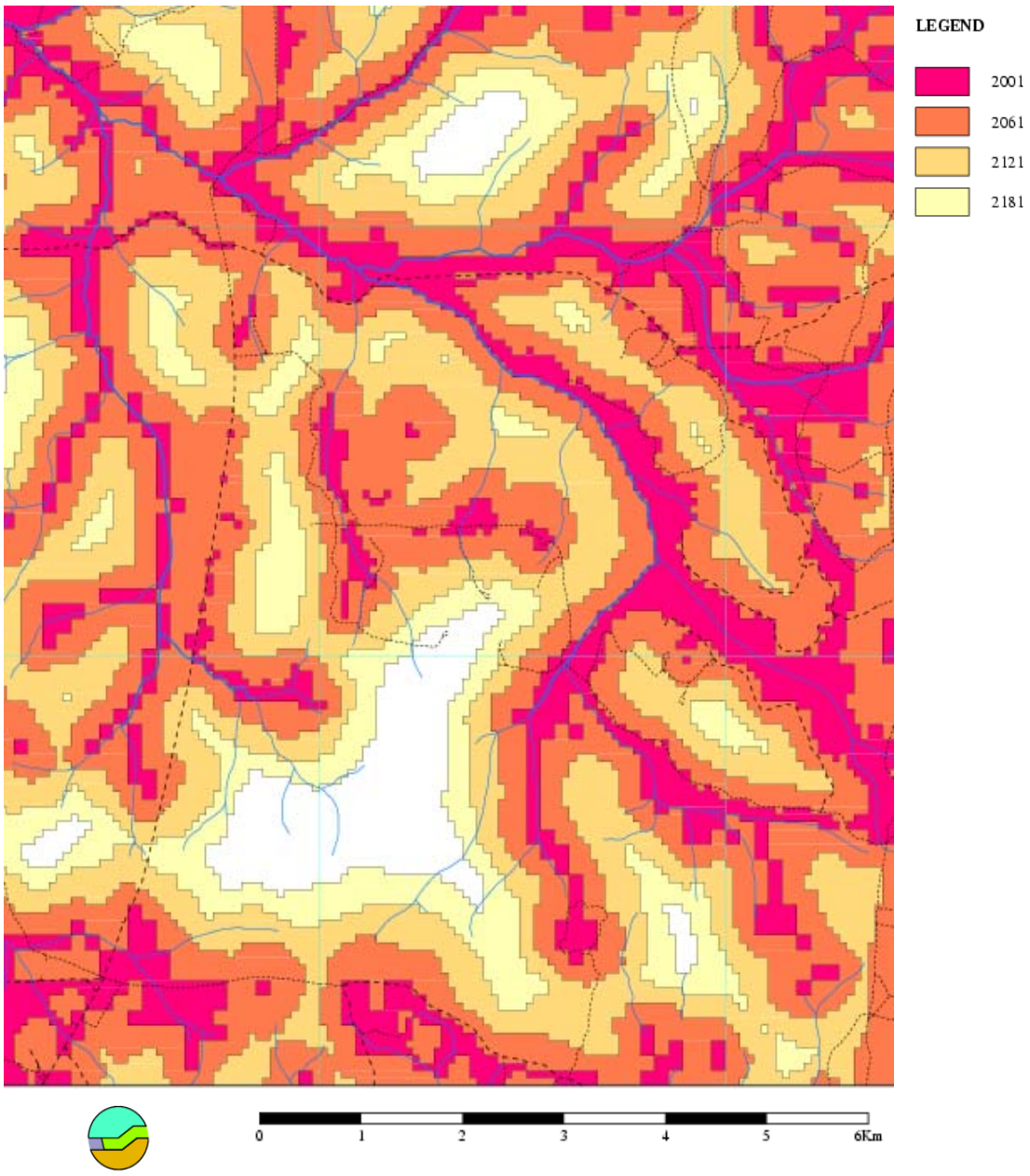

Figure 5.1 A map illustrating the simulated autonomous spread of dieback over time. The colours depict the modelled extent of dieback infestation at successive 60-year intervals. White areas remain free of autonomous dieback spread at 2181.

In the indicative simulation used for the sensitivity analysis, the projected extent of dieback in the jarrah forest available for timber production under Scenario D (b) (Table 9.1) increased over time from 14% in 2001 to 34% by 2061 and 46% by 2121 and 54% by 2181. The illustrative projected spread of dieback across vegetation complexes within the area of forest available for timber production used in the woodflow scheduling for Scenario D (b) is indicated in Table 5.1.

Table 5.1 Dieback spread and impact.

Year	High impact vegetation complexes		Moderate impact vegetation complexes		Other vegetation complexes	
	Area (ha) infested	% of net area scheduled for harvesting *	Area (ha) infested	% of net area scheduled for harvesting	Area (ha) infested	% of net area scheduled for harvesting
2001	48,300	6.2	58,800	7.6	13,500	1.7
2061	86,700	11.2	169,300	21.8	39,800	5.1
2121	108,200	13.9	235,200	30.2	59,200	7.6
2181	120,700	15.5	276,500	35.6	73,900	9.5

** The net area scheduled under Scenario D was 777,534 ha*

Recommendations of Environmental Protection Authority Bulletin 1010

Although interagency liaison on the implementation of the Bulletin 1010 still occurs, the Dieback Consultative Council now takes on a lead role in coordinating the implementation of the recommendations with Bulletin 1010 and developing a framework for the state-wide management of *P. cinnamomi.* Considerable progress has been made in a number of areas and the Dieback Consultative Council is progressing the scoping of an Environmental Protection Policy for the "Management of *P. cinnamomi* and disease caused by it (Dieback) in native vegetation in Western Australia". The Dieback Consultative Council, after consultation with key industry stakeholders, has also provided the Minister with advice on implementation of Recommendation 4 of the Western Australian Review Panel (Podger *et al.* 1996) which stated: *That industry, institutions and government agencies jointly address the extent to which operational schedules can be modified to ensure that activity on the protectable areas is focussed on minimising access during conditions which are conducive to dispersal of the pathogen and its establishment.* Many of the Dieback Consultative Council points of advice are relevant for the management of both non-timber production areas of the Plan area as well as production areas.

In addition it should also be noted that the Department of Conservation and Land Management is preparing an updated dieback policy for lands vested in the Conservation Commission.

In 2001 an expert working group was contracted to report to the Conservation Commission on the feasibility of designing a trial of the "Protocol for the identification and prioritisation for management of *Phytopthora cinnamomi* protectable areas as an experiment." It concluded that it was not feasible to have an experimental type trial to compare the previous hygiene system with that currently being used but the need for information on past rates of spread in different ecosystems was recognised.

Conclusions

For the jarrah forest over the period of the Plan, dieback must be considered the greatest natural hazard to biodiversity and a major risk to the health and vitality of a number of ecosystems

In view of the rapid progress by the Department of Conservation and Land Management in collating data on rate of spread, the recommendations of the Conservation Commission based on those of the expert working group may require updating or modification before they are forwarded to the Minister.

The maps of projected spread of *P. cinnamomi* will inform decision-making in a range of policy and management areas with respect to future impacts of dieback, not only on wood flows, but also biodiversity and ecosystem health and vitality. The methods developed have great potential in the definition of "protectable areas" and the setting of priorities for management in a range of ecosystems, regardless of tenure. The Panel identified a need for further commitments on dieback management, hence the mapping of infections, within the conservation estate.

The new simulation and mapping system also has the potential to be a powerful tool in demonstrating the effects of random infections on areas currently free of disease. This should be encouraged, as it is a useful way of demonstrating the consequence of poor hygiene on future spread. Best practice with regard to minimising dieback impacts is dependent on the use of this simulation and mapping system and its further refinement over time.

An earlier recommendation of the Environmental Protection Authority was that results of past monitoring of dieback spread and occurrence should be collated and made public. The Department of Conservation and Land Management now have material in a form that can be distributed following finalisation.

The findings and predictions of the Department of Conservation and Land Management research project should be used to assist in the implementation of a number of the recommendations stemming from Environmental Protection Authority Bulletin 1010 and related reviews. While much has been done in developing these for the management of the productive forest, they merit revision in the light of this new information. In addition, the Panel is especially concerned that little appears to have been done in developing management prescriptions specific to the conservation reserves concerned. In the light of this recent research, this represents a significant risk to biodiversity.

5.3 Recommendation

Recommendation 3

Department of Conservation and Land Management resources should ensure that disease status of 'uninfested' areas in both production and conservation areas is monitored adequately and reported separately for the production forest and reserves, with amendment of Key Performance Indicator 14 in the Interim Proposed Forest Management Plan accordingly.

The results of research relating to the spread and impact on jarrah growth of dieback should be

(i) promulgated in an appropriate form to the Western Australian community by the Department of Conservation and Land Management.

(ii) used to assist the implementation of Environmental Protection Authority and related recommendations on the management of the productive forest and especially on the management of conservation reserves.

The Department of Conservation and Land Management should ensure that the new dieback spread and impact models are further developed, especially to model the effects of random or new infections in areas of differing potential impact and that Objective 13 of the Interim Proposed Forest Management Plan be amended accordingly to incorporate the action.

6 SELECTING AND APPLYING SILVICULTURAL TREATMENTS

6.1 Introduction

Since the Panel's Stage 1 report (Ferguson et al. 2001a), the Department of Conservation and Land Management has developed and implemented a new computer-based silvicultural modelling system (SILVIA) to help estimate the likely yields from forest harvested to any specified silvicultural prescription and to quantify the variation arising from changes to silvicultural prescriptions. The prescriptions in the model are specified in a manner that as far as possible captures the prescribed Department of Conservation and Land Management Silvicultural Guidelines for the major species types (jarrah, karri and wandoo). The development of SILVIA is a response to the statement in our report "Yield estimates should be re-calculated whenever changes to silviculture are proposed so that changes to the yield are included in the evaluation of the proposal" (Ferguson et al. 2001a; p 44).

SILVIA accesses plot data in which individual trees have been measured and classified. Attributes such as species, size, sawlog presence, growth and silvicultural status, form, basal area, dominance and bole condition are available for applying tree-marking rules to a stand. All trees are flagged for their candidate status for tree marking (crop tree, habitat tree, potential crop tree, potential habitat tree, cull tree and/or diversity tree) based on individual trees attributes.

The new Silvicultural Guidelines have been translated into a series of sets of rules representing the treemarking rules for retention of basal area, habitat trees, crop trees, seed trees, and trees to be retained for species diversity purposes. These rule-sets are applied to the stand (as represented by an individual plot) to enable assessment of various silvicultural and management objectives (including the habitat tree prescriptions) and application of silvicultural regimes (eg. shelterwood, gap creation, selection, thinning, silvicultural treatment or clearing from mining).

SILVIA is then used to generate the expected yields associated with the harvesting of jarrah, karri and wandoo stands based on the various specified silvicultural prescriptions. The trees in the residual stand following the predicted harvesting are processed through the growth simulation packages to estimate growth. Predicted plot volumes in SILVIA are aggregated for the stratum and then used for scheduling.

6.2 Achieving balance

The Stage 1 report (Ferguson et al., 2001a) recognised that a deficiency in the planning process was that objectives were unclear or not evident, making it difficult to adequately evaluate balance or trade-off between competing values and the appropriateness of the balance between competing objectives. Trade-offs between values and objectives are important considerations as the Recommendations 3.4 Local reservation and exclusion tradeoffs, 3.12 Structural goals, 4.1 Whole of forest and landscape targets, 4.2 Fire management, 4.8 Bauxite mining sites in the Stage 1 report illustrate.

Burrows et al. (2001, 2002) also commented on this deficiency. They raised a major shortcoming of the present planning system being the lack of clearly articulated over-arching objectives to provide a framework for development of plans and associated guidelines. The overall planning framework, goals and objectives have to be understood as does the interrelationships between policies, agreements, contracts, plans, guidelines, prescriptions and codes of practice. This is necessary background to the consideration of trade-offs between wood and non-wood products. Further, Burrows *et al.* (2001,2002) proposed a new conceptual and planning framework that could assist in the delivery of ecologically sustainable forest management and achieving better integration of forest management.

Burrows et al. (2001) identify that clear objectives at various scales for forests are required to deliver ecologically sustainable forest management. They propose a cascading set of objectives. Hence for parcels of forests these cascading objectives should guide silvicultural decisions and management in balancing trade-offs between wood and non-wood products.

Explicit objectives are required in the Plan to allow operational decision-making processes to occur that will provide for transparent, repeatable and balanced decision-making for determining tradeoffs between wood and non-wood values, particularly in terms of timber production, non-wood product industries, biodiversity (habitat, fauna and flora values), recreation, water and aesthetics.

6.3 Fauna habitat objectives and structural goals

The Conservation and Land Management Act recognises the conservation of biodiversity (flora and fauna) as a key objective. The biodiversity principle is factored into the calculation of sustained yield through managing planning goals such as structural goals, netting down of area removed through biodiversity prescriptions (Fauna Habitat Zones), applying reductions to yield to accommodate the retention of habitat trees and conservation through the informal and formal reservation system.

The Interim Proposed Forest Management Plan has as its overall objectives for biological diversity: (i) to conserve biodiversity accounting for principles of Ecologically Sustainable Forest Management; (ii) the maintenance of self-sustaining populations of native species and communities and (iii) to ensure that biodiversity recovers between one rotation and the next (whole of forest and landscape objectives). These objectives are to be met through five sub-objectives using a sequence of strategies and actions.

A range of strategies and actions related to provision of fauna habitat (both spatially and temporally) in production forest are to be undertaken. Together the reserve system, logged forest, fauna habitat zones and habitat tree retention will contribute to the provision of overstorey and understorey vegetation structure through time and contribute to structural diversity and to meet landscape and whole of forest objectives. Fauna habitat zones are a mechanism to be put in place during the period of the plan to contribute to the recolonisation of logged areas and to help prevent fauna species populations declining to officially threatened status or declining to irretrievable low levels.

During the period of the Plan the following planning tasks are identified:

- goals will be developed for understorey structural diversity at landscape and operational scales that promote the maintenance of biodiversity (Action 6.A2)

- guidelines for the protection of understorey species in silvicultural operations are to be completed and incorporated into Silvicultural Guidelines (Action 6.A7)

- guidelines for the selection and management of fauna habitat zones are to be completed and incorporated into the Native Forest Timber Harvesting Planning Guidelines and the zones will be identified and implemented (Actions 7.A1-3)

- guidelines for the protection of selected habitat elements during timber harvesting are to be completed and incorporated into Silvicultural Guidelines (Action 7.A12)

Burrows et al. (2001) recognised that while difficult, given the inherent complexity of biodiversity through space and time and incomplete knowledge of biodiversity and disturbance ecology, the need for having clear conservation objectives is of key importance. The clear specification of objectives assists in setting silvicultural objectives and standards and making silvicultural decisions, determines sustained yield and determines the acceptability of environmental impact.

Fauna habitat zones and understorey species protection initiatives in the Plan result from Burrows *et al.* (2001, 2002). Their proposals were a response to a body of research arising from the consideration of Ministerial Condition 11 and met the requirements of the Stage 1 Recommendation 3.4. Burrows et al. (2002) specifically looked at the issue of habitat and biodiversity conservation with respect to jarrah silviculture. Two issues were identified of fundamental importance to biodiversity conservation in jarrah forests. The first issue was the "adequate provision of 'legacy' habitat components, such as large hollow-bearing trees, hollow logs and patches of structurally mature forest". The second issue was the "development of whole-of-forest objectives for spatial heterogeneity of forest structures and age classes" (Burrows *et al.* 2002: p. 11).

Clearly defined structural goals and objectives were identified as being important to the long-term continuity of mature forest patches providing refugia for fauna within forests subjected to harvesting. They identified that the adequate retention, distribution and ongoing availability of structurally mature forest is important for the long-term protection and conservation of fauna depending upon these habitat types. As a consequence they proposed a forest management unit scale conservation objective requiring that a proportion of the unit retained mature or old-growth overstorey structural characteristics or was within close proximity of forest with such characteristics.

Their report uses as an example of a reasonable measure to meet a forest patch conservation objective the retention of a target 200 ha per forest block for the retention of mature or old-growth overstorey structural characteristics (Burrows et al. 2002; option A). The basis for such a target is not documented. In their discussion of the management of habitat for arboreal and hollow dependent species and findings from the

Kingston study they report that there is good evidence for retaining a portion of the forest block as uncut, or with mature characteristics to provide refuges for faunal species requiring this type of habitat. The retention of these patches is useful for recolonisation by some species of surrounding forest subjected to disturbance. Using the Western Ringtail Possum as an indicator they proposed a minimum of 200 ha of retained mature (or old-growth) patches in a matrix of regrowth forest; such patches were preferably designed as continuous or connected (e.g. creek lines). Patches were to be developed through widening stream reserves and buffers, and linking riparian areas and known habitat areas. Regrowth areas could be inter-dispersed depending upon the dispersal capacity of threatened or vulnerable fauna species.

An alternative approach proposed by Burrows *et al.* ,2002; (option B) was to provide for a wider dispersal of mature forest characteristics by retaining mature trees at a density of about 10-15% crown cover in all forest that is more than 5 km from a reserve and where informal reserves constituted less than 20% of the forest block. Burrows et al. (2002) recognised that the retention of mature forests as refuges would have implications to wood supply. Bradshaw (2002) discusses the likely impact with respect to structural goals of the Burrows et al. (2002) proposals.

The requirement for Fauna Habitat Zones was supported following workshops held in February 2003. Support was based on the Kingston study highlighting the complexity between species sensitive to logging because of their association with forest habitats that display "mature characteristics" in the overstorey and understorey. Zones were seen as mitigating the risk that lack of full knowledge provides given the workshops general assessment that the level of knowledge of fauna was poor with the knowledge of invertebrates being less than that for vertebrates. The principle of zone selection should be flexible and there was general agreement that zones should be spread across the landscape sampling a broad range of habitats for a range of taxa and that habitat patches should not be restricted to mature overstorey. Views were expressed that the critical issues were for arboreal species in eastern forest and aquatic fauna in the western forest, while the southern forest was well represented by reserves.

Appendix 4 of the Interim Proposed Forest Management Plan provides the operational principles for incorporating fauna habitat zones into the Plan up until the guidelines for the selection and management of fauna habitat zones are developed and implemented. Zones are to be greater or equal to 200ha and located no more than 3 kilometres from conservation reserves, large informal reserves or other fauna habitat zones using specified decision rules. While zones can be rotated into regenerating forest over time zones are not to be logged. As a result the impact on the area statement in the rotation period would remain the same. Fire prescription to be applied is unclear and the possible increase in risk of fire as a result has not been incorporated into the assumptions.

The Panel accepts the objective that management should ensure that biodiversity recovers between one rotation and the next at the landscape scale and that an appropriate representation of mature habitat elements will be required across the landscape to achieve this. Difficulty in planning and management of these Zones will result from the absence of clear objectives or targets, the wide range of views on the purpose of the Zones and rationale for excluding logging, the wide range of proposed selection criteria in determining Zones and an absence of any evaluation of an appropriate landscape unit on which to base these habitat elements. The Panel is of the view that these Zones should not be implemented until a more thorough justification and evaluation has been undertaken from the commencement of the Plan.

In providing for the risk to sustained yield that any increase in Fauna Habitat Zones may involve an allowance for retained habitat patches at the minimum rate of 200 ha per forest block, including existing mature habitat in informal reserves was made for our assessment of sustained yield (see option 1, Chapter 9).

Structural goals are an important element of the current Forest Management Plan. The goal is based upon a "natural' distribution of forest structures that accommodate ecological principles and maintain a suite of structural values across the forest estate. These goals are seen as important means to manage biodiversity over a rotation period; an important consideration in the management planning process. They are also useful in balancing and planning structural attributes between those found in the reserve system and those in production forests. Fauna habitat zones, habitat tree prescriptions and the reserve system contribute to the structural goals. It is important to incorporate structural goals at a whole-of-forest and landscape level (Burrows et al. 2002). Goals should be described in the new management plan (see Stage 1 Recommendation 3.12)

6.4 Silvicultural prescriptions

Jarrah

The Draft Jarrah Silvicultural Guideline 1/02 (August 2002) builds on the Burrows (2001, 2002) reports and, with the exception of some matters relating to trade-offs, incorporates conservation objectives into the plan.

It is evident from Appendix 5 of the Interim Proposed Forest Management Plan that the advice of the Burrows Panel has been accepted and many modifications to the jarrah guideline made. Effort has been made to reduce the impact of silvicultural operations on flora diversity and abundance with a range of measures relating to post harvest operations. Habitat requirements have been explored in a number of ways with a number of specific changes incorporated into the current guidelines.

Salinity

With regard to measures to ensure that the levels of tree removal do not result in increased salinity in streams emanating in the intermediate rainfall zone the conclusion of the Burrows Panel is endorsed by the Panel. They found "no basis by way of new evidence for changing" the measures that have been current during the last decade but noted that new data may become available from a major current catchment study under-way in the northern jarrah forest. This is an important area of research and as funds permit the program should be expanded incorporate monitoring of aquatic biota for reasons outlined in Burrows et al. (2002) Panel report.

Water quality

An objective of the plan is to sustain water quality for biodiversity and consumptive uses. The Panel is aware that there has been considerable discussion during plan development based on a report from the Waters and Rivers Commission (2001). The outcome for the plan was that the current system of informal reserves on streams was to be maintained but reviewed as outlined in the Interim Proposed Forest Management Plan as part of adaptive management. A number of guidelines for the management and maintenance of the stream-zone informal reserves, will also be reviewed during the first half of the plan. A program for any change will be reported in the mid-term review of the Plan. The Panel was satisfied with this approach and considered that this flexibility did not present a risk to sustained yield based on the current allowances. Major increases of stream zone informal reserves are not envisaged.

Regeneration

Many modifications to the guidelines have been made to ensure jarrah is regenerated to satisfactory standards across a range of sites and zones. Planned actions to address all the specific recommendations with regard to regeneration, made in both the 2001 and 2002 reports by the Burrows committee have been tabulated in an internal report prepared by Department of Conservation and Land Management and have been incorporated into the strategies within the Plan.

Concerns about the regeneration adequacy of 'eastern forest' have been addressed in the Silvicultural Guidelines by re-evaluating the acceptable stocking standards and shifting the emphasis to the management of coppice regeneration, a more reliable form of regeneration in this environment. In addition a field survey of regeneration in the eastern zone forest has commenced recently. The strategy is to survey a number of attributes from a representative sample of eastern jarrah forest recently harvested and treated to the shelterwood objective. The objectives of the survey are five fold and will generate useful information on both form and stocking and levels of various stages of regeneration. One of the objectives of the survey is to determine the effects of timber harvesting, overstorey competition, soil disturbance and fire intensity on establishment of new regeneration.

Initial analysis of data from a very limited number of sites indicates considerable variation in results but does not raise any concerns with regard to the maintenance of ecologically sustainable forest management key values in the zone.

This data will inform future decisions on the management of eastern forest, but the Panel is of the view that there is a low risk that any further changes will be required to the jarrah guidelines for the management of the eastern zone jarrah that would impact on sustained yield in the long term.

Research

A commitment to the forest-monitoring program FORESTCHECK has also been made after the review of the program initiated by the Burrows committee. Views of scientists external to the Department of Conservation and Land Management were sought during the review and first results of the monitoring

have now been collated. Burrows et al. 2002 also summarised high priority forest research needed to underpin ecologically sustainable forest management in the jarrah forest. Existing research programmes already cover a number of the topics.

The Panel concluded that there has been a thorough review of the jarrah guidelines giving appropriate attention to regeneration adequacy, the maintenance of flora diversity and fauna habitat.

Karri

Key changes to the karri guidelines are listed in the Interim Proposed Forest Management Plan Appendix 5. As many issues relating to the management of karri regrowth were considered in 1999 by the Ministerial Advisory Group (Ferguson et al. 1999), further independent review of the karri guidelines has not been necessary. Recommendations from the Ministerial Advisory Group have been incorporated into the karri guidelines. Limitations to the size of clear fell patches are applied. They are 20 hectares for regrowth forest and 40 hectares for two-tiered forest.

There are changes to the Silvicultural Guidelines, which relate to the greater importance of the remaining two tiered forest contributing to the schedules and the recent dramatic increase in mature karri forest being reserved. The requirement for the retention of patches of mature forest every 400m became unnecessary following significant increases in the areas of formal and informal reserves and the implementation of the Fauna Habitat Zones.

Marri retention

Loss of markets for large marri have led to recent consideration as to how best to manage both jarrah and karri forest with a high proportion of marri. Excessive felling to waste is costly and aesthetically unappealing. Retention of marri can inhibit regeneration of both karri and jarrah and eventually impact on sustained yield. The guidelines have been revised such that if markets for certain sizes of marri are unavailable removals will be concentrated in areas where marri stocking is low. During the plan period current indications are that there may be markets for smaller rather than larger logs. Retained marri will contribute to habitat in areas of two tiered forest currently scheduled for logging.

Trade-offs

The Panel is in agreement with Burrows et al. (2002) that the silvicultural system has to be viewed within a broader ecological base to deliver ecologically sustainable forest management. Silvicultural guidelines need to be able to cater for non-wood values to enable appropriate silvicultural decisions to be made. Silvicultural decisions and practices can greatly change the forest structural and floral composition spatially and through time resulting in differential supply of ecosystem services and products (including water and biodiversity) through time. It is important that the Plan contain broader forest ecosystem objectives and guidelines that inform silvicultural decisions. Ecologically sustainable forest management is fundamentally about protecting the ecological integrity (biodiversity, health and productivity) of forest ecosystems while sustaining a supply of products and services to the community (Burrows et al. 2002).

The Panel believes that the current interim proposed plan still lacks (see Stage 1 Recommendation 4.1) clear objectives that enable trade-off decisions to be made in the context of forests at a whole-of-forest, landscape, forest patch (block) and coupe scales. Such objectives are required for looking at consequential impacts on wood and non-wood values and the potential effects on sustained yield. Hence the Panel recommends that the Conservation Commission provide explicit whole-of-forest and landscape objectives and targets that address these trade-offs during the period of the plan.

Fauna habitat zones and structural goals

The Plan needs to clearly articulate the objectives, role and purpose of Fauna Habitat Zones, as they are currently unclear in the Interim Proposed Plan. The Panel understands that the purpose of the zones is to assist species to recolonise adjacent regrowth forest as well as maintaining throughout the forest fauna that depend on forest habitat characteristics that may be adversely affected by forest operations. Hence Zones have a complementary purpose to forest set aside in formal and informal reserves.

These Zones may be placed on longer rotations or subjected to conservative logging with the objective of managing primarily for faunal habitat characteristics while allowing the removal of sawlog as a secondary objective. With appropriate training of Conservation and Land Management and Forests Products Commission staff and clear specification of objectives these forests could be managed for both fauna habitat and/or understorey flora and sawlog, so fulfilling Objective 7 of the Interim Proposed Plan.

The long-term objectives for sustained yield are determined by the objectives set through structural goals.

This issue is further discussed in Chapter 10. Structural goals determine the pattern of timber harvesting over the period of the plan. These goals need to be enunciated in the Plan.

Silvicultural prescriptions

The Panel concluded that there has been a thorough review of the jarrah guidelines giving appropriate attention to regeneration adequacy, the maintenance of flora diversity and fauna habitat.

With regard to measures to ensure that the levels of tree removal do not result in increased salinity in streams emanating in the intermediate rainfall zone the conclusion of the Burrows Panel is endorsed by the Panel. Burrows et al. (2002) found "no basis by way of new evidence for changing" the measures that have been current during the last decade but noted that new data may become available from a major current catchment study under-way in the northern jarrah forest. The residual risk to sustained yield is low of further changes being required to the jarrah Silvicultural Guidelines for the management of the eastern zone jarrah, which may impact on sustained yield in the long term.

Similarly the Silvicultural Guidelines for karri are well developed and the residual risk to sustained yield of further changes is low.

The risk to sustained yield through marri being retained due to a future lack of markets has been directly incorporated into the woodflow scheduling.

Conclusions

The Panel notes that the predicted verses actual outcomes of silvicultural treatments will be closely monitored for the period of the plan and recorded in the silvicultural information system, SILREC. Consistent differences between the estimated and actual estimates would have long term consequences to the projection of sustained yield and hence future adjustments may be required resulting from such monitoring.

The Panel is of the view that the proposed Fauna Habitat Zones should not be implemented until a more thorough justification and evaluation has been undertaken.

6.5 Recommendation

Recommendation 4

The Conservation Commission should

(a) provide explicit whole-of-forest and landscape objectives and targets to help address the trade-offs between wood and non-wood values at the various planning scales.

(b) clearly articulate the objectives and targets of Fauna Habitat Zones in the Forest Management Plan.

(c) review the selection criteria for the Fauna Habitat Zones in the light of the above.

7 PROVIDING FOR RISKS

Introduction

A wide range of future natural and human induced events and broader environmental, economic or social changes will have an impact on the forest and its ability to yield forest products and services in the long term. Some of these will, or have potential to cause large impacts or change, some leading to reductions in the yields of timber (or other products).

A range of factors have been evaluated as risks to the estimation or realisation of timber yields in relation to the Interim Proposed Forest Management Plan by the Department of Conservation and Land Management. Information was presented to the Panel by the Department of Conservation and Land Management staff covering evaluation and where relevant, adjustment methodologies and quantities for:

1. Fire
2. Fungal disease (*Armillaria, P. cinnamomi*)
3. Insect attack
4. Immediate climate (frost, drought and waterlogging)
5. Longer term climate change
6. Salinity
7. Forest area loss and conversion
8. Management practice and implementation
9. Data uncertainty

7.1 Fire

The Department of Conservation and Land Management was previously requested by the Panel to investigate the potential impacts of fire on the young even-aged karri resource (Ferguson et al., 2001a). Fire losses for other forest types (jarrah and older karri) are considered (a) to be captured by the routine inventory procedures, and (b) volume loss is limited because salvage log recovery is feasible, if needed.

Information presented by the Department of Conservation and Land Management suggested that stands are at risk of complete timber loss (no recovery) between the ages of 10 and 30 years. After this age, log material was assumed to be recovered. An analysis of fire probability and magnitude was undertaken by CALM Science and Forest Management Branch of the Department of Conservation and Land Management to fulfil this request. Analysis of previous records indicated an average loss of 1.7% over the last 12 years. Simulations of wildfire spread from single events under relevant 95 percentile weather conditions indicated average fire sizes of approximately 640 ha in karri regrowth.

The Karri Silvicultural Guidelines provide guidance for the silvicultural response to wildfire damage for stands of different age and condition.

An area loss factor of 3.4% of young even-aged karri regrowth for the period of stand growth between the ages of 10 and 30 years was used in the sustained yield calculations.

The Panel supports the approach and the fire risk setting for karri regrowth.

7.2 Disease

Reference has already been made to the prediction of dieback spread and impact. The impacts of these predicted spread patterns on sustained yield were then assessed by running the FORSCHED system with the revised dieback data.

The Panel supports the approach employed. A valuable new analytical tool has been developed. While further research is recommended to better establish rates of spread of dieback, and to enhance predictive modelling, the work already undertaken provides a valuable insight into likely impacts.

Armillaria is a significant naturally occurring fungal disease in Western Australian karri forest. The risk of Armillaria induced mortality in regrowth forests increases with every operation that leaves stumps and roots in place. The incidence of karri mortality post-thinning will be monitored. Impacts are assumed to already be present in the inventory and growth plot data and allowance is made for the realisable yield predictions. At the management level, a small group of specific “high risk” stands have been identified and deliberately deferred from thinning to allow the results of monitoring to be assessed.

The Panel supports the approach.

7.3 Insects

Insect attack from *Phoracantha acanthocera* (bullseye borer), *Uraba lugens* (Skeletoniser) and *Perthida glyphopa* (Jarrah Leaf Miner) are of importance. Allowance for *bullseye borer* is incorporated through the identification of infected area and a modified allocation of log products from that area. No increase in extent is assumed for the purpose of this plan. Incidence of Jarrah Leaf Miner is assumed to continue at low background levels already incorporated in growth and inventory data. No escalation of attack is assumed in the Plan but monitoring of the disease will need to be continued.

The Panel supports the approach adopted.

7.4 Immediate climate

Forest growth is affected by immediate climate i.e. frost, drought and, in some areas by waterlogging.

Past impacts from these sources are assumed to be already captured in inventory and growth plot data. It is assumed that these factors will maintain the same level of effect for the period of the Plan. Potential impacts of long term climate change are discussed below in Section 7.8. The Panel supports the approach adopted.

7.5 Salinity

Information provided by the Department of Conservation and Land Management is that stands whose management might contribute to increased salinity in catchments are actively managed to special prescriptions. The Interim Proposed Forest Management Plan includes objectives and performance targets covering monitoring of in-stream salinity levels for a number of catchments.

The silvicultural practice requires retention of a higher forest density than standard and in some areas, increased in stream zones. This modified silviculture will result in reduced yield and the buffer extension results in lost production area.

This effect is automatically captured in FORSCHED by the assignment of relevant areas to modified yield regimes, and adjustment to the net available area data.

The Panel supports the approach taken.

7.6 Silvicultural practice

The sustained yield projected by the Department of Conservation and Land Management wood-flow modelling systems assumes that silvicultural practice will be implemented according to the specified schedule. Failure to implement expected silviculture arises in two main areas.

Variation from prescription

Variation from prescription in near-term harvesting cycles (i.e. failure to remove stems that should have been harvested according to the guidelines) might result in different immediate yield and potentially reduced long term growth. This risk is addressed in the yield estimation procedure through (a) reliance on recovery and utilisation rates derived from field experience, and (b) growth projected from the long term inventory data which should capture past actual performance. The future risk is addressed under Department of Conservation and Land Management/Forest Products Commission procedures though harvest planning and monitoring and is intended to be overseen by audit. The Panel believes the residual risk is small.

Failure to implement scheduled follow-up silviculture.

In developing all options, the Department of Conservation and Land Management has stressed the importance of thinning and especially the potential effects on sawlog yield that delay in thinning of jarrah regrowth would have.

The Panel has no reservations about the importance of timely thinning in karri because this produces a viable commercial return and is already in progress. Delays to this work do represent a moderate risk to the karri sustained yield but possible delays to first thinnings in the regrowth karri have already been factored into the yield regimes across site qualities. The projected sawlog woodflows therefore already accommodate part of this risk. As well, the self-thinning nature of karri mitigates against major impacts arising from delays in subsequent thinnings.

However, non-commercial thinning of jarrah regrowth at about 20 and 50 years is not considered economically viable from the viewpoint of return on investment from wood products alone. Under such

an analysis incurring a cost of about $150/ha for each of the non-commercial thinnings represents a significant investment that cannot be adequately recouped from later commercial thinning revenues, nor from the sale of the final crop at any realistic stumpage price. This means that these early thinnings will only be economically viable if there is substantial revenue from firewood, woodchips or similar utilisation, or if significant economic value can be imputed to them from the additional water yields generated. This may be true of some areas but is unlikely to prevail for most areas in the period of the Plan and will hinge on utilisation of residual wood or the willingness of the water authorities and Government to fund the thinning in the interests of water production.

7.7 Loss of productive forest area

There are ongoing losses of productive forest area to meet requirements of forest management such as internal roads, water points and gravel pits, landings etc. Potential yield is also lost through inability to access for harvesting for reasons of slope, temporary exclusion or discovered as being operationally infeasible during harvest plan preparation.

The historical pattern of area losses for this group of uses has been analysed by the Department of Conservation and Land Management. The analysis excludes mining because the past and future extent of mining is separately identified in the scheduling. Data indicate losses ranging from about 4.5% for jarrah to almost 10% for karri. The anticipated yield loss is allowed for by making a corresponding reduction in net productive area in the yield scheduling system.

The Panel concludes that the level established and method used to make allowance for the risk is reasonable.

There are also ongoing risks to sustainable yield through management initiated rezoning directly removing forest from the harvestable area or through changes to operational or planning guidelines that prevent harvesting access. Such actions automatically affect sustained yield. The Panel reviewed the outcomes of the recent review of the adequacy of streamside reserves and buffers (Waters and Rivers Commission 2001) with a view to establishing if there was a likely substantial impact on either the area available for harvesting, including any changes associated with dieback, or rates of growth, or other possible influences on the calculation of sustained yield. On balance, the Panel is of the view that the implementation of the outcomes of that review will have marginal influence on the calculation of sustained yield.

A number of adaptive management trials are proposed under the Plan and a number of Guidelines and planning procedural documents remain to be completed. Changes to effective harvestable area, intended to improve ecologically sustainable forest management are possible from any of these sources. The Plan outlines a procedure for amending the Plan leading to approval by the Minister. Impacts on sustained yield should be calculated whenever proposals involving significant alterations to accessible harvesting area are proposed.

7.8 Long term climate change

Possible impacts of climate change were identified in the Stage 1 report of the Panel (Ferguson et al., 2001). The Department of Conservation and Land Management have subsequently undertaken further investigation and made some exploratory simulations of possible impacts.

Reviews of the literature suggest that climate change could lead to a reduction in rainfall for South-west of Western Australia although the onset of such phenomena would be progressive over long periods. Reduction in rainfall is associated with reduced forest growth. Simulations were performed under scenarios of reduced growth and confirmed expected losses in sawlog and total log volumes. These would principally impact on yield in the second century. Nearer-term yield depends on current standing inventory and growth under current climatic conditions but long-term climatic changes would only affect regrowth forest because no future net increment was assumed for most cohorts in two-tiered jarrah and karri strata. There are other potential risks such as changes in disease patterns and possible increases in occurrence of periods of extreme fire weather and in climatic variability (eg. droughts).

The Panel concludes that while the issue is an important one adjustment for climate effects is not necessary in the current planning period. Actual forest growth should continue to be monitored as the basis for forest yield simulation and possible adjustment for what is anticipated to be slowly changing phenomena, to be considered at the time of the next plan (2014). A watching brief should be maintained on relevant areas of climate change science.

Conclusions

The Panel has reviewed the methods used and the level of allowances made for the listed range of hazards. The Department of Conservation and Land Management has evaluated prior experience in relation to losses associated with these risks and the allowances made and the methods used to make the adjustments are reasonable.

For several of the risk classes identified, the Panel has specific recommendations that should help in reducing future additional losses. Area Reduction: The Panel recommends that any proposals for significant changes in zoning or operational guidelines that affect harvestable areas must be accompanied by a re-estimation of sustained yield to allow evaluation of impacts on ESFM values.

Phoracantha: During the period of the Plan, on-going monitoring should be conducted across the thinnable karri regrowth estate to further assess the potential impact on yield and refine the allowance for yield reduction to be used in the future.

Climate Change: Actual forest growth should continue to be monitored as the basis for forest yield simulation and possible adjustment for what is anticipated to be a slowly-changing phenomena. Data should be considered at the time of the next plan (2014). A watching brief should be maintained on relevant areas of climate change science.

7.9 Recommendation

Recommendation 5

Further refinement of the expected scheduling of jarrah regrowth thinning should be undertaken during the period of the Plan by the Department of Conservation and Land Management.

Any proposals for significant changes in zoning or operational guidelines that affect harvestable areas must be accompanied by a re-estimation of sustained yield by the Department of Conservation and Land Management to allow evaluation of impacts on ecologically sustainable forest management values.

8 SCHEDULING AND MANAGEMENT OF LOGGING

8.1 Yield forecasting

The woodflow scheduling model (FORSCHED) operates by simulating the yield that would flow over time if a particular harvesting and silvicultural regime (sequence of operations) is applied to a particular area of forest. The present stratification defines 263 strata according to species, site quality, forest structure, harvest and silvicultural history, incorporating 39 geographical areas (Supply Cells) across the forest. They are confined to the net area of forest that is available for harvest.

The type of harvest operation applied to each stratum, its timing and intensity can be varied to achieve a range of wood flow outcomes. In practice a range of 'standard' regimes, based on the Silvicultural Guidelines appropriate to the particular stand structure, condition, location and dieback status are applied and the timing of these operations is then adjusted to 'smooth' the yield as far as is possible within various constraints (particularly silvicultural requirements) and arrive at the level of non-declining yield. In general terms there are a number of harvesting operations that may be delayed to smooth the yield but there are fewer opportunities to bring the yield forward.

The basic regimes that are applied may be generalised as follows:

- A proportion of all strata within areas potentially available for bauxite mining are 'cleared' each year based on predicted mining rates (historical). These areas are assumed to be regenerated as even-aged stands and each of these stands then becomes a new 'stand' that is 'thinned' at appropriate times into the future, before final felling at rotation age. The growth rate that is assumed for these regenerating areas is currently based on the site quality of the stand as it was before mining. The intensity of thinning is that specified in the Silvicultural Guidelines.
- Strata that have been recently harvested to 'shelterwood' are scheduled for re-harvesting to a 'gap' at between 20 and 40 years after the shelterwood cut (to allow for regeneration establishment). These areas then become a new strata defined as regenerated, are 'grown on' according to their appropriate site quality, and are 'thinned' at regular intervals in the future to the standards specified in the Silvicultural Guidelines before gap creation with retained habitat is repeated at the end of the rotation, at which time they are 'regenerated' and the process repeated.
- The proportion of the jarrah two-tiered strata assumed to be thinned, harvested to a gap, shelterwood, selectively harvested or harvested to an 'eastern prescription' is estimated. The ratio is informed by past proportions, locality and the data derived from sample plots within the strata and by analysis in SILVIA. The proportion of the strata that will be harvested each year is determined by the initial period over which the strata is assigned to be harvested - initially based on the time from which significant volumes of sawlog will be available from regrowth forest. The date at which this initial harvest occurs fixes the periods for subsequent operations such as thinning, the second shelterwood cut or the return to Temporary Exclusion Areas.
- Existing even-aged stands are assigned to be thinned at a specified time to the density specified in the Silvicultural Guidelines. The initial harvest date sets in train the dates at which future thinnings vary according to site quality (i.e. growth rate).

Mention has already been made (Chapter 7) of the potential importance of thinning on the scheduling of logging and thus on sustained yield.

The nature, the timing and the yield from each stratum is explicitly recorded for each analysis. While relationships are complex, the basic operations applied to each strata are conceptually straightforward and the recorded assumptions are transparent. It is nevertheless essential that any yield scenario that is presented be accompanied by a summary of the key scheduling assumptions as well as those relating to the area base.

During the review the Panel had the opportunity to examine a number of strata and were able to track their development from underlying map data to their point of input to FORSCHED.

Although the new stratification includes spatial representation down to a silvicultural stratum within a Supply Cell, it is not of a sufficient resolution for detailed operational planning involving spatial adjacency issues. The schedules used in FORSCHED are therefore not fully spatial because they assume that operations are applied to a proportion of a stratum within a Supply Cell, and not to a spatially identified area within it. Hence the broad operational feasibility of these schedules is tested by simulating

logging operations over the Plan period in greater detail using a special and separate simulation program (IOPS).

8.2 Log yields

Concerns have been expressed that the estimation of log grade yields are inaccurate and that there will be substantial but unpredicted changes in the relative yields of different types of log from the forests to be cut in the planning period. The Panel notes that three forms of describing and controlling log yield are in use, (i) log grades, (ii) log description to diameter limit and (iii) whole bole volumes (being considered).

The details underpinning the system developed to predict log availability by grade and the procedures used to establish interrelationship between these measures have been investigated by the Panel.

Estimates of log yield by grade are made in two steps. In the first, the extensive systematic forest inventory database is interrogated for relevant plots located in the selected forest type and region. The IRIS system is used to process the individual tree data and log crosscutting rules to provide estimates of log availability to specified top diameters and defect limits. These are passed to the silvicultural analysis tool SILVIA which can estimate yield under defined silvicultural prescriptions. Sawlog volumes available by applying a 200mm Small End Diameter (SED) and a 300mm SED limit have been separately estimated . In a second step, a set of conversion factors is used to estimate the operationally realisable yield by grade. The conversion factors were established by the Department of Conservation and Land Management using measured field plots, from logging records and some expert judgement. These have been corroborated with longer term yield data. It must be emphasised that the system operates at the forest stratum and not individual coupe level.

The Panel has investigated the operation of the systems and reviewed the derivation of the conversion factors. It is satisfied that the system produces adequate estimates of utilisable yield for the planning period. However, there are some residual risks. If technologies and practices change or there are substantial changes in the acceptable grade descriptions, new conversion ratios would clearly be needed.

The Panel notes that from the viewpoint of yield estimation and control there are advantages to bole measures. We recommend that consideration be given to changing to a bole sawlog (i.e. to nominated top diameters) as a basis for yield estimation and control.

The Panel notes that there are many factors involved in ensuring that all economically recoverable yield is harvested from logging coupes. Waste at the coupe level could lead to pressure to extend harvesting areas to meet volume commitments, reducing long-term sustainable yield or conversely better utilisation would reduce the area to be harvested for the same volume. Forest Products Commission staff and the harvesting operatives play a key role. Ongoing development of the procedures and processes used to monitor utilisation and the effective conversion level is needed by the Department of Conservation and Land Management and the Forest Products Commission to ensure waste is minimised and planning predictions are accurate. Comparison with pre-harvest forecasts of available volumes for an individual coupe can provide only a guide because these are generated from stratum wide data and cannot reflect the specific circumstances of each coupe. Estimates of conversion factors were necessarily derived from past and recent operations. Periodic data needs to be collected across the range of coupes at the annual or three year level. These should be monitored by the Department and Commission as a basis for improved management and review.

8.3 Changes to log description

No scheduling will be workable if it is not viable for the industry purchasing the timber. Different species, log sizes and grades may have very different logging and processing requirements and economic implications. It is not possible for any planning model to reflect every variation but the current model is sufficiently robust in its capacity to be able to predict the outcomes of most of the major differences.

The planning model can separate the yields of jarrah and karri sawlogs in two sizes, to a 300 mm top diameter, and the additional volume above to a 200 mm top diameter. (The model is flexible and permits processing to be performed to any top diameter limit or product description.) As noted earlier, trials to test actual realised volumes against those estimated by the model indicate that they are sufficiently robust and accurate for the purposes of planning yield regulation and the three-year rolling logging plan.

Whole bole volume can also be estimated so that the additional volume beyond that of the volume to 200mm top diameter provides an estimate of the residual wood that might be commercially acceptable for uses other than sawing from the tops of trees felled for sawlogs.

There are proposals to change the basis of timber sale to whole bole measures. The Panel notes proposed

action 11.A6 in the Interim Proposed Forest Management Plan and recommends that additional work (if necessary) be undertaken to ensure both grade and whole bole measures are accurately predicted by the IRIS and SILVIA processing systems. The plot process currently employed by the Department of Conservation and Land Management provides a sound basis for ongoing development of these factors.

The Panel is concerned that consideration is being given to letting contracts in which the annual cut is solely Grade 1 sawlog. There are concerns that some associated Grade 2 sawlog might be left on the forest floor. To the extent that this may occur, it constitutes a risk to the sustained yield in that the monitoring of the actual cut for the period of the Plan could be inaccurate, relative to its definition. In short, more Grade 1 and 2 sawlog may effectively be being cut than would be apparent from records of sales.

The Panel believes that it may be preferable that all sawlog contracts be allocated and monitored on the basis of the volume to 200 mm top diameter combining Grade 1 and Grade 2 for the purposes of yield regulation and providing for all sawlog harvesting to be based on 'run-of-bush' i.e. harvesting all sawlog products from the forest in whatever ratio it occurs. Differential prices could still be applied for different log sizes and grades within that definition if required, but it would remove an otherwise unrecognisable source of error in the regulatory system and assist transparency.

For marri, no solution has yet been found to enable reliable estimation of sawlog volume because of the difficulties of estimating internal defect and the changing nature of what defines a marri sawlog. However, whole bole volume is available and very crude estimates from field operations indicate that there is no problem is sustaining current demands, both sawlog and other.

For wandoo and other species such as blackbutt, estimates of sawlog volumes are available similar to those for jarrah. No attempt is made to estimate the sustained yield as they are too small to be specifically regulated on this basis and generally occur in coupes that are predominantly jarrah. Thus the choice of silviculture and scheduling is regulated by the silvicultural and other settings used or determined for the jarrah forest types in the case of blackbutt or by the wandoo Silvicultural Guidelines.

8.4 Minimum viable logging volumes

When the volumes to be logged from an area fall below a certain level, the operation can become uneconomic because the costs of getting the logs to the landing and to the mill are too high. The viable level varies with factors such as proximity to mill, terrain, distribution of the trees to be logged (clumped versus individual trees), average log size, whether other products are being removed (e.g. commercial firewood) and the type of harvesting machinery available. As far as possible, those areas that have clear limitations because of low volumes and rocky or steep terrain have been removed from consideration as being inoperable. The Forest Products Commission has indicated that future harvesting contracts will include the requirement to harvest all areas to a minimum volume of 5 m^3/ha grade 1 and 2 sawlogs. SILVIA has been used to estimate the proportion of each strata that would have a total standing sawlog volume below this threshold and this area has been excluded from harvest scheduling.

The Panel is satisfied that the allowances made for minimum viable volume per hectare are appropriate and that the residual risk to sustained yield is small.

Conclusions

The Panel believes that the systems employed to simulate long-term woodflows (FORSCHED and its supporting systems) are appropriate and robust for the purposes of long term yield projection of jarrah and karri forests.

The Panel has investigated the operation of the systems and reviewed the derivation of the conversion factors. It is satisfied that the system produces adequate estimates of utilisable yield for the planning period.

The Panel notes that there are many factors involved in ensuring that all economically recoverable yield is harvested from logging coupes. Ongoing development of the procedures and processes used to monitor utilisation and the effective conversion level is needed. Periodic data needs to be collected across the range of coupes at the annual or three year level. These should be monitored by the Department and the Forest Products Commission as a basis for improved management and review.

The Panel is satisfied that the allowances made for minimum viable volume per hectare are appropriate and that the residual risk to sustained yield is small.

8.5 Recommendation

Recommendation 6.

Contracts let by the Forest Products Commission for the supply of sawlogs should be based on the volume to a 200mm top diameter, using current specifications to the lower limit of Grade 2. This will improve consistency and transparency of the level of removals against sustained yield calculations..

Within three years the Department of Conservation and Land Management should develop systems to monitor and report on differences between predicted yields and actual harvest volumes. These should be reported on annually.

9 CALCULATING SUSTAINED YIELDS

9.1 Introduction

The notion of sustained yield has wide appeal and support but little understanding of what is entailed. Surprisingly to some, it has analogies to a superannuation or pension account in that the notion of controlling the yield is to moderate and spread the use of the capital to enable the income to be maintained. Indeed, if the superannuation fund was required to pass on capital to the next generation and to sustain income over all future generations, the analogy would be still closer.

The principal difference is that a highly capitalised (i.e. predominantly old) forest grows only slowly, whereas a somewhat lowly capitalised (i.e. younger) forest grows much more rapidly. Very young forest, on the other hand, grows slowly in terms of the rate of increase in product volume although the rate increases rapidly as the forest ages up to some maximum, after which it declines. If timber production were the only goal, sustained yield would simply be about selecting the rotation length which achieved the highest social net benefit, based on that goal.

But timber production is not the only goal in the State forests and timber reserves of Western Australia. Other forest uses contribute to social net benefit and cause us to modify that solution so as to recognise and maintain those other values, not necessarily in their current form and extent, but in a form that is capable of returning to a similar or better condition over the rotation chosen. Much of the preceding review of selecting and applying silvicultural treatments is about giving recognition to those trade-offs on the ground in a particular forest type.

There are also spatial concerns as to where the income and/or capital is to come from at a particular point in time - this means that scheduling of logging and thinning needs to be moderated spatially, taking account of species, forest structures and site productivities, and while endeavouring to reduce fire, pest, soil and water risks. Spatial scheduling at the Regional (Swan, South West and Warren) and whole of forest levels is therefore required.

9.2 Sustained yield

The sustained yield is calculated by simulating the silvicultural and logging operations on a partly-spatial basis. The planning model is large and complex and has been refined and, as noted earlier, has been improved in a number of aspects since the Stage 1 report (Ferguson et al., 2001a). For a particular set of silvicultural and other options, the planning model enables the predicted values of sawlog and other volumes to be predicted over time.

Under the CALM Act, timber production from State Forest is required to be managed on a sustained yield basis. The Interim Proposed Forest Management Plan interprets sustained yield as ‘non-declining yield of sawlogs’ i.e. the sustained yield is not higher than the average level of wood flow estimated over a predefined period. In the case of the analysis for the jarrah forest, a common period to 2140 was adopted. This was based on the period before which major increase in yield will occur from existing regrowth stands (Figure 9.1). A similar approach was followed for karri although the defined period was shorter. To facilitate sensitivity testing the same two periods were used for all analyses.

An iterative process is involved because there are minor variations to the options that can be changed to shift short-term peaks to fill in part or in whole, short-term gaps. For example, logging of a particular area in advance of bauxite mining can be shifted in time to bring it forward (but not deferred) and so fill a gap in the pattern of annual volumes otherwise available. Alternatively some thinnings may be deferred but there are limitations to bringing them forward. The capacity to make such changes to rectify short term gaps is limited in the time profile and there are fewer opportunities to advance the yield than to defer it.

In all cases, the initial reference option was that specified in Appendix 15 of the Conservation Commission’s Interim Proposed Forest Management Plan. This option has been referred to as Scenario D. (The area basis for Scenario D is described in Appendix 1).

9.3 Jarrah and Karri sustained yield options

Two main options each with three variations were run for the Panel to test the trade-offs between the sustained yield and other values and to compare with Scenario D. Option 1 evaluated a specification of the proposed Fauna Habitat Zones based on those recommended in Burrows *et al*, 2002, Option A and explored sensitivity to variation in dieback spread, rotation length and thinning. Option 2 specifically tested the potential increase in socio-economic value that might be obtained by access to two tiered and

regrowth components within proposed reserves with the same variations in dieback spread, rotation length and delay to early thinnings. Due to time and resource constraints, it was not possible to undertake a simulation of the combined effects of the two options taken together.

Dieback spread

In the light of the various reports and research presented, the Panel decided that it could not confirm any sustained yield option that did not incorporate the recently completed dieback spread and impact estimates, such was the likely impact on growth, sustained yield and biodiversity values. The significant magnitude of this impact is illustrated in the reduction in sustained yield and simulated yield flows for Scenario D (b) (Table 9.1 and Figure 9.1) when compared to Scenario D(a).

Option 1: Alternative Fauna habitat zones

As noted in Chapter 6, alternative specifications for fauna habitat protection have been proposed. The potential impact on sustained yield of an alternative rule-set (Burrows et al. 2002, Option A) was examined. The Panel tested this option because it provided an alternative specification recently recommended by an expert panel. The results (Option 1(a) including dieback) are indicated in Table 9.1.

Option 1b: Delayed thinnings

As noted earlier, the Panel had major reservations concerning the assumption in Scenario D that non-commercial thinning of regrowth jarrah at ages 20 and 50 years represented an economically viable investment. It therefore examined that all jarrah thinnings would be delayed until an economic sawlog yield could be achieved. The results (Option 1(b) including dieback) are indicated in Table 9.1.

Option 1c: Shorter rotations

The Panel examined an alternative that reduced the rotation length for jarrah regrowth forest from 200 to 175 years and from 100 to 75 years for some 1,400 ha of pre-1942 karri regrowth.

Option 2: Access to two-tiered and regrowth in proposed reserves.

The Panel notes that there are significant areas of regrowth and two tiered forest in proposed reserves. Should parts of these areas be made available for timber production they would contribute to increased socio-economic return and the Panel believes that these might be accessed without compromising old-growth values. Because of time constraints, the Panel was only able to evaluate the option that made available all regrowth and two tiered forest in the new proposed reserves. The Panel does not wish to claim that this rule-set is optimal; its evaluation was designed to indicate the potential magnitude of the potential gain in yield. It is assumed that these would be capable of considerable refinement by local experts if the option were to be further evaluated.

Each of the variants delayed thinning, Option 2(b) and shorter rotations, Option 2(c) were again tested (Table 9.1) but now relate to the areas of productive forest *plus* all regrowth and two tiered forest included in the new proposed reserves.

In the time available, not all the possible combinations of these major changes to Scenario D and Options 1 and 2 could be run, but the Panel is confident that the summary of sustained yield provides a robust basis for designing a solution that better provides for ecologically sustainable forest management objectives.

The Panel favours a scenario incorporating a combination of options 1 and 2. However, potential yield loss from dieback must be incorporated in the final scenario for the Plan. The Panel believes that much of the thinning of jarrah will be delayed unless markets for these products can be developed or the Government is prepared to subsidise it and hence the majority of this impact will be felt whatever other modifications are selected. Shorter rotations should be confined to the more productive jarrah forest (i.e. other than eastern jarrah) and the inclusion of only that regrowth and two-tiered forest in Dalgarup and parts of other newly proposed reserves that are readily accessible and of low conservation value.

Local expertise is required to define this option in detail, so we cannot confirm the sustained yield for it. Nevertheless, it clearly represents a balance that meets almost all of the major underlying concerns and values. Almost every interest group will claim that it does not achieve its particular goals but the Panel would argue that, in aggregate, it is likely to achieve a higher level of social net benefit than any one of the preceding options or of those most favoured by individual interest groups. That is the essence of trade-offs at the whole-of-forest level

The Panel is satisfied that ample marri resource exists to support a substantial cut of residual wood, if markets are available, and to supply current sawlog demands.

Table 9.1 Estimates of sustained yield for jarrah and karri using Scenario and Panel Options 1 and 2. Appendix 1 of this report details the area basis for the sustained yield figures provided in this table.

Scenario / Option	Sustained yield (m3/y)	
	Jarrah	Karri
Scenario D*: Reference scenario		
D(a) No allowance for dieback spread	135,000	50,000
D(b) Allowing for dieback spread	116,000	50,000
D(c) Allowing for dieback spread, delayed thinnings	111,000	50,000
D(d) Allowing for dieback spread, shorter rotations	126,000	53,000
Panel Option 1:Alternative fauna habitat zones		
1(a) Allowing for dieback spread	126,000	52,000
1(b) Allowing for dieback spread, delayed thinnings	124,000	52,000
1(c) Allowing for dieback spread, shorter rotations	138,000	56,000
Panel Option 2: Access to regrowth/two-tiered areas		
2(a) Allowing for dieback spread	139,000	74,000
2(b) Allowing for dieback spread, delayed thinnings	133,000	74,000
2(c) Allowing for dieback spread, shorter rotations	151,000	78,000

* Scenario D is defined in the Interim Proposed Forest Management Plan Appendix 15 and provided to the Panel as the basis for assessment.

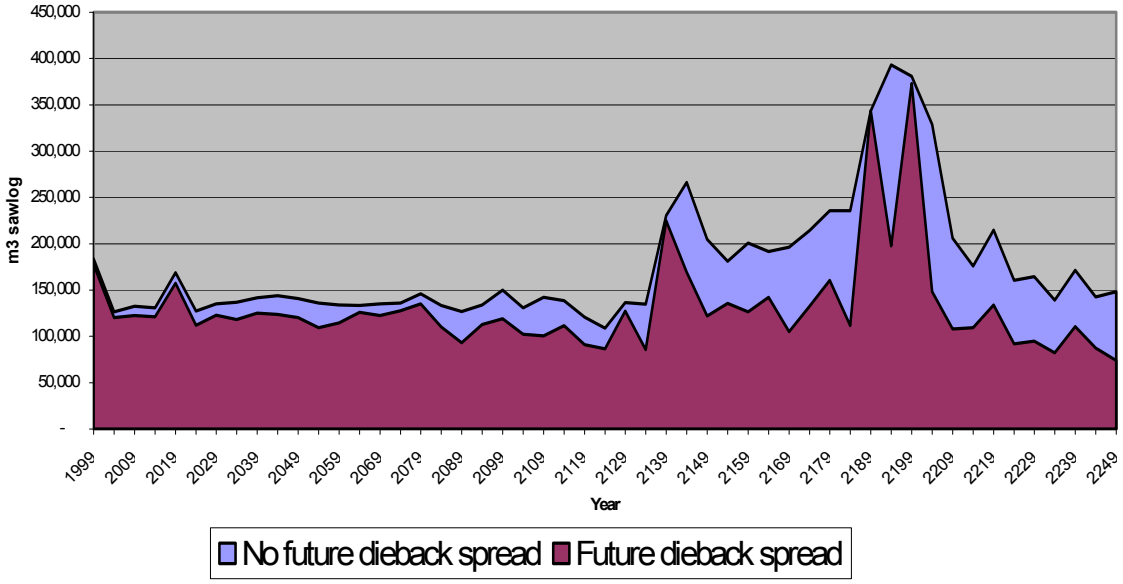

Figure 9.1 Simulated sawlog woodflow of jarrah for Scenario D(b) (no allowance for delayed thinning or shorter rotations) illustrating the impact of a prediction of simulated autonomous dieback spread.

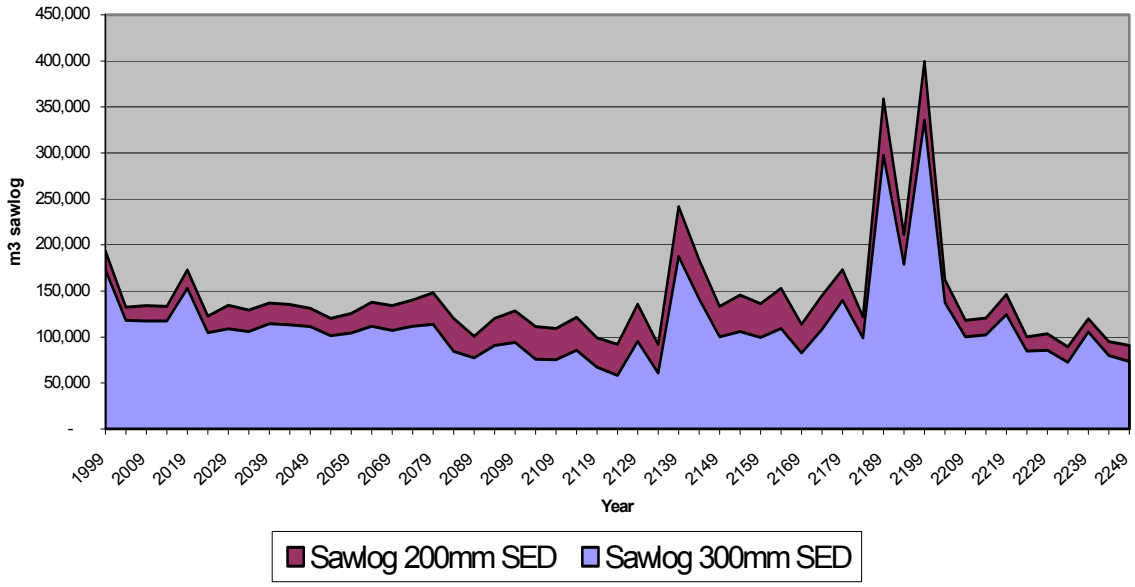

Figure 9.2 Simulated sawlog woodflow for jarrah for Option 1(a) (allowance for dieback spread, no allowance for delayed thinning or shorter rotations) to 300mm and 200mm top diameter limit.

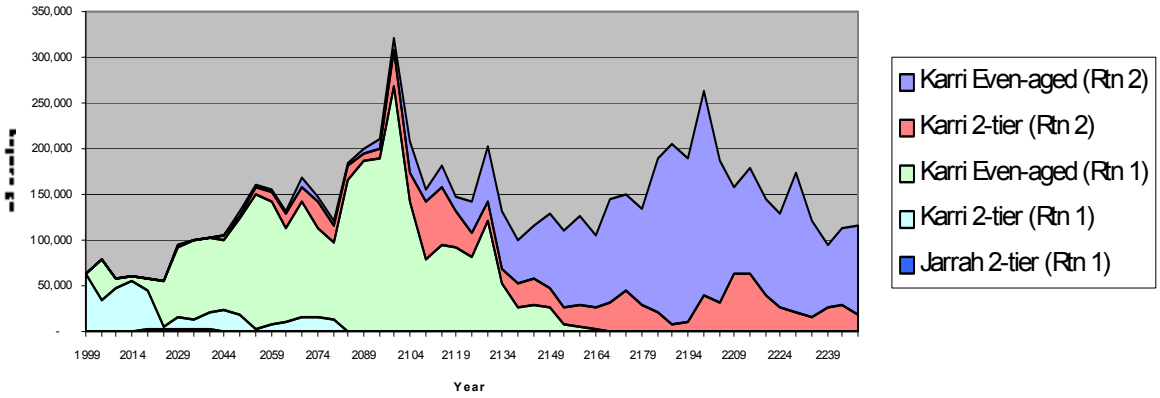

Figure 9.3 Simulated sawlog woodflow for karri for Option 1(c) indicating the yield that is sourced from two- tiered and regowth forest.

Conclusions

The Panel is well aware that various levels of allowable cut were proposed in the Draft Forest Management Plan and in recent Government statements. The role of the Panel is to confirm the levels of sustained yield appropriate to options that reflect different silvicultural and other settings and so enable the trade-offs between feasible options to be better evaluated through due processes.

While we have not been able to supply a single tightly defined final option, the implications of our work are clear and we are confident that the table setting out the levels of sustained yield for various options is robust, the values are conservative, and that the methodology for analysing operational feasibility is robust.

Each of the Scenario and Options evaluated provide different levels of contribution to socio-economic values and biological conservation. The Panel is of the view that a combination of options 1 and 2 will meet both the biological and other components of ecologically sustainable forest management to a satisfactory level as outlined in the objectives specified by the Interim Proposed Forest Management Plan.

10 OTHER MATTERS

10.1 Improving transparency

The Panel notes the considerable effort put in to improving transparency during the period of the period of development of the 2004-2013 Forest Management Plan and these are commended.

A wide range of reporting activity and of opportunities for public involvement is noted among the strategies and actions proposed in the Interim Proposed Forest Management Plan. The Panel notes a strong emphasis on the reporting of audit results and other compliance measures and the objectives for a mid-term review and consequent reporting. Effective communication with the broader community is also needed on more general forestry performance in relation to progress toward achievement of ESFM.

During the review the Panel was provided with statistics relevant to Scenario D that indicated:

- the area and proportion of the forest that would be impacted by varying degrees of harvest intensity during the life of the plan,
- the proportion of the forest that is managed under different rotation lengths, and
- the proportion of the standing inventory that is expected to be removed by harvesting during the life of the plan.

Inclusion of such statistics with the final plan would assist transparency and provide a useful perspective on disturbance due to harvesting.

Modern communication media such as the WWW , the Department of Conservation and Land Management's NatureBase website and video provide an excellent basis for timely provision of information on forest status, achievements and issues reports. The Panel recommends the increased use of these media to achieve timely communication with the community to increase awareness of issues and status in respect to forest management.

Nonetheless, increasing public concern and indeed involvement in management of forests through the stakeholder approach adopted by most governments, produces increasing demands for access to data and to the systems and methods used to estimate the Sustained Yield.

The Panel notes this increased pressure and urges that new resources be found to support public education and dissemination (including peer-reviewed publication) programmes.

There is a general lack of publicly available documentation and understanding of the methods and systems that are used to calculate the Sustained Yield. The Panel re-iterate the concerns expressed in previous reports and urge that suitably simplified diagrams and explanations be made available via the World Wide Web and through technical reports. The Panel also urge that, wherever possible, the systems and models be subject to peer-review through the processes of publication in the international scientific literature.

10.2 Relationship to the Regional Forest Agreement

Ferguson et al. (1997) provided the background to the assessment of ecologically sustainable forest management and the associated assessment of the Forest Management System during the assessment processes leading to the Regional Forest Agreement. Changes to the system at the Commonwealth and State level have occurred since the assessment was undertaken. Examples include the Regional Forest Agreement, changes to state legislation (eg. *Conservation and Land Management Act 1984*) and commencement of new legislation (eg *Environment Protection and Biodiversity Conservation Act 1999* (Cwth), *Forest Products Act 2000* and *Regional Forest Agreements Act 2002* (Cwth)).

While reference is made to the *Environment Protection and Biodiversity Conservation Act 1999* in the context of threatened species and communities provisions, the Interim Proposed Forest Management Plan when discussing the framework for the Plan (Chapter 2) does not discuss the legislative framework of the Plan within the context of the Commonwealth legislation.

Noting our Terms of Reference, the Panel is concerned about how the Regional Forest Agreement relates to the Forest Management Plan given the establishment of the *Regional Forest Agreements Act 2002* and the consequential obligations resulting from the Western Australian Regional Forest Agreement. This concern results from how commitments made in the Regional Forest Agreement flow from international obligations through the Commonwealth legislation (*Environment Protection and Biodiversity Conservation Act 1999; Regional Forest Agreements Act 2002*) and national policy (National Forest Policy Statement) to the State's Forest Management System and in particular the Management Plan.

Western Australia agreed in the Regional Forest Agreement "to produce and publish a Forest

Management Plan to implement the commitments of this Agreement" (Clause 43). The Commonwealth or other stakeholders may have concerns that the resource base for which Sustained yield is calculated is not consistent with the resource base commitments of the Regional Forest Agreement, or that Western Australian forest policy is not consistent with the policy settings and commitments agreed to in the Regional Forest Agreement. This raises issues concerning the possibility of legally enforceable rights and obligations that are outside the expertise of the Panel but should be considered by the Conservation Commission and the Government.

The Panel therefore recommends that Conservation Commission and Government should consider the possible impact of any legally enforceable rights and obligations associated with the Regional Forest Agreement that could affect the implementation and legal status of the Forest Management Plan.

10.3 Future determination of sustainable yields

In the calculations of the sustained yield by the Department of Conservation and Land Management, the assumption is made that non-declining yield is pivotal to the long term sustainability of the forest. However, reliance on the control of sustained yield of sawlogs alone is a simplistic device when the intention is to sustain all values. This has been recognised for many years (see Chikumbo et al. 2001) as evidenced by the increasing conservation and other constraints that have been applied in forest management over the last decade to ensure that other values are protected or enhanced.

From the social and economic perspective, absolute consistency of timber yield over very long periods does not necessarily lead to stability of industry. For example, the determination of yield on the basis of a current product specification in the expectation that this specification will still be relevant in 200 years time is not very realistic. However the concept of sustained yield as used in the Western Australian context applies an assumption that the "grade" of log available to the current generation will be similar for the generations that follow. While it is recognised that log grade standards to industry may change over a rotation period the objective applied is one where the quantity of the "quality of sawlogs" used by the current generation does not decline in the coming generations.

Attempting to forecast a control variable like sustained yield over 200 years will have issues associated with precision of the long term estimates. Precision declines radically the further the projection is away from the current date. Planning horizons of 50 to 80 years would be ample, much more realistic, and would simplify scheduling while focusing more specifically on what are the structural goals and forest objectives to be achieved at the end of that horizon. However longer-term projections are required to ensure there is no decrease in yield and other sustainability objectives in the long term (1 to 1.5 rotations).

Specifying the structural goals at the whole-of-forest and structural levels in greater detail for the 50-80 year planning horizon would do much to improve the sustainability of all forest values (including timber). This should be done in conjunction with the following:

- Consider the requirements of conservation values as it is done at present through a series of safeguards (salinity, rare species, CAR reserves etc).
- Consider similarly the requirements for wood and other non-timber products and services (e.g. water, recreation).
- Develop appropriate structural goals at the forest and the landscape level that are required to meet those needs.
- Directly monitor and regulate forest structure at the whole-of-forest and landscape levels to ensure protection of conservation and supply of wood and other non-wood values
- Develop a maximum timber yield based on an analysis of the capacity to sustain that value over the planning horizon, subject to achieving the structural goals prescribed above and the explicit recognition of the trade-offs involved in choosing that yield.
- Regulate and monitor the timber yield over the period of the Plan (10 years in the present case) within the requirements imposed by the structural goals.
- Check the yield strategy against longer-term projections of wood and non-wood values to ensure that they do not decrease to unacceptable levels to forgo intergenerational options.

The effect of this approach is consistent with what has already been initiated in this report and in the Interim Proposed Forest Management Plan, although the latter has not yet gone as far as we have recommended. It involves shifting the emphasis to the sustainability of whole-of-forest and landscape level structures, and away from a simplistic reliance on non-declining yield of sawlogs as the primary regulator of sustainability. There is no pre-emptive priority for wood over non-wood values or vice versa.

There may need to be an initial array of varying and independent priorities set for all values in the form of individual structural goals. If a feasible and near-optimal solution cannot be found that satisfies all these initial structural goals then the nature of the subsequent trade-offs required between goals becomes transparent. The present process obfuscates these trade-offs but cannot ultimately avoid them, as the present report shows. This approach is sometimes referred to as ecosystem management, which is an evolution of the concepts of sustained and sustainable yield (Chikumbo et al. 2001).

Conclusions.

The Panel is of the view that this new approach to the determination of sustained yield could result in greater benefits to both conservation and socio-economic values than does the rigid application of the current mechanisms. At the same time it would provide improved transparency of the mechanisms employed to achieve ecologically sustainable forest management.

The Panel recognises that such an approach would require more rigorous whole-of-forest and landscape level analyses, which would depend on data sets and approaches that need to be refined and expanded. These will take some time in their development. Sufficient data are not likely to be available until prior to the next revision of the Forest Management Plan in 2014. Hence the assumption of non-declining yield should be retained until an ecosystem management approach can be developed and checked against ecologically sustainable forest management principles and objectives. Extensive consultation would also be necessary to build consensus to support the approach.

10.4 Recommendation

Recommendation 7

The Panel recommends that alternative approaches be developed to determine the sustainable yields of a range of forest values while maintaining critical elements of ecosystem function. This should incorporate direct approaches to maintain target forest structures, and should be investigated and subjected to thorough analysis during the life of the plan.

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12 APPENDIX 1

DESCRIPTION OF SCENARIO D AND PANEL OPTIONS 1 AND 2 AREA BASIS

The estimates given of sustained yield for jarrah and karri presented in Table 9.1 were based on areas for timber production which varied between each of the scenarios as follows:

Scenario D

Consistent with the Interim Proposed Forest Management Plan, areas excluded from timber production included:

The reserve system as proposed in the Plan (April 2003). This includes all the proposed new national parks, with their proposed boundaries as progressed to 31 December 2002.

All informal reserves, including all mapped old-growth in State forest.

Areas recommended by the Conservation Commission to be set aside from timber harvesting as formal or informal reserves following the Review of High Conservation Values in Western Australia's south-west forests. This includes the reservation of occurrences of Darling Scarp ecosystem, Dalgarup block, the southern part of Witchcliffe block and a number of areas that are adjacent or near to new proposed parks.

Areas of less-well-reserved vegetation complexes on State forest that are proposed in the Plan to become informal reserves. These comprise those vegetation complexes with less than 5% of their estimated pre-European distribution currently reserved, and those vegetation complexes with 5 to 10% reserved and less than 15% remaining.

A version of the proposed Fauna Habitat Zones, using a 200 hectare patch size and a 3 kilometre geographic dispersion. The selection of patches followed the guiding preferences for locating the predominantly mature forest at the strategic level, whereby patches were aggregated around the informal reserves such as old growth, streams and DEZ, while attempting to avoid mapped dieback infested sites. The shape of individual patches would vary as detailed fine-scale design was undertaken to ensure management features (roads, tracks, creeks, ridge lines) where used as boundaries wherever practicable. Note that this is one of a number of possible variations in the extent and location of these zones.

Panel Option 1

Excluded from timber production:

The reserve system as proposed in the Plan (April 2003). This includes all the proposed new national parks, with their proposed boundaries as progressed to 31 December 2002.

All informal reserves, including all mapped old-growth in State forest.

Areas recommended by the Conservation Commission to be set aside from timber harvesting as formal or informal reserves following the Review of High Conservation Values in Western Australia's south-west forests. This includes the reservation of occurrences of Darling Scarp ecosystem, Dalgarup block, the southern part of Witchcliffe block and a number of areas that are adjacent or near to new proposed parks.

Areas of less-well-reserved vegetation complexes on State forest that are proposed in the Plan to become informal reserves. These comprise those vegetation complexes with less than 5% of their estimated pre-European distribution currently reserved, and those vegetation complexes with 5 to 10% reserved and less than 15% remaining.

Areas of additional mature forest sufficient to ensure that each forest block maintains a minimum of 200 hectares set aside from timber harvesting in each forest block. A total net area of 3,170 hectares of two-tiered jarrah was required to meet this criterion following exclusion of the areas listed above.

Panel Option 2

Excluded from timber production:

An amended reserve system, in which the net area of non old-growth areas within the new parks proposed under the *Protecting our old-growth forests* policy where made available for timber production. The area made available included both regrowth and two-tiered forests that had been previously cutover.

All informal reserves, including all mapped old-growth in State forest.

Most areas recommended by the Conservation Commission to be set aside from timber harvesting as formal or informal reserves following the Review of High Conservation Values in Western Australia's south-west forests, *except* Dalgarup block which was made available for timber production. The areas set aside include the reservation of occurrences of Darling Scarp ecosystem, the southern part of Witchcliffe block and a number of areas that are adjacent or near to new proposed parks.

Areas of less-well-reserved vegetation complexes on State forest that are proposed in the Plan to become informal reserves. These comprise those vegetation complexes with less than 5% of their estimated pre-European distribution currently reserved, and those vegetation complexes with 5 to 10% reserved and less than 15% remaining.

Note: This option makes no provision for fauna habitat zones as specified in Panel Option 1 or Scenario D.

Total area The total area of jarrah, karri and wandoo forest available for timber production in State forest and timber reserves under each of these scenarios, and used in the calculation of sustained yields, was as follows:

	Area (ha) of forest type available under this scenario		
	Jarrah	Karri	Wandoo
Scenario D	740,500	58,700	36,000
Panel option 1	803,300	61,200	38,000
Panel option 2	868,900	74,100	44,100

Note: Further reductions to the available areas occur during the timber scheduling process as provision is made for steep slopes, roading and other features.

13 APPENDIX 2

SPECIFIC COMMENTS ADDRESSING VIDEO PRESENTATION

Following discussion with members of the Conservation Council, the Council provided a copy of its recently completed video entitled 'The Collie Catchment Crisis'. While the Panel lacks first-hand knowledge of all the areas depicted in the video, individual members are reasonably well acquainted with the general region and the issues raised.

The Panel makes no comment on the overall picture presented but have instead tried to address a number of the embedded issues in their current report. We have listed and make comment here on those issues.

1. If there are clear breaches of logging guidelines (e.g. habitat trees) then these must be investigated by the Department and if necessary by the Commission. There are clear policies and guidelines as to the actions required if such breaches are found.
2. Salinity is a major issue for the south-west. The interim (Proposed) Forest Management Plan makes clear the scale at which logging impacts will be monitored. Monitoring of the impacts of logging at smaller scales requires more resources and the Panel is not convinced that further resources should be directed to the forest when the major issues lie within the agricultural zones.
3. Wastage is unfortunate but will always be present in commercial logging operations. The Panel note the concerns about material left in the forest after logging and have made specific recommendations about the minimum size of logs. More can be done to encourage non-commercial use of material left by logging contractors provided there are the resources available for supervision.
4. Collateral damage to understory species such as *Banksia, Casuarina, Xanthorrhea* is also inevitable at local scales. The Panel notes that the revised jarrah silvicultural guidelines now include directives for the greater retention of understory species (Appendix 5 of interim (Proposed) Forest Management Plan. The Panel has also reviewed the soil damage impacts on sustained yield and notes that the interim (Proposed) Forest Management Plan makes clear the use of internationally accepted indicators (e.g. Montreal Process Indicators) to guide management.
5. General retention of habitat trees and areas. The Panel notes that there are proposals to increase the retention of mature habitat. The Panel supports this initiative and makes comment to this effect in their report.

14 APPENDIX 3

Glossary

Adaptive management	The systematic process for continually improving management policies and practices by learning from the outcomes of operational programs.
Basal area	The sum of the cross-sectional areas of trees in a given stand measured at 1.3 metres above the ground. It is usually expressed as square metres per hectare.
Biological diversity (Biodiversity) (described in Conservation and Land Management Act)	The variability among living biological entities and the ecosystems and ecological complexes of which those entities are a part and includes: (a) diversity within native species and between native species; (b) diversity of ecosystems; and (c) diversity of other biodiversity components.
Biological diversity component (described in Conservation and Land Management Act)	Includes habitats, ecological communities, genes and ecological processes
Block	A named administrative subdivision of the forest, varying in size from about 3,000 to 8,000 hectares.
Bole	The tree trunk from the ground to the major branches supporting the crown.
Buffer strip	A strip of vegetation retained on the edge of a feature such as a stream or rock outcrop. Buffer strips can serve a variety of purposes in the landscape, including protection of the feature from a disturbing activity, and provide flora and fauna habitat and aesthetic values.
Catchment	The surface area from which water runs off to a river or any other collecting reservoir.
Coppice	A shoot (or shoots) arising from adventitious buds at the base of a woody plant that has been cut near the ground or burnt back.
Coupe	An area of forest that is planned for timber harvesting as a single unit. It may contain more than one silvicultural objective, such as a number of discrete gaps or clearfells or a combination of both.
Dieback	In the south-west of Western Australia a disease of plants caused by infection by the soil-borne organisms of the genus *Phytophthora.*
Disturbance	Any range of conditions affecting the condition of a natural area. Disturbance may be natural (e.g. fire) or human induced (e.g. timber harvesting).
Diverse ecotype zone	Areas of the forest, generally but not always with little tree cover, that are identified at the operational management scale to be protected from activities associated with timber harvesting because of their importance for the conservation of biodiversity. They include sedge and herb vegetation, rock outcrops, heath,

	wetlands, etc.
Ecologically sustainable forest management (ESFM)	Forest management and use in accordance with the principles described in section 19(2) of the Conservation and Land Management Act.
Ecosystem	A community or an assemblage of communities of organisms, interacting with one another and the environment in which they live.
Endangered	A taxon is endangered when it is not critically endangered but is facing a very high risk of extinction in the near future.
Environmental Management System	A framework for the systematic management of an organisation's environmental obligations and targets. Often conforming to a standard, the most popular being AS/NZS ISO 14001.
Fauna	The animals inhabiting an area; including mammals, birds, reptiles, amphibians and invertebrates. Usually restricted to animals occurring naturally and excluding feral or introduced animals. With respect to the Wildlife Conservation Act, fauna is: (a) any animal indigenous to any State or Territory of the Commonwealth or the territorial waters of the Commonwealth; (b) any animal that periodically migrates to and lives in any State or Territory of the Commonwealth or the territorial waters of the Commonwealth; and (c) any animal declared as fauna pursuant to subsection (2), and includes in relation to any such animal – (d) any class or individual member thereof; (e) the eggs, larvae or semen; (f) the carcass, skin, plumage or fur thereof, but does not include any prescribed animal or prescribed class of animal.
Flora	The plants growing in an area; including flowering and non-flowering plants, ferns, mosses, lichens, algae and fungi. Usually restricted to species occurring naturally and excluding weeds. With respect to the Wildlife Conservation Act flora is any plant (including any wildflower, palm, shrub, tree, fern, creeper or vine) which is: (a) native to the State or (b) declared to be flora pursuant to subsection (4), and includes any part of flora and all seeds and spores thereof.
FMIS	**F**orest **M**anagement **I**nformation System. The Department of Conservation and Land Management's raster-based geographic information system used to manage and analyse spatial forest data.
Forest	An area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding two metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20 per cent**.**
Forest ecosystem	An indigenous ecosystem with an overstorey of trees that are greater than 20 per cent crown cover. These ecosystems should normally be discriminated at a resolution requiring a map-standard scale of 1:100,000. Preferably these units should be defined in terms of floristic composition in combination with

	substrate and position within the landscape.
Forest operations	Work activities undertaken in the forest to achieve the management objectives for that forest.
Forest produce	For the purposes of the Conservation and Land Management Act includes trees, parts of trees, timber, sawdust, chips, firewood, charcoal, gum, kino, resin, sap, honey, seed, bees-wax, rocks, stone and soil but, subject to the foregoing, does not in Division 1 of Part VIII include minerals within the meaning of the Mining Act 1978.
Forest products	For the purposes of the Conservation and Land Management Act and the Forest Products Act: (1) Subject to subsection (2) trees or parts of trees; timber, sawdust or chips; charcoal, gum, resin, kino or sap; and firewood. If they are located on public land or share-farmed land. (2) When something referred to in subsection (1) has been removed under contract or arrangement entered into by the Commission, any residues that remain are not forest products for the purposes of this (FP Act) Act.
Forest regeneration	The renewal of a forest arising from planting or from seed or the young plants on a site. The process by which a forest is renewed.
FORSCHED	**FOR**est **SCHED**uler. A computer system for scheduling/ simulating yield from forest harvesting operations for one or more rotations.
Gap	A discrete opening in the overstorey canopy created to reduce competition to allow seedlings to become established and or develop.
Guideline	Principles, standards and practices for meeting goals that have been established as desirable outcomes for management. They can be quantitative or qualitative.
Habitat	A component of an ecosystem providing food and shelter to a particular organism.
Heritage	Something inherited from past generations that is valued.
High impact	A term applied to certain forest sites where *Phytophthora cinnamomi* has caused or is expected to cause extensive mortality of jarrah trees.
High rainfall zone	Areas where the average annual rainfall exceeds 1100 millimetres per year.
Hygiene – in relation to dieback	Actions that decrease the risk of the pathogen being introduced spread or intensified.
Intermediate rainfall zone	Areas where the average annual rainfall is between 900 and 1100 millimetres per year.
IOPS	**I**ntegrated **O**perations **P**lanning **S**ystem. A GIS/database system for simulating short to medium term plans and operations and their outcomes over time.
I.R.I.S.	Integrated Resources Information System. A computer system for storage, processing and retrieval of information for forest inventory with GIS linkages.
Landscape	The visual elements of both the natural and the built environment and including landforms, vegetation, waterform, land-use and architecture.
Lignotuber	A woody swelling formed at the base of some eucalypts that has the ability to produce new shoots when the existing ones are

	destroyed.
L.O.I.S.	Logging Operations Information System. A computer system operated by the Forest Products Commission used to manage log production and sales records.
Low rainfall zone	Areas where the average annual rainfall is less than 900 millimetres per year.
JARSIM	**JAR**rah **SIM**ulator. A computer system that estimates future growth of jarrah stands. The system connects to the forest yield scheduler, FORSCHED.
KARSIM	**KAR**ri **SIM**ulator. A computer system that estimates future growth of karri stands. The system connects to the forest yield scheduler, FORSCHED.
Monitoring	Regular assessment of a management program and of the resources being managed, checking that desired outcomes are achieved, and adjusting the new plan where necessary.
Old-growth forest	Ecologically mature forest where the effects of unnatural disturbance are now negligible. The definition focuses on forest in which the upper stratum or overstorey is in a mature to senescent growth stage.
Patch	A group of trees resulting from a natural regeneration event or a past management activity such as gap creation and regeneration.
Pest	Troublesome or destructive animals including insects, either introduced or native.
Prescription	A detailed specification of the objectives, area, procedures and standards for a task to be undertaken.
Policy	The course of action to be followed to achieve an organisation's objectives.
Reserve – conservation	An area set aside primarily for the conservation of natural ecosystems but which may allow a level of recreation consistent with the proper maintenance and restoration of the natural environment.
Reserve – formal	One of the land category categories of national park, nature reserve, conservation park, or Conservation and Land Management Act sections 5(1)(g) or 5(1)(h) reserves for the purpose of conservation.
Reserve – informal	An area set aside for conservation under an approved management plan; has had opportunity for the public to comment on changes to reserve boundaries; able to be accurately defined on a map; and is of an area and design sufficient to sustain the values it seeks to protect.
Riparian	Pertaining to the banks of streams, rivers or lakes.
Rotation	The planned number of years between the establishment of a crop and its felling.
Shelterwood system	A jarrah silvicultural system that involves a partial removal from the overstorey of some mature trees and action to establish regeneration under the remaining mature trees. When the regeneration is sufficiently established most of the remaining mature trees are removed to allow the regeneration to develop.
SILREC	**SIL**vicultural **REC**ord System**.** A Department of Conservation and Land Management spatial database for managing and recording harvesting extent and silvicultural practices.

SILVIA	**SILV**icultural **I**mpact **A**nalysis. A computer system for simulating silvicultural treatment and describes potential yield, silvicultural options and residual stand outcomes under user specified silvicultural strategies.
Silviculture	The theory and practice of managing forest establishment, composition and growth to achieve specified management objectives.
Specially protected	Those species declared under the Wildlife Conservation Act to be specially protected because they are deemed otherwise in need of special protection.
Stand	A group of trees or patch of forest that can be distinguished from other groups on the basis of size, age, species composition, condition or other attribute.
Structure	When applied to a forest is the vertical and spatial distribution of the vegetation.
Sustained yield	The yield that a forest can produce continuously at a given intensity of management..
Taxa (taxon)	A defined unit (for example, species or genus) in the classification of plants and animals.
Thinning	A felling made in an immature stand for the purpose of improving the growth of trees that remain without permanently breaking the canopy and encouraging regeneration.
Timber harvesting	The cutting, felling, and gathering of forest timber undertaken as part of a planned sequence of silvicultural activities including the regeneration of the forest.
Treemarking	The practice of marking trees for retention prior to harvesting in a forest.
Turbidity	Discolouration of water due to suspended silt or organic matter.
Unprotectable	A term that is applied to forest that will ultimately become infested with *Phytophthora cinnamomi* through the autonomous spread of the disease from adjacent areas.
Vegetation complex	A combination of distinct site vegetation types, usually associated with a particular geomorphic, climatic, floristic and vegetation structural association.
Yield	The amount of product produced from the forest by a particular management strategy.
Yield regulation	The process by which the yield of any product is controlled to achieve the stipulated levels in a management plan.