Australian Government
Department of Agriculture, Fisheries and Forestry

Safety implications of Aggregated Retention harvesting

Greg Howard

Timber Training Tasmania

April 2008

Forestry Tasmania

Safety Implications of Aggregated Retention Harvesting

Greg Howard
Timber Training Tasmania
April 2008

Safety Implications of Aggregated Retention Harvesting

A report to the Variable Retention safety and training sub-committee of the Forest Industry Safety Standards Committee, by;

Greg Howard
Timber Training Tasmania
April 2008

Committee members:

Owen Hoffmann, Gunns Ltd., Chair
Roger Geeves, Workplace Standards Tasmania
Daniel Barr, Workplace Standards Tasmania
Wayne Foss, Forestworks
Malcolm Whitmore, Forestworks
Tony Young, Les Walkden contracting
Ray Walker, Tasmanian Forest Contractors Association
Scott McLean, Construction, Forestry, Mining and Energy Union
Rod Hill, Forestry Tasmania
Robyn Scott, Forestry Tasmania
Mark Neyland, Forestry Tasmania

Table of Contents

Aim

To assess the safety implications of aggregated retention harvesting on the harvesting operation and subsequent operations.

Summary

Twenty-one aggregated retention (ARN) coupes were audited for safety. Audits included a visit to each coupe, and interviews with contractors, fallers, machine operators, Forestry Tasmania District staff, and a representative from Workplace Standards Tasmania.

All hazardous standing trees in the aggregates and along coupe edges as well as trees that had fallen into the harvested area (windthrown trees) were mapped and tallied. Surveys were completed either after harvest (2 coupes) or following the regeneration burn (19 coupes). A total of 505 windthrown trees were found, of which 83.7% were understorey species, 10.7% were regrowth eucalypts and 5.6% were oldgrowth eucalypts. Windthrow may prove to be a greater problem if ARN harvesting is used in regrowth coupes.

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 the regeneration burn. Some previously unidentified hazardous trees were also found. There is a need for more detailed assessment of trees during the harvesting process and greater attention to burning procedures to ensure that oldgrowth trees especially do not sustain severe fire damage. A post burning risk assessment of burnt trees will also be necessary.

No incidents or accidents were reported in any of the audited ARN coupes. In general, the hazards associated with ARN harvesting are the same as 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:area ratio in ARN coupes. The proportion of the harvested area within 1 tree height of standing trees, is higher in ARN coupes, with a resulting increase in the probability of a tree being blown over and causing an accident.

This increased risk will mainly affect post-harvest operations (e.g. 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 hazardous trees which could be prone to windthrow, then any increase in risk should be small. Designing coupes with fewer, larger aggregates and edge aggregates rather than island aggregates will help to reduce the perimeter:area ratio. There will also be a greater need for directional felling in ARN coupes, which will create some additional risk for fallers. There may be a need for a training procedure for machine-assisted manual felling.

Recommendations

1. The size of aggregates should be increased from the current range of 0.5-2.0 hectares to between 1.0-3.0 hectares. This should have the effect of reducing both fire damage and windthrow and ultimately reduce the number of potentially hazardous trees for future operations to contend with. An increase in size should also allow for fewer aggregates, which would produce the added benefit of less directional felling plus a shorter cut edge perimeter in comparison to the retained area.
2. Aggregates that are to be located close to coupe boundaries (within two tree lengths) should where possible be incorporated into the coupe boundary. This should provide the benefits of a shorter perimeter, less directional felling, less windthrow and make the aggregates more defendable during burning.
3. Planners should refrain where possible from locating aggregates on steep slopes where there is a significant area of the steep slope immediately above the top side of the aggregate. It is in this area that fallers have the most difficulty directionally felling trees because of their propensity to lean downhill into the aggregate. It is especially difficult to directionally fell the oldgrowth trees in this area.
4. Land managers should provisionally mark aggregates on the ground with tape, (suggest blue and white) to indicate the desired aggregate size and location, prior to the commencement of harvesting. These tape lines are to be treated as advisory boundaries only and contractors and fallers must be given the flexibility to change the shape, size and location of the aggregates to suit safe falling requirements.
5. Where possible, major snig tracks should be located away from aggregates to reduce exposure to potentially hazardous trees retained within the aggregates, for snigging machines and other machines and personnel entering and exiting the forest.
6. For each subsequent operation undertaken on aggregated retention coupes a new risk assessment should be completed for that section of the coupe which the operation will cover. Risk assessments need to be completed by appropriately qualified persons.
7. A register or file of identified hazards and risks should be kept for each coupe and this register should be made available to all subsequent operations or contractors.
8. Where a tree which has been deemed safe to leave standing becomes unsafe due to a major disturbance such as wind or fire damage that tree should either be removed or the area taped or closed off to prevent entry to the area or to warn persons entering the coupe of the imminent danger.
9. The TFITB/Forestworks should be engaged to produce an assessment tool for the assessment of machine-assisted manual felling operators.
10. Silviculture staff involved in experiments and surveys on aggregated retention coupes should receive training in native forest hazard identification and risk assessment.

Brief

- Review key documents (Forest Safety Code 2000, Paper 4, Safety Management from Towards a New Silviculture in Tasmania's Public Oldgrowth), Victorian Silviculture Systems Project Technical Reports on Safety (VSP Internal Reports No. 13 and 14 and VSP Technical Reports No. 21 and 23, British Columbia Partial Harvesting Safety Handbook).
- Interview key players (Tasmanian contractors who have undertaken variable retention harvesting, Roger Geeves (Workplace Standards Tasmania), variable retention (VR) champions from each FT District). Summarise incidents and reviews from all VR coupes within the Warra SST, plus consider and review upcoming coupes.
- Compile all hazard, incident and accident reports from contractors who have harvested current VR coupes and compare with appropriate clearfell burn and sow (CBS) coupes. Identify and document any specific issues that are peculiar to VR coupes.
- Undertake assessment of the increased 'edge' effect arising from VR harvesting compared to CBS, to identify the increased risk associated with increased retention both during harvesting and during subsequent monitoring operations (e.g., browsing monitoring, regeneration surveys).
- Undertake monitoring of VR harvesting (on a sample basis) to assess the extent to which VR harvesting limits the fellers choice of felling direction.
- Write report to Forestry Tasmania (FT). Make recommendations with respect to operational, policy and training issues.
- Provide input to the next review of the Forest Safety Code.
- Present paper at 2008 conference.

Process

- Conducted windthrow and hazardous tree assessments on 21 completed ARN coupes.
- Conducted 4 return visits to assess status of hazardous trees.
- Conducted inspections on 3 ARN coupes currently being harvested, later audited as completed coupes.
- Conducted one inspection on a harvested coupe EP031E which had not yet been prepared for burning. The results from this coupe have not been included in this report due to the likely removal of most of the windthrow and hazardous trees during the preparation process.
- Conducted interviews with 16 ARN harvesting contractors.
- Conducted interviews with 12 manual fallers and 3 mechanical felling machine operators who have worked on ARN coupes.
- Conducted interviews with Forestry Tasmania staff in each of the districts currently undertaking ARN.
- Conducted an interview with Workplace Standards regarding ARN.
- Conducted desktop audit of influence and perimeter distances in ARN coupes.
- Reviewed Forest Safety Code for compliance of ARN.
- Delivered presentation on safety implications of VR harvesting to ‘Old Forests New Management conference.
- Reviewed technical notes on partial cutting systems from Victoria and British Columbia.

Windthrow

Windthrow assessments were conducted on all twenty one completed aggregated retention coupes. Trees that had blown over and fallen into the cut area from both internal aggregates and from the harvested area boundary were tallied and classed as oldgrowth eucalypts, regrowth eucalypts or understorey species.

These trees were also assessed as to whether they had blown down recently or in the first twelve months post harvest. This was determined by age of foliage drying and lifting of stem bark and should only be considered approximate given that in general there was only one visit per coupe.

Because nineteen of the twenty one coupes were assessed after they had been burnt and some of the aggregates had sustained severe fire damage it was difficult to tell whether some of the understorey trees that had fallen into the harvested area had blown down or had burnt down. For the purposes of this report it has been assumed that the trees blew down and therefore they have been counted as windthrow.

There were also a very large number (literally thousands) of mainly small understorey trees which had blown down within the aggregates and apart from adding to the risk of the aggregate getting burnt, there appeared to be little chance that these trees would pose any risk to harvesting or burning preparation crews. After consultation with members of the committee it was agreed that these trees would not be individually counted and categorized as neither time nor budget constraints would allow this.

Table 1. Number of windthrown trees of each class in each of the twenty one coupes assessed.

Coupe	Oldgrowth Eucalypts	Regrowth Eucalypts	Understorey Species	Recently Windthrown
TE020C	0	14	22	1
PC007C	4	6	40	2
EP081B	11	2	24	1
NA023A	2	2	24	1
AR023E	5	3	27	1
SX018E	0	1	15	0
SX004B	0	0	35	1
SX007A	0	2	12	2
TE014A	0	2	35	1
HU322L	2	5	8	0
WR001E	0	10	28	2
WR008I	0	0	8	1
SR037C	1	3	8	2
BS118L	0	1	2	3
TO006F	1	0	5	6
FO042F	0	1	9	10
HU323Y	0	2	4	6
KD023E	1	0	43	38
FR039B	0	0	6	5
SR112C	1	0	42	36
SX020A	0	0	26	19
Total	28	54	423	138

Based on the figures accumulated during the windthrow assessment 5.6% of wind thrown trees are oldgrowth eucalypts. This figure is boosted by EP081B, which contained 11 of the 28 wind thrown old growth trees in the study. EP081B is a two-section coupe in the Huon District located on top of a hill with the western section very exposed to prevailing westerly winds. Some of the forest to the west of this section has been previously harvested and this would have exacerbated the exposure problem. Not surprisingly 10 of the 11 windblown oldgrowth eucalypts occurred in the western section of the coupe. The small size of the aggregates in this section would most likely have contributed to this figure. Had EP081B been excluded from the study then the percentage of windthrown trees that were oldgrowth would have dropped from 5.6% to 3.6%.

Regrowth eucalypts accounted for 10.7% of total windthrow, and two coupes TE020C and WR001E provided 24 of the 54 wind thrown trees recorded. Compared to other coupes in this study these two coupes were more mixed age forest rather than genuine oldgrowth and while we are currently basing the findings on a small number of coupes this anomaly may indicate that aggregated retention in regrowth forests will result in higher than expected rates of windthrow. Similarly had these two coupes been excluded from the study then the percentage of regrowth windthrow would have dropped from 10.7% to 6.9%.

Understorey species accounted for 83.7% of total windthrow. Most of the understorey species that were windthrown were smaller trees with breast height diameters of 20 cm or less. Understorey windthrow was consistently the largest component in all coupes with a couple of lower than average numbers being recorded in coupes that were reasonably well sheltered. In some aggregates almost 100% of the smaller understorey trees had been windthrown, however, only those trees extending into the harvested area were counted in the assessment.

The low number of recently windthrown trees in the first 13 coupes in Table 1 indicates that most trees that are likely to blow over will do so within a year of the completion of harvesting. These coupes had been harvested and burnt from 2005-2007. The high number of recently wind thrown trees in the last 8 coupes in Table 1 which were harvested and burnt in 2007-2008 indicate the same.

In general the smaller aggregates (those less than one hectare) were the worst affected. Some larger aggregates have sustained significant windthrow around the edges however it appears that the additional size of the aggregate has served to either absorb or deflect the wind strength therefore sparing the remainder of the aggregate (Figure 1).

Some options for reducing windthrow that warrant further investigation include:

a. Wind modelling for coupes during planning.
b. Placement of aggregates in less wind prone areas of coupes.
c. Retained aggregates to be larger in area with no feathered edges.
d. Incorporation of aggregates into the harvest boundaries.

Figure 1. Windthrown trees on edge of aggregate in SX018E.

Hazardous Trees

There are a number of standing trees within aggregates and outside of the harvest boundary that contain significant amounts of decay or have been burnt out and have a definite lean into the harvested area. The majority of these trees are oldgrowth eucalypts with some older understorey species included.

Given that these trees are exposed to stronger than usual wind pressure due to the removal of surrounding trees during harvest it is foreseeable that these trees could fall into the harvested area and potentially cause damage or injury. The fact that there are 28 oldgrowth trees that have been windthrown in coupes already assessed and that these have blown over either post-harvesting or post-burning indicates that this is a distinct possibility.

During the interviews conducted with the manual fallers most admitted that they did not check the safety and stability of trees within the aggregates, only those on the edge. A similar scenario occurs with trees outside of harvest boundaries.

Because all but two of the coupes were assessed after burning it is difficult to tell the status of some of the trees at the completion of harvesting but there is no doubt some of the trees have become hazardous due to the fact they have sustained significant fire damage. There are, however, trees both within the aggregates and outside the harvest boundaries that have been assessed during this project as hazardous, that have not been burnt and that were not identified during harvest or during burning preparation.

If a hazardous tree has not been identified during harvesting by the tree faller, do the people involved in subsequent operations have the necessary expertise to identify hazardous trees prior to commencement of their own operations? The answer is most likely not and therefore there would seem to be a need for post-harvesting and post-burning risk assessments of retained trees by persons with the necessary expertise.

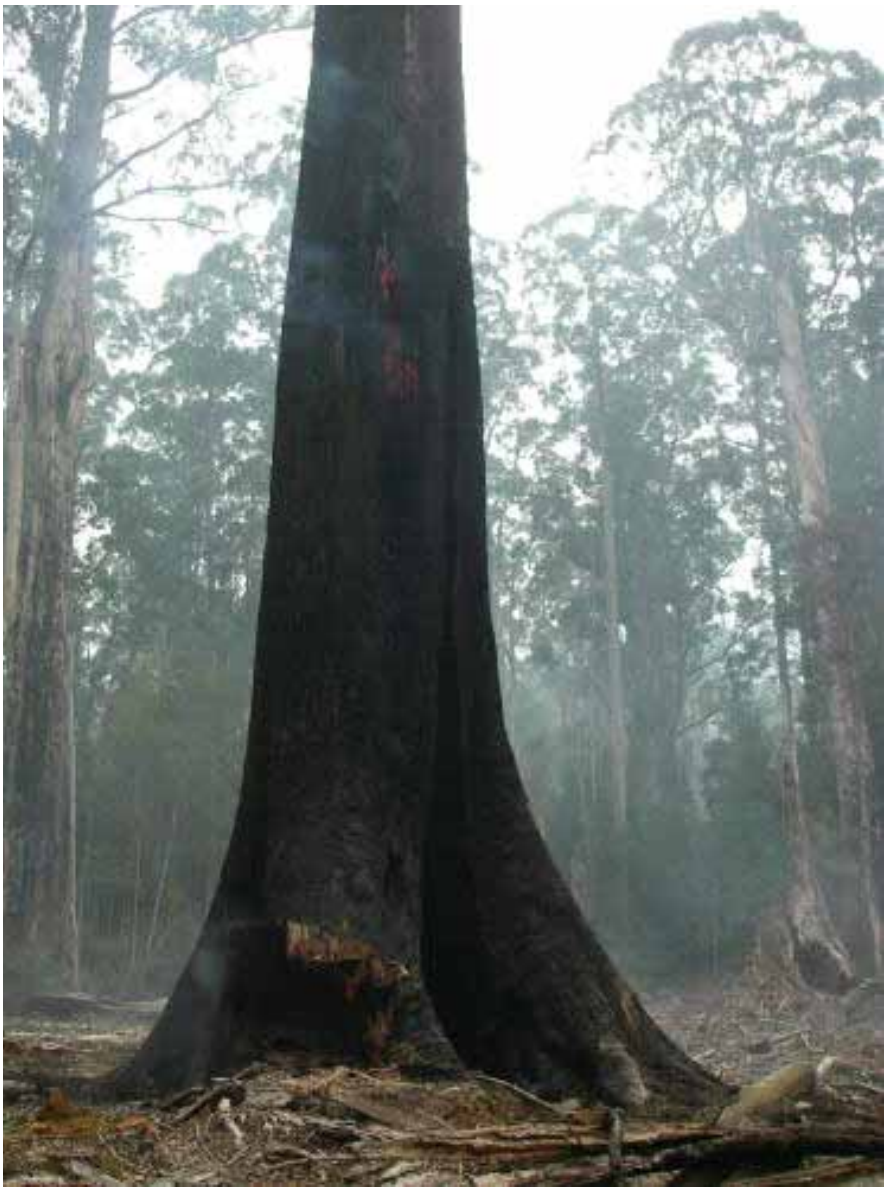
Table 2 shows the number of trees assessed as hazardous in each coupe with the number split between hazardous trees within aggregates and those outside harvest boundaries.

Table 2. Number of hazardous trees assessed in aggregates and on coupe edges in twenty one ARN coupes.

Coupe	Hazardous trees in aggregates	Hazardous trees outside boundary	Total
TE020C	0	0	0
PS007C	1	2	3
EP081B	2	0	2
NA023A	2	0	2
AR023E	3	0	3
SX018E	10	0	10
SX004B	1	0	1
SX007A	5	0	5
TE014A	0	1	1
HU322L	5	1	6
WR001E	1	0	1
WR008I	0	0	0
SR037C	1	1	2
BS118L	0	0	0
TO006F	0	0	0
FO042F	1	2	3
HU323Y	0	2	2
KD023E	0	0	0
FR039B	2	0	2
SR112C	1	1	2
SX020A	2	1	3
Total	37	11	48

The majority of the hazardous trees are situated within the retained aggregates indicating the need for more detailed assessment of trees during the harvesting process and greater attention to burning procedures to ensure that oldgrowth trees especially do not sustain severe fire damage (Figure 2).

Figure 2. An oldgrowth tree on fire in SX018E. This tree may well subsequently die and therefore present an ongoing risk to subsequent operations.



Regeneration Burns

Nineteen of the assessed coupes had been burnt prior to assessment. The remaining coupes (NA023A, FO042F) had not burnt been as at the last visit. The success of the burns covered almost the full range of outcomes from almost no fire damage to retained trees but significant amounts of unburnt fuel remaining (as in WR001E) to severe fire damage with little unburnt fuel (as in AR023E).

There is an obvious need to find some middle ground for future burns. While it is accepted that burning of retained aggregates may not be ecologically disastrous, where fire damage is severe, the resulting large numbers of dead and dying trees standing next to the harvested areas will likely impact on the safety of subsequent operations in varying degrees right up to and including the next harvest. Already at least one tree identified as hazardous in SX004B has fallen into the harvested area.

Without the benefit of ongoing visits it is difficult to determine just how many of the burnt trees will die, however it is likely to be a significant proportion especially in the predominantly *E. regnans* forests.

Severe burning of the retained aggregates was most common where the aggregates were smaller and contained significant windthrow (Figure 3). This result is no doubt caused by the fact that smaller aggregates would have dried out more because of increased penetration of the sunlight and the increased fuel load close to the ground caused by the windthrow. A good example of this can be seen in EP081B where the smaller aggregates in the western section of the coupe have been almost completely scorched whereas the two larger aggregates in the eastern section are almost untouched (Figure 4).

Options for reducing fire damage to retained aggregates may include:

a. Coupes to be lit later in the afternoon to take advantage of rising humidity and falling temperatures.
b. Increased use of manual lighting of coupes.
c. Heavy fuel loads to be moved further away from aggregates on the windward side.
d. Increased aggregate size.
e. Reduced windthrow in aggregates.

Figure 3. Severely burnt aggregate in SX007A.

Figure 4. Results of the regeneration burn in EP081B. The six smaller aggregates in the foreground section of the coupe and the one small aggregate in the far section have sustained significant fire damage while the two larger aggregates in the far section have survived relatively unscathed.

Interviews

Interviews regarding experiences with aggregated retention were conducted with the following groups:

a. Sixteen harvesting contractors, which comprise all the contractors who have harvested the completed coupes, (21 coupes in total).
b. Twelve of the fourteen manual fallers who had worked in the aggregated retention coupes. The remaining two fallers were not able to be contacted.
c. Three mechanical harvesting machine operators.
d. Staff from Forestry Tasmania in all five forestry districts.
e. Roger Geeves, Workplace Standards Tasmania

Contractors

Contractors were asked a standard list of questions (see Table 3) relating to their approach to the coupe/s they harvested, their opinions on the safety of aggregated retention, their opinion of marking procedures for aggregates, any difficulties they encountered on their coupes, incidents and accidents sustained and suggestions on changes to procedures for future coupes.

Table 3. Interview questions asked of contractors and their answers (n=15 contractors, 21 coupes).

Question	Yes	No	N/A or undecided
Were the aggregates marked?	16	5	
Did you use mechanical assistance to directionally fall trees?	21		
Did you encounter any problems with harvesting?	14	5	2
If aggregates were marked were they suitably positioned?	15	5	1
Would you prefer the aggregates to be provisionally marked but with flexibility to shift to suit falling?	15	1	
Would larger but fewer aggregates be preferable?	16		
Would incorporation of aggregates into boundaries where practical be preferable?	16		
Did you have any incidents or accidents on your coupe/s?		21	
Do you consider aggregated retention a safe system for harvesting of oldgrowth forests?	16		
Do you have any suggestions to improve the procedures?	11	4	1

Aggregate marking ranged from none through indicative marking to fully marked aggregates using blue tape with no flexibility. Three contractors used mechanical felling machines, the remainder either pushed some trees over or used mechanically assisted manual falling.

Problems encountered during harvesting were reported as:

- Some oldgrowth trees too rotten to directionally fall.
- Oldgrowth trees on the windward side of aggregates with significant lean into the aggregate are difficult to keep out of the aggregate even if they are reasonably sound.
- Oldgrowth trees on the uphill side of aggregates are difficult to keep out of the aggregate.
- Oldgrowth trees located close to harvest boundaries and leaning out of the coupe are difficult to keep within the harvest boundary.
- Some aggregates located too close to boundaries to allow trees to be fell without damaging either the aggregate or the uncut forest.
- Directional felling is difficult on windy days and in coupes regularly exposed to strong winds.
- Trying to determine location and size of aggregates in coupes where they are not marked takes too much time and adds extra pressure to the faller.

Suggestions for future coupes:

- Fallers need better maps, more detailed and in colour.
- Avoid locating aggregates on steep slopes.
- Avoid locating aggregates in areas exposed to strong winds.
- Larger and fewer aggregates.
- Aggregates incorporated into harvest boundaries where practical.
- Attempt to assess tree soundness during planning to determine suitability of coupe for aggregated retention.

Fallers and mechanical felling machine operators

Manual fallers and mechanical felling machine operator's responses to the same list of questions almost mirrored those of the contractors. The exceptions were:

- One faller was strongly opposed to having the aggregates marked for the reason that he wanted to be able to locate the aggregate, where there were trees that he didn't want to have to fall.
- One faller was unsure of the benefits of marking aggregates and the same faller questioned whether the coupe he felled was suitable for aggregated retention due to the amount of rot in the oldgrowth trees.
- One faller was happy to mark his own aggregates but suggested in general provisional marking of aggregates was a good idea.

Forestry Tasmania Staff

Forestry Tasmania (FT) staff were interviewed with regard to their opinions on aggregate marking, aggregate size, incorporation of aggregates into boundaries and their opinion as to the safety of aggregated retention.

FT staff were split on the question of aggregate marking with some staff wanting full control over aggregate location, while others favoured provisional marking. A minority of district staff preferred contractors and fallers to be fully responsible for locating aggregates.

Staff were united as to the advantages of larger aggregates and could see the benefits of incorporating aggregates into harvest boundaries. A number of staff reported that both of these changes had already been implemented.

On the issue of the safety of aggregated retention, staff were reasonably confident that the process fell within safe operating limits for forestry operations while accepting that some of the issues raised by contractors and fallers had some merit.

Workplace Standards Tasmania

Mr. Geeves' views on the safety of aggregated retention were recorded as follows:

- Preferred fallers to design aggregates because only fallers can see the problems as they go.
- Fallers to ensure the aggregate is big enough to include the fall zone of stag trees and unsound trees with a defined lean out towards the cut area.
- Additional risk assessments should be completed before each subsequent operation is undertaken.
- Where trees have been identified as hazardous after the completion of harvesting, either they should be removed or the tree and fall zone should be taped off with danger tape. Alternatively the entrance to the coupe could be taped off with a warning of the presence of hazardous trees. These warnings should remain in place for at least a year.
- No aggregate should be located closer than two tree lengths to the harvest boundary.
- Where silvicultural staff are conducting experiments etc. in retained aggregates they should identify safe routes to and from plots and only if plots are located in safe areas are written risk assessments not required.
- Silvicultural staff to ensure they abide by the Forest Safety Code requirements when working alone.

Incidents and Accidents

Contractors have reported no incidents or accidents on any of the aggregated retention coupes assessed during this project.

It will necessary to ensure that when recording any future incidents or accidents that they be investigated to gauge the relevance of the process of aggregated retention in contributing to the incident/accident. For example, an accident occurring at a landing is highly unlikely to have been caused by the process of aggregated retention.

Until we have sufficient incident/accident data from aggregated retention coupes, direct comparisons between aggregated retention coupes and clearfell coupes will likely result in unreliable conclusions.

Regulatory Issues

The process of aggregated retention harvesting was found to comply with all Acts, Regulations and Codes of Practice in relation to workplace health, safety and environmental care.

After reading the proposed changes to the 2007 Forest Safety Code and after consultation with members of the committee it was decided not to make any submission to the Forest Practices Code Review Committee, as there was nothing in either the previous Forest Safety Code or in the proposed changes which would impact on the use of aggregated retention harvesting as an alternative to clearfell harvesting. Also, the code is not concerned with particular silvicultural systems so much as it is concerned with safe working procedures. As this project has found that there are no particular safety issues that are specific to aggregated retention, there was no specific input required to be submitted to the code review.

Should all of the recommendations of this report be implemented then native forest harvesting using aggregated retention will be operating at a level above that required by the Forest Safety Code 2007.

Edge Effect

The increased edge effect of aggregated retention has been calculated by measuring the perimeter distance of the coupe had it been a clearfell coupe and then comparing that distance against the perimeter distance of aggregated retention harvest area including the perimeter distance of aggregates.

The influence figures are the percentage of the coupe that is within one tree length of standing tress. Once again the same coupe has been used with the comparison being made between the coupe if it had been clearfelled versus aggregated retention.

Year burnt	Coupe	'Final' provc-oupe area (ha)	Felled area (ha)	Reten-tion (%)	Influence ARN bdry (%)	Influence CBS bdry (%)	Perimeter ARN bdry (m)	Perim CBS bdry (m)	Boun dary % increa se
2005	WR001E	22.7	18.5	19	92	35	4658	2154	116%
2005	WR008I	15.6	12.2	22	93	48	3656	2121	72%
2005	HU322L	38.6	26.8	31	79	34	9381	4514	108%
2007	SX004B	35.3	18.0	49	86	49	5310	4706	13%
2007	SX007A	29.8	19.5	35	85	31	5663	2820	101%
2007	SX018E	30.3	21.5	29	91	42	4783	2608	83%
2007	AR023E	48.5	28.1	42	79	29	6139	2829	117%
2007	EP081B	97.2	47.3	51	69	37	8742	6260	40%
2007	PC007C	27.4	18.9	31	74	45	3242	2322	40%
2007	SR037C	44.7	31.3	30	87	35	7804	4048	93%
2007	TE020C	33.4	20.1	40	73	31	6507	4234	54%
2007	TE014A	20.1	15.6	22	93	69	8503	6322	34%
2008	BA118L	26	17.0	35	52	20	2953	2466	20%
2008	FO042F	32.7	17.6	54	85	31	4005	2884	39%
2008	SX020A	72.9	37.1	49	92	21	8201	4506	82%
2008	TO006F	21	10.3	51	57	35	1737	1564	11%
2008	KD023E	41.9	31.8	24	41	12	3504	2709	29%
2008	HU323Y	63.4	32.7	48	42	15	5545	4847	14%
2008	FR039B	40.5	40.5	36	60	22	8827	4726	87%
2008	NA023A	21.5	16.3	24	83	38	5333	3218	66%
2008	SR112C	60.5	39.7	34	63	27	6194	3581	73%
	Average			36	75	33.6			61.5%

Data provided by Robyn Scott, VR research officer, Forestry Tasmania

The results show that so far the industry has over-achieved on retention (where 20% would have been considered acceptable), and also on influence (where above 50% would have been considered acceptable). The average 61.5% increase in perimeter distance could be drastically reduced by increasing aggregate size. The increased perimeter distance will have some bearing on the exposure rate (e.g. the rate of being exposed to the risk of being hit by a falling tree) especially for post-harvesting operations.

Hazards and Risks

The process of aggregated retention harvesting is very similar to clearfell harvesting in that:

- There should be no additional hazards located in the coupe regardless of whether the coupe is clearfell or aggregated retention.
- There should be no additional procedures being used that are not already being used in clearfell harvesting.

The only real differences should be that in aggregated retention more trees will need to be felled in a direction other than their natural lean and the probability of a tree being blown over and causing an accident will increase by an amount to be determined by:

- Exposure of the coupe to strong wind events.
- The number, location and size of retained aggregates.
- Quality of the assessment of tree stability by fallers.
- Whether aggregates are big enough to encompass the fall zone of trees likely to blow over.
- Successfully keeping regeneration burns out of retained aggregates.

While falling trees away from their natural lean is a skill often used in clearfell harvesting, especially around boundaries and retained areas such streamside reserves, an increased use of this skill will be required when falling around aggregates.
How much that increase will be is determined by:

- The number, location and size of internal aggregates.
- The success of being able to incorporate aggregates into existing boundaries and reserves.
- The ability of machines to fall or assist in the falling such trees.

Given that there are no additional hazards, then any increase in risk will come from an increase in the probability of the same hazards causing an accident, or from increased exposure to that hazard. The consequence/outcome should remain constant. Any increase in probability of an accident occurring by a tree blowing over should only increase for post harvesting operations, that is, after the coupe has been opened up and exposed to additional wind pressure. The harvesting crew should be largely unaffected by any increase in probability because by the time a section of the coupe has been opened up enough to increase that probability, the harvesting crew should have cleared the area.

No increase in exposure to trees blowing over should be experienced by either the faller or operators of either mechanical felling machines and in forest processing machines. This is because these people usually spend almost all of their time working within reach of standing trees anyway.

The only increase in exposure to hazards experienced by this group of people should be that of being hit by part of a tree, when a tree being felled hits another tree on the way down. This increase is caused by the need to directionally fall more trees than in a clearfell coupe. This exposure can be minimised by:

- The use of mechanical assistance.
- Reduced numbers and increased size of aggregates.
- Incorporation of aggregates into existing boundaries.

Snigging machinery should only sustain an increase in exposure to falling trees if snig tracks are located within a tree length of aggregates. During the process of retrieving a load from the forest they usually operate within reach of standing trees.

Landing crews should not be affected by a change to aggregated retention.

Post-harvesting operations such as burning preparation, lighting and mopping up burns could sustain both increases in probability and exposure to falling trees.

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 should be small.

A major increase in risk could come from aggregates being burnt severely causing trees previously assessed as safe to become hazardous. A post-burning risk assessment of burnt trees will therefore become a necessity. Silvicultural staff will need to conduct their own risk assessment before working in and around aggregates as an increase in probability of and exposure to falling trees is possible. Most silvicultural staff would need to undertake at least a basic course in native forest hazard identification.

To ensure all subsequent operations are aware of previously identified hazards and assessed risks, an ongoing file on each coupe should be kept and made available to these operations.

Conclusions

1. Windthrow across the 21 completed coupes is represented by understorey 83.7%, regrowth eucalypt 10.7% and old growth 5.6%. Most of the windthrown understorey trees were less than 20 cm in diameter and therefore the risk of damage or serious injury to machinery or personnel is small. The regrowth windthrow figure is over-representative of the percentage of regrowth present in most coupes and suggests that the process of aggregated retention in predominately regrowth forests may result in excessive windthrow.

   A significant proportion of the oldgrowth windthrow (39%) occurred in one coupe (EP081B) which was a particularly exposed coupe located on top of a ridge and with a large section of the forest on the windward side of the coupe having been previously harvested.

   The majority of windthrow is likely to occur in the first twelve months post-harvesting. Small aggregates are more likely to sustain significant windthrow and in some small aggregates almost 100% of the understorey has been windthrown. Once again in EP081B in the two larger aggregates only six trees fell into the cut area while from the seven small aggregates thirty trees fell into the cut area.

2. There were a number of standing trees (mainly oldgrowth) in aggregates which have a pronounced lean into the cut areas and contain significant amounts of decay or fire damage. It is foreseeable that some of these trees will fall over in the not too distant future and they should have been removed during harvesting or the aggregate been extended to include the fall zone of these trees.

   Workplace Standards' view is that risk assessments of trees leaning out into cut areas need to be continually undertaken at each finite stage of the process, e.g. during harvesting and post-burning before silvicultural works, to ensure no retained tree poses an unacceptable risk to subsequent operations.

   Admittedly much of the fire damage has occurred during the regeneration burns and therefore some of these trees may have appeared to the harvesting crew to be safe to leave.

3. There are a number of aggregates which have sustained significant fire damage. Some of these aggregates contain badly burnt trees, which have become hazardous or at the very least will die and become hazardous at a later date. Because of their susceptibility to fire, trees within aggregates in the *E. regnans* forests are most at risk.

   Small aggregates are the most likely to have sustained the worst fire damage due to the fact that they have dried out because of their higher proportion of edge compared to larger aggregates. These small aggregates also generally contain a higher percentage of windthrow, which creates a drier fuel load within the aggregate.

4. Contractors, manual fallers and operators of mechanised felling machines are generally happy with the safety aspects of aggregated retention and consider the process to be infinitely preferable to either seed tree retention or basal area retention harvesting.

It was felt that for the process to work effectively land managers need to ensure that coupes designated for aggregated retention are:

(a) Not excessively steep due to the difficulty of directionally falling the trees above an aggregate on a steep slope.

(b) Not located in areas regularly exposed to strong winds.

(c) Assessed to identify reasonable soundness of the oldgrowth trees to enable directional felling.

It was also felt that the amount of time taken to identify the location and size of the aggregates was a problem. At times this seriously impacted on production and added pressure to manual fallers, which they did not need. It was agreed that provisional marking of aggregate size and location would be preferable although one faller and one contractor did not agree with this proposal and one other faller was unsure of the benefits.

Some coupes contained aggregates which were located very close to coupe boundaries making it extremely difficult to fall the trees in the narrow section between the boundary, and the aggregate without the tree falling into one of the two retained areas. These narrow sections are also difficult to burn safely. Contractors agreed that where aggregates are to be located close to coupe boundaries they should be incorporated into the coupe boundary.

5. No incidents or accidents, which could be attributed to the process of aggregated retention, have been recorded by any of the contactors involved in any of the 16 coupes covered during this project

6. The process of aggregated retention complies with all regulatory requirements under current Tasmanian OH&S legislation and also complies with the recently revised version of the Forest Safety Code.

7. Aggregated retention coupes completed so far have an average increase in cut edge perimeter of approximately 61.5% compared to the same coupe had it been clearfelled. The increase in perimeter ranged from 11% - 117%. This increase has the potential to increase the exposure rate of some members of the harvesting crew and personnel from subsequent operations, to the risk of being injured by something falling out of the uncut area.

   However a 61.5% increase in perimeter does not necessarily translate to a 61.5% increase in exposure especially on the windward side of an aggregate and especially for some personnel who are almost fully exposed to that risk anyway. Even a 61.5% increase in exposure would not translate to a 61.5% increase in risk given the implications of the two other factors used to calculate risk, probability and consequence.

8. Aggregated retention has made common the procedure of machine assisted manual felling. While this procedure is outlined in the Forest Safety Code, no training or assessment for this procedure is currently available in Tasmania. There is a unit of competence FPIHAR3213A listed in the national training package and this could be used as the basis for an assessment tool for this procedure.

9. Overall there will be small increase in the risk involved in management of forest coupes where aggregated retention has been used in comparison to the same coupe being clearfelled. This will be represented by:

   (a) A small increase in the risk to manual fallers and to a lesser degree mechanised felling machines or machines used in mechanically assisted manual felling. This increase occurs because of the requirement to directionally fall more trees away from their natural lean than they would otherwise have to in clear fell. This increases the chance of the tree being fallen contacting standing trees during the arc of fall. This possibility can be reduced if more aggregates are incorporated into coupe boundaries and aggregate size is increased and the number reduced. There should no increase in exposure due to the possibility of being hit by a tree that blows over because felling is almost always conducted within reach of standing trees.

   (b) A small increase in exposure to in-forest mechanical processors and excavators used to bark and bunch logs for snigging where those machines drive within a tree length of aggregates when entering and exiting the forest. Any risk encountered while entering and exiting can be reduced by locating major tracks away from aggregates. Generally these machines operate within reach of standing trees when processing.

   (c) A small increase in exposure to snigging machinery where they are required to snig around aggregates however this can be minimised by locating major snig tracks away from aggregates.

   (d) A small increase in exposure to machinery used for post harvesting restoration and burning preparation when working close to aggregates.

   (e) A small increase in exposure to fire crews when lighting and mopping up after fires if those operations are conducted in or around aggregates. A risk assessment of trees which have sustained significant fire damage during burning will become a necessity. Removal of trees that are deemed hazardous because of the fire, will dramatically reduce the risk to future operations.

   (f) A small increase in exposure to silviculture staff when operating in or close to aggregates. This exposure can be reduced providing experimental plots are located in safe areas within aggregates. To achieve this silvicultural staff would need some training in native forest hazard identification. Further exposure for staff conducting surveys or subsequent operations including future harvesting can be minimised if risk assessments are undertaken prior to commencement.

   It should be noted that clearfell coupes harvested in the last 1-5 years look vastly different than those harvested previously. Current coupes contain significantly more reserves (as required by the Forest Practices Code) than earlier coupes, especially with the current trend to upgrade Class 4 machinery exclusion zones to full streamside reserve status. There are some current clearfell coupes that look remarkably like aggregated retention due to the number of reserves located within their boundaries.