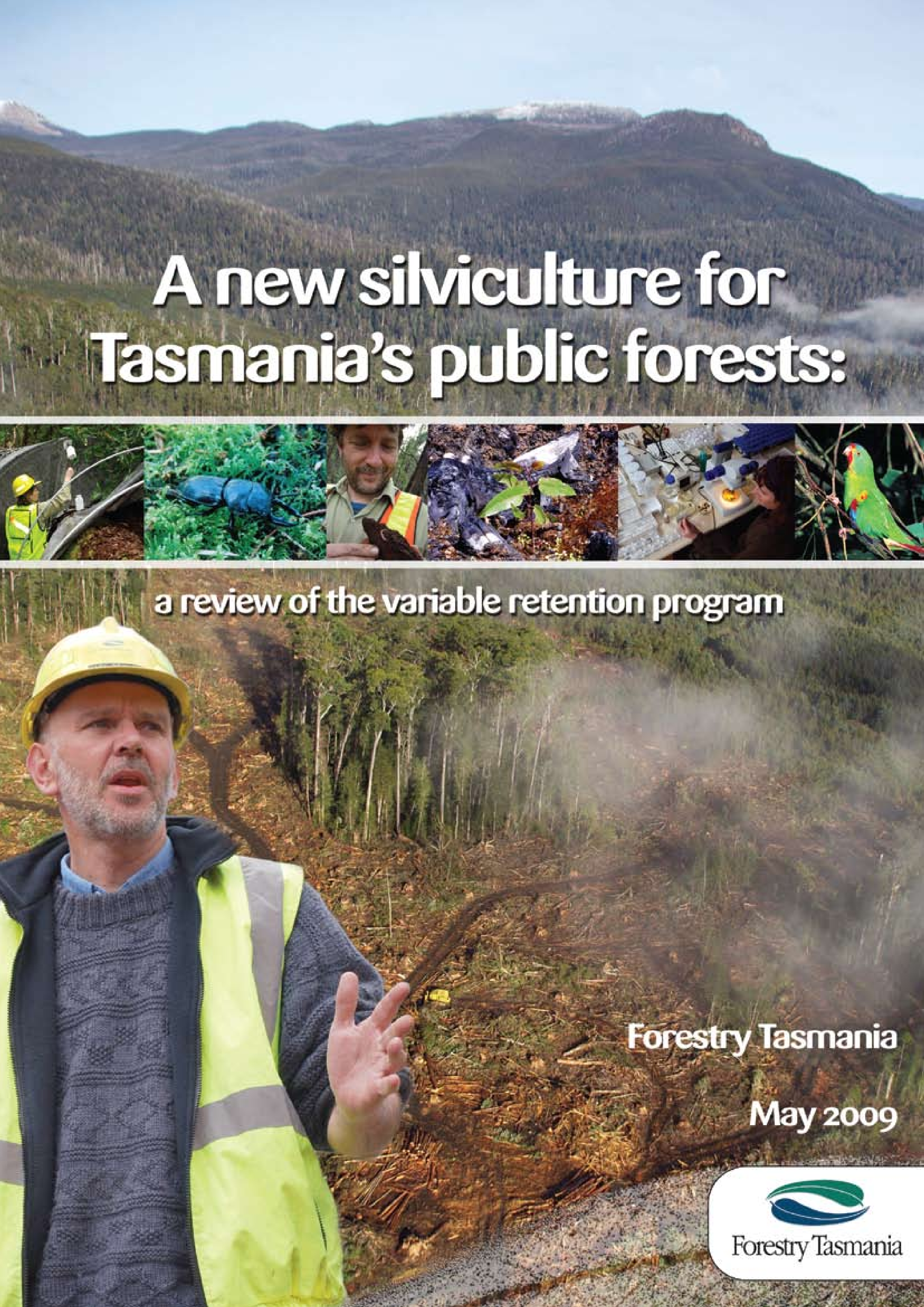
A new silviculture for Tasmania's public forests:

a review of the variable retention program



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This report is consistent with Forestry Tasmania's 2008 Sustainability Charter, which outlines its forest management strategy for the coming decade. Amongst other things, it states the following forest management aims:

"Maintain a minimum of 250 000 hectares of oldgrowth forests in reserves in State forests (25% of Tasmania's reserved oldgrowth forests) for conservation values.

Retain oldgrowth elements including large trees, stags, understoreys and logs across the forest estate.

This will involve:

- Continuing the TCFA variable retention program
- Developing landscape assessment methods to prioritise management for restoration of oldgrowth elements in forests where they are now sparse."

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Summary

In 2005 the Tasmanian Government adopted a policy to reduce the use of clearfelling as a harvest/regeneration (ie silvicultural) technique in public oldgrowth forests. This policy was recognised, and supported by the Commonwealth Government in the Tasmanian Community Forest Agreement (TCFA or Supplementary Tasmanian Regional Forest Agreement). This followed a decade of research by Forestry Tasmania into alternative silvicultural techniques, and a number of reports, public consultations and formal advice provided by Forestry Tasmania to the Tasmanian Government. Clause 30 of the TCFA included a specific commitment to achieve non-clearfell silviculture in a minimum of 80 per cent of the annual oldgrowth harvest area in State forests by 2010. Clause 32 of the TCFA indicated this commitment was subject to satisfactory progress being made to achieve safety, regeneration and log supply objectives. These issues have now been extensively reviewed, along with other ecological, social and economic aspects, and the results are presented in this report to provide further advice to the Tasmanian Government and other stakeholders.

The issue of oldgrowth clearfelling is the last significant item in a process of review and improvement in sustainable forest management in State forests since the adoption of the Forests and Forest Industry Strategy in 1990, which has seen 47% of Tasmania's forests protected in conservation reserves, including nearly one million hectares, or 80%, of oldgrowth forests; the elimination of the use of chemical control of browsing animals; the cessation of the use of atrazine to control woody weeds; the end of plantation conversion of native forest; and the periodic review, and regulation, of forest harvest levels to ensure sustainability of yield indefinitely.

The recommended strategy for achieving a reduction in clearfelling has been the progressive introduction of variable retention (VR) for the majority of oldgrowth forest harvesting in tall wet forests, recognising that non-clearfell techniques are already widely used in the drier forest types. VR systems were first developed in parts of Canada and the Pacific Northwest of the USA, and have been the subject of research in Tasmania and Victoria. A similarity of current oldgrowth forest management issues, and alternative silvicultural systems exists on four continents (Australia, North and South America, and Europe) and the Tasmanian experience fits well into the international context, with the Forestry Tasmania research trials being among several similar multidisciplinary forest management experiments on different continents.

VR silviculture is now the global standard for best-practice when harvesting oldgrowth forests.

Tasmanian oldgrowth forests are naturally regenerated by massive wildfires, which nevertheless usually leave elements of species and structures characteristic of older forests. These elements are important biological legacies that help to maintain biodiversity and variability at the stand level.

Variable retention silviculture emulates these ecological processes, while meeting timber production objectives. It provides tangible ecological benefits in terms of retaining older forest elements and structures in harvested coupes. Compared with clearfelling, VR coupes will have significantly higher habitat diversity. These benefits should increase over time, as oldgrowth species, particularly those with limited dispersal ability, move into felled areas from remnant patches.

A mixed silviculture strategy has been recommended for oldgrowth in Tasmania's State forests, that includes variable retention in most tall oldgrowth wet eucalypt forests (hereafter referred to as tall oldgrowth forests), limited clearfelling in steeper areas, single tree/group selection in designated Special Timbers Management Units and continuation of partial/selective systems for oldgrowth dry eucalypt forest.

The decision to reduce oldgrowth clearfelling was taken in response to continuing community concerns about clearfelling, and growing awareness of the ecological benefits of alternative approaches. However it was acknowledged that modern clearfelling, developed through decades of research and experience into the standard clearfell, burn and sow silviculture, is a proven and reliable technique that has enabled the establishment of nearly 200 000 ha of vigorous young eucalypt forest, with a broad complement of flora and fauna, on public land.

The VR guideline adopted by Forestry Tasmania is that the majority of the harvested area within a coupe should be within one tree height of forest that is retained for at least a full rotation. Twenty VR coupes have been established in State forests, including 17 operational coupes established since the signing of the TCFA. The proportion of oldgrowth harvested by non-clearfell methods has increased from 54 per cent in 2004/05 to 67 per cent in 2007/08.

This report reviews the progress of implementation of VR to date and evaluates the ecological and social drivers, as well as the implications for safety, silviculture, fire management, economics, timber supply and forest management. It also outlines a program of research and field trials that have been established to facilitate adaptive management. The review includes insights from the international Old Forests New Management Conference held in Hobart in February 2008 and a synthesis provided by an international panel of forest scientists.

Ecological evaluation

The fundamental premise of variable retention (VR) is that it is more ecologically valuable to distribute older forest elements throughout the production-forest landscape rather than to simply add an equivalent amount of older forest to the large, existing reserve system.

VR is expected to improve the ability of poorly dispersing plant and animal species to re-colonise harvested areas so coupes more rapidly achieve the biodiversity characteristics of older forest. This is a concept known as 'forest influence', where the amount and spatial distribution of retained elements enable the mature-forest legacies to influence the species composition and development of the majority of the harvested area as it regenerates.

Initial results from the Warra silvicultural systems trial, supported by monitoring of the operational coupes, indicate that retained aggregates provide viable habitat for many species associated with older forest while also providing key structural features such as trees with hollows. Future research will explore the role of retained aggregates in influencing the species composition of harvested areas.

Relative to clearfelling, VR is expected to alter the trajectory of re-colonisation to be more akin to natural disturbance events, with fine-scale patterning of oldgrowth features at the coupe scale. This should allow a biota to redevelop that is more equivalent to wildfire-regenerated forest and potentially more resilient to subsequent disturbance than is silvicultural regeneration arising from clearfelling. The adoption of VR, as part of a landscape-level planning approach, should have major benefits for biodiversity dependent on mature forest.

The Old Forests New Management Conference identified the importance of VR silviculture in oldgrowth forest management, along with adequate reserve systems and retention or restoration of oldgrowth elements in landscapes where oldgrowth forests are now sparse.

Social acceptability evaluation

Oldgrowth forests have aesthetic and cultural values important to the Tasmanian community and provide important wood and non-wood products, including high quality eucalypt sawlogs, special species timber, leatherwood nectar for beekeeping and opportunities for tourism and recreation.

The social acceptability of large-scale clearfelling of oldgrowth forests in Tasmania is now low. Most people rate clearfelling as the least acceptable harvest method and selective logging as the most acceptable. However, Tasmanian research has shown that when people understand the consequences of harvesting, variable retention systems become equally acceptable as selective logging.

Research from elsewhere indicates people discern harvesting systems as being different from clearfelling once forest retention levels reach a threshold of about 15 per cent of the coupe area. Marked differences in aesthetic perceptions between alternative treatments have been reported in the initial years but diminish after a decade as stand development continues. Forest management outcomes are often judged at the time of harvest and regeneration, but in fact develop throughout the management cycle, typically a century or so. Observations to date indicate that some VR coupes represent a marked improvement on aesthetics compared to clearfelling while others provide little improvement, particularly if the aggregates have been poorly located for visual management or the regeneration burn has scorched some of the aggregates.

Safety

The continuing safety of forest workers was identified in 2005 as an essential requirement for any shift from clearfelling to variable retention. There have been no incidents or accidents reported from any of the VR coupes established to date. An increase in risk arises from the higher perimeter-to-area ratio in coupes with retained aggregates, which can increase the time that contractors are exposed to potential hazards associated with those aggregates.

Designing coupes with fewer, larger aggregates and with more edge aggregates rather than island aggregates will help to reduce the perimeter-to-area ratio. Careful location of the aggregates and appropriate management by contractors and other staff can maintain the risk at an acceptable level.

In general, the hazards associated with the aggregated form of VR harvesting, on slopes less than 20 degrees, are similar to those known to exist in clearfell harvesting. However VR is still considered inappropriate for harvesting tall oldgrowth forests on steeper slopes due to the potential for increased risk to forest workers.

Silvicultural evaluation

A key goal of VR is to maintain forest influence (the biophysical effects of residual trees retained for the next rotation) over the majority (>50 per cent) of the harvested area. VR coupes harvested to date have considerably exceeded this target with an average of around 80 per cent. Similarly, retention levels in VR coupes have averaged around 40 per cent of the net harvestable area (in addition to standard 'coupe discounts' of around 25 per cent of the gross coupe area). This is considerably higher than the 20 per cent of net harvestable area predicted in the 2005 Advice to Government, and retention levels will need to be stabilised at about the 20 per cent level to avoid an excessive impact on the sustainable sawlog supply.

To date, retained trees have not been seriously affected by wind or harvesting damage.

Regeneration burns have had a greater impact, but fire damage to aggregates has generally been contained to acceptable levels (less than one third of aggregate area). VR regeneration burns have created less well-burnt seedbed than comparable regeneration burns in clearfell, burn and sow (CBS) coupes, which has implications for eucalypt seedling establishment and growth.

At year one, both stocking and seedling density are lower in VR coupes compared to CBS. VR coupes show continuing recruitment from retained trees and are generally expected to reach stocking standards by year three. However, the effect of browsing animals on seedling densities is expected to be greater for VR coupes than CBS coupes, due to the retention of more habitat within VR coupes.

The longer-term impacts of retained trees and less dense regeneration on productivity of the regrowth are currently unknown, but are the subject of active research.

Fire management evaluation

Management of harvesting debris has been recognised as the most significant operational issue associated with implementing alternatives to clearfelling. In 2005 it was envisaged that biomass harvesting for energy production may reduce fuel loads and allow less-intense burns, which would be more compatible with retention of aggregates in VR coupes. However, significant domestic markets for biomass have yet to be developed. An alternative method (slow burning) has been developed, which relies on sparse lighting of dry fuels under conditions of low but rising relative humidity. Slow burning requires specific weather and fuel moisture parameter values, which reduces the burning window for these types of burns and increases the likelihood that some planned burns will not be achieved. Slow burns remain alight longer than conventional high-intensity burns, increasing the risk of an escape. The reduced intensity of slow burns is also likely to result in less complete combustion of large fuel pieces, and greater production of smoke and particulate matter.

Several changes to coupe design and site preparation have been made in order to facilitate burning of VR coupes. These include fewer, larger aggregates, wider fairways, and reduced windrowing of debris near aggregates.

Additional harvesting of residues, either for pulpwood or biomass energy, would reduce fuel loads so the overall burn intensity may be reduced and allow burns to be conducted over a broader range of weather and seasonal conditions. The introduction of biomass harvesting might thus allow VR coupe designs with a greater proportion of island aggregates, which could be smaller in size, and allow a larger burning program to be achieved.

Financial and economic evaluation

A financial evaluation compared actual costs from 10 VR coupes with 10 similar CBS coupes (although the costs of roadworks and harvesting were based on a broader consideration). The additional cost of roadworks of $2.05/unit (tonne or cubic metre) due to VR is the most significant cost item. VR coupes generally require the same level of roading as clearfell coupes but result in lower reimbursement of road cost due to the forest retention within each coupe. This shortfall will be even greater if retention levels exceed the 20 per cent target recommended in the 2005 Advice to Government.

Firelines and burning were also significant additional cost items with VR, equivalent to a $1.53 increase per unit (tonne or cubic metre) harvested. Other management costs of sowing, game control, marking, supervision, Forest Practices Plan preparation, field inspections, special value inventories and operational inventory rose by $0.37 per unit harvested under VR compared with CBS. The average additional VR harvesting cost was estimated at $1.25 per unit. However, a higher differential could arise where harvesting contractors encounter more complexities such as an increased concentration of island aggregates.

Delivered log costs have thus risen approximately $5.20 per unit under VR compared with CBS silviculture. This does not include the high development costs of rolling out VR in the early years nor the cost of earlier road construction to access extra VR coupes to source a similar wood supply to that derived from clearfell coupes.

Timber jobs and supply contracts can be maintained if delivered log costs can be contained at levels that allow the continued viability of the timber processing industries. In order to contain costs for burning and roading, it would be preferable to increase the size of VR coupes. Harvesting costs should be negotiated based on the actual cost of additional work required for individual VR coupes.

Timber supply evaluation

The 2007 five-yearly review of sustainable high quality eucalypt sawlog supply from State forests updated the projected timber supply from that described in the 2005 Advice to Government. The updated model was constrained to meet the TCFA target that at least 80 per cent of the annual oldgrowth harvest be met from non-clearfell silviculture by 2010.

State forest classification as at 30 June 2007 indicates that a gross area of 97 000 ha of eucalypt oldgrowth coupes is available for harvesting. These include 61 000 ha of RFA-defined oldgrowth.

These are gross coupe areas and actual areas are an average of 25 per cent smaller, reflecting inoperable areas and additional reservations to meet conservation and other forest practice code requirements, with at least a further 20 per cent reduction in the harvested area of VR coupes due to the retention of aggregates.

For coupes containing oldgrowth, over the 20-year period from 2010-2029, the underlying RFA-defined oldgrowth area that is planned for clearfelling each year on average is 330 gross ha, and the RFA-defined oldgrowth area that is non-clearfelled (for example partial harvest or VR) each year on average is 1330 gross ha. Hence the proportion of RFA-defined oldgrowth area planned to be harvested by non-clearfell silviculture each year is 80 per cent, meeting the TCFA target.

Further modelling of timber yield implications of VR used sensitivity analyses for a range of retention and regeneration productivity levels to determine the feasibility of maintaining the 300 000 cubic metres annual supply target of high quality eucalypt sawlogs from State forests, given that at least 80 per cent of the annual oldgrowth harvest is met from non-clearfell harvesting.

At 20 per cent (and 30 per cent) retention in oldgrowth coupes designated for variable retention Forestry Tasmania can supply 300 000 cubic metres per year of high quality eucalypt sawlogs, but not at 50 per cent retention. Results were insensitive to regeneration productivity level using planning horizons of 90 years, due to coupes with retained aggregates being only a small component of the total eucalypt sawlog supply.

Oldgrowth coupes are important for the next 20 years in ensuring the legislated minimum eucalypt sawlog supply, but not in the long term. This is because there are insufficient alternative sawlog resources available now, while after 2030 native forest regrowth and eucalypt plantations will dominate sawlog supply. If VR silviculture were to be applied more broadly, for example to all native forest coupes or even to all coupes containing even a minor oldgrowth component, the effect of varying retention levels or regeneration productivity would be much more significant.

Advice from the Science Panel

A scientific panel of internationally recognised experts in forest and conservation science was established to review and provide advice to Forestry Tasmania on progress in practical implementation of silvicultural alternatives against international best practice standards.

The five panellists were Professor Jürgen Bauhus (Germany), Bill Beese (Canada), Jack Bradshaw (Australia), Professor Tom Spies (USA) and Professor Ivan Tomaselli (Brazil).

The panellists generally made recommendations independently, rather than as a collective, but did develop the following joint statement:

'All panel members were supportive of the use of mixed silviculture, particularly variable retention, as the best currently-known way for Forestry Tasmania to reduce clearfelling in oldgrowth forests while fulfilling its other requirements under applicable laws and policies.'

Each panellist provided detailed observations and recommendations from their own perspective and detailed knowledge from their respective fields, which included conservation biology, silviculture, landscape ecology, timber yield modelling and forest economics.

Five key needs emerged from the panellists' advice:

- development of landscape metrics to identify priorities for management of oldgrowth biodiversity
- effective treatment of harvest residues, primarily by burning but with a potential for harvesting some material for biomass energy with appropriate prescriptions for retention of coarse woody debris
- metrics and targets for VR implementation, guided by a balance of economic, social and biological objectives
- aggregate designs that recognise the need for burning as a seedbed preparation for eucalypt regeneration as well as ecological objectives
- improved social acceptability, brought about by more ecologically-based silviculture, continuing social research and ongoing dialogue with the public, including environmental non-government organisations.

Forest management evaluation

Since 2005 operational staff at Forestry Tasmania have identified and implemented several improvements to VR implementation in tall oldgrowth forests. These include:

- adopting slow-burning techniques based on lighting dry fuels under conditions of rising humidity (usually on dusk)
- retaining fewer, larger aggregates and using more peninsular or edge aggregates and fewer island aggregates
- considering multi-stage burns over progressive harvesting years.

Implementation costs can potentially be mitigated by:

- matching VR harvesting payments to the configuration and harvesting difficulty of individual coupes

- adopting larger coupes where appropriate
- seeking recognition by the Forest Practices Code that VR is a form of partial harvesting and not subject to coupe dispersal rules developed for clearfelling.

It is also important to maintain yields from VR coupes by an appropriate balance between ecological and productivity objectives. The trend to larger aggregates for sound ecological, safety and fire management has resulted in recent retention levels well above those foreshadowed in the 2005 Advice to Government. Various methods of stabilising or reducing retention levels to that recommended in 2005 are being implemented for current VR coupes.

The option of extending VR in tall oldgrowth forests onto steep slopes is considered very challenging from a worker safety and fire management perspective and is currently not recommended. This view could be revised if biomass energy markets develop and allow much of the current harvest residue to be removed rather than requiring burning on site.

Forestry Tasmania believes it can meet the 80 per cent non-clearfell target for the annual oldgrowth harvest beyond 2010, up to the required average level of 650 gross ha per year, although it recognises some negative aspects of VR. These include higher costs, more carry-over coupes following unsuitable burning conditions, an additional smoke nuisance, a greater risk of wildfire escape and less reliable regeneration.

In order to meet the TCFA target, Forestry Tasmania will need to ensure that subsequent three-year plans include sufficient levels of VR and other partial harvesting so the 80 per cent non-clearfell target is met from 2010/11. It is recommended that the reporting of actual outcomes in FT's annual Sustainable Forest Management Report is measured against a five-year average, which should be aligned with RFA five-yearly reviews.

The 80 per cent target may be hard to meet in years when the market focus is on sawlog-rich cable clearfell operations and pulpwood markets are low. In these years the level of oldgrowth clearfelling might well be less than 330 ha, which is 20 per cent of the average annual oldgrowth harvest predicted for the next 20 years, but would be above 20 per cent of the annual oldgrowth harvest for years when the non-clearfell oldgrowth harvest is significantly lower than average. It is therefore recommended the current target be amended as follows:

To reduce clearfelling of oldgrowth forest by achieving non-clearfell silviculture in a minimum of 80 per cent of the annual oldgrowth harvest or by limiting the annual clearfelling of oldgrowth forest to less than 330 ha per year.

Conclusion

Ideally several more years of operational experience would be available before drawing a definitive conclusion about the suitability of VR for tall oldgrowth forests in Tasmania, particularly as only three VR coupes have reached the age when regeneration success is determined.

We do now know, from Tasmanian research, that aggregates in VR coupes can be successfully retained in a mostly unburnt condition and provide viable habitat for many of the species associated with mature forests. We don't yet know if the aggregates will play a significant role in promoting the recolonisation of harvested areas by oldgrowth species. A still greater research challenge is to determine the landscape effects on biodiversity of moving to VR systems, rather than continuing with the modern application of clearfelling where there are, in most cases, substantial levels of retention between coupes.

The social acceptability of using some oldgrowth forests for wood production should be improved by a transition to VR because it represents a more ecologically-based silviculture than clearfelling. Previous research has shown a measurable acceptability benefit in applying VR at the coupe-scale and current research is examining the effects of applying VR on a landscape scale, particularly where VR is but one management practice in a broader landscape of regrowth forests, plantations and farmland.

The importance of oldgrowth forests for carbon storage and climate change requires more research and a thorough whole-system analysis that includes natural wildfire regimes and the risks owing to wildfire associated with different alternatives.

We can now be much more confident, compared to 2005, that worker safety can be maintained in VR operations given careful location of aggregates and appropriate management. This approach, combined with other initiatives such as increased mechanical felling, and the transition of log sorting from bush landings to new merchandising yards at the Huon and Smithton Wood Centres, should enhance the safety of forest operations.

We have demonstrated that VR coupes can be effectively burnt but the burning procedure is complex and difficult. The safe removal of residues is still the major limiting factor for the successful implementation, or broader application of VR. The effects of increased removal of residues for biomass energy on burning practices are still largely unknown.

We have demonstrated that VR coupes can be regenerated but don't yet know if regeneration can be reliably achieved at the better-than-95 per cent standard achieved by CBS operations. We do know that seedling densities tend to be lower, compared to clearfelling, primarily due to suboptimal seedbeds that result from incomplete burns. The potential for increased browsing in VR coupes may also lead to reduced seedling densities. The implications of lower seedling densities for sawlog productivity and quality are not yet understood.

The financial implications of VR are now better understood and appear to be around a $5.20 per unit (tonne or cubic metre) increase in delivered log costs. Depending how these costs are allocated or recovered, this will challenge the viability of some businesses and favour alternative sources of wood when supplies become increasingly available from regrowth and plantations. The quality of logs from these latter sources will be lower, but this disadvantage will be offset to some degree by increased uniformity of size and quality, allowing the application of sophisticated processing technology.

The legislated annual high quality eucalypt sawlog supply of 300 000 cubic metres can be maintained if non-clearfell silviculture is adopted for most oldgrowth harvesting. However, this assumes that there are no other requirements to further reduce harvesting in native forests. In fact, such pressures are quite considerable and further withdrawals are often required where research shows they are needed, for example for protection of particular threatened species or other special values.

Given these pressures, in order to maintain the legislated annual sawlog supply of 300 000 cubic metres, it will be very important for Forestry Tasmania to either expand, or improve the productivity of, its plantation estate, where opportunities exist. This must represent at least the productivity equivalent of the remaining 5300 ha of plantations provided for under the TCFA and must now not involve the broad-scale clearing of native vegetation. Access to cleared land is expensive and limited, and opportunities for further improving the productivity of existing plantations and native forest regrowth need to be evaluated as an alternative.

In 2005 operational staff at Forestry Tasmania had very little confidence, and generally no experience, in the implementation of VR in tall oldgrowth forests. Over the last three years they have embraced the concept and developed real improvements that facilitate its application, although they still recognise many operational difficulties that limit its implementation. Practitioners indicate they can implement a statewide VR program of up to 1000 ha in peak years but strongly caution against a broader program while burning is required for the safe removal of harvest residues and for successful regeneration. This limitation might lessen if much of the residues could be harvested for biomass energy.

Cost considerations will also limit the broader implementation of VR. The annual cost for a VR program of 650 ha would be $0.7 million at 20 per cent retention or $0.8 million at 35 per cent retention. A VR program of 1000 ha per year would cost between $1.0 million (at 20 per cent) or $1.3 million (at 35 per cent). The costs of ongoing VR implementation should be shared equitably among growers, the supply chain, consumers and perhaps the wider community.

In 2005 it was uncertain if the introduction of VR in tall oldgrowth forests designated for wood production would be recognised as an appropriate way forward by knowledgeable scientists, particularly forest ecologists. This uncertainty has been largely removed by the Old Forests New Management Conference and particularly by FT's Science Panel, which endorsed the 2005 mixed silviculture strategy.

Increasingly, scientific thinking is moving away from a narrow focus on the protection of oldgrowth forest *per se*, towards a greater focus on the maintenance of "oldgrowthness" or oldgrowth elements in the wider forest landscape. In this context it is important to recognise the high levels of oldgrowth reservation in Tasmania, and the somewhat arbitrary, and often debated, delineation between oldgrowth and non-oldgrowth forest. It could now well be argued that, if there exists a capacity, within operational, economic and safety constraints, to undertake around 1000 hectares of variable retention harvesting on State forest annually, there may be more ecologically beneficial ways of allocating that capacity over the whole forest estate than focussing it overly on defined oldgrowth forest. For example, there may be localities where oldgrowth elements in the regenerated forest are now sparse, and where the benefits of reintroducing such elements through VR would improve habitat values for biodiversity more than would a similar level of retention in oldgrowth forests in areas where oldgrowth elements are already represented at high levels in the landscape. This may be particularly pertinent for the enhanced management of habitat for threatened species in regrowth forests.

The operational experience to date and the judgement of local and international scientists provide strong support for the continued implementation of the TCFA variable retention program. Progress on the implementation of alternatives to clearfelling in oldgrowth forests should be further reviewed in 2015. This should include a particular focus on demonstrated ecological and social benefits, regeneration success, the development of biomass energy markets to facilitate the safe processing of harvest residues with reduced open-burning and smoke production, and the development of landscape assessment methods to prioritise management for maintenance and/or restoration of oldgrowth elements in forests where these elements are now sparse.

Recommendations

On the basis of this review, Forestry Tasmania should:

1. Confirm the RFA/TCFA commitment to maintain a minimum supply of 300 000 cubic metres of high quality eucalypt sawlog from Tasmania's State forests.

2. Affirm that the TCFA target of at least 80 per cent of the annual oldgrowth harvest will be met from non-clearfell silviculture from 2010/11.

3. Adopt a compliance target based on a five-year average, aligned with RFA five-yearly reviews. The target should be updated to read:

> *To reduce clearfelling of oldgrowth forest by achieving non-clearfell silviculture in a minimum of 80 per cent of the annual oldgrowth harvest or by limiting the annual clearfelling of oldgrowth forest to less than 330 ha per year.*

4. Refine the metrics and targets for VR implementation, guided by a balance of economic, social and biological objectives.

5. Continue to seek markets for biomass energy for harvest residues, with appropriate prescriptions for retention of coarse woody debris.

6. Complete the establishment of the remaining 5300 ha of plantations provided for under the TCFA on land that does not involve the broad-scale clearing of native vegetation, or achieve equivalent productivity enhancement through further treatment of existing hardwood plantations.

7. Seek funds to further expand its plantation estate, where opportunities exist on land not carrying native vegetation, to allow a broader adoption of VR silviculture while maintaining timber and employment levels in the forest industry.

8. Initiate research on landscape assessment methods and the development of silvicultural techniques for restoration of oldgrowth elements in regrowth forests.

9. Recognise that variable retention harvesting comes at a significant cost for forest managers, harvest contractors and processors, and with operational challenges which limit its application.

10. Seek recognition of variable retention harvesting as a silvicultural choice for forest managers within the Forest Practices Code, and encourage provisions (eg relating to coupe dispersal and size) to facilitate its implementation at least cost.

11. Continue to address community concern in regard to native forest management for wood production, through continuous improvement in ecologically-based silviculture, continuing social research and ongoing dialogue with the public, including environmental non-government organisations.

12. Further review the implementation of alternatives to clearfelling oldgrowth forests in 2015 with a particular focus on:

- demonstrated ecological and social benefits
- regeneration success
- development of biomass energy markets to facilitate the safe processing of harvest residues with reduced open-burning
- development of landscape assessment methods to prioritise management for restoration of oldgrowth elements in forests where these elements are now sparse.

13. Seek greater community recognition that oldgrowth is a dynamic, rather than a static, growth stage and that the debate about oldgrowth as mapped in 1996 will become less relevant over time. Rather, it will become increasingly important to focus on where oldgrowth forests, or regrowth forests with oldgrowth elements, are best located to meet biodiversity and social objectives over the long term.

14. Share the outcomes of this report with governments, key stakeholders and the wider public.

Introduction

Forest management in Tasmania has long been subject to intense public scrutiny and debate. Since the advent of the woodchip export market in the early 1970s, the last forty years have been characterised by a succession of public controversies and debate around such initiatives as the Wesley Vale pulpmill proposal (mid 1980s), the Labor Forests Accord/ Forests and Forest Industry Strategy (1990), the Regional Forest Agreement (1997), the Community Forest Agreement (2005) and the most recent pulpmill proposal. Over this time there have been ongoing assertions that Tasmania's forests were in imminent danger of disappearing, that destructive logging was continually reducing the area of forests, particularly oldgrowth forests, or converting them into industrial plantations and that future generations would be deprived of the benefits of the widespread natural forest cover for which Tasmania is justly renowned.

Particular community concern has surrounded the issues of adequate forest reservation, particularly of oldgrowth forests, and the protection of Tasmania's unique biological diversity; the conversion of natural forests to plantations, the use of chemicals, particularly 1080 poison for the control of native browsing animals; and the use of clearfelling (and associated burning) as a harvest/ regeneration (ie silvicultural) technique.

Over many decades, and particularly since the Forests and Forest Industry Strategy (Forests and Forest Industry Council 1990), there have been continuing improvements in forest management, particularly on the public State forest lands managed by Forestry Tasmania. Native forests still cover about 50% of Tasmania's land area (compared to about 67% at the time of European settlement), and 47% of these forests are protected within conservation reserves. This is an achievement of international prominence. Despite nearly 40 years of concern about the imminent loss of forests and the degradation of the oldgrowth forest estate, there are still over 1.2 million hectares of oldgrowth forest identified and mapped in Tasmania, of which nearly 1 million hectares are protected in conservation reserves.

Taking account of community concerns, Forestry Tasmania determined in 2000 to phase down the use of chemical control of browsing animals, resulting in a complete cessation by 2005 and achieving a virtual "organic" status in respect of all native forest management operations[1].

In 2007, Forestry Tasmania announced the cessation of conversion of native forests to plantation. While a relatively small proportion of State forests have been established as plantations[2], perceptions continued that most of Tasmania's natural forest were being systematically destroyed and converted into plantations. From 2007, all harvesting of native forests in State forests has been, and will continue to be, followed by re-establishment of natural forest cover, using the forest species and genetic stock natural to the sites.

Since 1990, the State forests of Tasmania have been explicitly managed on sustainability principles. Production of sawlogs from State forests, at levels consistent with those of the last two decades, have been projected for the next 90 years, with no diminution in ongoing forest productivity or forest growing stock. The proportion of mature eucalypt forest in State forest over this period is projected to be similar to the current level.

[1] Forestry Tasmania still uses some approved chemicals in the control of environmental weeds on State forest.

[2] About 6 per cent, or 100 000 hectares, of State forest is plantation. About half of this is softwood (pine) plantation established predominantly in the 1970-80s, and half is hardwood (eucalypt) plantation established over the last 15 years.

Oldgrowth and Clearfelling

In 2005, Forestry Tasmania sought to address another important issue, related to the use of clearfelling as a silvicultural practice, particularly in oldgrowth forests. Forestry Tasmania has been studying this issue since before 2000, and had initiated research programs to identify alternative approaches which would improve ecological outcomes, and address community concerns. Oldgrowth clearfelling represents the last significant item in the process of improvement in sustainable forest management outlined above.

In 2008, Forestry Tasmania published its Sustainability Charter, which outlined its forest management strategy for the coming decade. It states, among other things, the following forest management aims:

"Maintain a minimum of 250,000 hectares of oldgrowth forests in reserves in State forests (25% of Tasmania's reserved oldgrowth forests) for conservation values.

Retain oldgrowth elements including large trees, stags, understoreys and logs across the forest estate.

This will involve:

- *Continuing the TCFA variable retention program*
- *Developing landscape assessment methods to prioritise management for restoration of oldgrowth elements in forests where they are now sparse."*

Oldgrowth forests have aesthetic and cultural values important to the Tasmanian community as well as providing important wood and non-wood products including high quality eucalypt sawlogs, special species timber, leatherwood nectar for beekeeping and opportunities for tourism and recreation.

The 1997 Tasmanian Regional Forest Agreement sought a balance between conservation and timber production in Tasmania's oldgrowth forests by adopting national reserve criteria that included the reservation of at least 60 per cent of each oldgrowth forest community. This resulted in 69 per cent of Tasmania's 1.2 million ha of oldgrowth forest being reserved[3].

Following ongoing concern, particularly as expressed in the lead-up to the 2004 Federal election, the 2005 Supplementary Regional Forest Agreement (also known as the Tasmanian Community Forest Agreement or TCFA) increased the level of oldgrowth reservation to 79 per cent of the area mapped in 1996 and included a commitment to reduce clearfelling as a silvicultural technique in public oldgrowth forests. Clause 30 of the TCFA requires implementation of non-clearfell silviculture in a minimum of 80 per cent of the annual oldgrowth harvest area in State forests by 2010 (Commonwealth of Australia and State of Tasmania 2005).

This commitment resulted from a lengthy process, which began with a 2001 Tasmania Together benchmark to phase out clearfelling of oldgrowth forest on public land by 2010 (Community Leaders Group 2001). In 2003 the Tasmanian Government formally asked Forestry Tasmania to consider how government might address the Tasmania Together benchmark, within a context of maintaining sawlog and veneer supplies to industry, contractual arrangements, employment and maintenance of safety standards.

[3] The definition and identification of oldgrowth continues to be an issue of debate. The Australian and Tasmanian Governments adopted a definition as part of the regional forest agreement process, and oldgrowth forest in Tasmania was mapped using this definition. This map was adopted by governments as the basis for RFA commitments and remains the officially recognised basis for oldgrowth management. It is the one used by Forestry Tasmania. Popular perceptions of oldgrowth probably extend beyond this technical mapping, which can cause confusion in communication.

In 2004 Forestry Tasmania prepared a series of five issues papers for public information and comment. The papers examined feasible alternatives to clearfelling oldgrowth and the effects on wood supply, employment and gross value of production as well as the implications for worker safety and operability of forest management.

Issues Paper 1 (*Alternatives to Clearfell Silviculture in Oldgrowth Forests*) reported that preliminary research from the Warra silvicultural systems trial in southern Tasmania, and international experience with alternatives to clearfelling in tall wet forests, indicated that variable retention (VR) could be a practical silvicultural alternative to clearfelling tall oldgrowth[4] forests, provided harvest residues could be managed (Forestry Tasmania 2004a).

VR systems, as developed in parts of Canada and the Pacific Northwest of the USA, leave more than half the total area of a coupe within one tree height of the base of mature trees or groups of trees for at least one rotation. VR can be practised either as dispersed retention, which leaves individual trees for habitat purposes or aggregated retention, which leaves patches of forest to potentially provide for all oldgrowth biota.

The aggregated form of VR was predicted to be best suited to tall oldgrowth forests in Tasmania because it should be safer for forest workers and more compatible with regeneration and growth of eucalypts and rainforest species as long as harvest residues could be safely burnt, or otherwise reduced, to create seedbed without damaging retained aggregates.

The likely level of retention in most oldgrowth coupes was predicted to be about 20 per cent (in addition to the discount of about 25 per cent that normally occurs between planned and actual coupes) with a predicted reduction in stand productivity of the regrowth of about 10 per cent due to suppression of regrowth by oldgrowth trees.

Single tree/small group selection (SGS) was considered to be inappropriate for tall oldgrowth forests due to safety risks for forest workers, unburnt residues that pose a serious fire risk and the poor regeneration of eucalypts due to inadequate seedbeds and insufficient light. The paper noted that non-clearfell systems were already the predominant silviculture in shorter dry oldgrowth forests.

Issues Paper 2 (*Sustaining the Volume and Quality of Wood Yields from State forests*) reported that 12 per cent of Tasmania's oldgrowth forests was available for wood production (Forestry Tasmania 2004e). Of this, 60 000 ha was tall oldgrowth forest planned for wood production using clearfell systems.

Because oldgrowth, as mapped for the Regional Forest Agreement, occurs as a mosaic of larger contiguous areas and smaller fragmented pockets, Paper 2 introduced the concept of 'coupes containing oldgrowth', or CCOGs, to practically distinguish oldgrowth coupes from non-oldgrowth coupes. These CCOGs, when defined as containing at least 25 per cent mapped oldgrowth, held about one third of the currently available high quality eucalypt sawlog inventory.

Alternatives to clearfelling were predicted to reduce the sustainable yield from State forests by 10 to 40 per cent depending on the silvicultural options applied.

Issues Paper 3 (*Financial, Economic and Community Considerations*) reported that customers potentially affected by reduced wood supplied from oldgrowth forests included eucalypt sawmillers, special species sawmillers, veneer mills, pulp and paper mills,

[4] Oldgrowth forests at least 40 m tall, usually dominated by eucalypts and with a very dense understorey.

woodchip mills and users of smaller quantities of specialised forest products (Forestry Tasmania 2004b).

The financial implications of a complete cessation of oldgrowth logging were estimated at $134 million/year or $938 million for the period from 2010 to the expiry of the Tasmanian Regional Forest Agreement in 2017.

The associated employment loss was estimated at 800-1200 jobs.

If logging oldgrowth was allowed but without clearfelling, implementing non-clearfell harvest systems would mean customers would be affected by a reduced supply and an increase in delivered log costs.

Resource losses due to non-clearfell systems were predicted to be primarily from highly productive tall oldgrowth eucalypt forests, which would result in a disproportionately large loss for the sawmilling and sliced-veneer industries.

Any phasing out of clearfelling of oldgrowth forests needs to recognise section 22AA of the Forestry Act, as endorsed by the Regional Forest Agreement, which currently requires Forestry Tasmania to continue to make available a minimum quantity of 300 000 cubic metres per year of high quality eucalypt sawlog. This could be achieved with a significant investment in high-pruned hardwood plantations, although pruned eucalypt plantation sawlogs as a source of high value solid wood products are unproven, at least in Australia.

Issues Paper 4 (*Safety Management*) noted that non-clearfell systems are potentially more dangerous than clearfelling because workers are exposed to hazards and risks associated with felling and extraction under retained trees (Forestry Tasmania 2004d).

Tall oldgrowth forests pose greater risks to workers than regrowth forests because the tree sizes are much larger, there is a far higher level of decay in the trees, and the ability to influence the direction of fall is severely diminished. Dense understoreys in tall oldgrowth forests make it difficult for the feller to assess the characteristics of the tree crown and also impede workers when seeking escape routes from falling trees.

Limited results from silvicultural trials indicated that the safety hazard posed by aggregated retention may not be significantly greater than clearfells if the distance between aggregates is at least two tree lengths or about 80 m.

Dispersed retention is not suitable for tall oldgrowth forests, except at low retention levels, due to the need for careful manoeuvring of machines, directional felling of trees and the time required working under a retained canopy.

Selective logging in tall oldgrowth forests presents the greatest safety risk and small group selection, using gap sizes of less than a tree length, cannot be recommended. Partial felling of tall oldgrowth forests on steep country (greater than 20 degrees) is more hazardous than flatter land because the slopes are too steep to allow tracked machinery to assist in felling and clearing understorey around retained trees. VR was predicted to be inappropriate for harvesting tall oldgrowth forests on steeper slopes due to the potential for increased risk to forest workers.

Issues Paper 5 (*Forest Management Issues*) noted that non-clearfell systems produce less wood per hectare than clearfelling, which means that more areas need to be harvested per year to meet supply targets (Forestry Tasmania 2004c).

A shift to non-clearfell silviculture in tall oldgrowth forests would increase the complexity of forest management implementation by:

- increasing planning and field implementation costs per coupe
- increasing the number of coupes compared to clearfelling
- bringing forward future roadworks costs
- increasing the difficulty and costs of removal of harvest residues to create a seedbed for regeneration.

The most significant operational issue under non-clearfell systems in tall oldgrowth forests was predicted to be a reduced capacity to burn harvest residues to reveal seedbeds for regeneration and reduce subsequent wildfire hazards. This results from the need to protect retained trees or aggregates.

The development of a market for biomass for energy production could potentially provide an alternative, or supplementary, means for reducing harvest residues.

Regeneration under non-clearfell silviculture was predicted to be less effective due to poorer seedbed availability arising from lower post-harvest burning intensity, lower light levels as a result of retained trees, increased competition from other regenerating plants and greater levels of browsing.

In 2005, following a public comment period on the issues papers, Forestry Tasmania prepared its Final Advice to Government which outlined five forest management scenarios, including the complete cessation of logging within all oldgrowth forest (Forestry Tasmania 2005). The scenarios were compared with the prevailing clearfell silviculture, then intended for some 60 000 ha of oldgrowth forest on public land, using the following performance criteria:

- maintenance of a minimum supply level of 300 000 cubic metres of high quality eucalypt veneer and sawlog material as provided for in the *Forestry Act 1920*
- maintenance of contracted commitments to veneer, sawlog and pulpwood customers
- maintenance and enhancement of occupational health and safety in forest operations
- safe processing and removal of forest harvesting residues
- regeneration which meets stocking standards for sustainable forest management
- maintaining jobs of Tasmanian timber workers.

The 2005 Advice to Government recommended several key initiatives in the context of the performance criteria set by the Tasmanian Government. These initiatives were directed at minimising the risks that changes to prevailing practice may have on managing State forests for sustainable wood production, while seeking to enhance ecological and social outcomes. The report recommended:

- Adoption of a mixed silviculture strategy that included variable retention in most tall oldgrowth forests, limited clearfelling in steeper areas and single tree/group selection in designated Special Timbers Management Units. It recommended continuation of partial/selective systems for dry oldgrowth eucalypt forest.
- A program of hardwood plantation establishment and pruning to ensure long-term maintenance of sawlog supply to support the adoption of the mixed silviculture strategy. Native forest conversion to plantation was to be phased out by 2010, and no further conversion to plantation of coupes containing oldgrowth was to occur after 2005.

The major elements of this strategy, as approved by the Tasmanian Government within the context of the TCFA, was published as an addendum to the 2005 Advice to Government (Forestry Tasmania 2005), and is reproduced as Appendix 1.

The 2005 Advice set a target for full implementation of the strategy at 2010, subject to a publicly reported review and confirmation that appropriate progress across the range of initiatives was being made. This review would include:

- a scientific review of the results of the Warra alternative silviculture trial and associated operational trials
- an international conference hosted by Tasmania to bring together relevant forest scientists to consider the outcomes from the Warra research and evaluate them against international experience
- evaluation of progress, including technology testing and harvesting research, towards the establishment of a commercial market for harvest residues
- a report by an expert panel on safety and job impacts and their mitigation
- evaluation of progress in plantation establishment.

It was also proposed that a scientific panel of internationally recognised experts in forest and conservation science be established to provide advice to Forestry Tasmania on the implementation of alternative silviculture benchmarked against international best practice.

This current report provides that review and includes the above elements. It was originally intended for completion in 2007. Because the international conference, hosted by Forestry Tasmania and the Cooperative Research Centre for Forestry, with support by the International Union of Forest Research Organisations, occurred in February 2008 completion of this review has been delayed until 2008/09. The extended review period allowed VR coupes established in autumn 2008 to be included in the review.

The review has been informed by a $2 million program of research on alternatives to clearfelling in oldgrowth forests that commenced in 2005 and will continue until 2010 (http://www.daff.gov.au/_data/assets/pdf_file/0016/50326/alternatives_to_clearfelling_op.pdf).

The 2005 Advice to Government was finalised concurrently with discussions between the Tasmanian and Australian Governments on the implementation of the latter's Tasmanian Forest Policy published during the October 2004 Federal election and which culminated in the Tasmanian Community Forest Agreement.

The TCFA delivered, among other things:

- another 156 000 ha of new formal and informal reserves on public land
- adoption of the mixed silviculture strategy for remaining oldgrowth areas designated for wood production
- an investment of around $220 million, from both the Australian and Tasmanian Governments, in forest and forest industry-related initiatives to mitigate wood supply effects. This included funding to establish 16 000 ha of plantations to mitigate the effects on the sustainable sawlog supply due to the new reserves and the reduction in clearfelling of oldgrowth forest.

VR Implementation

The TCFA included three specific commitments, clauses 30-32, relating to the ongoing management of oldgrowth forest outside reserves on public land. These clauses are:

Clause 30: The Parties are seeking to strengthen protection and sustainable management of oldgrowth forest. The Commonwealth supports the State's policy to reduce clearfelling as a silvicultural technique in public oldgrowth forests and the State's commitment to achieve non-clearfelling silviculture in a minimum of 80 per cent of the annual harvest area of the couped oldgrowth forest on State forests by 2010. The Parties agree to jointly fund a package of forest management and operations, industry development, and research and development activities to implement this approach. The Parties note Forestry Tasmania will also undertake additional investments, beyond the scope of this funding package, to ensure its statutory wood supply requirements are met.

Clause 31: The State will publicly report the area of public oldgrowth forest harvested by silvicultural technique each year.

Clause 32. Progress to achieving safety, regeneration and log supply objectives will be reviewed by the State in 2007.

An interim progress report was provided in June 2007, as part of the report on Implementation of the Tasmanian Regional Forest Agreement 2002-2007 (Australian Government and Tasmanian Government 2007) prepared for the 2007 five-yearly review of the RFA. This report has been updated below to include further progress as at June 2008.

A program of research and field trials has been established to complement Forestry Tasmania's ongoing work to reduce the level of clearfelling of oldgrowth forests to no more than 20 per cent of the annual oldgrowth harvest in State forests by 2010. This additional research is listed in the Operating Plan for the Australian Government funded Research into Alternatives to Clearfelling in Oldgrowth Forests Program (Australian Government 2005) and outcomes to date have been incorporated in this review.

Two groups have been formed to guide the development of variable retention (VR).

An internal Variable Retention Implementation Group (VRIG), which consists of Forestry Tasmania's strategic planning and research staff as well as a VR 'champion' from each district, has helped to develop practical solutions for the operational challenges of VR harvesting.

An external Variable Retention Advisory Group (VRAG) was established to foster communication with industry stakeholders on worker safety issues and the implementation of programs for alternatives to clearfelling. VRAG includes representatives from Forestry Tasmania, various forest industry and forest contractor groups, Workplace Standards Tasmania, and the Australian Government's Department of Agriculture, Fisheries and Forestry.

Forestry Tasmania's implementation of VR has also been informed by experience elsewhere in the world.

In August 2006 three Forestry Tasmania research and operational staff members visited British Columbia, Oregon and Washington State to gather information on best practices related to variable retention planning, harvesting and site preparation (Hickey *et al.* 2006).

In late 2006, Bryce Bancroft and Ken Zielke of Symmetree Consulting Group, British Columbia, Canada, visited Tasmania to provide operational advice and training to field staff and harvesting contractors. They made a number of useful operational and strategic observations (Symmetree 2007), which are summarised in Appendix 2.

Forestry Tasmania engaged an international science panel to provide advice on the implementation of alternative silviculture. Brief biographies of the scientists are included in Appendix 3.

Panel members visited Tasmania in July and September of 2007, and submitted preliminary reports to Forestry Tasmania in November 2007. Final reports were submitted in June 2008, following the 2008 Old Forests New Management Conference, and are available from Forestry Tasmania's website, www.forestrytas.com.au.

The conference (see www.oldforests.com.au) brought together leading researchers from a range of disciplines focussed on achieving ecologically sustainable management of oldgrowth forests. A summary of the conference outcomes is provided in this review.

Forestry Tasmania has developed a set of goals and guidelines (Appendix 4) for implementation of variable retention in tall oldgrowth forests. These goals recognise that variable retention silviculture seeks to better emulate ecological processes while still meeting timber production objectives. A draft field manual for variable retention has been developed and distributed to operational staff (Forestry Tasmania 2007), as have two research notes. A GIS-based tool (*VR Calculator)* has been developed to help operational staff calculate influence and retention levels in VR coupes.

Variable retention is a term that has been adopted to describe any silvicultural system or management regime that prescribes long-term tree retention (Beese *et al*. 2003).

Forestry Tasmania currently uses the phrase variable retention to describe one of several non-clearfell approaches to harvesting (the others include various forms of partial harvest that don't necessarily require long term retention).

Aggregated retention (ARN) is the main silvicultural system being used to achieve the variable retention approach in tall oldgrowth forests (dominated by eucalypts at least 40 m tall). In this review, the term variable

Styx 18E is a 30 ha aggregated retention coupe, with 30 per cent retention, established in autumn 2007. The forest is dominated by *Eucalyptus regnans*, with a subcanopy layer of *Nothofagus cunninghamii* (myrtle) and *Atherosperma moschatum* (sassafras). Some eight-year-old regeneration established by clearfell, burn and sow silviculture can be seen towards the top of the photo.

Table 1. Number (hectares in brackets) of VR coupes established in Tasmania, using aggregated retention, up until Autumn 2008.

Year	Established	Cumulative	Comments
2003/04	2 (38)	2 (38)	Research coupes
2004/05	1 (39)	3 (77)	
2005/06	0 (0)	3 (77)	Post TCFA
2006/07	8 (342)	11 (419)	
2007/08	9 (413)	20 (832)	

retention is generally preferred, except where comparisons between different silvicultural systems are being made.

Table 1 lists the areas by years for all VR coupes established in Tasmania using aggregated retention, up until Autumn 2008. The first coupes were established in 2003/04 as part of the Warra silvicultural systems trial.

The cumulative area of established[5] VR coupes (felled area and aggregates) is now approximately 832 ha. These coupes generally contain a mix of RFA oldgrowth (as mapped in 1996) and non-oldgrowth forest, but some non-oldgrowth coupes have also been harvested using VR for visual management reasons. Hence the area of oldgrowth harvested using VR is less than the sum of the VR coupe areas.

The percentage of public oldgrowth forest harvested by clearfelling each year is reported in Forestry Tasmania's Sustainable Forest Management Report (Forestry Tasmania 2008b).

The average annual area of oldgrowth harvested between 2002/03 to 2007/08 is 2261 ha. The percentage harvested by non-clearfell methods (both VR and traditional partial harvesting) has increased from 49 per cent in 2002/03, 54 per cent in 2004/05 when the TCFA was signed, to 67 per cent in 2007/08 (Figure 1).

Planned oldgrowth harvest levels for 2008/09, 2009/10 and 2010/11 are 2340, 2040 and 1840 ha respectively, after allowing for average coupe discounts of 25 per cent. Planned areas assume full sawlog supply levels, but actual harvest levels can be less than this due to reduced market demand.

The 2005 Advice to Government recommended additional plantation establishment and a program of native forest thinning to offset the loss of wood supply due to the implementation of alternatives to clearfelling. Forestry Tasmania's target was to establish over the next five years an additional 16 000 ha of eucalypt sawlog plantation, and thin 2500 ha of native forests to offset reductions in sawlog supply from native forests. It also made a policy

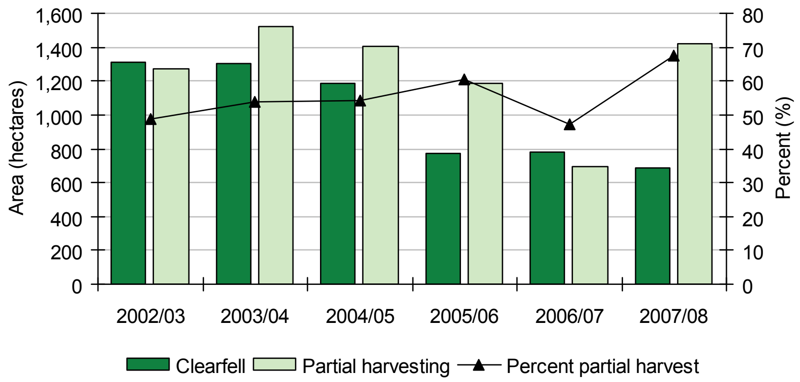


Figure 1. Area of oldgrowth forest harvested by clearfell and non-clearfell methods from 2002/03 to 2007/08.

[5] Harvested, burnt and sown

Table 2. Area (ha) of plantation and native forest thinning under the TCFA intensive-forest-management program.

Year	05/06 (ha)	06/07 (ha)	07/08 (ha)	08/09 (ha)	Total to date (ha)	Purchased[2]	Planned 09-122[3] (ha)	Total (ha)
Plantation area established	487	1882	3515	~3500[1]	~9384	1300	~5316	~16000
Native forest commercially thinned	150	531	544	~500	~1725		~775	~2500

[1] on land previously harvested and windrowed
[2] plantations purchased in 2006
[3] on land that does not involve the broad-scale clearing of native vegetation (for example establishing eucalypts on former pine plantations, rehabilitation of under performing eucalypt plantations previously managed on pulpwood regimes)

decision to end conversion of oldgrowth forest to plantation from 2005.

The TCFA provided funding for this program and, since the signing of the TCFA, more than 9000 ha of new eucalypt plantation forests have been established or prepared for planting (Table 2), mostly through conversion of native forests, other than oldgrowth forest. This includes about 3500 ha of land to be planted in 2008/09, which was previously harvested and windrowed. Under the program, a further 1300 ha of existing plantations were purchased and will be progressively replaced or upgraded to eucalypt sawlog plantation.

Broad-scale conversion of native forest to plantation ended in 2007, ahead of schedule and in accordance with the upgraded Australian Forestry Standard (Australian Forestry Standard Limited 2007), which does not allow broad-scale conversion of native forests. This decision was taken on the basis that coupes initiated (that is, where harvesting had commenced) prior to 31 December 2006 would proceed through to plantation establishment.

This achievement is currently 5300 hectares short of the 16 000 hectares envisaged in the TCFA.

The completion of the required program has been made somewhat more difficult with the cessation of native forest conversion, and will at least take longer to achieve than originally intended.

Other mitigation strategies including a higher proportion of plantation thinning and pruning, secondary fertilising, and more thinning in native forests, together with the completion of the plantation program will enable the high quality eucalypt sawlog supply of 300 000 m^3 per year to be maintained.

Forestry Tasmania has completed a $15 million TCFA program to upgrade the productivity of its existing plantation estate through secondary fertilising and higher lift pruning. It will complete the expansion of its hardwood plantation estate, where opportunities exist, on land that does not involve the broad-scale clearing of native vegetation. Given the limited nature, and potentially greater cost of these opportunities, consideration will also need to be given to further upgrade the productivity of existing plantations, in lieu of additional plantation establishment.

Ecological Evaluation

Background

Clearfell, burn and sow (CBS) silviculture has been the main harvesting system used in Tasmanian wet eucalypt forest since the 1960s, and is a successful means of regenerating eucalypts (Hickey and Wilkinson 1999).

It has proven to be a reliable technique that has enabled the establishment of nearly 200 000 ha of vigorous young eucalypt forest on public land (Felton and Cubit 2006).

Forest regenerating following clearfelling also provides habitat for most plants and animals that would naturally occur in young forest (Hickey 1994; Turner 2003; Baker *et al.* 2004).

However, since a clearfelled site does not contain many of the biological legacies that would survive a wildfire, and moreover since clearfelling of a site is intended to occur approximately every 80-100 years, forest managed by clearfell, burn and sow silviculture may not provide suitable habitat for species that either prefer or rely on much older forest, for example rainforest trees or birds and mammals that nest in tree hollows.

Variable retention silviculture is increasingly being applied in native forests worldwide in place of clearfelling (Vanha-Majamaa and Jalonen 2001; Beese *et al.* 2003; Bunnell and Dunsworth 2004). The 2005 Advice to Government predicted that the aggregated form of variable retention (VR) would result in improved biodiversity outcomes compared to the clearfell, burn and sow system that was then solely applied to tall oldgrowth forests in Tasmania. Trials of the aggregated form of variable retention are also being conducted in the tall eucalypt forests of Victoria (Lindenmayer 2007).

The primary objectives of variable retention thus relate to forest biodiversity, in particular through providing refuges for mature-forest species and structures that would suffer under repeated clearfelling rotations, and accelerating the development of mature forest habitat in the regenerating forest.

Specifically, the three main objectives of variable retention (Franklin *et al.* 1997) are:

- ‘lifeboating’ species and processes over the regeneration phase
- enriching re-established forest stands with structural features
- enhancing landscape connectivity.

Salmon River 37C in northwest Tasmania is a 42 ha aggregated retention coupe dominated by *Eucalyptus obliqua*. About 26 per cent of the coupe area has been retained in aggregates. The coupe was established in autumn 2007 and several of the aggregates were scorched by the regeneration burn, but still provide important structural features for oldgrowth biodiversity.

VR is expected to improve the ability of poorly dispersing plant and animal species, such as myrtle and log-dwelling beetles, to re-colonise harvested areas so coupes more rapidly achieve the biodiversity characteristics of older forest. This is a concept known as 'forest influence', where the amount and spatial distribution of retained elements enable the mature-forest legacies to influence the species composition and development of the majority of the harvested area as it regenerates (Mitchell and Beese 2002).

Internationally, VR is proving to be an effective system for maintaining mature-forest species,, and structures (Rosenvald and Lõhmus 2008).

In Tasmania, tall oldgrowth forests are naturally regenerated by massive wildfires which nevertheless usually leave late-successional species and structures, either as individual trees and stags scattered throughout regenerating stands, or as unburnt patches (fire skips) of variable size (Turner *et al.* in review). These mature forest elements are removed during clearfelling, but are important biological legacies that maintain biodiversity and variability at the stand level. An understanding of the structure and ecology of forests regenerated following natural wildfire is used to guide implementation of VR silviculture.

A very large number of forest-dwelling species are habitat-dependent. They cannot return after logging until an appropriate habitat is present, which for many species would not occur in coupes within the 80-100 year clearfelling rotation but which VR silviculture is designed to promote.

Some of the critical habitats are:

- habitat trees (for hollow-dependent vertebrates)
- large coarse woody debris (CWD) (for invertebrates and fungi)
- very old large-diameter eucalypts or tall, mature understorey trees (for lichens and bryophytes).

In Tasmania's State forests, these habitats have traditionally been maintained at the landscape level by formal and informal reserves, often connected by wildlife habitat strips, and areas outside designated harvest areas.

More than 53 per cent of State forests are managed for protection of environmental values, including 34 per cent within formal and informal reserves, and another 19 per cent that lies outside areas currently designated for wood production (Forestry Tasmania 2008b). The formal and informal reserves form part of Tasmania's Comprehensive, Adequate and Representative (CAR) reserve system, which is managed primarily by the Parks and Wildlife Service.

Even within areas designated for wood production, a considerable portion remains unharvested (on average, about 25 per cent of designated harvest areas are retained due to a variety of operational reasons including topography and Forest Practices Code requirements for streamside reserves and other local environmental set-asides). Most of these latter 'coupe discounts' result in retention of patches of mature forest between coupes rather than within them.

Forestry Tasmania (2005) recommended using VR (in particular aggregated retention) in tall oldgrowth eucalypt forests as part of a mixed silviculture approach, in order to enhance biodiversity and aesthetic outcomes.

An ecological research and monitoring program has been integral to the roll-out of VR in Tasmania. Developing VR in tall oldgrowth eucalypt forest has been, and continues to be, an adaptive management process. This adaptation has occurred to improve silvicultural outcomes, address operational and safety requirements and respond to improved understanding, both locally and internationally, of the biodiversity benefits of VR.

Forestry Tasmania's goals and guidelines for implementation of VR (Appendix 4) are central to achieving positive biodiversity outcomes, with the following being especially relevant:

- To more closely emulate natural ecological processes within managed tall oldgrowth forest by retaining late-successional species and structures (biological legacies) for at least a full rotation.
- To maintain a forest edge influence over the majority of the felled area thereby differentiating the regenerating stand ecologically from stands regenerating following clearfelling. The majority of the felled area should be within one tree height of forest that is retained for at least a full rotation (for aggregated retention this requires most felled areas, often described as 'fairways', to be two to four tree-lengths wide).
- Retained areas can be free-standing islands (island aggregates) or may be contiguous with standing forest outside of the coupe (edge aggregates). Aggregates should generally be at least one hectare in size.
- Aggregates should be anchored on specific locations of ecological value (for example biological legacies, special vegetation communities) and include the range of habitat types (for example vegetation types, stand ages, landforms) present within the coupe.

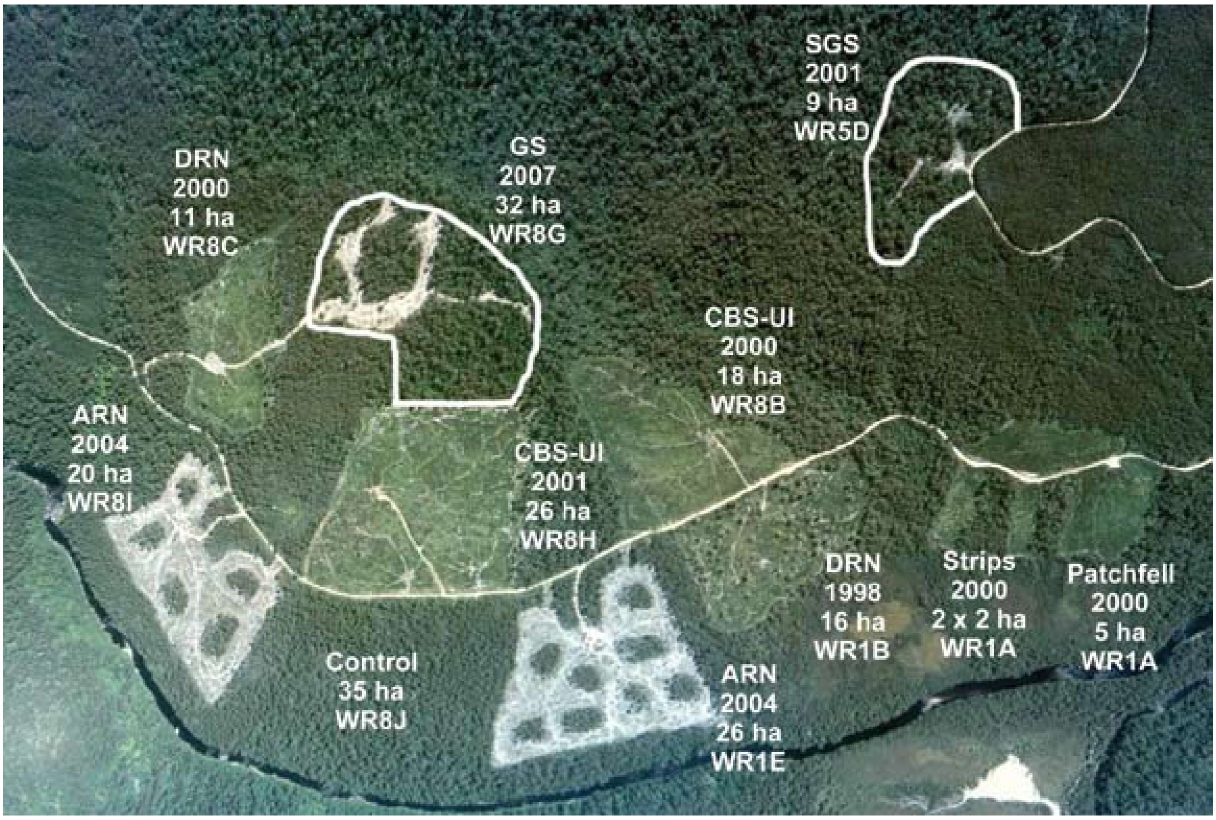


Figure 2. Aerial overview of the Warra SST showing layout of treatment coupes in the trial area.

ARN = aggregated retention, CBS-UI = clearfell, burn and sow with understorey islands, CON = unharvested control, DRN = dispersed retention, GS = group selection, SGS = single tree/small group selection, Strips = Stripfells

Research findings from the Warra silvicultural systems trial

Since 1997 the Warra silvicultural systems trial (SST) has been the focus of very intensive long-term research into the responses of a number of biodiversity elements to several alternative silvicultural systems.

The objective of this research is to assess the degree to which mature-forest biodiversity can be maintained within coupes harvested by the following systems: aggregated retention; dispersed retention; clearfell, burn and sow with understorey islands; stripfell; and group selection (see Table 3 and Figure 2). Clearfell, burn and sow and unharvested controls were used for comparison.

Research at the Warra SST seeks to investigate how effectively the silvicultural systems:

- allow organisms to persist in harvested areas from which they would otherwise be eliminated, that is, by providing refuges for species and processes during the regeneration phase
- enrich re-established stands with structural features and habitat heterogeneity
- improve the ability of poorly dispersing species to re-colonise the harvested area so that the coupe more rapidly achieves the biodiversity characteristics of older forest, that is, demonstrate influence of the retained forest on the regenerating forest (Franklin *et al.* 1997; Lindenmayer and Franklin 2002).

Research has included monitoring of birds, litter beetles, vascular plants, bryophytes, lichens, fungi and habitat trees. Mammal surveys were discontinued because of very low detection rates. The results of some of these studies were presented at the Old Forests New Management Conference (Hobart, 2008), with the conference field day also showcasing the Tasmanian research to the international audience.

Several papers arising from research at Warra and in the surrounding landscape have been submitted to a special issue of *Forest Ecology and Management* arising from the conference (Baker *et al.* 2009, in press; Turner *et al.* in review; Neyland *et al.* 2009 in press; Lefort and Grove, in review) and one in *Tasforests* (Gates *et al.* in press).

The multi-species community composition of birds and litter beetles responded strongly to the silvicultural system, and particularly benefited from the aggregates retained in aggregated retention. Figure 3 shows the results of ordination analyses for birds and beetles. Ordination analysis is a technique used by ecologists to graphically compare sites along axes on the basis of data on species composition of those sites.

Both groups of animals had very different community composition in recently harvested forest compared to unharvested control areas. This is illustrated in the ordinations by the lack of overlap in the scatter of symbols representing the harvested area and unharvested control plots.

For birds (Figure 3A), the scatter of plots in retained aggregates (large grey circles) overlaps that of plots in both the harvested and the control areas. This shows that bird community composition was quite variable in aggregates. Some areas supported communities affiliated with mature forest while other areas supported species affiliated with young forest, or a mix of birds from both habitats.

By contrast, litter beetle communities in aggregates (Figure 3B) were much more similar to the communities found in the unharvested control areas, with no overlap in the scatter of points with those from the harvested area.

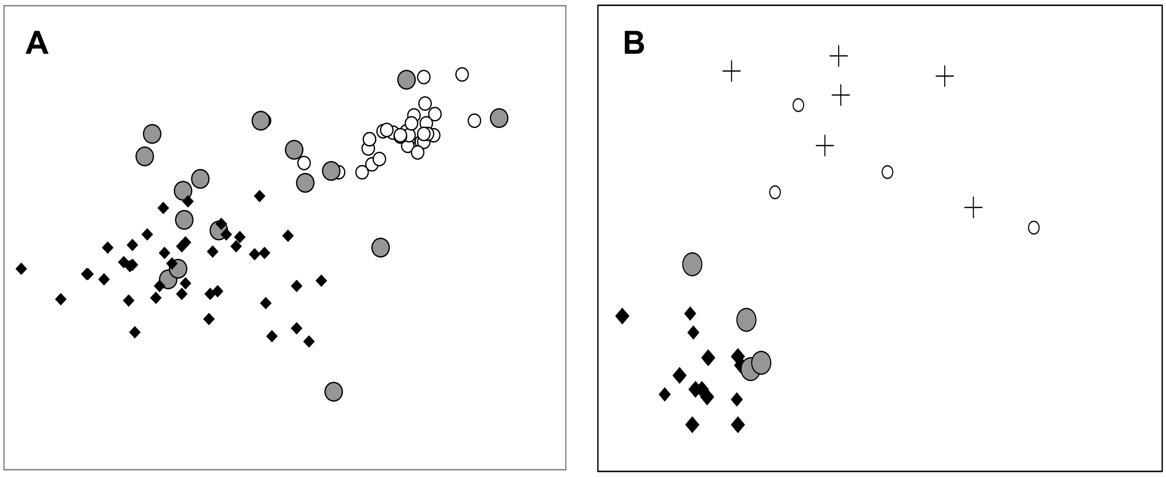
For beetles, it was also possible to compare the communities present in the harvested area of the aggregated retention coupes with

Table 3. Treatments at the Warra silvicultural systems trial

Treatment and description	Objectives
Clearfell, burn, and sow (CBS)	
Large openings with no structural retention, high intensity burn, applied seed.	Efficient and safe eucalypt harvest with maximum growth of eucalypt regeneration. Maintain biodiversity representative of younger successional forest.
CBS with understorey islands (CBS + UI)	
As for CBS but with 40 m x 20 m machinery exclusion zones in up to five per cent of the coupe area.	Efficient and safe eucalypt harvest with good growth of eucalypt regeneration and enhanced local survival of understorey flora on the machinery-free areas. Survival of some late-successional flora, source of seeds for the regeneration of rainforest species.
Dispersed retention (DRN)	
10 to15 per cent basal area retention of overstorey eucalypts, low intensity burn, natural seedfall.	Harvest eucalypts as safely as possible with adequate growth of eucalypt regeneration, and enhanced biodiversity outcomes by using individual eucalypt trees retained for a full rotation for habitat and seed supply. Retained trees provide habitat for hollow-dependent fauna and epiphytes and provide continuity in supply of coarse woody debris.
Aggregated retention (ARN)	
30 per cent of coupe area retained in aggregates of 0.5-1 ha with the majority of the harvested area within one tree height of retained forest, low-intensity burn, natural seedfall.	Harvest both eucalypt and special species as safely as possible, with adequate growth of eucalypt regeneration and enhanced biodiversity outcomes by using patches of undisturbed forest retained for a full rotation for habitat, seed supply (all species) and aesthetics. Provide intact habitat and colonisation sources for late successional species.
Stripfell (STRIP)	
Cable harvesting, 250 m x 80 m strip openings, low-intensity burn, natural seedfall.	Harvest eucalypts as safely as possible with adequate growth of eucalypt regeneration, and enhanced biodiversity outcomes by using strips of undisturbed forest retained for half the rotation for habitat and seed supply (all species including rainforest trees).
Single-tree/small group selection (SGS)	
Retention of >75 per cent forest cover, permanent snig tracks, harvest 40 m^3/ha every 20 years, openings < one tree height wide, heaping of slash, mechanical soil disturbance (no burning), natural seedfall.	Harvest mature trees as safely as possible with adequate growth of eucalypt and special species regeneration, and enhanced biodiversity outcomes by maintaining a high proportion of tall forest cover. Encourage the development of rainforest elements within the regenerating stands.
Group selection (GS)	
Retention of >70 per cent forest cover, permanent snig tracks, harvest 30 per cent of the canopy cover every 30 years using groups and strips, openings twice tree height wide, low-intensity burning, natural seedfall.	As above, but with greater safety and operability.

Figure 3. Ordination results for A) birds and B) litter beetles in the Warra SST aggregated retention coupes three years following harvesting.

Each symbol represents the multi-species community composition of birds or beetles from a single plot. Symbols that are closer together in space have more similar community composition. Black diamonds represent unharvested controls, large grey circles represent aggregates and small open circles indicate the harvested part of aggregated retention coupes. Plus signs represent harvested area of clearfell, burn and sow coupes (beetles only).



those in the clearfelled coupes. Although there was overlap in the scatter of points, there is a trend for the beetles in the harvested parts of aggregated retention coupes to be slightly closer in community composition to those in the unharvested forest than those in the clearfelled coupes.

It is expected that mature-forest beetles with poor dispersal abilities will more rapidly re-colonise the harvested areas of aggregated retention coupes than the harvested areas of clearfelled coupes. The beetle community appeared to respond more strongly to the treatments than the birds, with more distinct clustering of plots for harvested and unharvested treatments in the ordinations.

Although the majority of bird and beetle species had a preference for either unharvested or harvested forest habitats, individual species had quite variable responses to the silvicultural systems. This is illustrated in Figure 4 in relation to the aggregated retention system.

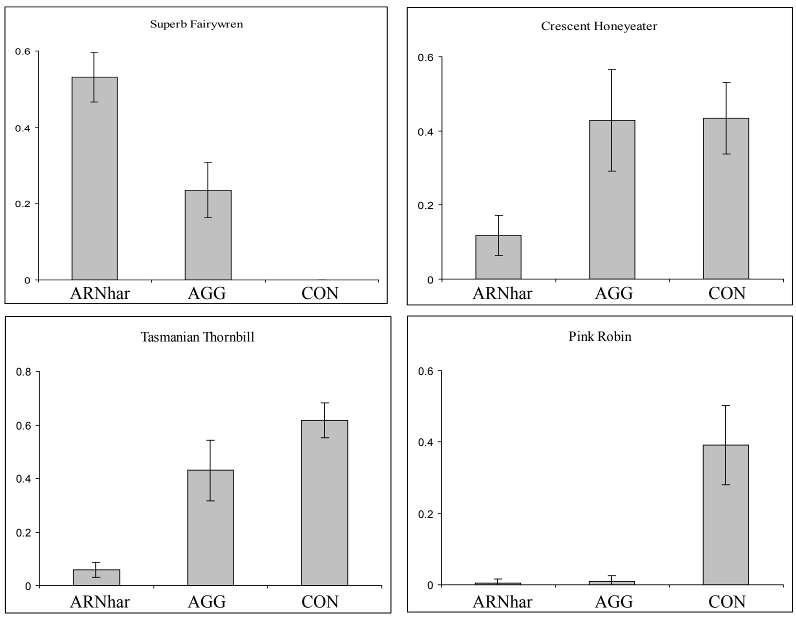
Of the birds (Figure 4A), the Superb Fairywren is an open-country species that was not recorded in control areas or prior to harvesting, but was common in harvested areas and found to have intermediate relative incidence in aggregates. The Crescent Honeyeater is a generalist mid-layer bird which was equally common in aggregates and unharvested controls. The Tasmanian Thornbill, a shrub-layer bird, was reasonably common in aggregates but more common in controls, possibly because much of the understorey has been windthrown in the aggregates. The aggregates at three years after harvesting appeared to be unsuitable habitat for the Pink Robin, a forest specialist shrub-layer species.

Of the beetles (Figure 4B), the carabid *Cyphotrechodes gibbipennis* was common in the harvested areas of aggregated retention and clearfelling but absent from aggregates in aggregated retention coupes and unharvested controls.

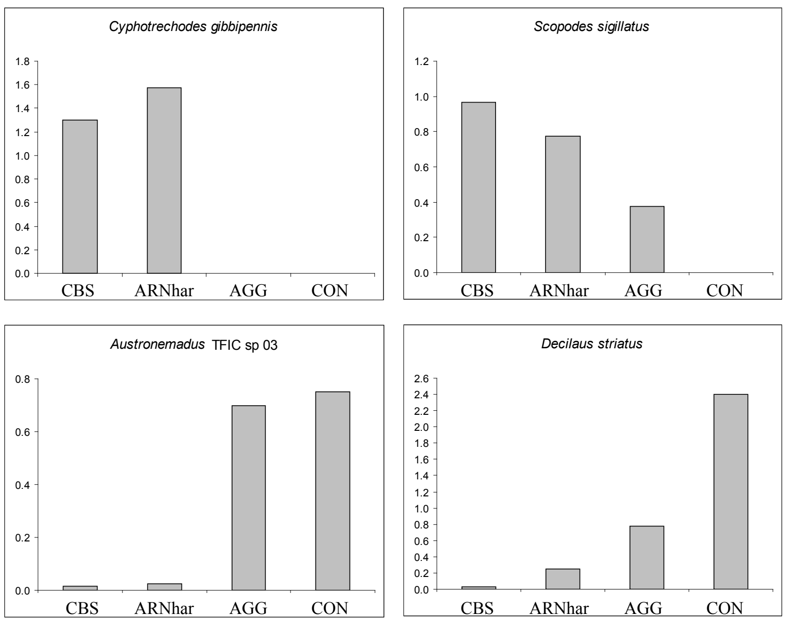
Figure 4. Individual species responses to silvicultural system in the Warra SST. A) relative incidence of birds (with 95 per cent confidence intervals) and B) abundance of beetle species.

Data are from year three post-harvesting. Treatments are the harvested area of aggregated retention (ARN-har), aggregates in aggregated retention coupes (AGG), unharvested control (CON), and clearfell, burn and sow (CBS, beetles only).

A) Birds



B) Beetles



The Tasmanian Thornbill was reasonably common in aggregates in the Warra silvicultural systems trial. Photo: Alan Fletcher.

Another carabid species with a preference for young forest, *Scopodes sigillatus*, was also present in intermediate numbers in the aggregates of aggregated retention coupes while being absent from the unharvested controls.

The leiodid *Austronomemadus* TFIC sp 03 is a mature-forest generalist (Baker *et al.* 2007), and was common in both aggregates of aggregated retention coupes and in unharvested controls.

By contrast, the weevil *Decilaus striatus*, which is a mature-forest species known to be less common in edge-affected habitat (Baker *et al.* 2007), was much less common in aggregates of aggregated retention coupes compared to the intact unharvested controls.

The results for both birds and beetles indicate that aggregates provide suitable habitat for some species, are of intermediate or sub-optimal habitat value for others, and are unsuitable for some sensitive species. This demonstrates that while aggregates provide mature-forest values and support many mature-forest species, as designed in the Warra SST, they are either too small or too disturbed and edge-affected to provide entirely equivalent habitat value to unharvested forest.

The results of these and other biodiversity surveys however do clearly illustrate that aggregated retention is better able to achieve VR's 'lifeboating' and structural objectives compared to dispersed retention or understorey islands in clearfell coupes (Table 4).

The success at retaining mature-forest biodiversity elements approximately corresponded with the percentage of mature forest retained in each system, although retention of undisturbed understorey is very important for many species.

Surveys of vascular plants and birds indicated that STRIP and group selection (GS) also have positive short-term benefits. However, as currently proposed, the vast majority of mature-forest habitat will be harvested within the rotation under STRIP and GS systems. STRIP systems are unlikely to be widely implemented because they require many more regeneration burns and can create bizarre visual landscapes. Group selection systems are used for very limited production of special timbers on long rotations.

Aggregates, although edge-affected, were found to function as refuges and habitat for all the biodiversity groups studied. For example mature-forest litter beetles and vascular plant communities differ little in aggregates from unharvested controls, while habitat quality was somewhat compromised for sensitive species from other biodiversity groups.

By contrast, understorey islands were found to have only limited ability to act as refuges. Burnt understorey islands were little

Table 4. Ranking of responses of important mature-forest biodiversity attributes to different silvicultural systems at the Warra SST in the first few years following harvesting.

Systems are ranked from 1 to 4, where 1 is best at maintaining mature-forest elements within coupes. These mature-forest attributes were identified from surveys of unharvested control sites. The superscript 'e' indicates that the response ranking is based on empirical evidence, and 'j' indicates expert judgement. For a particular biodiversity attribute, equally rated treatments were ranked as the lower number. (ARN = aggregated retention, DRN = dispersed retention, CBS = clearfell, burn and sow, UI = understorey islands)

Biodiversity attribute	ARN	DRN	CBS + UI	CBS
Widely used by shrub, mid-layer and canopy birds	1^e	2^e	4^e	4^e
'Lifeboat' mature-forest litter beetles	1^e	2^e	3^e	4^e
Maintain mature-forest vascular plants	1^e	3^e	2^e	4^e
Maintain mature-forest bryophytes	1^j	3^e	3^e	4^e
Maintain mature-forest lichens	1^j	4^e	4^e	4^e
Maintain mature-forest ectomycorrhizal fungi	1^e	2^j	3^j	4^e
Provide habitat trees for hollow-dependent fauna	1^e	2^e	3^e	4^e
Provide continuing availability of CWD	2^j	2^j	3^j	4^j
Sum of the above rankings	9	20	25	32
Overall value for mature-forest biodiversity	**1**	**2**	**3**	**4**

different from clearfelled areas, and unburnt understorey islands are unrealistic because excluding the regeneration burn from such small patches is rarely likely to be successful.

These early results also found that the dispersed retention system was not effective in providing refuges for mature-forest litter beetle, bryophyte or lichen communities, although there may be benefits provided by the retained trees for these groups in the longer term.

However, retaining overstorey eucalypts does have benefits in maintaining structural diversity and habitat trees, and in providing some continuity in supply of coarse woody debris (CWD).

The Warra SST biodiversity studies used unharvested mature forest as a reference for comparing the ability of the silvicultural systems to retain mature-forest species and structures. However, recent harvesting, regardless of silvicultural system, should not be expected to provide equivalent habitat value to extensive unharvested forest. Regrowth forest arising from recent wildfire would be a more appropriate natural reference for comparison with harvesting systems. As there has not been a recent wildfire at Warra to act as a reference for the SST, such comparisons are not currently possible. However, because aggregated retention retains unharvested areas akin to fire skips, this type of variable retention is the silvicultural system most likely to result in similar communities of plants and animals to a natural wildfire at all stages of regeneration.

Previous fire history has a large impact on forest structure and biodiversity species composition. Although many of the overstorey *Eucalyptus obliqua* trees within the Warra SST area are oldgrowth, the impact of the 1934 wildfire on the understorey means that the forest is not actually 'oldgrowth' in terms of the species composition of bryophytes, lichens and understorey vascular plants. Hence conditions in the Warra aggregates are not equivalent to conditions in many aggregates in other aggregated retention coupes in RFA-mapped oldgrowth areas.

The regeneration burns at Warra were found to have a substantial influence on forest vegetation, in both the harvested area and those parts of aggregates and understorey islands that were burnt.

Wherever the vegetation has been burnt there is a very marked effect (high loss of pre-harvest species) in the early years following the fire. This is particularly the case for species such as lichens and bryophytes because they are mostly consumed by the fire, and don't have fire-protected organs (underground buds, lignotubers or buried seed), and thus must re-colonise from pioneering propagules. The longer-term impacts of fire on these organisms are not known, but may depend on the distance to source populations for re-colonisation.

The Warra SST had only two replicates of each silvicultural system in a single study area, with limited sampling effort in some cases. In spite of these constraints, biodiversity elements exhibited very clear responses to harvesting systems.

It must be recognised that the aggregated retention treatments at Warra are somewhat different from those now being implemented operationally, since the system is continually evolving in response to operational constraints and research outcomes.

Compared with many current operational coupes, the Warra aggregated retention treatments had a greater percentage of coupe area retained in aggregates, narrower fairways, a greater percentage influence of retained trees over the harvested area and smaller aggregates. These factors will all significantly impact forest biodiversity. Hence, Warra findings may serve as a guide, but will not be fully representative of current practices.

FT will not rely solely on the Warra SST for information on biodiversity responses. Biodiversity monitoring in operational aggregated retention areas will also be an important component of adaptive management.

The intensive sampling of several organisms at the Warra SST will help guide operational monitoring programs in the production forest landscape beyond Warra.

The studies (like others elsewhere, Oliver *et al.* 1998; Mac Nally *et al.* 2002) suggest that vascular plants are not an effective surrogate for other organisms with different habitat requirements. Therefore operational monitoring will include other organisms.

While surveying beetles, fungi, bryophytes and lichens is labour-intensive, they are probably more sensitive and thus more responsive to silvicultural systems. Data from year three post-harvest were generally more informative measures of early responses than those from year one, although year one data were quite informative for vascular plants.

Warra results suggest that three years post-harvesting is too early to detect significant influences of aggregates on the harvested area. In the longer term it is anticipated that aggregates will enable animals, plant propagules and fungi to colonise adjacent harvested forest. Hence, monitoring of operational VR coupes will initially focus on the refuge function of aggregates, with increasing emphasis on the influenced regenerating stand as the coupe ages (for example at canopy closure and later).

Monitoring in operational VR coupes

Biodiversity monitoring of operational aggregated retention coupes commenced in 2007.

Compared to Warra, the larger suite of operational coupes provided a range of forest types as well as diversity of geographical layouts and proportions of aggregates burned in regeneration burns.

Ground-based surveys comparing the habitat value of aggregates to continuous unharvested control areas have been conducted in the 11 coupes burnt up to, and including, 2007. The approach seeks to understand the range of floristics and structures present in aggregates, and their response to harvesting.

Helicopter-based surveys are being used to count habitat trees in all aggregates and control areas and to map the penetration of the regeneration burn into aggregates and surrounding forest.

Across the eight VR coupes burnt in 2007, approximately 1400 habitat trees were present in aggregates. This is an average of 3.6 mature trees and stags with visible hollows per hectare of gross coupe area.

Approximately 25 per cent of the aggregates in 2007 coupes were burnt in the regeneration burns. This differed markedly between edge and island aggregates: six per cent of edge aggregate area and 51 per cent of island aggregate area were burnt.

This finding will have implications, at least in the short term, for forest biodiversity, since in burnt areas of aggregates the fire killed much of the understorey vegetation, bryophytes and lichens, and presumably also many of the invertebrates.

Changes to coupe design, with fewer island aggregates and fewer smaller aggregates, and application of the slow burning prescriptions, meant that less than 10 per cent of the aggregate area was burnt in 2008.

While retention of unburnt aggregates will be beneficial to the majority of species, certain species either require, or are favoured by, burnt conditions. Hence, the operational objective

This photograph of an aggregate in Styx 7A was taken during a helicopter-based survey of habitat trees and regeneration burn impact.

is to minimise, but not exclude, the impact of regeneration burns on retained aggregates. It is not intended that killed trees should be salvaged as they contribute to structural diversity.

Future research will focus on the influence of the aggregates on the harvested area, which is one of the target parameters for VR.

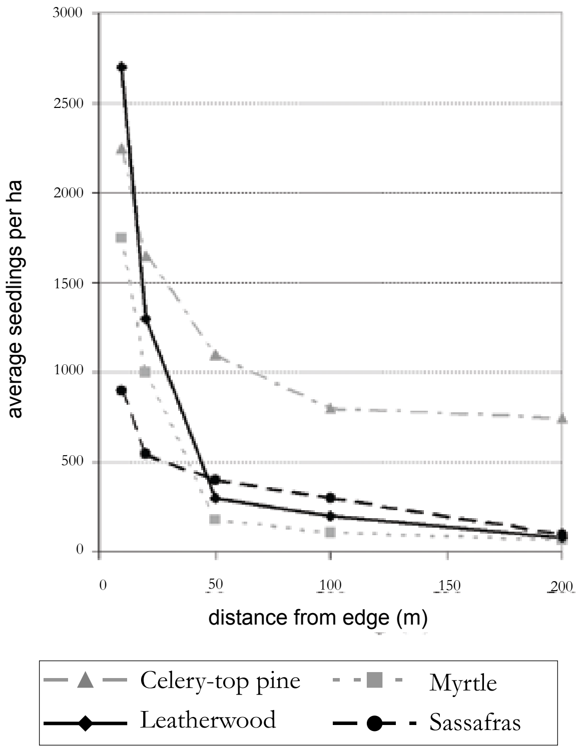
Previous research by Tabor *et al.* (2007) found that regeneration of the four dominant rainforest tree species declined rapidly with distance away from mature-forest seed sources into clearfelled coupes (Figure 5). There was relatively little rainforest tree regeneration beyond approximately 50 m from mature mixed forest edges, with the exception of celery-top pine germination from bird-dispersed and soil-stored seed (Tabor *et al.* 2007).

Aggregated retention, where the majority of the harvested area is within one tree height of retained forest, is therefore expected to enable higher densities of seedlings of rain-forest trees, and other species with low seed dispersal characteristics, to establish throughout a larger proportion of the coupes relative to clearfelling.

A current project is assessing regeneration of vascular plant species in the 2007 aggregated

Vegetation surveys are assessing plant species composition in harvested areas near to burnt and unburnt aggregates (Picton 7C).

Figure 5. The regeneration of four rainforest tree species at five distances into clearfelled forest. Data derived from Tabor *et al.* (2007).



retention coupes. To date, low numbers of rainforest seedlings have been found. Tabor *et al.* (2007) found that the numbers of seedlings of rainforest trees increased significantly with time since harvesting up to the age of 15 years.

Summary of biodiversity benefits and disadvantages of aggregated retention

The results from the Warra silvicultural systems trial and from monitoring of operational VR coupes can be used to summarise the advantages and disadvantages of aggregated retention for the maintenance of biodiversity in tall oldgrowth forests used for wood production.

Advantages:

- maintenance of structural complexity and age-class distribution more akin to forest regenerating following wildfire disturbance, compared to regeneration after clearfell, burn and sow treatments
- maintenance of hollow-bearing trees and stags of various form-classes, providing habitat for hollow-dependent fauna
- maintenance of existing coarse woody debris (CWD) in aggregates and some continuity of supply of CWD for both aggregates and adjacent harvested areas for the next and subsequent rotations
- larger unburnt aggregates maintain relatively undisturbed vascular plant communities, including rainforest trees

- aggregates provide foraging habitat and stepping-stones for movement of canopy, shrub and mid-layer birds, which are otherwise largely displaced by recent harvesting and may also provide nesting habitat, including hollows
- aggregates are able to maintain litter beetle and fungal communities similar to those in unharvested forest, although habitat suitability for some sensitive species may be reduced
- unburnt aggregates are able to maintain some mature-forest bryophytes, lichens and filmy ferns, although edge effects are significant
- in the longer term, by providing mature-forest influence, aggregates are expected to provide a source of dispersing animals and propagules of plants and fungi, thus altering the succession of the harvested area
- by maintaining patches of forest rather than individual trees, aggregates are able to provide refuges for representative ecosystems including species interactions
- aggregates will assist in maintaining local eucalypt genetics by providing a source of seed (coupes will also often be oversown with seed from a local provenance)
- aggregates appear large enough to withstand significant windthrow and retain habitat trees
- aggregates increase the proportion of production forest proximal to mature forest, which may increase overall habitat connectivity across the landscape.

Disadvantages:

- harvesting and roadworks over a greater overall area of forest for the same amount of timber could increase habitat fragmentation with its ecological consequences, for example edge and area effects, weed invasion (however, the area of oldgrowth forest available for harvesting is finite, so in the long term there will be no net increase in roadworks).
- compared with aggregated retention, dispersed retention provides mature trees scattered across the harvest area, which may be more beneficial for territorial birds and mammals and future connectivity of large CWD.

Future directions

The aggregated retention harvesting system will continue to evolve with adaptive management, and will continue to be informed by ongoing biodiversity research at the Warra SST and in operational ARN coupes.

Warra will be the focus for detailed research into those organisms that are time-consuming to monitor, and will continue to enable aggregated retention to be contrasted with other alternative systems as well as clearfell burn and sow.

Operational monitoring will continue to investigate the ability of this harvesting system to provide refuges for mature-forest species and structures, and to influence the species composition of the harvested area. Understanding the role of factors such as aggregate size and connectivity, influence levels and regeneration burn impact will be central to this research.

It is planned to next resample Warra treatments at year 10 post-harvesting, and thereafter to coincide with important structural stages of forest development.

The more intensive research at Warra can inform appropriate timescales for monitoring various biodiversity elements in operational coupes. For example, it will be important to know at what developmental stage differences between the harvested areas in aggregated retention and clearfell treatments become apparent, such as at canopy closure (age five to 10), or self-thinning (age 20-40).

There is also an opportunity to consider how variable retention could be used to restore oldgrowth elements in regrowth forest landscapes.

Modelling and landscape planning (Yee *et al.* 2008) could help identify and prioritise management for restoration of oldgrowth elements in forests where they are now sparse.

The ongoing Wildfire Chronosequence Study in Tasmania's southern forests (Turner *et al.* 2008), and previous comparisons between wildfire and clearfelling (Hickey 1994; Turner 2003; Baker *et al.* 2004), can help provide a natural disturbance benchmark for harvesting treatments, although an important gap in our current research is a comparison of harvesting treatments with natural wildfire regeneration of a similar age. This could be conducted if suitable sites become available following a wildfire.

Implications for forest management

The ecological implications for forest management of applying the aggregated form of variable retention in tall oldgrowth forests are discussed below.

Because oldgrowth species and structures are better maintained at a stand-level in VR than with clearfelling, there should be reduced likelihood of species becoming rare or threatened. This should potentially reduce the likelihood of harvesting restrictions triggered by concerns for species that might otherwise be considered as threatened.

Although VR will reduce the wood supply from oldgrowth forests, the aggregates are potentially available for harvest in subsequent rotations (depending on their ecological objectives), as long as alternative aggregates are selected at the next harvest. Aggregates are also likely to reduce the productivity of adjacent regrowth through restricting light availability, particularly for eucalypt regrowth. The requirement for lower intensity regeneration burns may also result in less dense and less productive regrowth.

The criteria for safe removal of harvest residues have ecological implications. Residues are reduced to safe levels in standard clearfell operations through high intensity burns but it seems likely that a greater proportion of residues will remain partially unburnt in aggregated retention coupes.

Regeneration burns that more fully reduce harvest residues in VR coupes risk burning through aggregates and killing many retained trees. Less intense burns allow unburnt aggregates but may also leave more harvest residues. This may impede regeneration as well as pose a subsequent wildfire risk, although these ideas remain conjectural.

The 2005 Advice to Government recommended exploring a market for harvest residues as part of residue management in VR coupes. Removal of coarse woody debris (CWD) from harvested areas may create a conservation threat for some of the many species (for example invertebrates and fungi) that require this habitat (Grove and Meggs 2003). Adoption of residue harvesting needs to integrate measures to ensure maintenance of sufficient CWD. Prescriptions have been developed to this end for routine harvesting and require at least 30 per cent of the area within harvested coupes to be delineated for CWD. Aggregated retention provides for sufficient CWD within coupes such that removal of harvest residues for fuelwood markets does not require additional constraints.

The 2005 Advice to Government noted that, for the small proportion (≤20 per cent) of oldgrowth areas continuing to be clearfelled, management on longer rotations would be expected to have important benefits to biodiversity, and should be considered.

Limiting the size of these remaining clearfell burn and sow coupes in oldgrowth areas to approximately 20 ha, as suggested in the 2005 Advice, would also benefit forest biodiversity by increasing the proportion of coupe area influenced by adjacent forest, for as long as that adjacent forest remains unharvested. Careful design of coupe shape would have similar outcomes.

The average size of coupes-containing-oldgrowth on steep country for the past three years, after allowance for coupe-discounts, has been 32 ha, ranging from nine to 70 ha. Thus, a limit of 20 ha would be a significant change from current practice.

A better balance of ecological and economic outcomes might be to aim for an average coupe size of 25 ha for oldgrowth coupes on steep country, with an upper limit of 50 ha.

The 2005 Advice to Government predicted that the aggregated form of VR would result in improved biodiversity outcomes compared to the clearfell, burn and sow system that was then solely applied to tall oldgrowth forests.

This ecological evaluation, based on three years of research, has now provided evidence that VR is meeting its stated objectives; namely to provide refuges for oldgrowth species, to enrich regenerating stands with structural features and to facilitate re-colonisation of harvested areas by oldgrowth species. The aggregated form of variable retention is clearly better for retaining elements of mature-forest biodiversity than clearfelling at the stand level, and also achieves better biodiversity outcomes than other VR systems tested in the Warra silvicultural systems trial.

There is still a need to further demonstrate the influence of aggregates in accelerating the production of mature forest elements in the regenerating stand. Because aggregated retention retains unharvested areas akin to fire skips, this type of VR is the silvicultural system most likely to result in similar communities of plants and animals to a natural wildfire at all stages of regeneration. However, this assumption is yet to be tested through a comparison with natural regeneration of similar age.

Old Forests New Management Conference

The international Old Forests New Management Conference was held in Hobart in February 2008. The conference covered the ecology and silviculture of temperate and boreal old forests, and included insights from many large-scale, long-term, multidisciplinary experiments. The program, details of speakers, and many of the presentations can be found at the conference website www.oldforests.com.

The conference attracted 270 registrants from 20 countries. It was funded through the Tasmanian Community Forest Agreement and additional sponsorship was obtained from the Sir Mark Oliphant International Frontiers of Science and Technology conference series. The conference was hosted by Forestry Tasmania and the Cooperative Research Centre for Forestry, with the support of IUFRO Units 4.00.00 Forest Assessment, Modelling and Management and 1.05.00 Uneven-Aged Silviculture.

The conference was subtitled *Conservation and use of oldgrowth forests in the 21st century*. Its core was biology, ecology and silviculture, surrounded by presentations on social, historical and regulatory aspects. The majority of researchers and practitioners involved in silvicultural experiments on various continents also attended.

The conference included a field trip (see photo) to the Warra Long-Term Ecological Research site in Tasmania's southern forests (www.warra.com), and the Warra silvicultural

Old Forests New Management Conference field trip to Warra.

systems trial of alternatives to clearfelling in tall eucalypt forests.

Selected conference papers are being published in a special issue of *Forest Ecology and Management.*

The conference was acclaimed as a significant success, and at least in part this could be attributed to the simultaneous timeliness of the subject matter at local, national and international levels. The conference also attracted significant media interest.

Key messages resulting from the conference were:

- reservation, restoration and retention are the three Rs of modern management of oldgrowth forests - on a global scale Tasmania has high levels of native forest reservation, is trialling retention silviculture in its tall oldgrowth public forests and the restoration of oldgrowth features into landscapes lacking these is a challenge for the future.
- a similarity of current oldgrowth forest management issues, and alternative silvicultural systems on four continents (Australia, North and South America, and Europe), indicated the Tasmanian experience fitted easily into the international context, with FT's silvicultural systems trial at Warra being one of several similar multidisciplinary forest management experiments on different continents.
- variable retention silviculture is now the global standard for best practice when harvesting oldgrowth forests.
- aggregated retention is the form of variable retention that appears to work best in tall eucalypt forests in Tasmania, with a number of uneven-aged treatments appropriate for the drier Tasmanian forests.
- there is an advantage of a structural definition of oldgrowth, rather than a recovery-from-disturbance definition because biodiversity responds to forest structural elements, and structural definitions lead to management for features from older trees across a wider forest landscape.
- the importance of a landscape-scale view of forest management outcomes, rather than the coupe-scale view usually adopted, as this logically leads to different prescriptions for coupe management based on the nature of the surrounding forest.
- climate change will change the forest landscape in unpredictable ways, most especially through altered disturbance regimes, such as more frequent or more intense fires.
- oldgrowth forests have a complex interaction with the carbon cycle, storing substantial amounts of carbon but either absorbing or releasing carbon depending on the particular forest in question.
- the dynamic nature of the carbon cycle in disturbance ecosystems such as eucalypt forests allows use of timber from properly managed and certified forests.

The two plenary speakers captured the mood of the Old Forests New Management Conference.

Professor Jerry Franklin, from the University of Washington, USA, opened the conference with a stimulating and personal overview of the biological values of oldgrowth forests, noting how continued disturbance is often needed for their renewal, but also how legacy structures surviving disturbance are vital for developing complexity in the regenerating forest.

Professor Jürgen Bauhus of the University of Freiburg, Germany, closed the conference by describing the importance of silvicultural systems that develop, maintain and retain oldgrowth features in stands of various ages across the forested landscape - "silviculture for old growthness".

Social Acceptability Evaluation

Background

The social acceptability concept encompasses two components:

- people's values and beliefs.
- their aesthetic responses.

Research has shown that for people with existing environmental attitudes to either resource protection or production, there are significant differences between acceptability and aesthetic judgements (Ribe 2002).

Several studies, polls and community consultation processes on the social acceptability of forest management in Tasmania indicate there are differing values and beliefs about forestry issues (eg. Ford *et al* 2009). The concerns of those who would like to see changes in forest management often focus on the practice of clearfelling, particularly when it is carried out in oldgrowth forests.

The Tasmania Together *benchmark for oldgrowth forests*

The social acceptability of clearfelling oldgrowth forests is informed, to a limited extent, by the Tasmania *Together* process. In 1999 the Tasmanian Government appointed the Community Leaders Group to run a wide-ranging community consultation process aimed at developing a 20-year social, environmental and economic plan for Tasmania. This resulted in Tasmania *Together,* a community-owned vision for the State designed to help shape government and non-government policy, which included a vision to phase out clearfelling of oldgrowth forests.

However, the participants acknowledged that there was not a consensus on the issue of clearfelling oldgrowth forests within the Community Leaders Group or the Tasmanian community (Tasmania *Together* Community Leaders Group 2001). Tasmania *Together* was revised in 2006 but still includes a target for a complete phase out of clearfelling in oldgrowth forests by 2010 (Indicator 11.2.1).

The justification for this position is that: 'oldgrowth forests are a finite and highly valued resource. Encouraging the reduction and overall elimination of clearfell logging practices in oldgrowth forests provides for greater protection of their natural values into the future' (Tasmania *Together* Progress Board, 2006).

The Tasmania *Together* target to completely phase out clearfelling of oldgrowth forests has not been endorsed by the Tasmanian Government although it has recognised community concern through the TCFA target to reduce clearfelling of oldgrowth forests to less than 20 per cent of the annual oldgrowth harvest area on State forest by 2010.

The latest Sustainable Forest Management Report (Forestry Tasmania 2008b) shows a marked reduction in clearfelling of oldgrowth since 2004/05, following the signing of the TCFA, and this is expected to reduce to below 400 ha per year beyond 2010 if the VR alternative proves feasible.

Research

The social acceptability of various silvicultural systems in wet eucalypt forests, but not specifically oldgrowth forests, has been studied in some detail at the coupe level (Ford *et al.* 2005; Williams *et al.* 2007; Ford *et al.* submitted 2008a; Ford *et al.* submitted 2008b).

This research used computer-simulated images to survey the attitudes of more than 500 people to clearfelling, variable retention and selective logging alternatives (see photo).

In the absence of any further information most participants rated clearfelling the least acceptable and selective logging the most acceptable. However, when participants were shown information about the consequences of harvesting, variable retention systems became equally as acceptable as selective logging.

These consequences include effects on biodiversity, forest growth, availability of special timbers, economics, worker safety and risk of subsequent wildfires.

Aggregated retention is deemed more acceptable in Tasmania than dispersed retention systems of similar harvest intensity, which differs from findings reported elsewhere (Ford *et al.* Submitted 2008a). One explanation for these differing results is that burning is required for regeneration of wet eucalypt forests in Tasmania but is less commonly used in forests elsewhere, which generally have less dense understoreys. Aggregated retention coupes contain areas of unburnt forest with intact understorey which serves to hide some of the harvested coupe whereas dispersed retention results in harvested and burnt understoreys throughout the coupe (Ford *et al.* submitted 2008a).

The research has subsequently been expanded to compare the social acceptability of alternative management options for a broad landscape in Tasmania's southern forests which includes parts of the Huon, Arve and Picton valleys (Ford *et al.* 2007).

This project is using simulation technology, based on a real landscape, to explore social acceptability judgements by a range of people including local residents, other Tasmanians and tourists. The simulations allow views to be projected over a full rotation of 90 years.

One of the management options to be tested on participants is different levels of variable retention and clearfell silviculture across the forested landscape over time. This is important because forest management outcomes should not be judged merely at the time of harvest and regeneration but throughout the management cycle. Results from this study will be available in late 2009.

Top: Simulated aggregated retention (from Ford *et al.* 2005). Symbols summarise consequences for a range of conservation and industry outcomes.
Bottom: A similar view of an actual aggregated retention coupe in northern Tasmania (Huntsman 322L).

A considerable body of research on aesthetic perceptions of clearfelling and variable retention options has been conducted elsewhere, particularly in the Pacific Northwest of America and Canada. It indicates that people discern harvesting systems as being different from clearfelling once the retention levels reach a threshold of about 15 per cent of the coupe area.

In the Pacific Northwest, where forest understoreys are generally much less dense than in Tasmania and fire is not commonly used for regeneration, dispersed retention is generally perceived as more visually acceptable than aggregated retention (Ribe 2005).

Aesthetic perceptions are highly influenced by the viewpoint and time since harvesting. For example, viewers who rated six different harvest treatments from within the harvest area reported marked differences in scenic quality in the initial years but these differences had substantially diminished after a decade of stand development (Shelby *et al.* 2003).

Feedback on operational coupes

The Tasmanian anecdotal experience is that some VR coupes represent a marked improvement on aesthetics compared to clearfelling. For example Huntsman 322L, a 2004 VR coupe, is barely discernible when viewed from the towns that lie to the north of the Great Western Tiers (see photo) whereas other VR coupes can appear quite stark soon after the regeneration burn if some of the aggregates have been burnt. Some commentators (for example Morris (2007), based on a post-burn inspection of Styx 7A) have suggested that VR is worse than clearfelling. In reality, most Tasmanians have probably never seen a VR coupe and have had little opportunity to decide if they prefer the scenic quality of VR or clearfell coupes. Over time, some forest landscapes will appear more diverse, at a fine scale, if a significant proportion of the production forest has been managed using variable retention rather than clearfelling.

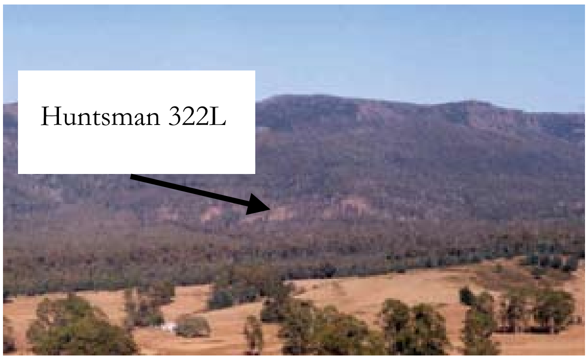
Public submissions to the draft Forest Management Plan 2008

Current perceptions of the acceptability of oldgrowth forest management for wood production can be informed, to a limited extent, from the public submissions to Forestry Tasmania's draft Forest Management Plan 2008-2017, which has subsequently been amended and approved (Forestry Tasmania 2008a).

The plan outlines high-level aims, consistent with the *Forestry Act 1920*, the Regional Forest Agreement (RFA) and the Tasmanian Community Forest Agreement (TCFA), to achieve a number of core management objectives for Tasmania's State forests.

The draft plan, exhibited for public comment during December 2007-February 2008, outlined the new reservation levels for oldgrowth forests and the program for reduced clearfelling in oldgrowth forests designated for wood production.

Thirty-two public submissions were received during this process. They raised some 467 issues of which only two per cent related to oldgrowth forest management (Table 5), with greater concern being indicated for carbon storage/climate change and water quantity and quality.



This 40 ha VR coupe (Huntsman 322L) in the Great Western Tiers is far less evident in the landscape than would be a similar sized clearfell coupe.

This provides some evidence that public concern about management of some oldgrowth forests for wood production may have lessened. This might be due to recognition of the increased oldgrowth reservation and reduced clearfelling targets of the TCFA and the increasing prominence of more significant environmental concerns, particularly climate change.

The following views were expressed in the public submissions that related to oldgrowth forest management:

- all oldgrowth in Tasmania should be protected
- FT should cease the conversion of oldgrowth forests
- end clearfelling of oldgrowth
- why is clearfelling of oldgrowth forests still permitted?
- aggregated retention is another form of clearfelling.

The submissions on oldgrowth forests included deeply held value-judgements as well as some misconceptions. Some submissions indicated that aggregated retention is another form of clearfelling, although research indicates that most people discern harvesting systems as being different from clearfelling once retention levels reach a threshold of about 15 per cent.

Forest ecologists have defined clearfelling in terms of the minimum size of opening in relation to the height of the surrounding forests. This is commonly taken to be an area greater than four tree heights in diameter (Bradshaw 1992; Keenan and Kimmins 1993).

The Tasmanian Forest Practices Code 2000 permits clearfells to be up to 100 ha, which is equivalent to openings up to one kilometre wide (Forest Practices Board 2000). Clearly there is a marked visual difference between clearfelling at this scale and the VR that is increasingly replacing large-scale clearfells in oldgrowth forests (see photos of Styx 7A on next page). However, definitions of clearfelling are somewhat arbitrary and can differ between jurisdictions.

Rather than unduly focus on clearfelling definitions, it is fundamentally more important, from an ecological perspective, to design VR treatments to which oldgrowth species respond more favourably than to large clearfells.

Table 5. Issues raised by public submissions to the draft Forest Management Plan 2008.

Category	Times raised	Percentage
Wording changes/clarifications	49	10%
Carbon and climate change	38	8%
Water	26	6%
Pulp mill	18	4%
Plan contents/structure	13	3%
Chemicals	8	2%
Forestry Act requirements	11	2%
Forest Practices Code	8	2%
Hunting	9	2%
Oldgrowth	11	2%
Special species timbers	10	2%
Other categories < 2%	266	57%
Total	467	100%

Implications for forest management

The maintenance of the timber supply from a portion of Tasmania's public oldgrowth forests is important for society in sustaining regional economies and jobs. This includes supplies of special species timber and access to leatherwood nectar resources as well as eucalypt sawlogs.

The social acceptability of clearfelling oldgrowth forests is now low and can be expected to further decline. The adoption of VR is likely to increase the security of timber jobs, compared to clearfelling, because VR provides some aesthetic improvement over clearfelling and, more importantly, because it should increasingly be recognised by the community as delivering better outcomes for oldgrowth plants and animals.

Aerial view of Styx 7A after an aggregrated retention treatment (above) and as it might have looked if it had been clearfelled (below).

Safety Evaluation

Background

Issues Paper 4 (*Safety Management*) noted that non-clearfell systems are potentially more dangerous than clearfelling because workers are exposed to hazards and risks associated with felling and extraction under retained trees (Forestry Tasmania 2004d). It was predicted then that the safety hazard posed by the aggregated form of variable retention may not be significantly greater than clearfells if the distance between aggregates is at least two tree lengths or about 80 m. VR was predicted to be inappropriate for harvesting tall oldgrowth forests on steeper slopes due to the potential for increased risk to forest workers.

This information was adopted in the 2005 Advice to Government. Even so, there was considerable unease among harvesting contractors about the safety implications of the transition from clearfelling to VR for tall oldgrowth forests. This was clearly expressed at a 2006 meeting of the Variable Retention Advisory Group (VRAG), which included representatives from Forestry Tasmania, various forest industry and forest contractor groups[6], Workplace Standards Tasmania, and the Australian Government's Department of Agriculture, Fisheries and Forestry.

VRAG endorsed a proposal, foreshadowed in the TCFA research program, for a thorough investigation of the safety aspects of variable retention. An experienced private consultant, Greg Howard, of Timber Training Tasmania, was engaged to undertake the project (Howard 2008). The project was managed by a sub-committee of the Forest Industry safety and training committee, which reports to the Tasmanian Forest Industry Training Board (TFITB), which has since become part of *ForestWorks,* a national body that facilitates learning and skill development in the forest industry.

The project comprised:

- a review of relevant documents
- interviews with key players: Tasmanian contractors who have undertaken variable retention (VR) harvesting, Workplace Standards Tasmania inspectors and FT staff involved in variable retention operations
- compilation of all hazard, incident and accident reports from contractors who have harvested current VR coupes and comparison with appropriate clearfell, burn and sow (CBS) coupes; identification and documentation of any specific issues peculiar to VR coupes
- assessment of the increased edge effect arising from VR harvesting compared to CBS, to identify any increased risk associated with increased retention both during harvesting and during subsequent monitoring operations (for example browsing monitoring, regeneration surveys)
- monitoring (on a sample basis) to assess the extent to which VR harvesting limits the feller's choice of felling direction
- a report to the sub-committee including recommendations with respect to operational, policy and training issues
- input to the next review of the Forest Safety Code
- presentation of a paper to the Old Forests New Management Conference.

[6] Construction Forestry Mining Energy Union, Forest Industries Association of Tasmania, Forest and Forest Industry Council, ForestWorks, Gunns Limited, Tasmanian Forest Contractors Association, TAFE Tasmania-Forest Industry Training

Method

Twenty-one aggregated retention (ARN) coupes were audited for safety, including one coupe being prepared for burning and sowing in 2009 and two experimental ARN coupes from the Warra silvicultural systems trial. Audits included coupe visits, as well as interviews conducted with contractors, fellers, machine operators, Forestry Tasmania district staff, and a representative from Workplace Standards Tasmania.

All hazardous standing trees (as defined in the Tasmanian Forest Safety Code 2007) in the aggregates and along coupe edges, as well as trees that had fallen into the harvested area (windthrown trees), were mapped and tallied.

Results

A total of 48 hazardous trees were found, most of which occurred within the aggregates, and several of which had become hazardous following damage by regeneration burns. Some previously unidentified hazardous trees were also found. No incidents or accidents were reported in any of the audited ARN coupes.

A total of 505 windthrown trees were found, of which 84 per cent were understorey species, 11 per cent were regrowth eucalypts and five per cent were oldgrowth eucalypts. Windthrow may be a greater problem if ARN harvesting is used in regrowth coupes.

In general, the hazards associated with ARN harvesting are the same as those known to exist in clearfell harvesting, with any increased

VR harvesting at Styx 20A. In general the hazards associated with the aggregated form of VR harvesting on slopes less than 20 degrees are similar to those known when clearfelling, but there is an increase in the time that contractors work near retained trees.

risk due mainly to the greater exposure to existing hazards caused by the higher perimeter to area ratio in ARN coupes. This increased risk will mainly affect post-harvest operations (for example regeneration surveys, browsing monitoring). Provided the harvesting operation has correctly removed hazardous trees that could fall into the cut area and left aggregates of a size that incorporates the fall zones of trees which could be prone to windthrow, then any increase in risk should be small.

Designing coupes with fewer, larger aggregates and with more edge aggregates rather than island aggregates will help to reduce the perimeter to area ratio. There will also be a greater need for directional felling in ARN coupes, which will create some additional risk for fellers. There may be a need for a training procedure for machine-assisted manual felling.

Howard (2008) made many specific recommendations to the sub-committee of the Forest Industry safety and training committee with the primary ones being that the size of aggregates should be increased to at least one hectare, that aggregates close to the coupe boundary should be incorporated into the coupe boundary and that planners should avoid locating aggregates on steep slopes.

Implications for forest management

The maintenance of occupational health and safety in forest operations is an essential requirement for implementation of alternatives to clearfelling, as identified in the 2005 Advice to Government.

This safety evaluation has found that, in general, the hazards associated with the aggregated form of VR harvesting, on slopes less than 20 degrees, are similar to those known to exist in clearfell harvesting, with any increased risk due mainly to the greater exposure to existing hazards caused by the higher perimeter to area ratio in ARN coupes. This view was acknowledged by representatives of the Workplace Standards Tasmania and the Tasmanian Forest Contractors Association at a subsequent meeting of VRAG in 2008.

It was also acknowledged that VR is still inappropriate for harvesting tall oldgrowth forests on steeper slopes due to the potential for increased risk to forest workers.

Silvicultural Evaluation

Background

The 2005 Advice to Government recommended the aggregated form of VR as the most practical silvicultural alternative to clearfelling of oldgrowth forest, although at that time the requirement for successful regeneration of any of the three recently established VR coupes was undemonstrated.

The likely level of retention in most oldgrowth coupes was predicted to be about 20 per cent (in addition to the discount of about 25 per cent that normally occurs between planned and actual coupes) with a predicted reduction in stand productivity of the regrowth of about 10 per cent due to suppression of regrowth by oldgrowth trees (Forestry Tasmania 2004a).

Aggregated retention (ARN) is now the main silvicultural system being used to implement variable retention (VR) in Tasmania. VR retains patches of the original forest within the coupe boundary for the next rotation to maintain late-successional species and structures important for biodiversity, and to maintain forest influence over the majority of the coupe (Franklin *et al.* 1997; Mitchell and Beese 2002).

Forest influence refers to the biophysical effects of the residual trees on the surrounding environment (Keenan and Kimmins 1993), including effects on microclimate, light availability, seed-and litter-fall and evapotranspiration. This greater level of forest influence differentiates aggregated retention coupes ecologically from clearfells, and better meets habitat requirements for some species (Lindenmayer and Franklin 2002).

However, the retained trees are expected to have some suppressive effect on the regenerating stand, while the higher perimeter to area ratio of ARN coupes makes them more difficult to burn for regeneration and may lead to increased browsing pressure. ARN harvesting may also increase negative impacts on the soil due to more constrained harvesting patterns, and the practice of putting firebreaks and/or access tracks around coupe edges and aggregates. In combination, these factors may lead to reduced eucalypt seedling establishment and growth and lower productivity under this silvicultural system.

The impact of retained trees on growth of eucalypt regeneration can be significant (Bradshaw 1992; Bassett and White 2001). The suppressive zone of influence for single retained trees has been found to extend a distance that ranges from one to six times the crown radius (Opie 1968; Incoll 1979; Rotheram 1983; Bowman and Kirkpatrick 1986; Bi and Jurkis 1997).

Reductions in growth tend to increase as retention level increases, and to affect volume more than height or diameter (Dignan *et al.* 1998). Increasing height to diameter ratios and decreasing seedling densities have also been observed as retention levels increase (Dignan *et al.* 1998).

Growth impacts on regeneration due to retained aggregates/edges are expected to be less than those due to dispersed retention (Franklin *et al.* 1997) but are generally not well quantified.

Significant reductions in growth in Tasmanian and Victorian eucalypt forests have been found in small gaps (<2 ha) compared to larger clearfells (Bowman and Kirkpatrick 1986, Basset *et al.* 2000, Faunt *et al.* 2006, Van der Meer and Dignan 2007).

N. Smith (pers. com.) examined the influence of forest edges and aggregates on seedling growth in the coastal temperate forests of

British Columbia. He found that most of the impact occurred within 10 m of the edge of the retained patch or adjacent stand.

A recent study in mixed species eucalypt forests in Victoria similarly found that suppressive edge effects on regrowth extended 10 m or less from mature forest edges (Wang *et al.* 2008).

The first operational ARN coupes were harvested in 2004. Since then, 832 ha in 20 ARN coupes have been established across Tasmania. A monitoring program has been established in these operational ARN coupes to assess silvicultural outcomes including influence and retention levels, damage to retained trees, seedbed and regeneration success. A number of clearfell, burn and sow (CBS) coupes have also been assessed to allow comparisons between the two silvicultural systems.

Influence and retention levels

Initial guidelines for ARN coupes called for 20 per cent of the coupe to be retained in aggregates of at least 0.5 ha.

In 2007, FT developed specific goals and guide-lines for aggregated retention (Appendix 4).

At that time, forest influence was selected as the main silvicultural target for ARN coupes because it was felt this would allow the ecological objectives of variable retention to be met while minimising the need for 'extra' retention.

Discounted or excluded areas typically associated with forest harvesting in State forests usually amount to about 25 per cent of the provisional gross coupe area (known as 'provcoupe') and provide many of the same benefits as VR-specific retention, including maintenance of forest influence and biological legacies.

Larger aggregates (>0.5 ha) were specified for Tasmania because of the need to burn ARN coupes for regeneration. As FT has gained more experience with burning ARN coupes, coupe designs with fewer and even larger aggregates (now mostly > 1 ha), and more edge aggregates have increasingly been used.

The effect of these design changes can be seen in Figures 6 and 7, which depict influence and retention levels in FT's ARN coupes over the past two years.

The average influence level has decreased (2007 mean = 84 per cent, 2008 mean = 73 per cent), while the average retention level due to variable retention silviculture has increased (2007 mean = 33 per cent, 2008 mean = 47 per cent). Note that this retention is over and above the area discount of about 25 per cent of the original gross area, which typically is incurred when provisional coupes are actually harvested.

In VR coupes harvested to date, retention levels are considerably higher than the 20 per cent estimated in the 2005 Advice to Government. FT's targets for retention and influence will need to be reviewed to ensure that both the ecological and economic objectives of VR can be met.

Figure 6. Percentage of ARN coupes under forest influence. For 2008 coupes, influence level is estimated from current mapping and has not been finalised.

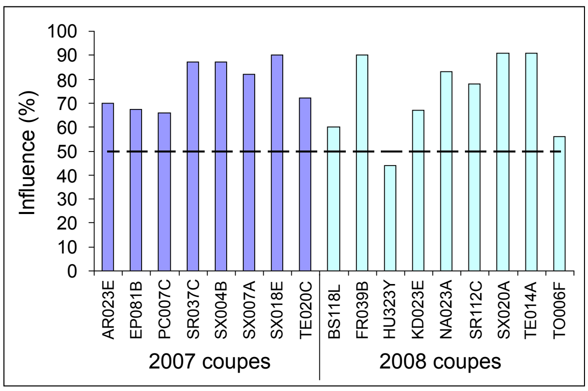
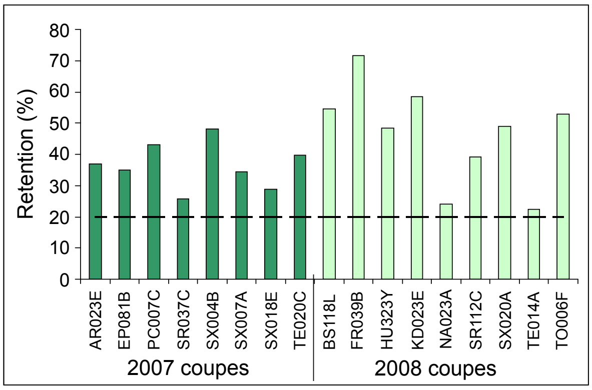


Figure 7. Percentage of ARN coupe area retained. For 2008 coupes, retention level is estimated from current mapping and has not been finalised.



Damage to retained trees

Wind damage associated with VR silviculture in Tasmania has not reached significant levels, although a large number of understorey stems have been windthrown, particularly in small aggregates (Wood *et al.* 2008). More than 90 per cent of assessed windthrown trees were understorey stems.

The proportion of near-edge eucalypts damaged by harvesting was similar in the 2008 ARN and CBS coupes. The average number of trees at risk of damage was higher in ARN coupes, largely because of their greater perimeter to area ratio.

To date, regeneration burns had the greatest impact on retained trees (see photo of Styx 7A). In the 2007 ARN coupes, the proportion of retained aggregate area damaged by the regeneration burn ranged from 8 to 52 per cent .

Island aggregates had considerably higher fire damage levels than edge aggregates (51 per cent versus six per cent, mean = 25 per cent).

Mineral earth firebreaks established around island aggregates provided little protection for retained trees from burning.

In the 2008 ARN coupes, less than 10 per cent of aggregate area was damaged by regeneration burns, which is a substantially lower impact than experienced in the 2007 ARN coupes.

Aerial photo of Styx 7A shows damage to retained aggregates from the regeneration burn (note aggregate at bottom left).

Seedbed

Seedbed surveys were conducted within a few months of the regeneration burn in each coupe in order to characterise the distribution and intensity of soil disturbance due to the burn and harvesting activity.

Seedbed has been shown to affect seedling establishment and growth, with studies at the Warra silvicultural systems trial showing that higher seedling densities and faster growth rates occur on the most hotly burnt seedbeds (Neyland *et al.* 2009). Lower seedling densities occur on unburnt/undisturbed seedbeds, while seedlings on compacted seedbeds have reduced growth rates. Sufficient seedbed was created in both dispersed and aggregated forms of variable retention to allow regeneration to meet stocking standards by year three, but usually not at year one.

Results from the operational ARN coupes burnt in 2007 indicate that burns in ARN coupes were less intense than burns in CBS coupes, with less well-burnt soil and ashbed created (see photo of typical seedbeds). There was more disturbed and compacted soil in ARN coupes than in CBS coupes. This is due in large part to the firebreaks that are established around the coupe edges and aggregates. ARN coupes have greater perimeter to area ratios than CBS coupes, and therefore firebreaks affect a larger proportion of the coupe. In 2007, mineral earth firebreaks were also established around island aggregates, further adding to the amount of soil disturbance (see photo of SX007A). This practice has now been discontinued to minimise soil damage due to compaction, and to reduce cost.

Regeneration

Successful regeneration in wet eucalypt forests depends on access to light, sufficient seedfall, availability of receptive seedbed and control of damage due to browsing. (Gilbert 1959; Cunningham 1960; Gilbert and Cunningham 1972; Cremer, Cromer *et al.* 1978).

Research at Warra (Neyland *et al.* 2009) has confirmed the importance, and practical necessity, of burning to create seedbed and promote abundant regeneration and rapid early growth of eucalypts. Height growth of seedlings on burnt seedbeds was approximately twice that on unburnt seedbeds over the first three years. Rapid early growth is important for eucalypt seedlings to gain dominance over dense competing vegetation.

Typical seedbed created following a 'slow' ARN burn (left) and a high-intensity CBS burn (right) Note the areas of unburnt seedbed in the ARN coupe.

The research at Warra also indicates that light levels in ARN coupes are unlikely to be limiting for successful eucalypt regeneration. Measured light levels near the edges of aggregates were at least 50 per cent of full sunlight, and increased rapidly with distance from the edge. Eucalypt seeds will germinate under low light conditions, and require only 10 to 30 per cent light levels for continued survival, but not optimum growth (Gilbert 1959; Cunningham 1960; Ashton 1981; Alcorn 2002).

Although the experimental ARN coupes at Warra relied on natural seedfall, seedcrops in the operational ARN coupes have not been consistent or well distributed, and all coupes have been supplementary sown at rates similar to those used in clearfells.

From 2005 FT ceased application of 1080 poison to control browsing mammals. ARN provides habitat refuges for browsing mammals, which is likely to increase browsing damage and result in lower seedling densities.

Standard browsing monitoring and control, primarily through trapping and shooting where necessary, is being carried out in all ARN coupes with browsing pressure appearing to relate more to specific coupe conditions than to silvicultural system.

Browsing control has been undertaken in six of eight ARN coupes burnt in 2007. Preliminary data suggest that trapping is more efficient than shooting in ARN coupes.

Seedling densities in ARN coupes are lower than for clearfell coupes which may have implications for tree form and productivity.

To date, the effort required for browsing control has been similar in ARN and CBS coupes, with similar outcomes (for example average number of browsing animals shot/trapped per coupe).

Regeneration surveys were undertaken to assess the success of harvesting and regeneration treatments. The standard for native forest coupes requires that 65 per cent of 16-m^2 plots be stocked by year three after a burn.

The experimental ARN coupes at Warra barely reached the stocking standard by year three. To date, only one operational ARN coupe has reached that age (HU322L), and it is well above standard with 77 per cent of 16-m^2 plots stocked.

Data from the eight operational ARN coupes burnt in 2007 indicate that at year one, both stocking and seedling density are lower in ARN coupes than in comparable CBS coupes.

The average stocking in ARN coupes was 62 per cent, while in comparable CBS coupes stocking averaged 73 per cent. Average seedling density in ARN coupes was 1479 stems/ha, while in CBS coupes density averaged 2700 stems/ha.

Studies at Warra have shown that some further recruitment can be expected in the ARN coupes over the next two years (Neyland *et al.* 2008).

The low seedling densities observed in the ARN coupes may have implications for tree form and reduce the suitability of these stands for future thinning operations (Lockett and Goodwin 1999, Rothe *et al.* 2008).

The 2005 Advice to Government predicted a 10 per cent reduction in regrowth productivity due to the suppression of oldgrowth trees but the longer-term impacts of ARN on productivity, from suppression and lower stocking levels, are currently unknown.

Monitoring of operational ARN coupes will continue, and a new research project will examine the impact of edges on regeneration in older clearfelled coupes using remotely sensed data (LIDAR).

Implications for forest management

Regeneration in the operational ARN coupes is likely to meet the stocking standard at year three if coupes show a similar recruitment pattern to that observed at the Warra silvicultural systems trial.

However, the lower initial seedling densities observed in operational ARN coupes to date indicate there is still some uncertainty about regeneration success, due to less favourable seedbeds and a probable higher browsing risk. This highlights the importance of effective management of browsing mammals and a further evaluation, based on regeneration assessments at year three.

Retention levels in ARN coupes must be stabilised at or below their current levels in order to avoid an excessive impact on yields and ensure that both ecological and economic objectives of VR are met. The long-term impact of VR on regrowth productivity is as yet unknown.

Fire Management Evaluation

Background

In 2004, the management of harvesting debris was recognised as the most significant operational issue associated with implementing alternatives to clearfelling (Forestry Tasmania 2004c).

In tall wet eucalypt forests, fine fuel (<25 mm diameter) loads following harvesting amount to 40-85 tonnes per hectare (Marsden-Smedley and Slijepcevic 2001), while total biomass can be up to 800 tonnes per hectare (Slijepcevic 2001).

The objective of the regeneration burn for clearfelled coupes is to create receptive seedbed while reducing slash loads and fire risk. With VR, an additional burn objective is to minimise damage to retained trees, which constrains the use of high-intensity burns.

Low-intensity burns were attempted in the two experimental aggregated retention (ARN) coupes at Warra. While damage to the retained aggregates was minimal (11 per cent of aggregate area, unpublished data), the low-intensity burns created receptive seedbed over only half of the felled area and resulted in marginal seedling densities at year three (Neyland *et al.* 2008).

Similar attempts to burn the first four operational ARN coupes were not made until late in the season in order to minimise the risk of escapes. Three of four burns failed to create sufficient seedbed because of wet fuels, and required burning in subsequent years.

Regeneration burning is a key challenge for implementing variable retention.

Biomass harvesting

Biomass harvesting of residues for energy production could provide an alternative or complementary method of slash management, and small-scale trials of residue removal were undertaken both at Warra and in one operational ARN coupe. In the Warra trials, fuel loads were reduced by approximately half and receptive seedbed was created (by mechanical disturbance) over 50 per cent of the harvested area. Subsequent regeneration burning of the coupe resulted in a lower proportion of burnt seedbed in the fuelwood harvested area compared to the majority of the coupe where residues remained on-site. Stocking and seedling densities within the areas from which fuelwood was harvested were similar to stocking and density in untreated areas (unpublished report).

Results from the fuelwood trials indicate that biomass harvesting could be used to reduce fuel loads in VR coupes. However, opportunities for operational-scale biomass harvesting are currently limited. The economics of fuelwood harvesting dictate that it will be more feasible for coupes closer to infrastructure and potential power plants rather than in more remote areas.

Fuelwood harvesting is likely to remove only some of the largest fuels (some will be needed for habitat) rather than the more flammable fine fuels, which need to be removed to reduce the fire hazard and create a seedbed.

For these reasons, biomass harvesting is unlikely to replace burning altogether, although the overall burn intensity may be reduced and the reduction in fuel loads may allow burns to be conducted over a broader range of weather and seasonal conditions.

Slow burning

In 2006, Forestry Tasmania engaged fire researcher Dick Chuter to develop better burning prescriptions for ARN in consultation with districts.

A new prescription (slow burning) was developed specifically for aggregated retention (Chuter 2007).

Slow burning allows a high-intensity burn to develop slowly without central ignition and the resulting convection column. Slow burns need to be lit sparsely and late in the day under conditions of dry fuel and low but rising relative humidity. The ideal result is an intense but less active fire that spreads slowly and will self-extinguish in the wetter coupe edges/aggregates with relatively little aggregate damage.

In 2006/07, eight of 10 harvested ARN coupes were burnt. Six of these were burnt to the slow burning prescription, while two were lit earlier in the day under more conventional high-intensity burning conditions. Outcomes were generally good, with burnt or disturbed seedbed created over 80 per cent of the felled area, although 25 per cent of aggregate area was scorched or burnt. The two coupes lit earlier in the day had higher levels of burn damage than coupes lit later in the day. Aerial ignition was more efficient and cost-effective than hand-lighting.

Following the 2006/07 burning season, several changes to ARN coupe design and site preparation were recommended:

- plan coupes with fewer, larger aggregates (at least 1 ha) and wider fairways
- plan coupes with more edge aggregates
- avoid locating aggregates in areas of high fire risk
- discontinue the practice of bulldozing mineral earth firebreaks around island aggregates, instead remove fine fuels within five metres of aggregate edges by 'raking' with an excavator
- avoid creating large windrows close to aggregates or vulnerable coupe edges.

The 18 ha coupe (including aggregates) on the left had only edge aggregates, which allowed for a conventional high intensity burn. The 66 ha coupe on the right had both island and edge aggregates and required the slow burning technique to be used.

It was also recognised that some scorching of aggregates is inevitable but also acceptable and possibly beneficial for fire-adapted species.

In 2008, nine of 11 harvested ARN coupes were burnt. The coupes varied considerably in design, from small coupes containing only edge and no island aggregates (patchfells) to large complex coupes with both island and edge aggregates.

Site preparation varied but in most coupes fuels were raked away from island aggregates with some attempt to minimise windrows, while standard mineral earth firebreaks were established around external coupe edges.

A conventional high-intensity burn was used to good effect in one patchfell. One coupe that had been carried over for several years was mechanically heaped, and the heaps burnt. The slow-burning prescription was applied in the other seven ARN coupes. Weather conditions were not ideal, with too-dry conditions in most of March followed closely by too-wet conditions in April. With time running out in the burning season, several coupes were lit with wetter than prescribed fuels, and required multiple lighting attempts.

Despite the less-than-ideal conditions for some burns, outcomes were reasonable, with burnt or disturbed seedbed created over 49 to 93 per cent (mean = 67 per cent) of the felled area and less than 10 per cent of aggregate area scorched or burnt. These seedbed results are more similar to results obtained after high-intensity burning in CBS coupes at the Warra silvicultural systems trial (74 per cent burnt or disturbed seedbed) than to results following low-intensity burns in the two ARN coupes at Warra (43 per cent burnt or disturbed seedbed).

Issues

Slow burning is a feasible burning method in ARN coupes. However, there are costs and risks associated with this type of burning that must be recognised. Slow burning and associated site preparation for ARN coupes is more costly than conventional high-intensity burning (see financial and economic evaluation). The recurrent costs associated with slow burning can be reduced by developing the capacity to remotely monitor coupe weather conditions using automatic weather stations, and enhancing district communications networks through additional radio or phone repeaters.

The slow burning prescription relies on specific weather and fuel moisture, and therefore requires close and careful monitoring to identify favourable lighting conditions. These conditions may not occur often, reducing the burning window for these types of burns and increasing the likelihood that some planned burns will not be achieved. Further experience will help to refine the slow burn prescription.

There may also be difficulties in scheduling ARN burns due to shading by smoke from high-intensity burns lit earlier in the day. Conventional high-intensity burns can be used in some ARN coupes that do not contain island aggregates (patchfells) and will simplify the ARN burning program to some extent.

Slow burns remain alight longer than conventional high-intensity burns, increasing the risk of an escape or wildfire. This risk is greatest for coupes lit early in the burning season, before the end of March. Post-burn monitoring of forest fuel conditions is required and any persistent creeping fires must be suppressed, placing additional demands on district staff.

Smoke management is becoming an increasingly significant consideration in conducting any form of burning operation. The reduced intensity of slow burns is likely to result in less complete combustion of large fuels, and greater production of smoke and particulate matter. If correctly conducted, slow burning will not produce a convection column and smoke will remain low in the atmosphere, where it is highly visible. This is mitigated to some extent by the fact that ARN burns form a minor part of the overall burning program. Smoke plume models from the Bureau of Meteorology are used to plan the timing and location of burns to reduce impacts on local residents and tourists.

Implications for forest management

VR burns in tall oldgrowth forest that meet the almost incompatible objectives of reducing harvest residues and minimising damage to retained trees are more difficult to conduct and require more specific weather conditions than conventional high-intensity burns.

Slow burning, or the small patchfell technique, can remove an acceptable proportion of the harvest residues in order to create seedbeds and reduce subsequent fire risk. Additional harvesting of residues, either for pulpwood or biomass energy, would reduce fuel loads so that the overall burn intensity may be reduced and allow burns to be conducted over a broader range of weather and seasonal conditions. The introduction of biomass harvesting might thus allow design of coupes with a greater proportion of island aggregates, which could be smaller in size, and allow a larger burning program to be achieved.

Financial and Economic Evaluation

Background

Issues Paper 5 (*Forest Management Issues*) noted that variable retention (VR) harvesting in oldgrowth was expected to result in a 20 to 30 per cent reduction in sawlog volume compared to a similar coupe harvested under a clearfell, burn and sow (CBS) operation (Forestry Tasmania 2004c).

Issues Paper 3 (*Financial, Economic and Community Considerations*) predicted that delivered log costs were expected to increase by 10 per cent to 20 per cent (Forestry Tasmania 2004b).

An evaluation of the above estimates has now been undertaken based on a case study of actual financial figures derived from the activities of 20 coupes across the State, including 10 coupes where VR was practised and 10 "like" or twin coupes where CBS occurred. The "like" CBS coupes were selected on the basis of best fit with their twin VR counterparts, with key criteria being geographic proximity, size, forest type (for example wet forest) and orientation of slope (aspect). Burning and regeneration of the 20 coupes occurred between 2005 and 2008 inclusive.

Future operations and their economics may be impacted by the additional benefits and costs of harvesting biomass. However, this remains an uncertain prospect at this stage, and its implications have not been considered in this economic evaluation.

Table 6 compares the attributes and costs of the 10 sampled VR coupes with 10 similar CBS coupes. Table 7 summarises incremental cost differences per gross area, logged area and unit (tonne or m^3) harvested.

The unit costs in Table 7 for roadworks and harvesting were calculated from a broader consideration than the sampled coupes. It would have been inappropriate to use actual roading costs for the sampled coupes for several reasons:

- maintenance costs are incurred over a much greater period than the period for which data are available for the coupes in the sample;
- the sampled coupes are not necessarily representative of the range of conditions in which roads are constructed and maintained (i.e. it is a very small sample); and
- the cost of constructing and / or maintaining spur roads and internal roads for any one coupe does not reflect the total cost of road access for logs transported from that coupe.

Instead, the additional cost of roadworks (both establishment and maintenance) due to VR was calculated by using volume estimates and planned areas of VR predicted from FT's forest estate model for the 20 year period from 2010-2029 (see Timber Supply Evaluation). It assumed that the road toll per unit received for timber harvested from clearfelled coupes is a good indicator of the actual cost of road establishment and maintenance. VR coupes generally require the same level of roading but there is a shortfall in cost reimbursement through road tolls on harvested timber because a portion of the forest is retained for another 90 years or so.

At 20 per cent VR, the level predicted in the 2005 Advice to Government, the shortfall amounts to $2.05/unit. However, at 35 per cent VR, the level achieved in the 10 sampled coupes in the case study (see Table 6), the shortfall amounts to $3.49/unit. The lower

Table 6. Comparison of attributes and costs for sampled VR and CBS coupes.

	Variable retention	**Clearfell burn and sow**
Gross* areas of the 10 coupes (ha)	404	309
Area of island and edge retention deducted from VR coupes (ha)	141	
Percentage retained due to VR	35%	0%
Felled area (ha)	247	309
Production from coupes - sawlogs (cubic metres)	18 515	25 803
Production from coupes - pulpwood (tonnes)	88 902	101 337
Production per felled ha (tonnes + cubic metres)	434	411
Perimeter of coupes (m)	65 893	35 883
Perimeter of 10 VR coupes had they been clearfelled (m)	45 780	
Total costs of aggregate marking (VR coupes only), supervision and FPPs for 10 coupes as calculated by the hours consumed for the various activities at the relevant salary level	$80 520	$73 200
Total costs of field inspections, special value inventories, and operational inventory for 10 coupes based on hours taken at the relevant salary level	$55 520	$53 250
Total costs of site preparation (fireline, burning, etc) for the 10 coupes	$261 993	$115 371
Total costs of seeding and game control for the 10 coupes	$43 740	$38 820

* Gross coupe area equals felled area plus aggregates (where applicable)

cost has been used in Table 7 but note that this is a conservative estimate and the real cost will be higher where retention levels exceed 20 per cent.

Tables 6 and 7 indicate the following:

- The proportion retained in the sampled VR coupes was 35 per cent. Given that the annual average amount of oldgrowth clearfelled over the six financial years to 2006/07 was 1100 hectares (Forestry Tasmania 2007b) the equivalent area requiring harvesting under variable retention to produce the same amount of CBS wood would be 1700 hectares. Given an average coupe size of 40 ha, this translates into 42 VR coupes requiring harvest to produce the same wood volume as 27 CBS coupes, an increase of 15 coupes. In order to contain costs, and limit the area of forest affected by roading, it would be preferable to increase the size of VR coupes, as well as limit retention levels to the 20 per cent VR target.
- In terms of production of sawlog volume it is logical that the magnitude of the reduction in sawlogs from VR coupes compared with CBS coupes will correlate broadly with the percentage retained in VR coupes. In the coupes analysed the reduction in sawlog volume under VR was a bit less, or 28 per cent.
- The cost of foregone revenue for roadworks of $2.05/unit (tonne or m^3) due to VR harvesting is the most significant cost item. This cost will be even greater if retention levels exceed the 20 per cent target recommended in the 2005 Advice to Government.
- Firelines and burning are also significant cost items in VR. In the figures analysed they represent a dramatic 168 per cent above the CBS figure, equivalent to $1.53 increase per unit (tonne or m^3) harvested. There is some potential for this cost to be reduced through a reduction in firebreaks around internal aggregates.

Table 7. Incremental cost differences gross ha, logged ha and unit (tonne or m^3) harvested between VR and CBS silviculture.

	Variable retention			**Clearfell, burn and sow**			**Additional Cost of VR**
	Cost per gross coupe ha	**Cost per logged ha**	**Cost per unit harvested (tonnes or m^3)**	**Cost per gross coupe ha**	**Cost per logged ha**	**Cost per unit harvested (tonnes or m^3)**	**Cost per unit harvested (tonnes or m^3)**
Cost of marking, supervision and preparation of Forest Practices Plans	$199	$325	$0.75	$237	$237	$0.58	$0.17
Costs of field inspections, special value inventories, and operational inventory	$138	$225	$0.52	$172	$172	$0.42	$0.10
Cost of site preparation (fireline, burning, etc.)	$649	$1,060	$2.44	$373	$373	$0.91	$1.53
Cost of sowing and game control	$108	$177	$0.41	$126	$126	$0.31	$0.10
Additional roadworks costs per unit (m^3 or tonnes)							$2.05
Additional harvesting cost per unit (m^3 or tonnes)							$1.25
Total							**$5.20**

- The other costs of sowing, game control, marking, supervision, Forest Practices Plan preparation, field inspections, special value inventories and operational inventory rose by $0.37 per unit harvested under VR compared with CBS.
- Delivered log costs (assuming all the additional costs are passed on), as reflected in Table 7, thus rise approximately $5.20 per unit compared with CBS. It should be noted that not included in the $5.20 per unit figure is the high development cost of rolling out VR in the early years.

Impact on harvesters

The new technique of VR harvesting requires adaptation, at some cost, from the traditional CBS form. This includes a greater requirement for directional felling, longer average snigging distances from stump to landing and raking back of some harvest residues from aggregates.

Impact on wood processing industries

With access to the eucalypts in oldgrowth forests made more difficult and expensive, it will be harder for industry to source logs that are easy to saw, slice and dry into high value products (Symetrics 2004). Older larger logs produce wider boards that are sought after for furniture, flooring and appearance grade products.

The reduced availability of oldgrowth forest for wood production, as a result of the TCFA, has had an effect on log quality. Although the TCFA provided funds for more plantations to maintain the sustainable sawlog supply, eucalypt plantations will not produce the size and quality of log available from native forests. The logs will be smaller and fast grown, resulting in the need for new technologies for processing. The implementation of such processing technologies, including peeling and hew sawing, has already been initiated in Tasmania.

While log sizes from regrowth forests are generally less than oldgrowth forests, most native eucalypt forests are managed on rotations of around 90 years, which is sufficient for dominant trees to produce sawlogs that are still considered large in comparison with many other forests around the world. A small ongoing supply of even-larger logs will also be available from a range of partially harvested forests, including the eventual harvesting of aggregates in VR coupes, which will include trees of oldgrowth size and quality.

VR harvesting also increases the costs of pulpwood from oldgrowth forests. This product is primarily sold as woodchips to the export market, which increasingly prefers younger wood, from plantations and regrowth. However, continued pulpwood sales from oldgrowth forests will generally be required in order to allow the commercial harvesting of their eucalypt sawlog component.

Implications for forest management

The annual total cost of VR implementation per year can be estimated from the unit cost presented in Table 7 and the average annual VR harvest modelled for the period from 2010-2029 (see Timber Supply Evaluation). This indicates an annual cost of $0.7 million at the targeted retention rate of 20 per cent. At 35% retention the annual cost would be $0.8 million.

Once the present TCFA funds for additional costs of forest management and harvesting are exhausted, the costs of VR will have to be fully borne by the forest grower and/or passed on to the supply chain and processing industries, resulting in higher log costs. The financial implications of applying the aggregated form of variable retention in tall oldgrowth forests indicate that current contracts can be met. However, delivered log costs must be contained if the timber industries are to remain viable.

Harvesting costs should be negotiated based on the true cost of additional work required for VR. In order to contain costs, particularly for roads and burning, it would be preferable to increase the size of VR coupes instead of harvesting more coupes each year. It is also important that the level of retention is maintained at around 20 per cent because significantly higher retention levels significantly increase costs per unit harvested.

Timber Supply Evaluation

Background

Since the Advice to Government (Forestry Tasmania 2005) the following timber supply evaluation activities have occurred:

- the five-yearly RFA Review of Sustainable High Quality Eucalypt Sawlog Supply from Tasmanian State Forest, also known as the Wood Review, was published in August 2007 (Forestry Tasmania 2007)
- an updated classification of oldgrowth coupes by planned harvest treatment
- sensitivity analyses of timber yield implications of variable retention (VR) based on various levels of retention and productivity of subsequent regeneration (McLarin 2008).

The Wood Review modelled the expected establishment of 9000 hectares of new eucalypt plantations under the TCFA. When plantations established or purchased since 2006 are included, the establishment of new plantations for eucalypt sawlog production will be about 5300 hectares short of the 16 000 hectares envisaged in the TCFA to maintain high quality eucalypt sawlog supply at 300 000 m^3 per year, given increased oldgrowth forest reservation and alternatives to clearfelling in oldgrowth forests. Completion of the full program has now been made more difficult by Forestry Tasmania's 2007 decision to end broad-scale conversion of native forests to plantation.

Strategies including a higher proportion of thinning, pruning and secondary fertilising in plantations, and more thinning in native forests, are required to enable the high quality eucalypt sawlog supply at 300 000 m^3 per year to be maintained, although with less margin for future developments which impact on forest yield capacity.

Forestry Tasmania will seek to expand the extent and capacity of its hardwood plantation estate, where opportunities exist, on land that does not involve the broad-scale clearing of native vegetation. This could include purchasing private land and increasing the productivity of existing plantations through an expanded secondary fertilising program.

The 2007 Wood Review

The 2007 Wood Review used an updated forest estate model that included new growth estimates, based on more recently measured plot-based inventory than the previous model used to inform the 2005 Advice to Government. The updated model was constrained to meet the TCFA requirement that at least 80 per cent of the annual oldgrowth harvest be met from non-clearfell silviculture by 2010.

Figure 8 shows the 90-year view of high quality eucalypt sawlog sustainable yield from State forests and has the following features of relevance to this evaluation:

- While there is no current eucalypt sawlog supply from plantations, from about 2020 plantations will supply half of the sawlog supply target from State forests.
- The mature eucalypt forests (which generally coincide with tall oldgrowth forests) form nearly 30 per cent of the current sawlog supply but this becomes negligible after 2030.

This does not mean there will be no more mature eucalypt forests in State forests after 2030, because there are substantial areas not zoned for wood production (Table 8). In fact, the 2007 Wood Review indicated the proportion of mature forest on State forests remains similar between 2006 and

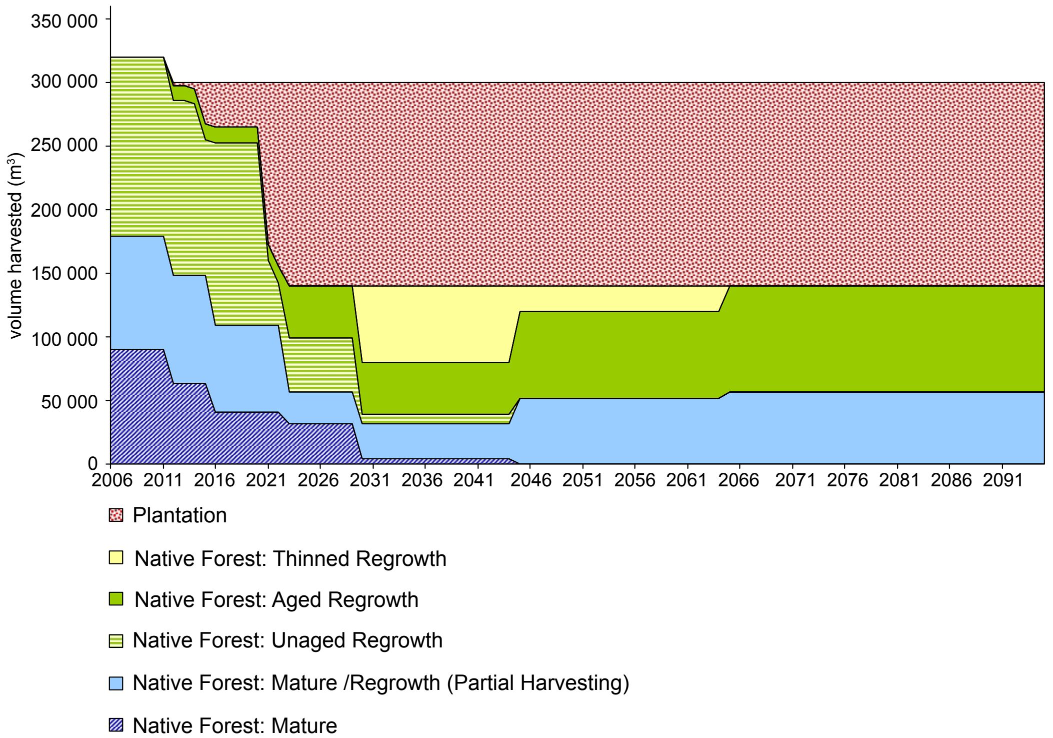


Figure 8. 2007 90-year view of high quality eucalypt sawlog sustainable yield from State forests (from Forestry Tasmania 2007c)

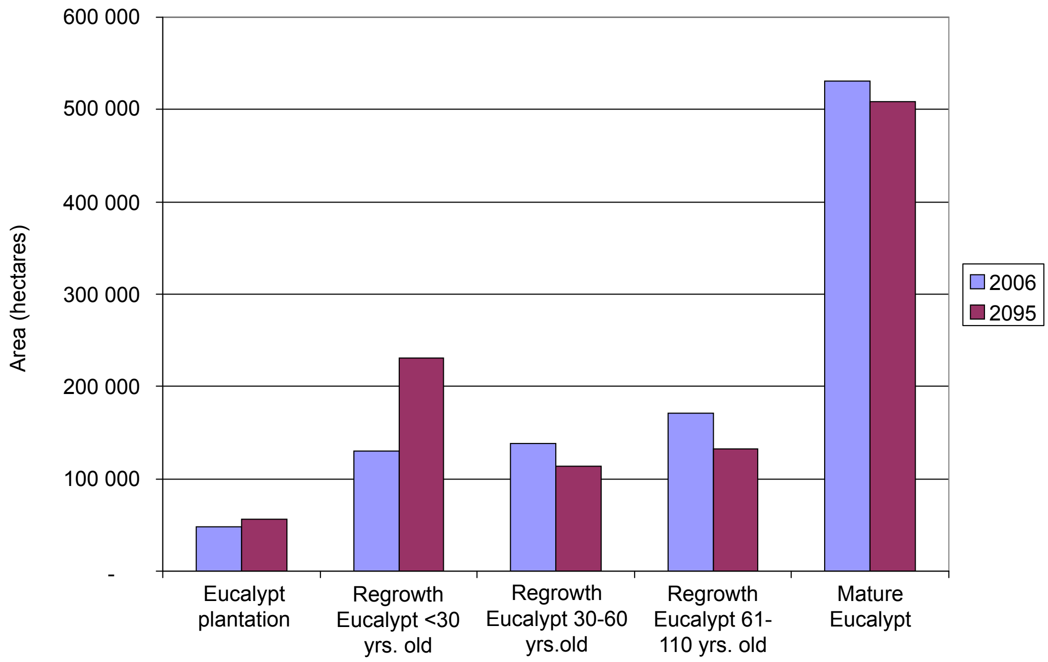


Figure 9. Eucalypt forest growth stage in State forests in 2006 and projected for 2095.

Table 8. State forest classification as at 30 June 2007

	Area (ha)	Area (per cent)
Reserves and non-harvest areas	760 000	51
STMUs	69 000	5
Softwood plantation coupes	54 000	4
Eucalypt coupes		
Non-oldgrowth/plantations	509 000	34
Coupes-containing-oldgrowth:		
- partial harvest	41 000	3
- variable retention	30 000	2
- clearfell	26 000	2
Total State forest	1 489 000	100

Table 9. Gross and net area of RFA-defined oldgrowth, in eucalypt coupes containing at least 25 per cent oldgrowth, by planned harvest treatment.

Planned treatment	Gross oldgrowth (ha)	Net oldgrowth (ha)
Partial harvest	28 000	21 000
Variable retention	19 000	10 000
Clearfell	14 000	11 000
Total	61 000	42 000

2095 (Figure 9). However the spatial pattern will change over the period so that there is less mature forest within harvested areas but more mature forest within reserves and other unharvested areas as the forest ages. This analysis took account of the effect of wildfire, based on the average area of forest burnt by severe wildfires over the previous ten years.

Classification of oldgrowth coupes by planned harvest treatment

About 97 000 ha of eucalypt coupes containing oldgrowth (including at least 25 per cent mapped oldgrowth) are available for harvesting. Table 8 indicates 41 000 ha are classified as partial harvest, 30 000 ha as variable retention and 26 000 ha as clearfell, burn and sow. (Note the comparison with the 2005 published position (Appendix 1-Table 14), showing a reduction of 13 000 ha in the area of State forest, and an increase of 50 000 ha in the area of State forest in reserves, compared to the position projected at that time).

These are gross provisional coupe areas. Actual harvest areas are typically about 25 per cent less due to various operational factors including streamside reserves, other set-asides required by the Forest Practices Code, and inoperable terrain. The harvest area in VR coupes will also be reduced by at least a further 20 per cent due to the retention of aggregates.

Table 9 shows the gross and discounted areas of RFA-defined oldgrowth for the partial harvest, variable retention and clearfell classifications shown in Table 8. It shows that the total net area of oldgrowth designated for clearfelling, as at 30 June 2007, is 11 000 ha.

For coupes containing oldgrowth, during the 20-year period from 2010-2029, Forestry Tasmania has modelled an annual average of 1100 gross ha of partial harvest, 650 gross ha of VR and 650 ha of clearfelling (including 500 ha of coupes on steep land).

Based on this activity the underlying RFA-defined oldgrowth area that is planned for clearfelling each year on average is 330 gross ha, and the RFA-defined oldgrowth area that is planned for non-clearfell (for example partial harvest or VR) each year on average is 1330 gross ha. Hence the proportion of RFA-defined oldgrowth area planned to be harvested by non-clearfell silviculture each year is 80 per cent, thus meeting the TCFA target.

Table 8 also indicates an area of 69 000 ha of Special Timbers Management Units (STMUs) which have been designated to provide a small, ongoing supply of special (primarily non-eucalypt) timbers to meet the needs of the Tasmanian fine timbers industry. The use of clearfelling is precluded from these areas and the volume of eucalypt sawlogs arising from small-scale selective logging is negligible and not considered as part of the five-yearly reviews of eucalypt sawlog supply.

In addition to special timbers, there is also a potential for a small ongoing supply of about 10 000 m^3/year of large-dimension eucalypt sawlogs. These could be supplied from a range of sources including Special Timbers Management Units, multi-aged partially harvested forests, and from some areas of regrowth forests that could be managed on longer rotations (Leech 2008).

Sensitivity analyses of VR timber yields

The TCFA Research Project on VR timber yield modelling (McLarin 2008) included sensitivity analyses of a range of retention levels and regeneration productivity levels to determine the feasibility of the 300 000 m^3 annual supply of high quality eucalypt sawlogs from State forests, given that at least 80 per cent of the annual oldgrowth harvest is met from non-clearfell silviculture.

A range of retention levels, above the normal provisional coupe area discounts that result from clearfell coupes, were chosen. Retention levels included those assumed in Forestry Tasmania (2005) and those actually achieved (Scott 2007).

In addition, a range of regeneration productivity levels were applied to growth curves for silvicultural regeneration to test implications of future reduced growth, due to suppression and lower stocking, on sustainable yield.

Levels for sensitivity analyses, from which a 6x6 matrix of model scenarios were built, are:

Retention level percentage	Regeneration productivity level percentage
5	-5
10	-10
20	-20
30	-30
50	-40
75	-50

The base forest estate model for undertaking sensitivity analyses was the latest five-yearly Wood Review (Forestry Tasmania 2007c). The model was run to identify at what level of retention and regeneration productivity the supply of 300 000 m^3 per year of high quality eucalypt sawlogs became infeasible.

Table 10. Sensivity Analyses Matrix

		Regeneration productivity level %					
		-5	-10	-20	-30	-40	-50
Retention level %	5	✓	✓	✓	✓	✓	✓
	10	✓	✓	✓	✓	✓	✓
	20	✓		✓	✓	✓	✓
	30	✓	✓	✓	✓	✓	✓
	50	✗	✗	✗	✗	✗	✗
	75	✗	✗	✗	✗	✗	✗

Table 10 shows the results of the sensitivity analyses. Green ticks represent achievement of the target 300 000 m^3 per year of high quality eucalypt sawlogs, and conversely, red crosses represent the inability to achieve this same target.

The green cell represents assumptions as modelled for the TCFA (that is, 20 per cent retention and 10 per cent reduction in regeneration growth).

Results were sensitive to retention level (Table 10). At 30 per cent retention in oldgrowth coupes designated for variable retention, Forestry Tasmania can supply (assuming all other factors remain constant) the 300 000 m^3 per year of high quality eucalypt sawlogs, but not at 50 per cent retention.

This is because of the importance of oldgrowth in the short to medium term to the high quality eucalypt sawlog supply. The supply of eucalypt sawlogs from oldgrowth forests will be progressively reduced from the current level of about 30 per cent of the legislated eucalypt sawlog supply of 300 000 m^3 per year to less than two per cent by 2030 (Forestry Tasmania 2007).

In contrast, results were insensitive to regeneration productivity level using a planning horizon of 90 years. This could either be because coupes with retained aggregates are such a small component, about five per cent by area of the total eucalypt sawlog supply, or because few of the regenerated coupes were harvested in this planning horizon.

A 200-year model, that assumed that coupes containing oldgrowth that were first harvested using aggregated retention had VR applied in subsequent rotations, was also unaffected by regeneration productivity level in aggregated retention coupes, indicating this result was due to coupes with retained aggregates being only a small component of the total eucalypt sawlog supply.

Sensitivity analyses around the assumptions made regarding retention level and regeneration productivity level, for modelling alternatives to clearfelling in oldgrowth forests in the TCFA, have identified that Forestry Tasmania can achieve the legislated 300 000 m^3 per year of high quality eucalypt sawlog requirement at a retention level of 30 per cent above the normal provisional coupe discount of around 25 per cent.

The 30 per cent retention level is similar to what has been achieved in the first 11 aggregated retention harvest coupes established by 2007, and about 10 per cent more than the assumed retention level used for modelling in 2005 (Forestry Tasmania 2005).

However, based on these sensitivity analyses, it is not possible to make available the required sawlog if the retention level increases to 50 per cent. In other words, the boundary between feasibility and infeasibility falls somewhere between the 30 per cent and 50 per cent retention levels. The average retention level in VR coupes established in 2008 was 47 per cent, which, if continued at that level, would probably make the ongoing sawlog supply of 300 000 m^3/year infeasible.

In contrast, but again based on these sensitivity analyses, it does not matter what level of regeneration productivity is assumed, as the achievement of the required sawlog is insensitive to future growth in these aggregated retention coupes.

These oldgrowth coupes are important in ensuring the sawlog supply in the short to medium term, but not in the long term. This is because there are insufficient alternative coupes available now, but after 2030 native forest regrowth and eucalypt plantations, will dominate sawlog supply (Forestry Tasmania 2007c).

Modelling of the effect of variable retention implementation beyond the oldgrowth coupes currently designated is beyond the scope of this project. The area of coupes designated for VR currently forms about five per cent of the productive eucalypt forest estate. If VR silviculture was to be applied more broadly, for example to all native forest coupes or even to all coupes containing even a minor oldgrowth component, then the effect of varying retention levels or regeneration productivity, would be expected to be much more significant.

Implications for forest management

The timber supply implications of applying the aggregated form of variable retention in tall oldgrowth forests indicate that the eucalypt sawlog supply target of 300 000 m^3/year can be maintained if VR is applied as per the TCFA as one part of a mixed silviculture strategy for oldgrowth coupes. This is conditional on VR retention levels within coupes being kept at levels below 30 per cent. If higher retention levels are widely used, the sawlog supply target may become unachievable.

Advice From Science Panellists

Background

The 2005 Advice to Government recommended a scientific panel of internationally recognised experts in forest and conservation science be established to review and provide advice to Forestry Tasmania on progress in practical implementation of silvicultural alternatives against international best practice standards (Forestry Tasmania 2005). The terms of reference for the panel were as follows:

In the context of Forestry Tasmania's desire for better management of oldgrowth forests for wood production for social, economic and environmental outcomes, the expert science panel and its individual members will advise the Forestry Tasmania Board from time to time on:

1. Scientific aspects of the Warra alternative silviculture trials.

2. Progress in the operational implementation in Tasmania forests of silvicultural alternatives to CBS against international best practice standards.

3. Implications and consequences of alternative silvicultures for management of Tasmanian oldgrowth forests.

Forestry Tasmania engaged five scientists to form the panel, which included Professor Jürgen Bauhus (Germany), Bill Beese (Canada), Jack Bradshaw (Australia), Professor Tom Spies (USA) and Professor Ivan Tomaselli (Brazil).

The panellists all made one-week visits, as individuals, to Tasmania at various times during winter/spring 2007 and were shown a full range of VR operations. They also met FT Board members, operational staff, researchers and visited the Warra Long-Term Ecological Research Site.

Each panellist provided a preliminary report to the Forestry Tasmania Board which was subsequently published on the FT website.

The panellists returned to Tasmania in summer 2008 and gave presentations to the Old Forests New Management Conference in February 2008 (available at http://www.cdesign.com.au/oldforests2008) and provided further verbal advice to the FT Board. They have since provided written final reports, the last being received in May 2008.

The panellists generally made recommendations independently, rather than as a collective but did develop the following joint statement as a succinct summary:

'All panel members were supportive of the use of mixed silviculture, particularly variable retention, as the best currently-known way for Forestry Tasmania to reduce clearfelling in oldgrowth forests while fulfilling its other requirements under applicable laws and policies.'

Mr Beese noted the fundamental premise of variable retention (VR) is that it is more ecologically valuable to distribute mature forest elements throughout the production-forest landscape rather than to simply add an equivalent amount of mature forest to the large, existing reserve system.

Professor Spies observed that VR will provide tangible ecological benefits in terms of retaining older forest compositional elements and structures in coupes where it is applied. Compared with conventional CBS, these coupes will have significantly higher structural and compositional diversity than coupes where no remnant patches are retained. These benefits should increase over time, as late-successional species disperse into cut areas from remnant patches. As the regenerated

Mark Neyland (left) briefs Professor Tom Spies (centre) and Professor Ivan Tomaselli (right).

eucalypt stands grow in stature the entire coupe should more rapidly move toward the structural and compositional diversity of the previous older forest than it would under a CBS system.

Each panellist provided detailed observations and recommendations from their own perspective and detailed knowledge from their respective fields, which included conservation biology, silviculture, landscape ecology, timber yield modelling and forest economics. Their final reports are lodged on the FT website. The reports vary widely in their emphasis and cover some 30 subjects that are relevant to the implementation of alternatives to clearfelling in tall oldgrowth forests in Tasmania.

The major five themes to emerge from the panellists' reports are:

1. Development and application of landscape metrics to help determine priorities for management for oldgrowth biodiversity

Several panellists, particularly Professor Spies, noted that oldgrowth is a dynamic, rather than a static growth stage and urged the development of landscape metrics that would allow society to choose where oldgrowth forests, or regrowth forest with oldgrowth elements, are best located to meet biodiversity and social objectives over the long-term.

Professor Bauhus highlighted a need to develop and implement silvicultural techniques such as variable retention in order to manage forests for 'oldgrowthness' to meet these objectives.

Professor Spies noted that one of the major challenges in implementing biodiversity practices is specifying the goals and outcomes at multiple scales. Without some sense of what the goals are or expected trends are, it is difficult to know when a management agency has done "enough" to provide for native biodiversity. It would be desirable to determine how certain biodiversity conditions might change over time in the same way that trends in sources and volumes of wood are projected. Key measures could include forest development stages (for example oldgrowth) but also key forest structures and landscape metrics including area types by eco-region, edge, and patch sizes.

Professor Spies observed around 20 per cent (currently averaging 25 per cent) of the native forest production areas are set aside because of streams or non-suitable site conditions. These represent a landscape-level retention that contributes to biodiversity but is invisible if the focus is only on retention in coupes. VR coupes, informal reserves and other non-operational areas, formal reserves and managed native forests all contribute to native forest biodiversity in some way.

Professor Spies felt that without this recognition, it may appear to some that native biodiversity only occurs in large formal reserves and some VR coupes. It may be that Forestry Tasmania is not getting full credit for the biodiversity values it is really producing.

He recommended a broader landscape analysis across all land tenures to help place FT lands in a continuum of forest management goals. He suggested this broader landscape analysis would presumably also point out that many of the most threatened elements of biodiversity in Tasmania are not associated with old forests but with drier open forests and non-forest types and that many of these are located off public lands.

2. Effective treatment of harvest residues

Several panellists commented on the importance of effective treatment of harvest residue to the implementation of VR in Tasmanian's tall oldgrowth forests. Current residue levels are very high as noted by Professor Tomaselli and the operability and economics of VR implementation would be improved considerably if more of this residue could be sold as pulpwood or for biomass energy. However, further removals need to be by integrated harvesting, rather than by additional operations, and should only proceed if appropriate prescriptions for retention of coarse woody debris (CWD) are in place to provide habitat for log-dependent fauna.

Professor Bauhus also noted that plans to use a large proportion of slash for the generation of bioenergy might provide opportunities to regenerate these forests with less intensive burning or through mechanical disturbance of the surface soil to create a receptive seedbed. However, any such proposals must specify CWD retention at the coupe level as well as consider the landscape context and acknowledge the role of aggregates as a long-term source of CWD.

Mr Bradshaw noted the use of high intensity fire to achieve satisfactory eucalypt regeneration, while protecting retained aggregates from fire damage, is the most problematic aspect of a non-clearfelling system in wet eucalypt forests. Even so, he acknowledged that this very difficult task had been achieved, on a limited basis, with satisfactory results. He noted that some aggregates had been burnt but did not view this as a matter of concern because it is well within the range of what could be expected in wildfire conditions.

Mr Bradshaw noted that a burning program that includes a significant number of VR burns will be more difficult because there will be fewer days suited to burning coupes with retained aggregates. The likely outcome will be a higher proportion of carry-over coupes. This is a particular problem in these forests since the consequences of delayed regeneration are severe and the options for remedial action are limited. This is predicted to result in a higher proportion of failed or marginal regeneration results.

Mr Bradshaw suggested possible options to increase the likelihood of satisfactory regeneration could include:

- simplifying the design of aggregates to facilitate burning
- less reliance on natural seed fall by increasing the supplementary application of seed to achieve higher regeneration rates in the first year
- increasing browsing control efforts.

Mr Bradshaw indicated that it would need several years of operational experience and development to resolve the uncertainty over the reliable treatment of harvest residues.

3. The need to develop clear metrics and targets for VR implementation

At the broad level, panellists were comfortable with a mixed silviculture strategy that included some clearfelling.

Mr Beese, who is probably the world's foremost implementor of variable retention, considered the 80 per cent non-clearfell target to be appropriate and that it was useful to retain clearfelling of oldgrowth for some difficult sites. Conversely he noted that VR could be considered for regrowth in landscapes where there is very little oldgrowth, to retain or develop older forest elements.

However he noted Tasmania's very high levels of reservation moderate the need for additional VR in many forested landscapes. He observed that Tasmania is far ahead of most places in the world in total forests (47 per cent) and oldgrowth forests (79 per cent) in formal protected status.

A number of panellists commented on the potential for excessive retention at the coupe level through setting targets for each of forest influence, aggregate size and retention levels.

Mr Bradshaw identified the level of forest influence as the most useful target but urged that the limit of one tree height not be locked in too firmly at this stage of development until further evaluation of production and biological outcomes. He cautioned against being too prescription-driven and advised that if the emphasis is on attempting to more closely emulate natural structure a broader interpretation can be considered.

Professor Bauhus noted that 'over-achievement' of retention may have benefits at the coupe level, but it may also have undesirable consequences in terms of overall harvesting disturbance, roadworks, etc at the landscape level.

Mr Beese noted the retention levels being achieved in Tasmanian VR coupes exceeded the 21 per cent average, including stream buffers, in VR operations in coastal British Columbian forests.

He observed that retention levels in Tasmania were great for biodiversity values but seemed higher than desirable for an economic application of VR and recommended the goals for percentage retention in coupes be guided by a balance of economic and biological considerations.

He noted that FT should be getting credit for all of the reserves on the landscape that contribute to old forest attributes, regardless of the other reasons (such as streams, steep areas, geomorphic values etc) for leaving them.

He considered a system of accounting for long-term retention within coupes and across landscape units was needed to allow assessment of the true costs and benefits.

4. Aggregate designs that meet fire management and ecological objectives

Several panellists commented on the need for aggregate design to recognise the need for burning as a seedbed preparation treatment for eucalypt regeneration.

Professor Bauhus noted the value of edge (or peninsula) aggregates, best located in moist environments, rather than island aggregates, to facilitate fire management.

Mr Bradshaw urged more consideration be given to the specific purpose of particular aggregates in order to guide their size, separation and composition.

Mr Bradshaw also noted there appeared to have been little explicit attention given to the placement of aggregates and their impact on aesthetics and considered visual outcomes could be improved to some extent if more focus were placed on aesthetics.

Mr Beese observed some portions of coupes with smaller aggregates and more dispersion of habitat attributes throughout the next stand would be desirable if burning was not an issue.

5. Improved social acceptability

Several panellists noted that VR offers benefits for social acceptability as well as ecological benefits.

Mr Beese observed that to help meet the social objectives of moving to VR, Forestry Tasmania should continue to seek opportunities to engage in dialogue with moderate environmental, recreational and community groups.

Professor Spies noted VR outcomes should not be judged merely at the time of harvest and regeneration. He commented that VR is about creating forest structural variability that will provide habitat benefits throughout the management cycle and benefits could be illustrated through modelling and visualisation products that show how multi-coupe landscapes will develop under VR and other retention practices.

Professor Spies also supported the value of social science research that explores the role of society in forest policies and practices because it could help provide some context for forestry debates.

Professor Tomaselli noted a need for more attention on global perspectives and interactions to consider where alternative supplies would come from if wood supply was reduced in one area.

Forest Management Evaluation

Background

Forest management implementation encompasses silvicultural decision-making, harvest control, post-harvest treatment and monitoring. Issues Paper 5 (*Forest Management Issues*) (Forestry Tasmania 2004c) foreshadowed that variable retention in tall oldgrowth forests would increase the complexity of forest management implementation by:

- increasing planning and field implementation costs per coupe
- increasing the number of coupes compared to clearfelling
- bringing forward future roadworks costs
- increased difficulty and costs of removal of harvest residue to create a seedbed for regeneration.

The 2005 Advice to Government noted that this complexity, and worker safety concerns, would be greatest for steep coupes and hence these were deemed unsuited for variable retention.

In July 2005 Forestry Tasmania formed an internal Variable Retention Implementation Group (VRIG) to facilitate the transition towards variable retention in most tall oldgrowth forests. VRIG includes representatives from each of FT's five districts as well as strategic planners and researchers and provides a forum for sharing experience and knowledge of the best ways to implement variable retention in the Tasmanian context. Many operational matters have been raised, and addressed, as variable retention coupes have been progressively implemented. VRIG has met formally seven times since 2005 and its key issues and recommendations are summarised in Table 11. VRIG has also considered and will progressively implement many of the operational recommendations made by FT's science panellists. Panel recommendations for research are under active consideration by FT's Division of Forest Research and Development.

Fuels should be evenly distributed throughout the harvested area. Windrows should not be created when clearing firebreaks.

Large oldgrowth trees, including dead trees, make valuable biological anchors when designing aggregates.

Table 11. Summary of operational issues, implications and outcomes identified by VRIG since July 2005.

Year	Issues	Implications	Outcome
05/06	Excessive retention levels.	Lower coupe yields mean more coupes are needed to maintain supply.	Clear guidelines needed for VR targets and reporting.
	Excessive firebreaks around aggregates.	Compacted soil around aggregates reduces effective regeneration.	Cease or reduce clearing to mineral soil to minimise soil damage and cost. Fuels should be evenly distributed throughout the harvested area, rather than windrowed.
	Clarify need for coupe-dispersal between VR coupes.	VR requires more coupes to be established and more roads. Offset costs by allowing more coupes to be harvested from current road networks.	VR coupes should be considered as partial-harvesting and not subject to Forest Practices Code dispersal rules developed for clearfell coupes.
	Sub-optimal VR burning prescriptions.	VR burns left to end of burning season to minimise risk but fuels become too wet for effective burns.	Engage fire researcher Dick Chuter to develop better burning prescriptions in consultation with Districts.
	Harvesters concerned about safety.		Additional focus on thorough risk assessments. Engage safety consultant Greg Howard to interview harvesting personnel and analyse reported hazards.
06/07	Response to operational recommendations from Symmetree Consulting Group (British Columbia), which visited all current Tasmanian VR coupes in December 2006:		
	• Focus on the biological value of VR, rather than the operational difficulties.	Operational staff are more motivated towards VR implementation if they understand the ecological benefits	Endorsed.
	• Reduce optimum forest influence targets from > 90 per cent of felled area to around 60-70 per cent.		Endorsed.

Year	Issues	Implications	Outcome
06/07 cont.	• Use biological 'anchors' such as very large oldgrowth trees or rainforest patches for designing aggregates (see photo of habitat tree).	Aggregates have more ecological value when oldgrowth elements are included.	Endorsed where applicable. In some coupes the forest influence targets require aggregates where no 'biological anchor' is evident.
	• Use clearfelling strategically in areas where VR is difficult.		Endorsed, especially for steeper areas and sites with many hazardous trees.
	• Trial mix of marked aggregates versus contractor selection to identify aggregates.	Pre-marking aggregates gives better spatial arrangement but harvesters often have best understanding of local features and safety implications. Need to retain flexibility depending on site conditions and experience of personnel.	Endorsed.
	Good initiative displayed by districts towards 2007 VR burning season with a range of outcomes achieved.	VR burns shown to be more complex than high-intensity burns.	Fully adopt slow burning techniques for VR burns next year. Retain fewer, larger aggregates to facilitate burning and ensure greater ecological integrity of retention areas.
	Need for clear goals to guide operational staff in implementing VR.		Goals and guidelines endorsed by VRIG for inclusion in VR Silvicultural Manual.
07/08	The 2008 VR burning season indicates slow burning techniques work, but require specific weather conditions and fuel moisture levels; hence a narrower burning window.	Risk of VR burns not being completed due to insufficient burning days.	Use slow burning technique for "island aggregate" coupes, but either slow burn or traditional convection high-intensity burning for predominantly edge aggregate coupes.
	VR burns produce more smoke which stays closer to the ground than high-intensity clearfell burns.		Reducing the proportion of the VR regeneration burns done with slow low-intensity fires and increasing the proportion done with convection burning will improve smoke dispersion.
	Should aggregates be selectively logged for special timbers?	Some special timbers will be foregone for at least another 90-year-rotation.	Any unharvested forest within VR coupe that will be harvested or partly harvested within the next rotatisdon should not be counted as 'forest providing influence'.
	Additional payments for VR harvesting to be reviewed because of a shift to fewer larger aggregates.	VR coupes with predominantly edge eggregates may not attract an additional payment for harvesting.	Negotiate payments based on more realistic additional costs given changes to VR coupe design (fewer island aggregates).

Year	Issues	Implications	Outcome
08/09	Operational retention levels are generally greater than planned because of unrecognised constraints and harvesters being unwilling to fell marginal timber. The use of fewer, larger aggregates and more edge aggregates is contributing to high overall retention levels.	Coupe yields are reduced well below that predicted in the 2005 Advice to Government, which challenges financial viability as well as long-term sawlog supply.	Plan for 51 per cent forest influence and 20 per cent retention levels, given that operational outcomes are almost always greater. Allow some smaller aggregates to help achieve influence levels, with a reduced loss in yield. Supervise contractors closely. Progressively review retention levels during harvesting. If necessary, review the goals and guidelines for VR to optimise the balance between ecological, safety, fire management and regrowth productivity outcomes as well as effects on yield.

Can field managers achieve 80 per cent non-clearfell for annual oldgrowth harvest by 2010?

A key question for VR implementation is whether FT district staff believe they can meet the 80 per cent non-clearfell target for the annual oldgrowth harvest by 2010. Most believe they can, up to the required average level of 650 gross ha of VR coupes per year, but they recognise some negative aspects. These include higher costs, more carry-over coupes following unsuitable burning conditions, an additional smoke nuisance, a greater risk of wildfire escape and less reliable regeneration.

Operational staff have already identified, and in some cases put into practice, several improvements to VR implementation in tall oldgrowth eucalypt forests. These include:

- adopting slow-burning techniques based on lighting dry fuels under conditions of rising humidity (usually at dusk)
- retaining fewer, larger aggregates; using more peninsular or edge aggregates and fewer island aggregates
- considering multi-stage burns over progressive harvesting years.

Implementation costs can potentially be mitigated by:

- matching VR harvesting payments to the configuration and harvesting difficulty of individual coupes
- adopting larger coupes where appropriate
- negotiating more flexible coupe dispersal rules that recognise VR as a form of partial harvesting.

Coupe dispersal rules are prescribed for clearfell coupes in the Forest Practices Code (Forest Practices Board 2000) and require any adjoining coupes to have achieved a dominant vegetation height of at least five metres before an adjoining coupe should be clearfelled.

For sound ecological and safety reasons, the majority of the retention should be as patches of at least one hectare, rather than individual or small clumps of trees. Beyond this requirement, it is highly desirable to allow operational planners as much flexibility as reasonably possible to meet specific coupe objectives while meeting the overarching VR target. For example, in areas of high visibility the retention might well be placed strategically to meet visual management objectives.

In coupes in areas important for beekeeping, the retention might well be centred on leatherwood-rich areas.

Operational staff have considered the option of extending VR on to steep slopes where cable harvesting is employed. Techniques for this practice have been developed in British Columbia but the forests there have lower slash levels and burning is not required for their regeneration.

Although there are ecological and aesthetic reasons to reduce clearfell coupe sizes in steep country, the implementation of VR in Tasmania's tall oldgrowth forests is still considered very challenging from a worker safety and fire management perspective. This view could be revised if biomass energy markets allowed much of the current harvest residue to be removed rather than requiring burning on site.

All five districts have scheduled some variable retention operations in 2010/11 and will reassign more clearfell coupes to VR, or plan for more VR coupes for that year if the 80 per cent non-clearfell target is confirmed after considering the outcomes of this review.

The forest management capacity to operationalise and deliver an annual VR program of 650 gross ha of variable retention silviculture in tall oldgrowth forests is crucial to the successful implementation of the mixed silviculture strategy.

In October 2008 the Variable Retention Implementation Group (VRIG), which includes representatives from all districts, indicated a cautious yes to delivering the program.

The key issue for all districts is the difficulty of undertaking the more complex burning required for VR coupes.

While the planned program is probably achievable, a significantly larger VR program could not be undertaken, at least not without a substantial increase in resources and or alternative technologies, such as biomass harvesting to reduce fuel loads.

Review of the TCFA target

If the target is confirmed Forestry Tasmania will develop a process that ensures that subsequent three year plans include sufficient levels of variable retention and other partial harvesting so the 80 per cent non-clearfell target is met each year from 2010/11.

Some districts have expressed a concern that the target may be hard to meet in years when the market focus is on sawlog-rich cable clearfell operations and pulpwood markets are low. In this situation it would be perverse to require the scheduling of additional areas of oldgrowth for non-clearfell harvesting merely to maintain the target ratio. In these years the level of clearfelling of oldgrowth might well be less than 330 ha, which is 20 per cent of the average annual oldgrowth harvest predicted by wood modelling, but above 20 per cent of the annual oldgrowth harvest for years when the oldgrowth harvest is significantly lower than average.

For this reason it is recommended the current target include a complementary clause that would acknowledge that the TCFA target has been met for years when the annual oldgrowth harvest from clearfelling was less than 330 ha, even if the amount of non-clearfell harvesting was less than the predicted long-term average. The amended target could read as follows:

To reduce clearfelling of oldgrowth forest by achieving non-clearfell silviculture in a minimum of 80 per cent of the annual oldgrowth harvest or by limiting the annual clearfelling of oldgrowth forest to less than 330 ha per year.

It is recommended that the reporting of actual outcomes, in FT's annual Sustainable Forest Management Report, be measured against a five-year average, which could be aligned with RFA five-yearly reviews.

Unlike clearfelled coupes, part of the area within a VR coupe is left standing for the next rotation. This unharvested area is part of the coupe, and will be counted as being 'non-clearfelled' even though it has been retained. To be consistent, oldgrowth areas within the aggregates that have been counted as being 'harvested' by non-clearfell methods will not be included in maps and tables of extant oldgrowth area (for example for State of the Forests Reports).

Conclusion

The evaluations contained in this report, together with the reports by the science panellists and the international insights provided by the Old Forests New Management Conference, provide a sound basis for recommendations for implementation of alternatives to clearfelling in public oldgrowth forests designated for wood production.

The preferred alternative, the mixed silviculture strategy, has been assessed against the key performance criteria listed in the 2005 Advice to Government and is summarised in Table 12. There is a reasonable expectation that all the criteria can be met for a variable retention program of 650 ha per year over the next 20 years (and up to 1000 ha in peak years).

Table 12. Summary of implementation of alternatives to clearfelling assessed against key performance criteria for the mixed silviculture strategy.

Criterion	Forest management implication
Maintenance of 300 000 m^3/yr sawlogs	The 300 000 m^3/yr can be maintained if VR is applied as per the TCFA as one part of a mixed silviculture strategy for oldgrowth coupes. This is conditional on VR retention levels within coupes being kept at levels below 30 per cent. If higher retention levels are widely used, the sawlog supply target will become unachievable.
Maintenance of contracts	Current contracts can be met but delivered log costs must be contained if the timber industries are to remain viable.
Maintenance of occupational health and safety	With careful design and location of aggregates, and appropriate management by harvesting contractors, safety risks to forest workers can be maintained at acceptable levels.
Safe removal of harvest residues	VR burns, using the 'slow burn' or small patchfell technique, remove an acceptable proportion of the harvest residues in order to reveal seedbeds and reduce the subsequent wildfire risk. VR burns tend to produce more smoke at low levels, and for longer duration, than conventional high intensity burns. Additional harvesting of residues might facilitate VR burns. Harvest residues can be safely reduced at the planned level of 650 gross ha per year. A significantly larger program would not be achievable, at least not without biomass harvesting to reduce fuel loads.
Maintainance of regeneration standards	Too soon to fully determine, but reasonable to assume that most VR coupes will meet stocking standards, although likely at lower seedling densities than for CBS coupes.
Maintenance of timber jobs	The implementation of non-clearfell silviculture, particularly variable retention, is likely to maintain timber jobs by improving the social acceptability of oldgrowth harvesting, through adoption of more ecologically-based silviculture. Beyond that, jobs will be maintained provided volumes, quality and cost of wood supply is maintained. This will continue to require careful management of retention levels and coupe scheduling.

What we still need to know

The VR program in tall oldgrowth forests in Tasmania is still very new and only three VR coupes have reached the age when regeneration success is determined.

Ideally several more years of operational experience would be available before drawing a definitive conclusion about the suitability of VR for tall oldgrowth forests.

We do now know, from Tasmanian research, that aggregates in VR coupes can be successfully retained in a mostly unburnt condition and provide viable habitat for many of the species associated with mature forests. We don't yet know if the aggregates will play a significant role in promoting the re-colonisation of harvested areas by oldgrowth species.

A still greater research challenge is to determine the effects on biodiversity, such as migration patterns and species population viability, of moving to VR systems rather than continuing with the modern application of clearfelling where there is substantial level of retention between coupes.

The social acceptability of using some oldgrowth forests for wood production may be maintained or increased by a transition to VR because it represents a more ecologically-based silviculture than clearfelling, and is perceived in that way.

Research has now shown a measurable level of acceptability when applying VR at the coupe-scale. However, the effects on a landscape scale are yet to be understood, particularly where VR is just one management practice in a broader landscape of regrowth forests, plantations and farmland.

There is also the question of carbon storage and climate change, which have gained more prominence in the oldgrowth debate. This requires much more research and a thorough whole-system analysis that includes natural wildfire regimes and the risks of wildfire associated with different alternatives.

Compared with 2005 we can now be much more confident that worker safety can be maintained in VR operations, given careful location of aggregates and appropriate management. This approach, combined with other initiatives such as increased mechanical felling, and the transition of log sorting from bush landings to new merchandising yards at the Huon and Smithton Wood Centres, should enhance the safety of forest operations.

We have demonstrated that VR coupes can be effectively burnt but that the burning procedure is complex and difficult. The safe removal of residues is still the major limiting factor for the successful implementation, or broader application, of VR. The effects of increased removal of residues for biomass energy on burning practices are still largely unknown.

We have also demonstrated that VR coupes can be regenerated but don't yet know if regeneration can be reliably achieved at the better-than-95 per cent standard achieved by CBS operations. We do know that seedling densities tend to be lower, compared to clearfelling, primarily due to suboptimal seedbeds that result from incomplete burns. We are also yet to fully understand the implications for regeneration success of FT's decision in 2005 to cease application of 1080 poison to control browsing mammals. VR provides habitat refuges for browsing mammals, which is likely to increase browsing damage and result in lower seedling densities. The implications of these lower densities for sawlog productivity and quality are not yet understood.

The financial implications of VR are now better understood and will result in increased delivered log costs. Depending how these costs are allocated or recovered, this will challenge the viability of some businesses and favour alternative sources of wood if and when supplies become increasingly available from regrowth and plantations. The size of logs from these latter sources will be lower, but this disadvantage will be offset to some degree by increased uniformity of size and quality, allowing the application of sophisticated processing technology.

We have confirmed that the legislated annual high quality eucalypt sawlog supply of 300 000 cubic metres can be maintained if non-clearfell silviculture is adopted for most oldgrowth harvesting. However, this assumes there are no other pressures to further reduce access to native forests. In fact, such pressures are quite considerable and further withdrawals are often required where research shows they are needed, for example for protection of particular threatened species or other special values.

It will be very important for Forestry Tasmania to either expand, or improve the productivity of, its plantation estate, where opportunities exist. This must represent at least the productivity equivalent of the remaining 5300 ha of plantations provided for under the TCFA, establishment of which now must not involve the broad-scale clearing of native vegetation. Access to cleared land is expensive and limited, and the opportunities for further improving the productivity of existing plantations need to be evaluated as an alternative.

In 2005 operational staff had very little confidence, and generally no experience, in the implementation of VR in tall oldgrowth forests. During the past three years they have embraced the concept and developed real improvements that facilitate its application in tall oldgrowth forests, although they still recognise many operational difficulties that prevent its broad application.

Practitioners indicate they can implement a statewide VR program of up to 1000 ha in peak years but strongly caution against a broader program while burning is required for the safe removal of harvest residues and for successful regeneration. This limitation might lessen if much of the residues could be harvested for biomass energy.

It is likely that cost considerations will also limit the broader implementation of VR. The financial evaluation indicated that the annual cost for a VR program of 650 ha would be $0.7 million at 20 per cent retention or $0.8 million at 35 per cent retention. A VR program of 1000 ha per year would be $1.0 million or $1.3 million respectively.

In 2005 it was uncertain if the introduction of VR in tall oldgrowth forests designated for wood production would be recognised as an appropriate way forward by knowledgeable scientists, particularly forest ecologists. This uncertainty has been largely removed by the Old Forests New Management Conference and particularly by FT's science panel, which endorsed the 2005 mixed silviculture strategy.

Some scientists at the conference may well prefer an end to oldgrowth logging but they recognised that Tasmania is far ahead of most places in the world in total forest area (47 per cent) and oldgrowth forest area (79 per cent) in formal protected status.

While many scientists saw ecological value in broader adoption of VR, they acknowledged that Tasmania's very high levels of reservation moderate the need for additional VR in many forested landscapes.

All scientists recognised that oldgrowth is a dynamic, rather than a static, growth stage and urged the development of landscape metrics that would allow a choice of where oldgrowth forests, or regrowth forest with oldgrowth elements, are best located to meet biodiversity and social objectives over the long-term.

There was also general support for the development of silvicultural techniques such as variable retention in order to manage forests for 'oldgrowthness' to meet these objectives.

In this context it could now well be argued that, if there exists a capacity, within operational, economic and safety constraints, to undertake around 1000 hectares of variable retention harvesting on State forest annually, there may be more ecologically beneficial ways of allocating that capacity over the whole forest estate rather than focussing it solely on defined oldgrowth forest. For example, there may be localities where oldgrowth elements in the regenerated forest are now sparse, and where the benefits of reintroducing such elements through VR, would improve habitat values for biodiversity more than would a similar level of retention in oldgrowth forests in areas where oldgrowth elements are already represented at high levels in the landscape. This may be particularly pertinent for the enhanced management of habitat for threatened species in regrowth forests. This will be an important area for further future elaboration.

Concluding statement

The operational experience to date and the judgement of local and international scientists provide strong support for the further implementation of variable retention up to a level of around 1000 ha per year.

Progress on the implementation of alternatives to clearfelling oldgrowth forests should be further reviewed in 2015 with a particular focus on:

- demonstrated ecological and social benefits
- regeneration success
- development of biomass energy markets to facilitate the safe processing of harvest residues with reduced open-burning
- development of landscape assessment methods to prioritise management for restoration of oldgrowth elements in forests where these elements are now sparse.

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Glossary

Aggregate	An area of standing forest retained for VR purposes and intended to be kept for at least the next rotation.
Aggregated retention (ARN)	A form of variable retention harvesting in which patches of intact forest are retained either as island or edge aggregates.
Biodiversity	The diversity of all life forms, including species, genetic and ecosystem diversity. Biodiversity can be assessed at a variety of levels; for example harvesting area, catchment, landscape, national and global.
Biological anchor	A biologically important feature or legacy used as an 'anchor' for retention. Possible biological anchors include class 4 streams, a single large stag, a patch of large-diameter live trees, large decaying logs, etc.
Biological legacy	Important features from the oldgrowth stand (large live and dead standing trees, decaying logs and patches of undisturbed understorey) that are retained.
Blocks	Tasmanian State forests are subdivided into numbered compartments within named blocks, for descriptive and record-keeping purposes. These units are for administrative purposes only and have no direct effect on the management of the forests.
Carbon stock	The quantity of carbon held within a pool at a specified time, for example forest, wood products.
Carbon sink	A carbon pool which accumulates atmospheric carbon, during a given time, such that more carbon is flowing into it than out of it. The opposite of a carbon source.
Carbon sequestration	The capture and long-term storage of carbon in forests and soils or in the oceans, so that the build-up of carbon dioxide (one of the principal greenhouse gases) in the atmosphere will reduce or slow. Managing land and vegetation to increase carbon storage can help reduce greenhouse gas emissions.
CAR reserve	Comprehensive, adequate and representative reserve system, established during the 1997 Tasmanian Regional Forest Agreement, meeting the JANIS criteria.
Clearfelling	The removal of all trees on a harvesting area in a single operation, and the subsequent regeneration of an even-aged stand by sowing or planting. A canopy opening of four to six times mature tree height may be considered the lower limit for clearfelling. In the tall wet eucalypt forests of Tasmania, the minimum clearfell size is about five hectares. In practice, most clearfelled production coupes in Tasmania range between 10 to 100 hectares, with an average size around 50 ha.
Conversion/ clearing	The permanent or long-term removal of significant areas of native vegetation and its replacement by non-native vegetation, such as plantations, orchards, crops or pastures; different native species such as a blue gum plantation, or unvegetated developments, such as artificial water bodies, buildings and other infrastructure.
Coupe	For harvesting, State forests are subdivided into discrete areas called coupes.
Coupe containing oldgrowth	Coupes containing at least 25 per cent oldgrowth, based on area.
Dispersed retention (DRN)	A form of variable retention harvesting in which single trees or small clumps of trees are retained evenly dispersed throughout the coupe.

District	Regions for which State forests are broken into for the purposes of operational management. Forestry Tasmania has five districts: Bass, Derwent, Huon, Mersey and Murchison.
Edge aggregate	An area of trees retained for VR purposes and intended to be kept for at least the next rotation that is contiguous with standing forest outside of the coupe.
Felled area	Area within the coupe from which trees have been removed.
Forest Practices Code	A code established under the *Forest Practices Act 1985* which prescribes the manner in which forest practices must be conducted in order to provide reasonable protection to the environment.
Forest Practices Plan	A plan for forest operations, specified in Section 18 of the *Forest Practices Act 1985*.
Forest influence	The biophysical effects of the residual trees on the surrounding environment, including effects on microclimate, light availability, seed-and litter-fall and evapotranspiration.
Forest providing influence (FPI)	Areas of standing forest adjacent to the felled area of VR coupes. To provide forest influence these areas must consist of native forest at least 15m tall that will remain unharvested for at least the next rotation. These areas must be designated as Special Management Zones (FlVr).
Forest reserve	An area of State forest, formally gazetted for long-term intent, to be managed for recreational, scientific, aesthetic, environmental or protection purposes.
Forest	An area incorporating all living and non-living components, dominated by trees having usually a single stem and a mature (or potentially mature) stand height exceeding five metres, with existing or potential projective foliage cover of overstorey strata, about equal to or greater than 30 per cent. This definition includes native forests and plantations regardless of age, and areas of trees sometimes described as woodlands.
Formal reserve	A reserve equivalent to the International Union for the Conservation of Nature and Natural Resources (IUCN) Protected Area Management Categories I, II, III, IV or VI as defined by the World Commission on Protected Areas (http://www.iucn.org). The status of formal reserves is secure, in that revocation requires approval of the Tasmanian Parliament. A forest reserve in a State forest.
Geomorphology/ Geoconservation	Geomorphology is the study of the evolution and configuration of landforms. Geoconservation is the identification and conservation of geological, geomorphological and soil features, assemblages, systems and processes (geodiversity) for their intrinsic, ecological or heritage values.
High quality eucalypt sawlogs	First-grade eucalypt sawlogs as specified in the *Forestry Regulations 1999,* Schedule 1, Part 2. These logs are referred to as Category 1 sawlogs when derived from mature forests and Category 3 logs when derived from regrowth forests or plantations.
Informal reserve	A reserve other than a forest reserve. In State forests, this comprises an area identified as a protection zone under the Management Decision Classification system. It also includes other administrative reserves on public land managed to protect CAR values.
Intensive forest management (IFM)	Silvicultural management beyond the minimum required to ensure regeneration. Usually refers to thinning native forest, or establishing and managing plantations.

Island aggregate	A free-standing patch of trees retained within a coupe for VR purposes.
Mature forest	Forest containing a majority of trees more than 110 years old.
Native forest	Forest consisting of tree species that are native to Tasmania, other than plantations. Native forests include mature, regrowth forests and regeneration forests.
Oldgrowth forest	Ecologically mature forest where the effects of disturbances are now negligible.
Partial harvesting	Harvesting systems which include the retention of some trees, for example seed tree, shelterwood, thinning and variable retention.
Plantation	Forest established by planting seedlings rather than sowing seed. Plantation areas usually have intensive site preparation prior to planting. They are managed intensively for future timber harvesting.
Pulpwood	Logs below sawlog quality but suitable for manufacturing pulp, paper and panel products.
Rainforest	Forest dominated by tree species such as myrtle, sassafras, celery-top pine and leatherwood, in which eucalypts comprise less than five per cent of the crown cover. Rainforest generally occurs in areas with high rainfall.
Regional Forest Agreement (RFA)	A long-term agreement between the Australian and Tasmanian Governments, to ensure the sustainable management of the State's forests.
Reserves	Includes formal and informal reserves in State forests, crown land and private land.
Retention	Includes island and edge aggregates left within the final provcoupe boundary specifically for VR purposes that are intended to be kept for at least the next rotation.
Retention level	The percentage of the coupe that has been retained unharvested. Calculated as (final provcoupe area – felled area)/final provcoupe area * 100.
Sawlog	A log suitable for processing into sawn timber.
Selective logging	Harvesting which targets a small proportion of a stand for specific products which are removed as single trees or small groups of trees. All other growing stock is retained for potential harvest in subsequent cycles.
Silvicultural system/ silviculture	All the manipulations (for example harvesting, regeneration, thinning) carried out during the life time of forest stands or trees to achieve the management objectives of the landowner.
State forest	Land managed by Forestry Tasmania under the *Forestry Act 1920*, including purchased land.
Sustainable forest management	Management to maintain and enhance the long-term health of forest ecosystems while providing ecological, economic, social and cultural opportunities for the benefit of present and future generations.
Sustainable yield	The level of commercial timber (or product mix) that can be maintained under a given management regime, without reducing the long-term productive capacity of the forest.
Tall oldgrowth	Oldgrowth forest at least 40 m tall, usually dominated by eucalypts and with a very dense understorey.
Tasmanian Community Forest Agreement (TCFA)	A supplement to the RFA (commonly referred to as the TCFA) signed in 2005 by the Australian and Tasmanian Governments, that resulted in additional protection of oldgrowth forests in Tasmania.

Thinning	A silvicultural treatment to overstocked regrowth or plantation stands to release potential sawlogs from competition. There is no intention to induce regeneration.
Threatened species	Groups of plants or animals listed in Schedule 3, 4 or 5 of the *Threatened Species Protection Act 1995*.
Three-Year Wood Production Plan	Companies harvesting more than 100 000 tonnes per annum must lodge a three-year plan annually to the Forest Practices Authority. The plan outlines proposed operations, and is finalised after consultation with local government.
Variable retention	A harvest system where structural elements or biological legacies (for example old trees, stags, logs, tree ferns) from the harvested stand are retained for the new stand to achieve various ecological objectives. The system typically requires the majority of the felled area to be within one tree height of forest that is retained for at least a full rotation.
Wildfire	Unplanned vegetation fire, which burns out of control.

Acronyms

ARN	Aggregated retention
CAR	Comprehensive, Adequate and Representative
CBS	Clearfell, burn and sow
CCOG	Coupes containing oldgrowth
CRC	Cooperative Research Centre
DAFF	Department of Agriculture, Fisheries and Forestry
DFRD	Division of Forest Research and Development
DRN	Dispersed retention
FFIC	Forests and Forest Industry Council
FFIS	Forests and Forest Industry Strategy
FIAT	Forest Industries Association of Tasmania
FPA	Forest Practices Authority
FPP	Forest Practices Plan
FT	Forestry Tasmania
GIS	Geographic Information System
IFM	Intensive forest management
JANIS	Joint Australian and New Zealand Environment and Conservation Council and Ministerial Countil on Forestry, Fisheries and Aquaculture National Forest Policy Statement implementation sub-committee
RFA	Regional Forest Agreement, 1997
SFM	Sustainable forest management
SGS	Single tree/small group selection
STMU	Special Timbers Management Unit
TCFA	Tasmanian Community Forest Agreement (Supplementary RFA), 2005
TFCA	Tasmanian Forest Contractors Association
TFIC	Tasmanian Forest Insect Collection
VR	Variable retention

Appendix 1. Addendum to the 2005 Advice to Government (Forestry Tasmania 2005)

A1. Background

Concurrently with the finalisation of this Advice, discussions between the Tasmanian and Australian Governments were concluded in respect of the latter's Tasmanian Forest Policy. The agreed outcome (the Integrated Forest Strategy) represents a strategy of enhanced protection of oldgrowth forest, a reduced reliance on clearfell silviculture within oldgrowth forest retained for timber production, and an investment strategy designed to mitigate social and economic impacts and maintain long-term sustainable yields from public forests and regional forest sector jobs.

The Integrated Forest Strategy embodies the main elements of this Advice, with the further inclusion of an additional 140 000 ha of formal and informal conservation reserves on State forest land, and investment of around $220 million in forest and forest industry related initiatives to mitigate wood supply effects.

A2. Integrated Forest Strategy—Mixed silviculture

A2.1 Management regimes

The Integrated Forest Strategy generally adopts the Mixed Silviculture scenario (Scenario 1) identified within this Advice but varied to reflect the proposed new conservation reserves. The Strategy provides for the harvest of remaining coupes containing oldgrowth forest by 2030 so as to maintain hardwood log quality to industry, and retain regrowth stands for additional growth as far as other constraints allow. An additional 6000 ha have been added to the area of plantation recommended in Section 7 of the Advice to mitigate the effects of the proposed new reserves (making a total of 16 000 ha of new hardwood plantation). A mitigation strategy to ensure continued availability of special timbers has been developed. Figures 14 and 15 present the distribution of oldgrowth forest under the new strategy, including the new conservation reserves, and can be compared with Figures 1 and 2 (page 3). Land allocation on State forest is shown in Table 14.

Under this Strategy:

- 47% of the area of State forest is unavailable for timber harvest in conservation reserves (forming part of an enhanced State CAR reserve system) or generally outside coupes, an increase from the current 42%.
- The area of STMUs has been reduced by 50% to 71 000 ha. These areas will be developed and managed for the long-term production of special species timbers using SGS regimes.
- Areas available for harvest using CBS are constrained to account for no more than 20% of oldgrowth forest harvested in any year. Wood yield is optimised by choosing coupes with low proportions of oldgrowth. Since variable retention is not practicable on steeper cable coupes, much of the CBS will occur on these areas.
- Harvesting in dry oldgrowth forest coupes will continue to use partial harvest (non-clearfell) techniques. Non-oldgrowth coupes will be managed in accordance with current practice, using both CBS (tall wet eucalypt) and partial harvest (dry eucalypt) regimes, depending on the character of the stands.

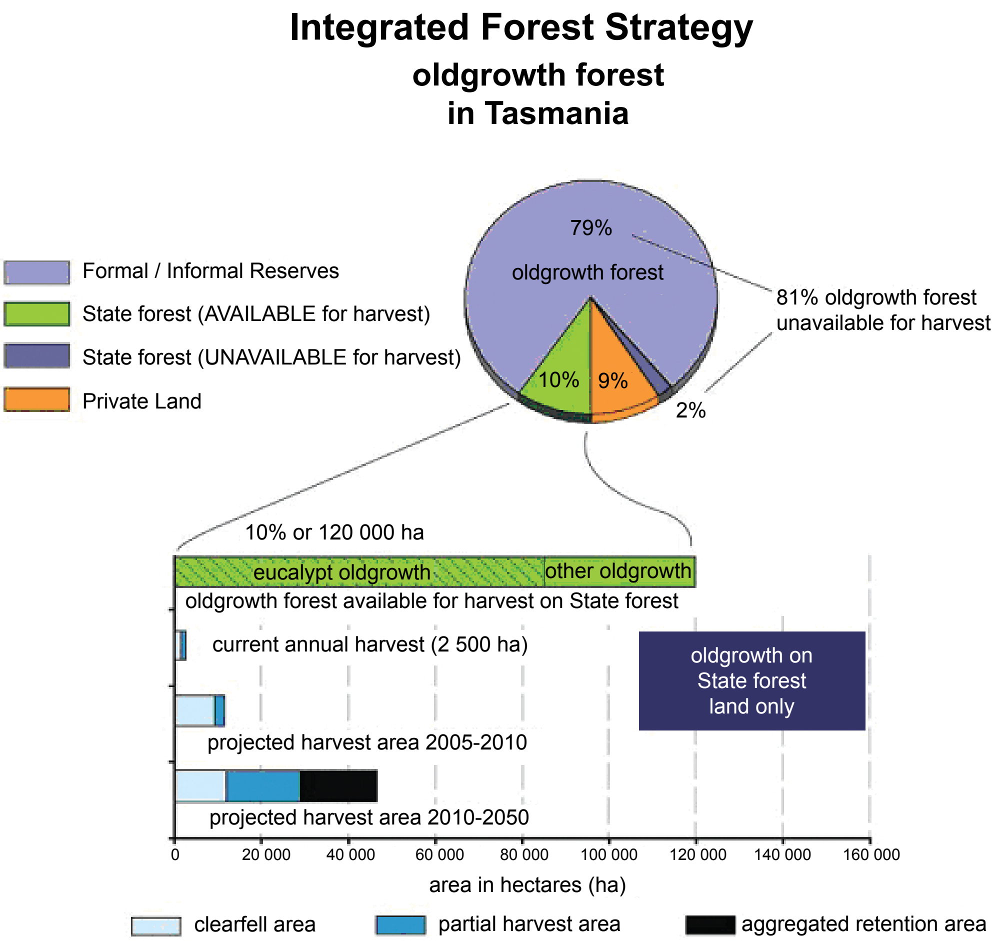

Figure 14. Tenure and management of oldgrowth forest in Tasmania under the Integrated Forest Strategy.

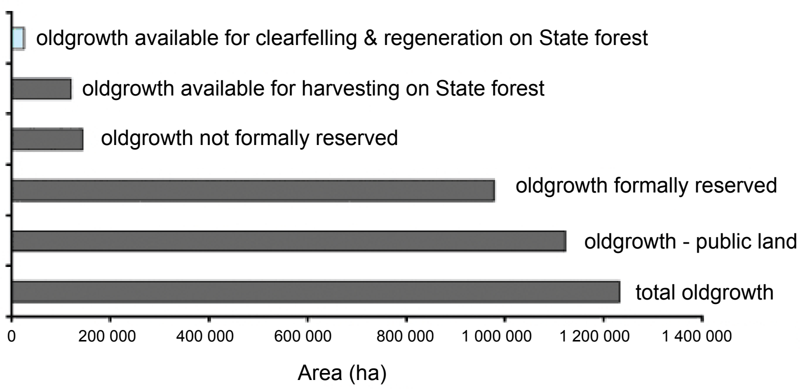

Figure 15. Area of oldgrowth forest in Tasmania under the Integrated Forest Strategy.

Table 14. Land allocation on State forest under the Integrated Forest Strategy.

	Area (ha)	Area (%)[1]
Reserves and non-harvest areas	710 000[2]	47
STMUs	71 000	5
Softwood plantation coupes	54 000	4
Eucalypt coupes		
non-oldgrowth/plantations	550 000	37
coupes containing oldgrowth		
- partial harvest	52 000	3
- clearfell, burn and sow	23 000	2
- variable retention	42 000	3
- single tree/small group selection	0	0
Total State forest	1 502 000[2]	100

[1] Figures rounded to the nearest whole number.
[2] 10 000 ha of reserves to be transferred to Nature Conservation Act tenures, managed by the Parks and Wildlife Service.

The modelled areas of harvest for coupes containing oldgrowth are shown in Figure 16. This demonstrates that, after 2010, the area of CBS of oldgrowth within these coupes falls to less than 300 ha/yr for the ensuing 20 years.

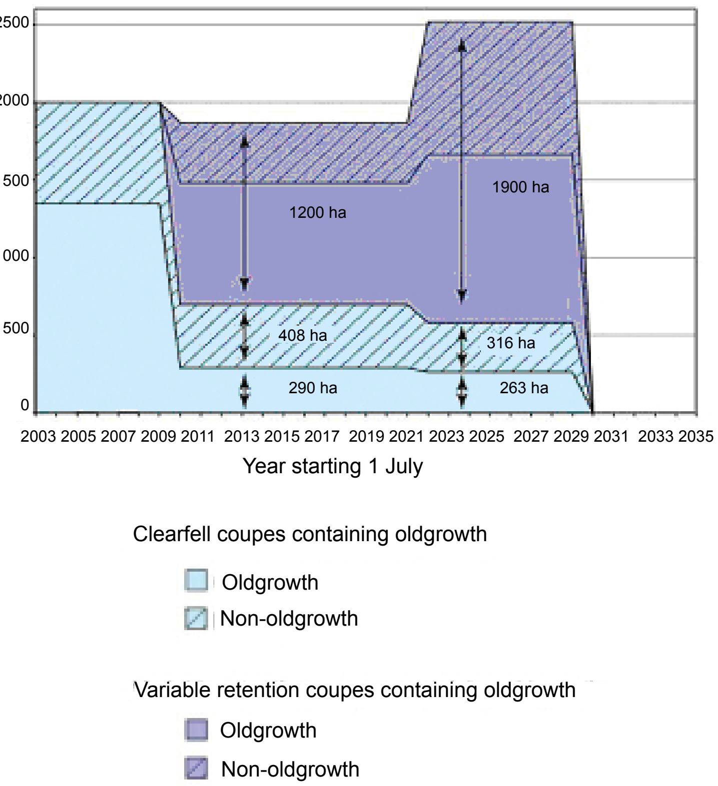

Figure 16. Area of clearfell and variable retention harvested in coupes containing oldgrowth under the Integrated Forest Strategy.

A2.2 Eucalypt timber supply

Projected future eucalypt timber supply under the Strategy is shown in Figures 17 and 18.

High quality sawlog supplies to meet short-term contracts and longer term requirements for a minimum of 300 000 m^3/yr will continue to be maintained. Coupes containing oldgrowth will continue to provide around one-third of sawlog supply for the next 20 years, maintaining the proportion under current practice. Volumes from partial harvest (dry forest) and variable retention will make up the major component from 2010. From 2022, the reliance on plantation sawlogs will increase from around 75 000 m^3/yr under current practice to around 115 000 m^3/yr, an increase of 53%.

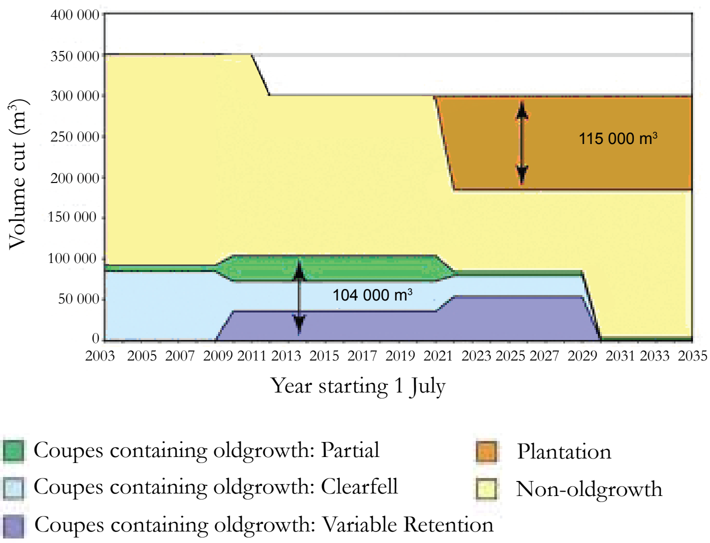

Figure 17. Eucalypt timber supply: high quality sawlog under the Integrated Forest Strategy.

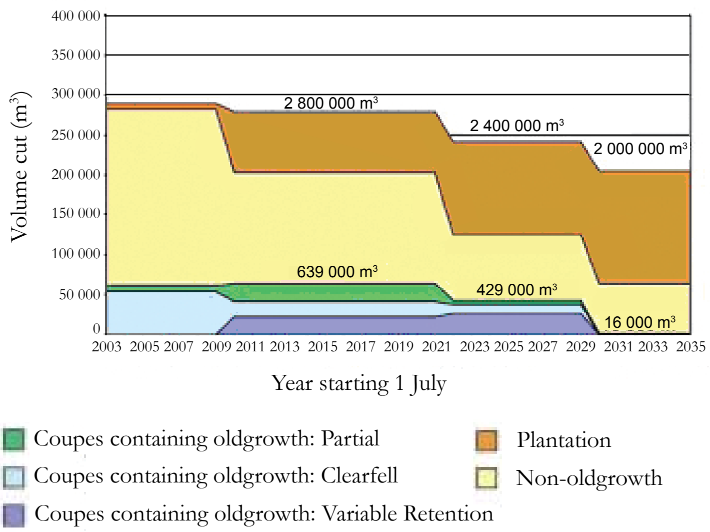

Figure 18. Eucalypt timber supply: pulpwood and related products under the Integrated Forest Strategy.

An additional 16 000 ha of eucalypt plantation will be established on State forest before 2010, together with high pruning and fertilising of existing and second rotation plantations.

Supply of pulpwood and related products will be somewhat lower than projected under current practice until 2010, decreasing by about 100 000 m^3/yr to 2 800 000 m^3/yr, and then maintaining 2 400 000 m^3/yr for the following 10 years.

A2.3 Special species supply

Under the Strategy, there will be a small reduction in the availability of special species, reflecting the retention of about 20% of the trees within the coupes being managed under variable retention regimes (see Figure 6, p. 34).

The new conservation reserves reduce the area of STMUs from 143 000 ha to 71 000 ha, and this will reduce long-term supplies available from these areas. However, provision for improved access into remaining areas will mitigate this reduction and ensure continuing long-term supplies of these species.

A2.4 Residue management

Disposal of logging residue to provide a seedbed for regeneration and to minimise potential future hazard will remain a crucial issue. Around 1200 ha/yr of variable retention harvesting will be required initially. The Strategy includes initiatives to facilitate the establishment of a market for harvest residues to ameliorate the significance of this issue.

A2.5 Biodiversity and landscape conservation

Biodiversity and landscape outcomes will be greatly improved by the adoption of this Strategy through the additional reservation of 140 000 ha of State forest and the retention of oldgrowth elements in the 42 000 ha of forest that would otherwise have been managed under the CBS regime.

Further conversion of State forest to plantation will be capped, and completely phased out by 2010, with conversion of coupes containing oldgrowth being discontinued immediately.

A2.6 Worker safety

Safety will remain a priority issue, and the Strategy provides for additional expert assessment and advice and a significant effort in workforce training.

The modelled areas of harvest for coupes containing oldgrowth are shown in Figure 16. This demonstrates that, after 2010, the area of CBS of oldgrowth within these coupes falls to less than 300 ha/yr for the ensuing 20 years.

A2.7 Socio-economic impacts

The Strategy will allow high quality sawlog production to be maintained at 300 000 m^3/yr. Existing contracts can be honoured and provision has been made for addressing the increased costs of variable retention compared to CBS.

Additional funds have been committed to establish, prune and manage an extra 16 000 ha of plantations to secure future industry supply.

Under the Strategy, there will be a gradual ramp-up between 2005 and 2010 in variable retention harvesting to achieve the desired level by 2010. Funding to address increased costs over this five-year transition period will avoid any immediate negative effects.

There should be little, if any, significant impact on short- to medium-term wood quality, with wood from coupes containing oldgrowth increasing from around 100 000 m^3/yr to about 104 000 m^3/yr. Provision has been made in the Strategy for mill retooling and new investment to facilitate industry accommodation to any minor resource changes that might nevertheless eventuate.

From 2020, the proportion of high quality sawlog production sourced from plantations instead of native forest is projected to increase to about 115 000 m^3/yr, representing 38% of production. Provision has been made in the Strategy to facilitate industry transition to this new resource.

Investment of around $50 million in industry retooling and restructure, and facilitation of new industry based on regrowth and plantations means that industry will have at least 10 to 15 years lead time to achieve adjustments to future resource changes.

Symetrics (2005) have undertaken further analysis of the Strategy, including the investment initiatives, and have concluded that it will be significantly jobs positive. Small, potentially negative impacts on log quality in the period 2010–2020 will be significantly mitigated by the investment strategy, which will enhance job growth in each period.

Under the Strategy, current industry development plans, including investments in rotary veneer plants, biomass energy and a new pulp mill, will be facilitated and lead to further positive job growth.

A2.8 Forest regeneration

Regeneration establishment from variable retention will remain an important issue, and continued research and monitoring will be undertaken to ensure that adequate regeneration levels can be assured on these areas.

Appendix 2. Summary of observations from Symmetree Consulting Group on implementation of variable retentions by Forestry Tasmania (Symmetree 2007)

In 2006 Forestry Tasmania asked Ken Zielke and Bryce Bancroft from the Symmetree Consulting Group, based in British Columbia, to visit Forestry Tasmania's VR harvesting operations and provide feedback on implementation of VR in the Tasmanian context.

Symmetree Consulting Group was instrumental in training and monitoring the development and implementation of VR with the MacMillan-Bloedel company in British Columbia (BC) and has also assisted with development of retention strategies in the BC interior, Idaho and the Canadian boreal forests.

They visited non-clearfell operations in all five Forestry Tasmania districts and held on-site discussions with operational staff and contractors. Their observations are summarised below:

Coupe design and layout:

- The clearfell, burn and sow silvicultural system is well developed- VR should just be a small adjustment. We noted the original FT guidelines for VR were well-followed (for example leave aggregates between 0.5 and one hectare at approximately two tree heights between aggregates).
- Consider focussing retention in 'biological anchors' as much as possible to design VR coupes. Some marking may be useful.
- FT should explore more flexibility in their design criteria for forest influence.
- Reliance on logging contractors to choose retention works well for ground-based harvesting. However, some other approaches might be worthwhile testing.
- If steep cable coupes must use VR, they will require marking of retention groups. Also, choose cable equipment carefully, relegating less suitable machines to the 20 per cent clearfell ground.
- Use clearfell strategically.
- Keep the attitude positive towards VR.

Burning for site preparation and fuel reduction

- Several burning options are available- until fine details of operations can be worked out, innovation should be encouraged.
- Guidance for fire damage to retention groups (aggregates) is good - it may even boost ecological value in some cases. Social concerns however may be important - these should be tested.
- Reliance on groups or aggregates should be continued, with options to leave smaller clumps or individual trees where feasible or desirable.

Windthrown and browsing damage

- Windthrow does not appear to be a major challenge.
- Animal control is challenging, but is well-understood, with innovative approaches being considered.

Appendix 3. Brief biographies for members of Forestry Tasmania's science panel

Professor Jürgen Bauhus

Director, Institute of Silviculture, University of Freiburg, Freiburg, Germany

Professor Bauhus studied forestry in Freiburg, Vienna, and Göttingen and worked in Germany and Canada before he became part of the Australian National University Forestry Program between 1996 and 2003.

Since June 2003 he has held a professorship and the Chair of Silviculture in the Faculty of Forest and Environmental Sciences at Freiburg University, Germany.

His research focuses on ecology and silviculture of native forests, carbon and nutrient cycling, dynamics of mixed-species stands, structural diversity and coarse woody debris.

He is section editor of the European Journal of Forest Research, associate editor of the Canadian Journal of Forest Research and an associate of the Cooperative Research Centre for Greenhouse Accounting.

At Freiburg University, he is directing the international PhD program, Forestry in Transition, the German-French binational PhD program in Risk Management in Forestry, and the new international MSc course Forests, Environment and Bioresources.

William J. (Bill) Beese

Forest Ecologist, Corporate Forestry, Western Forest Products Inc. British Columbia, Canada

Mr Beese is forest ecologist for Western Forest Products in Campbell River, British Columbia (BC), Canada.

Since completing a master's degree in forest ecology at the University of BC he has worked for more than 25 years on the BC coast

Mr Beese is responsible for a program that includes research in silvicultural systems, prescribed burning erosion control, forest regeneration and stand tending, biodiversity, and small stream management. He leads the company's monitoring and adaptive management program, oversees ecosystem mapping, and is project co-coordinator for the multi-agency MASS research partnership investigating silvicultural systems for high elevation forests.

He was part of a team that developed and implemented the Coast Forest Strategy - the company's forest ecosystem stewardship program, including phase-in of variable retention harvesting. The program received the Ecological Society of America's Corporate Award for 2001.

Mr Beese is a registered professional forester, and was chosen as Coastal Silviculturist of the Year in 2000.

Jack Bradshaw

Forestry consultant

Mr Bradshaw completed a diploma of forestry from the Australian Forestry School (Canberra) in 1963 and graduated from the University of Western Australia with a Bachelor of Science (Forestry) in 1965.

He is an eminent eucalypt silviculturalist and worked for many years with the Western Australian forest agency and now as forestry consultant. He has also excelled in the fields of inventory, planning, communication, and forest education.

Mr Bradshaw was a member of the 1996 Independent Expert Advisory Panel that informed the RFA process of Tasmanian's progress towards ecologically sustainable forest management.

He was the winner of The Institute of Foresters NW Jolly medal in 2006 for outstanding service to the profession of forestry in Australia.

Professor Thomas Spies

Forestry Sciences Laboratory, 3200 Jefferson Way, Corvallis, Oregon, US

Professor Spies is a research ecologist in the PNW Research Station. His expertise is in forest stand structure and dynamics, old-growth ecology and conservation, landscape ecology and wildlife habitat.

He has studied the ecological basis of forest management in the lake states, Germany, New England, Australia, and the Pacific Northwest.

Professor Spies has published more than 120 papers on subjects including, ecological land classification, old-growth ecology and conservation, structure and dynamics of coniferous forests, remote sensing applications, landscape ecology, riparian forest ecology, gap dynamics and integrated regional assessments.

He was a member of the Forest Ecosystem Management Assessment Team (FEMAT) that helped develop the Northwest Forest Plan for Federal Lands.

He is currently team leader of the landscape and ecosystem team of the PNW Station.

For the past 12 years he has been co-leader of the Coastal Landscape Analysis and Modelling Study (CLAMS), a long-term, large, interdisciplinary project to model and evaluate forest policy effects at multiple scales.

Dr Ivan Tomaselli

Professor of Wood Science and Technology, Federal University of Paraná, Brazil

Dr Tomaselli is Professor of Wood Science and Technology at Federal University of Paraná, Brazil.

He completed his MSc in wood technology at Federal University of Paraná, Brazil in 1974 and his PhD in wood science from University of Melbourne in 1977.

Dr Tomaselli's research activities include wood properties, wood drying, biomass energy, and wood utilisation.

He is currently Director of STCP Engenharia de Projetos Ltda, Curitiba, Brazil.

Dr Tomaselli has strong international consulting experience in South America, the Asia Pacific and Africa with organisations such as the United Nations Forum on Forests (UNFF), Centre for International Forestry Research (CIFOR, Indonesia), United Nations Development Program (UNDP), International Tropical Timber Organisation (ITTO), World Bank, and Food and Agriculture Organisation of the United Nations (FAO).

Appendix 4. Framework for developing and implementing variable retention in Tasmania’s tall oldgrowth forests

Forestry Tasmania's goals in developing variable retention

Context:

Tall oldgrowth forests are naturally regenerated by massive wildfires which nevertheless usually leave late-successional species and structures. These elements are important biological legacies that maintain biodiversity and variability at the stand level.

Variable retention (VR) silviculture seeks to emulate these ecological processes, meet timber production objectives, and maintain the social licence to harvest these forests. Specific goals for VR in tall oldgrowth forest include:

- more closely emulate natural ecological processes within managed tall oldgrowth forest by retaining late-successional species and structures (biological legacies) for at least a full rotation
- maintain a forest edge influence over the majority of the felled area thereby differentiating the regenerating stand ecologically from stands regenerating following clearfelling
- ensure that each coupe is an example of good forest stewardship
- achieve adequate productive regeneration of both eucalypts and other species
- to ensure safety of forest operations

Forestry Tasmania's guidelines for implementing variable retention

Context:

Variable retention silviculture can be achieved by aggregated retention (which retains patches of forest), dispersed retention (which retains individual trees), or a mixture of the two. For biodiversity, safety and fire management reasons, the majority of VR silviculture in Tasmania’s tall oldgrowth forests will be by aggregated retention. The following guidelines will allow FT’s goals for VR to be achieved.

Guidelines:

- The majority of the felled area should be within one tree height of forest that is retained for at least a full rotation (for aggregated retention this requires fairways two to four tree-lengths wide).
- Retained areas can be free-standing islands (island aggregates) or may be contiguous with standing forest outside of the coupe (edge aggregates). Aggregates should generally be at least one hectare in size.
- Aggregates should be anchored on specific locations of ecological value (for example biological legacies, special vegetation communities) and include the range of habitat types (for example vegetation types, stand ages, landforms) present within the coupe.
- Coupes should look different from clearfelled coupes. Large gap areas and long view lines should be avoided.

- Coupe layout and fuel preparation should allow safe and effective burning to create a receptive seedbed over more than two thirds of the felled area.
- Firebreak and access track area should be minimised and their preparation should not unduly compact soils, damage soil profiles, or otherwise compromise ecological values.
- Coupe should meet seedling stocking standard (65 per cent 16 m^2 stocking) at three years.
- Hazardous trees in aggregates and edges should be sufficiently buffered to ensure they do not pose a danger to workers in the harvested area.