Background Report

North Coast LRMP

Environmental Risk Assessment: Implementing Variable Retention on the North Coast LRMP Area

SUMMARY REPORT

DRAFT

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Executive Summary

This summary report provides an overview of work that is a continuation of a previous assessment of risks to coarse filter biodiversity (Holt and Sutherland March 2003). Given the nature of the timelines associated with the NC LRMP, this is a summary of approach and key results only.

A previous report (Holt and Sutherland 2003) assessed the range of risks to individual ecosystems in the North Coast landscape resulting from Basecase (or current - clearcut) management. We compared the amount of old forest in each ecosystem present on the landbase now and into the future (as predicted by the North Coast Landscape Model – SELES), with the predicted 'natural' amount of old forest in each ecosystem as determined by expert opinion.

The basic approach used in our model is the same as that taken for the basecase analysis (Holt and Sutherland 2003). However, the intention of this work is to assess the **regional level coarse filter**[1] implications of implementing two different variable retention scenarios, and compared with an alternative Protected Areas scenario. As a result, we modified the basic model to accommodate variable retention, in particular:

- Use recovery curves for each ecosystem to estimate the percentage recovery of a block at each time step, given clearcut harvest
- Modify clearcut recovery curves for each ecosystem on an area-weighted basis to reflect variable retention. E.g. a block with 30% retention at time zero would have a recovery of (0.3*100)+(0.7*0), meaning 30% is fully recovered (i.e. an old growth retention patch) and 70% is not recovered at all (a new clearcut). Assumes that all retention is representative old growth for that ecosystem.
- Use a sensitivity analysis and a threshold to determine the implications of different assumptions regarding when a block is sufficiently recovered to be considered to contain enough attributes to reduce coarse filter risk.
- The level of recovery at each time period is used to calculate an 'equivalent old growth area' for each block – i.e. a block that is 100ha, and 40% recovered would be counted as 40ha of old growth forest
- Equivalent old growth area for each ecosystem is then added back onto other remaining (unharvested) old forest in the remainder of the landbase to determine the 'total equivalent old growth area'
- Compare the total equivalent amount of old forest to the predicted natural level of old forest to determine risk to each ecosystem through time.

Assessing the coarse filter biodiversity benefits of VR is a new endeavour within science, and our approach should be viewed as a series of hypotheses with assumptions and predictions that require further exploration, refinement and testing. However, within this current framework we suggest that our results provide a useful examination of issues and possible outcomes.

Note that the results obtained here reflect the very specific application of variable retention as applied by the SELES landscape model. In particular, variable retention is applied to a relatively small percentage of the landscape (e.g. 9.4% in VR1 reserved as retention), and was applied more in heli-zone areas than in conventional areas, and was applied randomly within this until targets were met. Different results would be obtained if variable retention were applied using different rules over the landbase.

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[1] This analysis cannot provide detailed local assessment of costs of benefits of VR because of the mismatch of scales when the comparison with natural disturbance approach is applied to areas that are too small. In these cases the assumptions of applying natural disturbance rates fail to apply, and results can be misleading.

Key Results and Comments

- Reducing the AAC in order to implement the VR scenarios (12.7 and 17% for VR1 and VR2) had smaller impacts on risk than initially predicted. In particular, the VR1 reduction had almost no discernible change to ecosystem risk at the regional scale[2], while the VR2 reduction resulted in a relatively small reduction in risk for a number of ecosystems. This low level of effect can be explained by the relatively low *difference* in old forest harvested *within each ecosystem* over the total landbase in the different scenarios. Although the rate of harvest is changed, the location of harvest does not, and the AAC reduction results primarily in an effective long rotation in the timber model – the transition from old to managed forest in VR1 is 140 to 160 years. The VR1 AAC reduction appears too small on this constrained yet diverse landbase to significantly impact *regional* risk for ecosystems. The VR2 AAC reduction is approaching the order of magnitude where reductions in risk are observed.
- Variable retention did result in lower risk levels, compared with clearcut harvesting, though the reduction differed with the scenario (VR1 / VR2), the ecosystems involved, and the assumptions being applied:
    - Ecosystems with high operability and high levels of past harvesting (e.g. most cedar high ecosystems) see generally low risk reduction occurring as a result of VR. This is because risk is already high or very high, and the amount of area available remaining to 'reduce risk' by implementing VR is very small. Although VR generally results in lower risk in these ecosystems than does clearcut harvesting, the reduction in risk is very small and these ecosystems remain at high risk into the future.
    - Variable retention had very little influence on risk levels for lower productivity ecosystems because relatively little harvesting occurs there, and overall risk is dominated by the large area of inoperable forest, generally maintaining low risk. In the scenarios examined, much of the VR was modelled to occur in the designated "heli- zone". These areas tend to be lower productivity sites in many cases (A. Fall pers. comm.). The potential biological gains associated with VR may therefore have been lost when the most benefit could likely have been garnered from higher productivity sites which were lower risk but move to high risk over time and under conventional management.
    - Ecosystems with high operability, but relatively low levels of past harvesting (e.g. some cedar/ hemlock medium, hemlock/ balsam medium and spruce ecosystems) do have a reduced risk as a result of variable retention. Even the most conservative assumption of recovery (100% RT) results in lowered risk for these ecosystems, at least in the long-term. Short-term gains are considerably lower, and occur only for a very limited number of ecosystems.
    - Comparing the two scenarios, risk is reduced for the same ecosystems, except that the VR1 scenario also reduces risk for an additional 5 ecosystems over VR2 in the long-term. We cannot determine whether this is a result of different levels of retention, or different placement of VR harvesting in each scenario. The results highlight the need to target variable retention application, if the intention is to reduce risk. A generic guideline for application of VR (such as those given in the SELES model) may, or may not, result in the desired effect – depending on their specificity.
- Variable retention (at least for VR2 over the long-term) does result in lower risk levels compared with clearcutting. However, the magnitude of the risk reductions was relatively small. There are a number of reasons why this may be the case:
    - the percentage of the landbase being impacted by variable retention is relatively low, and distributed across a range of ecosystems. Hence the actual level of VR per ecosystem is quite small, and does not dramatically affect risk.
    - The VR scenarios are compared to their scaled basecase – i.e. a scenario that has the same harvest rate, but is applied by clearcutting rather than partial harvest. So, while on any

[2] I.e. risk is still considered at the level of ecosystems, but ecosystems at the regional, not local scale.

particular VR cutblock trees are retained, an equivalent number of trees are removed from an adjacent block. The risk is therefore *distributed* over a larger area and time frame and overall risk stays relatively even. In addition the extra roads required to implement the ground-based (not heli) VR resulted in increased landbase loss over the 150 years, and so further increased risk for some units.

- The scale at which we are investigating risk – at the level of the subregion – affects the apparent result. At the scale of individual landscape units or watersheds variable retention can result in lower risk values, but at the level of the region, the benefit can be offset by the increased harvest in an adjacent watershed / landscape. Our analysis does not say that local benefits are not obtained from VR, rather than without more specific planning rules, the overall benefits may be cancelled out over the landscape.
- The direction of the changes is in some cases contrary to expected, for example some ecosystems increased in risk even with application of the VR scenario. This is due to a number of factors:
  - Arbitrary placement of VR. The VR was not targeted to particular ecosystem types, rather it was applied across all units[3], and so did not necessarily impact those units of concern (e.g. those which are low / moderate risk now, but increase in risk in the future).
  - Ecosystems at high risk currently will continue to rise in risk, whether clearcut or variable retention harvesting techniques are applied
- The protected areas scenario was not a true comparison with the others, because we had to compare it with a similar, but not identical basecase. However, the comparison provides an overview of the relative risk reduction. Long-term risk was reduced by this scenario to an equivalent extent to that seen in the variable retention scenarios (VR1 and VR2) but only when the least conservative assumptions regarding retention are used (0RT and full old forest retention). Short or mid term risk were not greatly affected, because either ecosystems are at high risk and protection now cannot bring back old forest (which is what is required to lower risk), or because ecosystems were moderate or low risk and variable retention needed to be applied through time before risks were reduced. When the most conservative assumptions are used (e.g. the forest must be fully recovered before it can reduce coarse filter risk) VR has apparently fewer conservation benefits. However, the level of reduction is more certain for the PA13 scenario simply because we are more certain what old forest attributes are being maintained over time, and the interpretation does not rely on recovery assumptions, or assumptions regarding the quality of the stand structure retained on site.
- Risk reductions associated with variable retention are reliant on assumptions regarding the recovery rates of the forest and the 'quality' of the retained attributes. These two assumptions are discussed below:

Assumption: That biologically, a stand with a particular recovery level (e.g. 40%) can be converted into an old growth equivalent area (40% * 100ha = 40ha old forest). This assumption will be false particularly where unique old growth attributes accumulate through time – i.e. where a 50% recovered stand never contains particular elements of 100% recovered true old growth stand.

In all the runs presented, we used a recovery threshold of 100% as the base comparison. This means that an area of forest must be 100% recovered before it can be counted a equivalent old forest. In addition, we also examined the implications to risk of using different recovery thresholds (40 and 0% - i.e. an area must be 40, or 0% recovered before it can contribute to lowering risk). As expected, the benefits of implementing variable retention are quite sensitive to this threshold.

Using thresholds of 40% and particularly 100% recovery in the VR2 scenario, many of the regional scale gains associated with VR are lost and the scenario becomes a similar risk level than the scaled basecase at the regional scale.

[3] Harvest is applied using two rules: a) oldest first modified by b) accessibility (the model prioritises harvest in areas that are already roaded).

Assumption: that all retention is representative / fully functioning old growth forest, spreading 'old forest influence' throughout the cutblock.

This assumption may not hold under the following circumstances:

i) Where non-representative trees or patches are retained

ii) Where there is selective (non-representative) harvest of a particular species, such as red or yellow cedar

iii) Where retention is lost due to windthrow (at a higher probability than seen in unharvested forest stands)

iv) Where retention is on the edges of patches, not contained within its boundaries (i.e. there is no forest influence effect)

v) Where wildlife / dead trees are lost due to worker safety concerns

vi) Where understory or other attributes (e.g. coarse woody debris or microclimate) are not retained in concert with retained trees (e.g. particularly in dispersed retention where standing structures are retained, but all other old forest attributes are lost)

To 'model' the influence of this, we reduced the recovery curve for 30% dispersed retention, and examined the change in risk levels for ecosystems. Short-term and mid-term effects were small (because not much VR had occurred, or recovered in any scenario in the Short-term), but in the long-term the gains associated with VR were reduced by 1.5% (on average not area weighted), and on an individual ecosystem basis, risk was reduced by more than 1% for 26 of 48 ecosystems. As with other analyses, the ecosystems most affected by the change are high and moderate productivity ecosystems, with low productivity ecosystems in general unaffected by the assumption.

The implication from this sensitivity analysis is that the values associated with variable retention cannot be fully predicted (or expected) unless there is certainty about the actual attributes being retained. Retention that is not representative of the old forest within a particular ecosystem will not provide the risk reductions observed in some of these scenario runs.

Acknowledgements

We thank Andrew Fall for his ever patient responses and rerunning of models. Allen Banner, Jim Pojar, Dave Daust, Don Reid, Don Morgan and Hubert Burger contributed to the development of rules for recovery of ecosystems after different levels of harvest.

Alton Harestad and Bruce Marcot discussed ideas about ecosystem recovery at an early stage and provided many helpful insights.

1. Introduction

This report is written for the North Coast LRMP table. It is an extension of previous work summarised in Holt and Sutherland (2003) which presents a Coarse Filter Environmental Risk Assessment of the basecase harvesting scenario.

This report uses the same approach in the 2003 basecase assessment, but extends it primarily to assess the potential coarse filter implications of implementing variable retention harvesting regimes across different locations of the LRMP area. In addition, a single Protected Areas scenario is also included to provide a preliminary comparison of potential conservation benefits.

The science surrounding the implications to biodiversity of using different partial harvest techniques is new, and generally unquantified, particularly at a regional scale. As a result, our approach suggests hypotheses with relate to the implications of partial harvest for biodiversity, based on a combination of expert opinion and literature review.

Our intention is not to specifically quantify the difference in risks to coarse filter biodiversity resulting from different partial harvest scenarios, but to a) identify those ecosystems which may benefit most (have highest risk reduction) from application of partial harvest scenarios and b) identify how different assumptions relating to how partial harvest is implemented may alter the outcomes for biodiversity.

Due to the short time period available for this work, and the time period required to make it available to the table, this report is summary in nature. Additional details are available from the authors.

1.1. Conceptual Approach

Our analysis is simply an interpretation of data produced by the North Coast Landscape Model (Andrew Fall) which uses timber supply rules as determined by the resource ministries and the NC GTT, to harvest the forest over time.

In interpretation of the timber supply data, our approach mirrors that of the basecase report (Holt and Sutherland 2003) which compared the amount of old forest in each ecosystem present on the landbase now and into the future, with the predicted 'natural' amount of old forest in each ecosystem.

However, in these scenarios, variable retention harvest techniques are applied across the landbase, which requires us to estimate the value to 'coarse filter biodiversity' of cutblocks which have some old forest retention, and are also regrowing through time.

In order to compare the coarse filter biodiversity benefits associated with each of the two variable retention (VR) scenarios, we assess the 'recovery to old growth condition' of cutblocks through time. From this we determine the 'old growth equivalent' area of recovering blocks, and add this to unharvested old forest to assess the total potential pool of functioning old forest on the landscape for each ecosystem.

In particular, the methodology includes the following steps:

- Use recovery curves for each ecosystem to estimate the percentage recovery of a block at each time step, given clearcut harvest (provided by A. Banner and J. Pojar),
- Modifying this recovery curve on an area-weighted basis to reflect variable retention. E.g. a block with 30% retention at time zero would have a recovery of (0.3*100)+(0.7*0), meaning 30% is fully recovered (i.e. an old growth retention patch) and 70% is not recovered at all (a new clearcut). Assumes that all retention is representative old growth for that ecosystem. Through time the predicted recovery of the cutblock is added until the entire block is 100% recovered (i.e. old growth forest). A sensitivity analysis and a threshold were used to determine the implications of

different assumptions regarding when a block is sufficiently recovered to be considered to contain enough attributes to reduce coarse filter risk.

- The level of recovery at each time period is used to calculate an 'equivalent old growth area' for each block – i.e. a block that is 100ha, and 40% recovered would be counted as 40ha of old growth forest
- Equivalent old growth area for each ecosystem is then added back onto other remaining (unharvested) old forest in the remainder of the landbase to determine the Total Equivalent amount of old forest
- Compare the total equivalent amount of old forest to the predicted natural level of old forest to determine risk to each ecosystem through time.

2. Ecological Approach

Retaining old forest across the forested landscape will tend to result in reduced risk to biodiversity values. Old forest can be retained as large blocks of contiguous old forest (usually thought of as landscape level / regional retention / protected areas), or as 'within block' stand level retention (alternatively known as variable retention or partial harvesting). Each type of retention is considered crucial to maintain ecological integrity; but their contribution differs (Swanson and Franklin 1992; DellaSalla et al. 1996).

Retaining old forest in contiguous patches likely results in a straightforward reduction in risk to biodiversity proportional to the amount of old forest retained. Such an approach increases the likelihood that large patches of habitat (interior conditions, low disturbance) are present in the landscape, and decrease the probability of human-induced disturbances (roads / hunting pressures etc). For the greatest likelihood of benefits to biodiversity, retained patches large enough to encapsulate natural disturbances are a goal. Such areas are considered as 'core reserves' and can act to buffer ecosystems from disturbances by providing large scale refuges, adequate ecosystem representation, and a diverse array of habitat types.

Stand level within block retention (through VR or partial harvesting) is less well studied in terms of costs and benefits to coarse-filter biodiversity. These patches are usually not large enough to provide interior forest conditions, or to provide refuges from disturbances. However, they do provide

- increased structural attributes or microclimate at the stand level, thereby increasing the 'oldgrowthness' or 'recovery to old growth' of the entire stand - resulting in possible acceleration of habitat recovery for old seral species,
- lifeboating of individual species within the stand, increasing the rate of recolonisation for poorly vagile species,

The success of stand-level retention to provide these benefits will likely be dependent on

- the level of retention. Lifeboating the full species complement is thought to require a high retention level than simply changing microclimate
- the type of retention. Increasing the oldgrowthness or recovery to oldgrowth will require that old forest attributes were retained within the retention. These attributes should reflect the mean attributes within the original stand, and should be representative of the range of types of attributes/ ecosystem / tree species found within the original stand.
- the extent of any additional disturbance caused by the new harvesting technique (e.g. additional roads being built, loss of snags due to WCB guidelines, the extent of any high-grading etc.).

The hypothesis then is that maintaining a distribution of old forest attributes at the stand level can potentially reduce the risk of losing ecosystem integrity across a geographically larger area, and / or for a wider range of ecosystems across that area than would conventional clearcut harvest techniques.

3. Analysis of Scenarios

A number of different runs and comparisons have been made – which need to be clearly understood before comparing the results of this work to any other analysis.

Table 1. Summary of comparisons available.

Name	Key Elements	Original Model / Author	Link to CF Reports
Spatial Basecase [1]	• Spatially explicit • Equivalent AAC to NC Timber Supply	SELES (Fall, Morgan, Bolster et al.)	Provided data for March 2003 CF report
Spatial Basecase + explicit RRZ [2]	• Spatially explicit • RRZ area removed explicitly – to better meet industry practices	SELES	This report only
Variable Retention 1 (VR1) [3]	• As [2], but implementation of variable retention • Conventional: 20% VR (30% retention) and 80% clearcut Heli: 80% VR (30% retention) and 20% clearcut. •	SELES AAC lower than [2] by 12.7% to allow implementation of VR	Data for VR1 expt (this doc)
Scaled Basecase – VR1 [4]	• Basecase model (no VR), with lower AAC. Provides direct comparison of implementation of VR	SELES	All results for VR1 presented as a comparison with this basecase.
Variable Retention 2 (VR2) [5]	• As [2], but implementation of variable retention • Conventional: 80% clearcut; 15% VR (30% retention); and 5% VR (70% retention) Heli: 20% clearcut; 60% VR (30% retention); and 20% VR (70% retention). •	SELES AAC lower than [2] by 17.4% to allow implementation of VR	Data for VR2 expt (this doc)
Scaled Basecase – VR2 [6]	• Basecase model (no VR), except lower AAC to provide direct comparison of implementation of VR	SELES	Results for VR2 compared with this basecase
Protected Area: 13	• Protection of 10% of THLB in Campania, Dundas, Johnson, Kshwam, Kwinamass, Stephens and Hartley Landscape Units	AAC lower by 10% than [2].	

4. Methodology

4.1. Models

Base data for each scenario in this assessment were obtained from MSRM (via Andrew Fall) using the North Coast Landscape Model. Information regarding the assumptions made in the model is available (Morgan et al. 2003).

In our interpretation of these data, three analysis models (tools) were used.

The first is an Excel model that generates recovery curves for each ecosystem, based on the original clearcut recovery curves obtained from experts (J. Pojar and A. Banner). Two sets of curves are drawn up a) Base Curves, and b) Forest Influence Negative. Curves a) were used in the basic assessment and curves b) were used to test the sensitivity to key biological assumptions.

The second is an Excel model that applies recovery curves to the areas undergoing variable retention as projected by the SELES model. The Excel model subsequently calculates the area of Equivalent Old Forest for each ecosystem at each time period. This ‘old growth equivalent’ for each ecosystem is then added to the actual area of old forest to provide an estimate of the total amount of old forest available in each ecosystem at each time period.

The third model is the Bayesian Belief Network (BBN) model used in the previous report (Holt and Sutherland 2003). The BBN model takes the key output from the Excel model (total area of Equivalent Old Forest) that has been converted to a percentage of Equivalent Old Forest for each ecosystem and landscape unit. This is compared to the predicted amount of old forest (as in Holt and Sutherland 2003) to estimate base risk for that ecosystem. Risk classes used are the same as in that report (table 2):

Table 2. Risk Categories

Deviation from mean predicted Natural percent old forest	0-20%	20-40%	40-60%	60-80%	80-100%
Risk Class	Very Low	Low	Moderate	High	Very High

4.2. Approach and Assumptions

Our approach in this analysis is to attempt to quantify the 'old growth equivalent[4]' of an area harvested using variable retention harvest techniques. We have used a series of assumptions in order to do this. The key ones are:

a) Recovery of the Cutblock. The amount of old forest retained in the block (the retention level) and the predicted recovery of the remainder of the block (the harvested portion) is used to determine the overall recovery of the block. This approach uses expert opinion recovery curves, and assumptions about the extent to which the retention would function as old forest once the block has been harvested.

b) Old Forest Equivalence. Once the recovery of an area has been predicted, a simple area-weighted assumption was used to assign an old growth equivalence to the block. For example, if a 100ha of an ecosystem was predicted to be 60% recovered, then 60ha of old growth equivalence was tallied.

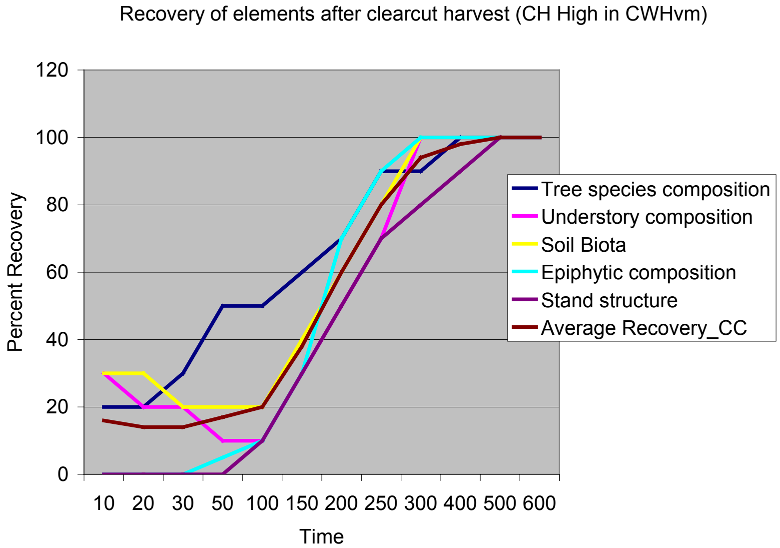
4.2.1. Recovery of the CutBlock

A number of factors were used to determine the recovery of harvest blocks in each ecosystem, given a particular harvest treatment, and the amount of time elapsed since harvest. The factors are: the temporal recovery of key stand elements important to biodiversity in these ecosystems, the type of harvest, the proportion of a block subject to a given harvest treatment, and modifications to recovery to account for operational practices. We converted the effects of these assumptions into ecosystem-specific "recovery curves" that describe the expected contribution of the recovering forest to old growth function, as described below.

1. Clearcut recovery curves. Expert opinion was used to draw recovery curves for 5 different elements of stands assuming the stand was clearcut harvested, for each ecosystem (see Figure 1) over time.

Figure 1. Recovery of five stand elements after clearcut harvesting, for a cedar/ hemlock high productivity analysis unit, in the CWHvm. Data based on expert opinion

[4] 'Old growth equivalent' – en expression to define how similar a partial harvested and regrowing cutblock is to unharvested old forest in that ecosystem



2. Area-weighted assumption: The base assumption made[5] is assume that blocks have an 'area weighted' recovery. For example, if 30% retention was applied to a 100ha cutblock, the 'recovery' at time zero would be 30% (since 30% of the block is 100% recovered). After 50 years, the recovery would be 30% of the block 100% recovered (the initial retention) plus 70% at X recovery as read from the clearcut recovery curve (Figure 2).
3. Exceptions to the area-weighted assumption: a number of exceptions to the area-weighted rule were identified by the experts. In particular, the recovery for stand structure and epiphytic composition was assumed to be less than the area-weighted value. For example, the stand structure recovery for retained 'old' forest was reduced in the 30% retention harvest scenario because snags would tend to be removed to meet WCB guidelines[6] (see summary in Table 3 of percent reductions). Similarly, epiphytic composition was considered to decrease in retained old forest because of microclimatic changes caused by opening up the stand.
4. Final base recovery curves (from assumptions 2 and 3 above) are shown in Figure 3.

[5] based on agreements made at a workshop held in March 2003 with ecoloigcal and data experts Allen Banner, Jim Pojar, Dave Daust, Don Morgan, Don Reid.

[6] WCB – Workman's Compensation Board regulations apply to improve worker safety and require that dead trees can only be retained when contained within a patch of standing timber, unless they have been safety checked. In dispersed retntion therefore, very few if any snags are retained.

Figure 2. Explaining the Area Weighted Assumption for a 30% retention cutblock

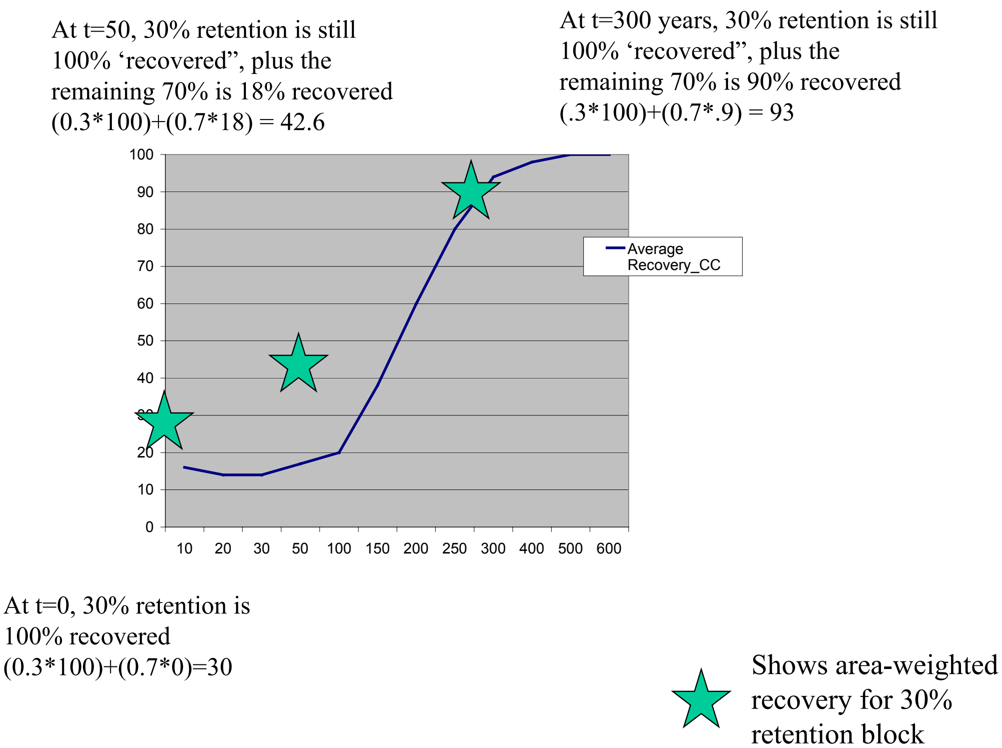
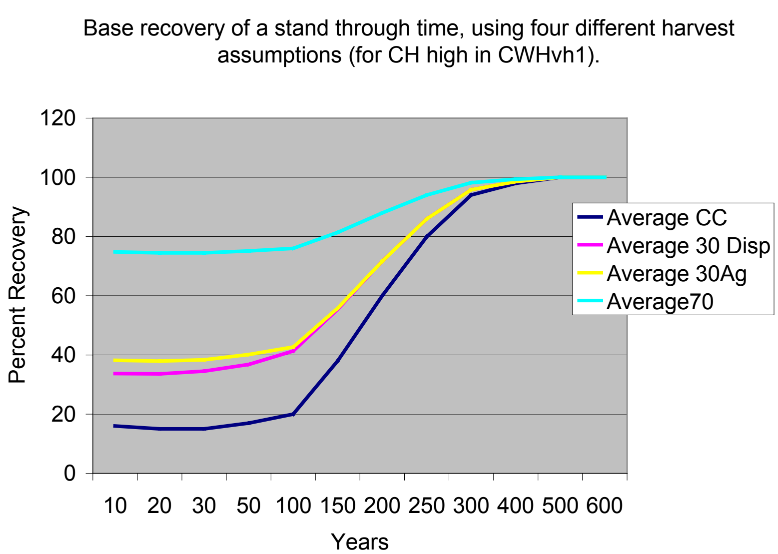


Figure 3. Recovery curves for four harvest options: clearcut, 30% retention (dispersed), 30% retention (aggregated) and 70% retention.



5. Forest Influence: An additional modifier was used to apply a sensitivity analysis to the use of recovery curves. This modifier is attempting to quantify additional potential impacts of the inblock

retention on the old forest values present in the entire block. The modifier has been applied under the following hypothesis:

2) **Old forest retention has a lower influence on the block than that predicted by a simple area-weighted model.**
This may occur where partial harvesting is implemented, but does not retain attributes that best meet biological requirements. For example, high-grading of stands, retention of poor old forest value attributes (small / non-representative tree sizes etc.), retention of non-representative parts of the stand, loss of forest area due to roads, damage to stands due to machinery etc., may result in the percent of forest retained being of less value than would be predicted based on the percent retained. For example, if 30ha of forest is retained, but it tends to be all a single species or small tree sizes that are non representative of the original old forest stand, then that forest may only be equivalent to 10ha of old forest. The longer term influence of these impacts will vary by the specific type, but in general the following assumptions were made:

   a) 70% retention. Since the amount of harvest is low within this area, the retention is likely to be relatively representative of the block. High-grading (selective removal of a particular tree species type) is one concern that may represent a likely scenario in this landscape. A relatively low 'modifier' is used to represent this (see Table 3)

   b) 30% retention dispersed. The potential for implementing 'low quality VR' is relatively high here. Small sized, non-representative retention may be pervasive, resulting in little or no old forest influence at the start of the recovery period. Through time, presumably these attributes will still result in faster retention of old forest attributes than suggested from a clearcut, but the difference will not be large (Table 3; Figure 4).

   c) 30% retention aggregated. The potential for low quality VR to be implemented here is midway between the two previous scenarios. Retained patches will result in at least some old forest values being retained. However, selective placement of retention patches so they are non-representative, or removal of snags or trees from the edges of patches may result in the lower values than predicted. For example, 30ha of old forest may only be equivalent to 25ha of actual old forest (Table 3).

Figure 4. Forest Influence – a comparison of how assumptions may influence recovery curves for 30% retention.

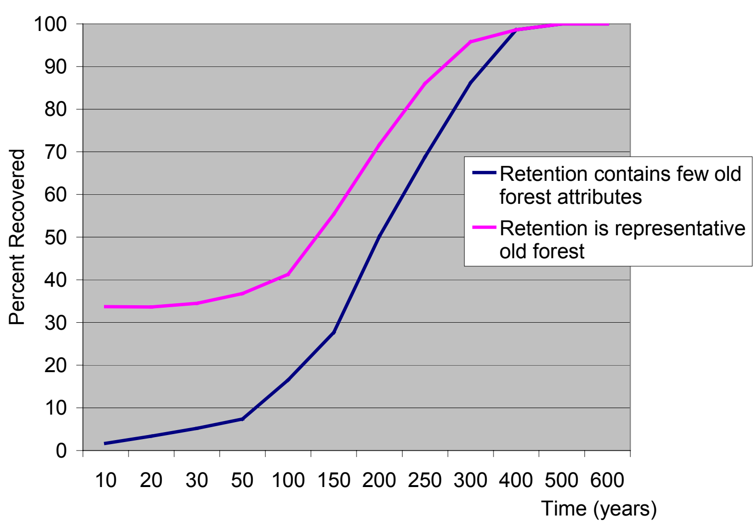


Table 3. Recovery Curve Modifiers (AW = Area weighted)

Modifier type	Element	30% Dispersed retention	30% aggregated retention	70% retention
Area weighted assumption	Tree species Understory composition Soil biota Epiphyte composition Stand structure	AW AW AW 70% of AW 5% of AW	AW AW AW 90% of AW 60% of AW	AW AW AW AW AW
Forest Influence – base curves		None	None	None
Forest Influence Negative * (as a percent of the AW numbers)		5% at 10 years 20% at 50 years, 40% at 100 years 70% at 200 years 100% at 100 years	10% at = 10 years 60% at 50 years 90% at 200 years 100% at 300 years	60% at 10 years 80% at 50 years 95% at 150 years 100% at 200 years

AW = area weighted

A full set of curves can be made available.

4.3. Scenario Comparisons

Implementation of variable retention has a number of implications. The first is that in order to implement the various scenarios, a timber supply impact over the basecase was observed (summarised in Table 1, details in Morgan et al. 2003). A key assumption that results in this timber impact is that the timber harvesting landbase does not increase over its current size (which may or may not be correct if (for example) a move towards additional helicopter harvest was made).

Since the intention of this scenario assessment is to ask what additional benefits to coarse filter biodiversity may accrue from implementing VR, it was therefore necessary to rerun the timber supply model with the new predicted AAC and the basecase assumptions, in order to provide a comparison that only showed the effects of VR and not the effects of both VR and the new reduced AAC.

The results show each (VR) scenario compared with its equivalent basecase (i.e. scaled basecase with lower AAC). Additionally a single protected Areas (PA) scenario is presented (PA13).

Additionally, an assessment of the implications of a) different recovery thresholds and b) different (negative) recovery curves are presented to understand how assumptions alter the outcomes.

5. Results

Given the requirement for a 'summary' of results only (D. Reid pers. comm.), we present our key results in terms of the differences made in each scenario.

In general, in this regional analysis, we observed only relatively small changes in coarse filter risk levels for most ecosystems as a consequence of the different harvest scenarios we examined. To simplify somewhat the results, we present those ecosystems for which risk is changed more than 1%, in addition, any changes in risk category (e.g. from high to moderate) are highlighted.

Interpretation of the results of these models is implicitly dependent on scale (both time and space), . This analysis is a regional one – e.g. for any particular ecosystem we present the impact on risk over the entire region. Results can therefore be counter intuitive if thinking only about smaller scales e.g., a portion of a particular LU. For example, variable retention occurring in a particular ecosystem, in a particular landscape unit can locally lower the risk in that area, but overall the risk could increase because an increased area of that ecosystem may be accessed for harvesting.

In the variable retention scenarios, we included a sensitivity analysis that investigates the implications of allowing forest at different levels of recovery to 'count' towards the old forest targets (0%RT = recovery threshold of 0% i.e. all forest can count towards the target immediately; 40%RT = 40% recovery threshold must be reached before the forest can be used to lower risk; 100%RT = the forest must be fully recovered to old growth (250 years, or 100% recovered) before it can count as old growth equivalent. The 100RT is used as the standard comparison in tables below, and 40RT and 0RT are provided as sensitivities to this assumption.

Results are only presented for ecosystems >200ha throughout all results.

5.1. Original Basecase versus Basecase + RRZ explicit netdown

Comparison [1] with [2] – see Table 1.

Note that not all the changes associated with this comparison are a result of the RRZ netdown alone, and so are not presented in detail.

Key Result: Implementation of the explicit netdowns for riparian reserve zones does appear to result in a reduced risk overall in the long-term. After 100 years, risk levels were reduced by more than 2% points for 23 ecosystems (of 48 > 200ha). Risk categories were reduced for 6 of these. The majority of the changes are associated with spruce ecosystems and so are riparian associated as expected.

This explicit RRZ methodology is used in the harvest model projection for the remaining scenarios, and so is part of all other comparisons described below (see Morgan et al. 2003 for details).

5.2. Variable Retention Scenario 1

5.2.1. Spatial Basecase versus VR1 Scaled Basecase (the AAC reduction effect):

For each scenario, the first comparison is the spatial basecase compared with the scaled basecase for (i.e. a run with the basecase clearcutting assumptions, but that has a lower AAC to match the AAC reduction resulting from implementation of VR – see Morgan et al. 2003). This comparison shows the impact on risk resulting from the lower AAC (12.7%) associated with the VR1 run.

Contrary to initial expectations, we found very little net impact on coarse filter risk comparing the VR1 scaled basecase with the spatial base (SBC). Although detailed data on the age classes and volumes harvested for each scenario was not available to us at the time of writing this report, these results suggest that while VR1 scaled basecase slows down the rate of harvest (relative to the SBC) but not the location of harvest.

Key results:

Short-term (20 year): There are no Short-term (20 year) implications of changing from SBC to scaled basecase. No ecosystems changed risk level by more than 1%., and the vast majority did not alter at all in this timeframe.

Mid-term (50 year): although a few ecosystems did change risk levels at 50 years, compared with those at 20 years, no ecosystems changed risk by more than 1% in the midterm.

Long-term: (150 years): there are no discernible long term differences resulting from this scenario. No ecosystems changed risk level by more than 1%.[7] [table not shown].

[7] Note that we do not know what constitutes a significant biological change in risk in this analysis. We chose at 1% cut-off because there are various stochastic aspects of the multiplemodels, particularly the uncertainty within the BBN that cause

5.2.2. VR1 Basecase versus VR1 Scenario (the VR effect)

To isolate the effects of variable retention alone, the VR1 scenario is compared with the VR1 scaled basecase.

Using RT = 100, (see below for discussion recovery thresholds)

Short-term (20 years): short term risk implications are very minor. Most ecosystems do not change risk at all in this short timeframe, and none change by >1%.

Mid-term (50 years): there are only minor mid-term impacts. Only 1 ecosystem showed more than 1% reduction in risk).

Long-term (150 years): 26 of 48 ecosystems showed a risk change of >1%, all of them having decreased risk compared with the VR1 basecase. The average reduction in risk for ecosystems over 200ha is 1.9 % (not an area-weighted average). The risk categories were reduced for 5 ecosystems as a result of the VR treatment as compared with the basecase.

The pattern of risk reduction is not clearly defined in terms of groups of ecosystems. Low productivity systems have the least change in risk, though this stems from the general low level of harvesting, combined with a relatively low percent of that landbase having VR applied to it. Higher risk reductions are seen across medium and high productivity ecosystems, but the exact reduction depends on the remaining area of old growth, the percent operability and the percent area that actually received a VR treatment.

Table 4. The VR1 Effect. Original risk rating, plus reduction in risk and associated change in risk category (if any) for 100% retention threshold (100RT). Additionally, additional risk reduction associated with 40RT and 0RT[8].

AU	BEC	VR1-Scaled Basecase	SBC minus [100% RT VR1]	Original / change in risk class	SBC minus [40% RT VR1]	SBC minus [100%RT VR1}
CedarHigh	CWHvh2	86.16	-2.16	VH	-2.83	-5.11
CedarHigh	CWHvm	87.45	-2.02	VH	-2.36	-5.51
CedarLow	CWHws1	33.90	-0.98	L	-1.67	-1.51
CedarLow	CWHvm	11.03	-0.09	VL	-0.15	-0.14
CedarMed	MHwh1	38.45	-0.12	L	-0.40	-1.56
CedarMed	CWHvh2	50.73	-1.94	M	-3.06	-3.85
CedarMed	CWHvm	68.39	-2.03	H	-3.26	-4.32
CedarMed	CWHwm	55.43	-0.86	M	-1.68	-2.52
HemBalHigh	CWHws2	47.04	-2.08	M	-2.48	-6.21
HemBalHigh	CWHvh2	88.03	-1.45	VH	-1.63	-4.11
HemBalHigh	CWHws1	47.66	-3.06	M	-4.72	-6.12
HemBalHigh	CWHvm	82.88	-2.02	VH	-2.44	-5.21
HemBalHigh	CWHwm	49.16	-1.05	M	-3.54	-3.57
HemBalLow	CWHws2	20.69	-1.47	**L / VL**	-3.94	-3.70
HemBalLow	CWHvh2	15.33	-0.71	VL	-1.21	-1.18
HemBalLow	CWHws1	58.96	-0.53	M	-0.58	-1.51
HemBalLow	CWHvm	18.10	-1.05	VL	-1.73	-1.89
HemBalMed	MHwh1	58.85	-3.18	M	-5.35	-5.14

minor fluctuations in risk. We therefore chose not to report on less than 1% change to avoid picking up these artefact changes.

[8] Risk class is determined from the percent risk, translated using the risk table 2 (e.g. 86% for Cedar High in the CWHvh2 = very high risk)

AU	BEC	VR1-Scaled Basecase	SBC minus [100% RT VR1]	Original / change in risk class	SBC minus [40% RT VR1]	SBC minus [100%RT VR1}
HemBalMed	MHmm2	42.09	-4.66	**L / VL**	-7.93	-7.15
HemBalMed	CWHws2	56.79	-5.75	M	-10.16	-9.41
HemBalMed	CWHvh2	63.03	-2.79	H	-4.49	-5.18
HemBalMed	MHmm1	36.34	-2.27	L	-4.40	-4.58
HemBalMed	CWHws1	77.90	-3.73	H	-6.31	-5.67
HemBalMed	CWHvm	60.91	-3.53	**H / M**	-5.78	-6.09
HemBalMed	CWHwm	51.72	-1.03	M	-2.80	-2.74
SpruceHigh	CWHvh2	62.74	-2.92	H / M	-4.56	-5.39
SpruceHigh	CWHvm	49.56	-1.21	M	-2.01	-2.83
SpruceHigh	CWHwm	22.42	-0.71	L	-1.21	-1.08
SpruceLow	CWHvh2	21.06	-1.20	**L / VL**	-2.14	-2.20
SpruceLow	CWHvm	36.39	-1.54	L	-2.65	-2.99
SpruceMed	CWHvh2	67.33	-3.61	H	-5.63	-7.02
SpruceMed	CWHvm	50.51	-3.20	M	-5.35	-6.09
SpruceMed	CWHwm	70.74	0.56	H	-0.21	-1.67

Sensitivity to Recovery Threshold (RT)

The results outlined above are sensitive both in terms of extent of ecosystems affected and magnitude of reduced risk, to the recovery assumption/ threshold used. The 100%RT (recovery threshold) provides a direct comparison with the basecase of any reduced risk associated with VR. The two sensitivity analyses (using 40% and 0% recovery thresholds) examine potential higher benefits that may be associated with VR, assuming that cutblocks do in fact reduce risk to coarse filter biodiversity at these lower levels of recovery (Table 4).

Short-term (20 years): very little additional benefit is gained from assuming forest becomes equivalent old growth at an earlier level of recovery. We can assume therefore that this result is robust, and that VR1 gains little for coarse filter biodiversity in this short period irrespective of the recovery assumptions. This is unsurprising because in this timeframe, relatively little area has had VR applied to it.

Mid-term (50 years): An additional 5 and 12 ecosystems respectively had risk reduced by 1% or more using 40 and 0 recovery thresholds. At this time period, the assumption of how much recovery to count as equivalent old forest does change the overall risks associated with the scenario.

Long-term (150 years): As the recovery threshold is relaxed (40% or 0%), the number of ecosystems with 1% change increases (from 26 to 29 and 32 respectively). In addition, the overall magnitude of the risk reduction increases. The average risk reduction (not area-weighted) is 3.2% using the 40% threshold, and 3.9% using the 0% threshold.

5.2.3. Key results from VR1 Scenario

Application of VR (see table 1 for details) requires a 12.5% reduction in AAC. This results in very little discernible reduction in risk. Although initially counter intuitive, this seems to occur because:

a) the reduction in risk is seen largely as lengthening the rotation age of the forest. The pattern of harvest is the same, but the rate is reduced. For VR1, the amount of reduction is quite low, for example the transition from harvesting old forest to managed stands only changes from 140 to 160 years.

b) The effects of reduced AAC are dispersed over the large number of ecosystems within the relatively small THLB, and the actual changes per ecosystem (difference in area harvested) is quite low, and does not apparently reduce regional risk. Note this is not equivalent to assuming that local risk does not change – where risks may indeed be reduced by a lower local AAC.

Application of variable retention alone does result in reduced risk, but not in the short term and at the long-term, but at relatively low levels. As above, the effect is distributed across the entire landbase, so potential conservation benefit in specific ecosystems is relatively low. In particular, most VR occurs in the heli zone under the SELES model rules, and as a result tends to occur in lower productivity, and generally lower risk ecosystems. The variable retention results are quite sensitive to the assumptions regarding when recovering forest should be allowed to reduce the risk level.

5.3. Variable Retention Scenario 2

5.3.1. Basecase versus VR2 Scaled Basecase (the AAC reduction effect)

Short-term: no ecosystems have reduced risk (>1%) in the short-term,

Mid-term: no ecosystems have reduced risk (>1%) in the mid-term,

Long-term: risk starts to change (generally decline) for some ecosystems at 100, or 150 years, and the maximum change for an individual ecosystem may be at either time period. Risk levels reduced by more than 1% for 18 of 48 ecosystems at 150 years (

Table 5). This result represents a low change in regional risk levels associated with the reduction in AAC associated with this scaled basecase.

The results suggest that a similar conclusion to that obtained for the VR1 Scaled basecase compared with the SBC with explicit RRZ applies here (section 5.1). Simply reducing the AAC does not substantially change the locations of harvest (at least regionally) and so the net effects on ecosystem risk are dampened, cancelling out differences that occur at a local scale.

Table 5. Risk levels for spatial basecase compared with scaled basecase for VR2, at 150 years. Only ecosystems with >2% change in risk are shown. Only ecosystems greater than 200ha are shown. Summary of ecosystems with 1% or more change in risk level, at 150 years. [8]

AU	BEC	Spatial Basecase	Spatial Basecase minus VR2 Scaled Basecase
CedarMed	CWHvh2	50.50	- 0.98
CedarMed	CWHwm	55.66	- 1.09
HemBalHigh	CWHws2	46.80	- 1.02
HemBalHigh	CWHws1	47.35	- 1.28
HemBalLow	CWHws2	21.42	- 2.88
HemBalMed	MHwh1	58.60	- 1.02
HemBalMed	MHmm2	41.69	- 1.68
HemBalMed	CWHws2	55.93	- 3.64
HemBalMed	CWHvh2	62.73	- 1.24
HemBalMed	MHmm1	36.43	- 2.01
HemBalMed	CWHws1	77.63	- 1.16
HemBalMed	CWHvm	60.56	- 1.48
SpruceHigh	CWHvh2	62.52	- 0.90
SpruceLow	CWHvh2	20.81	- 1.07
SpruceLow	CWHvm	36.22	- 1.09
SpruceMed	CWHvh2	67.07	- 1.34
SpruceMed	CWHvm	50.31	- 1.69
SpruceMed	CWHwm	70.99	- 1.20

In order to understand why risk was reduced only minimally in VR2 (and were generally indistinguishable in VR1) we examined the output data from the SELES model directly. As with VR1 scaled basecase, we find that the percent of old forest in each ecosystem changes by only quite a small amount at each time period, and the maximum change can be highest at different time periods – making an overall effect difficult to detect.

Table 6. Change in percent old forest present in spatial basecase compared with old forest in VR1 and VR2 scaled basecases, at each time period, for each ecosystem.

Example: -0.8 means that the percent of old forest for that ecosystem is 0.8% lower in the scaled base compared with the spatial basecase. Changes >1% are bolded.

			Spatial Basecase minus VR1 basecase					Spatial Basecase minus VR2 basecase				
		TIME	0	20	50	100	150	0	20	50	100	150
ANALYSIS UNIT	BEC	AREA										
CedarHigh	CWHvh2	766.0	0.00	-0.26	**1.83**	0.00	0.00	0.00	-0.26	0.91	0.00	0.00
	CWHvm	652.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CedarLow	CWHvh2	489228.0	0.00	0.00	-0.03	-0.72	-0.02	0.00	0.00	-0.25	-0.98	-0.09
	CWHvm	90814.0	0.00	-0.04	-0.03	-0.77	-0.07	0.00	-0.07	-0.14	**-1.27**	-0.11
	CWHwm	35495.0	0.00	0.03	0.02	-0.54	-0.42	0.00	0.01	-0.12	-0.65	-0.82
	CWHws1	201.0	0.00	0.00	**-1.00**	**-1.00**	0.00	0.00	0.00	**1.49**	**-1.99**	0.00
	CWHws2	1429.0	0.00	0.00	-0.21	**-1.33**	0.00	0.00	0.00	0.28	-0.56	-0.28
	MHmm1	24782.0	0.00	0.00	0.00	-0.12	-0.01	0.00	0.00	0.00	-0.13	-0.11
	MHmm2	730.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MHwh1	42534.0	0.00	0.01	-0.03	-0.20	-0.01	0.00	0.01	-0.07	-0.37	-0.14
CedarMed	CWHvh2	12554.0	0.00	-0.45	-0.70	**-2.31**	0.00	0.00	**-1.20**	**-3.17**	**-3.23**	-0.50
	CWHvm	6575.0	0.00	-0.25	**-1.11**	-0.54	-0.18	0.00	-0.64	**-2.04**	**-2.09**	-0.41
	CWHwm	1989.0	0.00	-0.65	0.05	**-1.06**	-1.61	0.00	-0.90	-0.15	**-1.21**	**-3.57**
	MHwh1	656.0	0.00	0.00	0.00	**-3.31**	**-2.44**	0.00	0.00	-0.76	**-4.27**	**-4.12**
HemBalHigh	CWHvh2	1261.0	0.00	0.00	0.32	-0.40	0.00	0.00	0.00	-0.16	-0.56	0.00
	CWHvm	4642.0	0.00	0.00	-0.30	-0.21	0.00	0.00	0.00	-0.24	-0.37	0.00
	CWHwm	519.0	0.00	0.19	**1.16**	-0.77	0.00	0.00	-0.39	-0.39	**-2.50**	**-2.70**
	CWHws1	678.0	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.88	0.00	0.00
	CWHws2	325.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.62
HemBalLow	ATp	1169.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	CWHvh2	35767.0	0.00	0.06	-0.11	**-2.38**	-0.12	0.00	-0.10	-0.38	**-3.79**	-0.26
	CWHvm	70875.0	0.00	-0.24	-0.05	-0.87	-0.07	0.00	-0.23	-0.46	**-1.74**	-0.22
	CWHwm	29896.0	0.00	0.02	-0.10	-0.38	-0.13	0.00	-0.02	-0.15	-0.41	-0.42
	CWHws1	2481.0	0.00	-0.48	-0.97	**-3.75**	0.00	0.00	0.28	-0.60	**-4.88**	-1.25
	CWHws2	7764.0	0.00	-0.09	-0.28	**-2.24**	-1.47	0.00	0.03	-1.09	**-2.95**	**-3.79**
	MHmm1	44085.0	0.00	0.00	-0.07	-0.16	-0.02	0.00	-0.02	-0.13	-0.26	-0.05
	MHmm2	14148.0	0.00	0.02	-0.15	-0.55	-0.01	0.00	0.06	-0.11	-0.77	-0.03
	MHwh1	15109.0	0.00	0.03	-0.12	-0.86	-0.03	0.00	0.02	-0.06	-0.96	-0.07
HemBalMed	CWHvh2	13493.0	0.00	-0.09	-0.03	**-1.84**	-0.12	0.00	-0.89	-0.53	**-2.49**	-0.29
	CWHvm	22006.0	0.00	-0.44	-0.29	-0.27	-0.10	0.00	**-1.81**	-0.87	-0.50	-0.58
	CWHwm	5336.0	0.00	-0.06	0.09	**-1.37**	**-1.24**	0.00	-0.21	-0.82	**-1.42**	**-3.97**
	CWHws1	2022.0	0.00	-0.05	**-1.73**	-0.89	0.00	0.00	-0.20	-0.25	-0.99	-0.49
	CWHws2	1626.0	0.00	-0.18	-0.86	**-1.05**	-0.68	0.00	-0.06	-0.92	**-2.64**	**-4.98**
	MHmm1	933.0	0.00	0.21	-0.19	**-1.23**	-0.54	0.00	0.00	**-2.18**	**-1.44**	**-3.11**
	MHmm2	302.0	0.00	-3.64	**-1.99**	0.00	0.00	0.00	**-1.99**	-0.99	0.00	0.00
	MHwh1	823.0	0.00	**-1.14**	**-2.07**	**-1.22**	0.00	0.00	**-1.94**	**-2.55**	**-4.82**	-0.47
Pine	CWHvh2	59370.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MHwh1	1220.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

			Spatial Basecase minus VR1 basecase					Spatial Basecase minus VR2 basecase				
		TIME	0	20	50	100	150	0	20	50	100	150
SpruceHigh	CWHvh2	579.0	0.00	-0.17	0.00	**-2.91**	0.00	0.00	-0.17	0.00	**-6.19**	0.00
	CWHvm	2698.0	0.00	-0.04	-0.11	-0.56	-0.07	0.00	0.00	-0.11	-0.70	-0.56
	CWHwm	213.0	0.00	-0.47	-0.47	0.00	0.00	0.00	-0.47	-0.47	0.00	0.00
SpruceLow	CWHvh2	3544.0	0.00	-0.23	-0.38	**-1.38**	0.06	0.00	-0.31	-0.80	**-2.11**	-0.62
	CWHvm	3733.0	0.00	-0.05	-0.04	**-1.34**	-0.21	0.00	0.00	0.15	**-1.63**	-0.62
	CWHwm	500.0	0.00	0.40	-0.20	0.00	0.00	0.00	0.40	-0.20	0.00	0.00
	MHmm1	214.0	0.00	0.47	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MHwh1	335.0	0.00	0.00	0.00	**-2.99**	0.00	0.00	0.00	0.00	**-3.28**	-0.90
SpruceMed	CWHvh2	1973.0	0.00	0.51	-0.56	**-1.47**	-0.30	0.00	0.35	-0.51	**-2.65**	-0.91
	CWHvm	4716.0	0.00	-0.19	-0.61	-0.72	-0.17	0.00	0.04	-0.57	-0.91	-0.89
	CWHwm	390.0	0.00	0.00	0.00	0.00	**-3.33**	0.00	0.00	0.00	0.00	**-6.67**
Grand Total		1064459.0	0.00	-0.04	-0.07	-0.73	-0.08	0.00	-0.10	-0.29	-1.07	-0.24
AVERAGE change (by time period)			*0.0*	*-0.1*	*-0.3*	*-0.7*	*-0.2*	*0.0*	*-0.2*	*-0.4*	*-1.0*	*-0.8*

5.3.2. VR2 Basecase versus VR2 Scenario (the VR effect)

Using the most conservative recovery threshold assumption (RT=100), there are risk reductions associated with the VR2 scenario.

Short-term (20 years): 0 ecosystems change risk by more than 1%.

Mid-term (50 years): 3 ecosystems have reduced risk of >1% compared with the basecase.

Long-term (150 years): risk is lowered (>1%) for 23 of 48 ecosystems using 100RT. Average risk is lowered by 1.8% (not area-weighted). The risk categories for four ecosystems were reduced as a result of the risk change.

Table 7. The VR2 Effect. Original risk rating, plus reduction in risk and associated change in risk category (if any) for 100% retention threshold (100RT). Additionally, additional risk reduction associated with 40RT and 0RT.[8]

AU	BEC	VR2 Scaled Basecase	SBC minus 100RT VR2	Original / new risk	SBC minus 40RT VR2	SBC minus 0RT VR2
CedarHigh	CWHvh2	85.71	- 1.86	VH	- 2.15	- 4.26
CedarHigh	CWHvm	87.06	- 2.86	VH	- 3.21	- 4.74
CedarLow	CWHws1	33.45	- 0.69	L	- 0.88	- 1.60
CedarMed	MHwh1	37.89	- 0.15	L	- 0.51	- 1.08
CedarMed	CWHvh2	49.52	- 1.45	M	- 1.92	- 2.55
CedarMed	CWHvm	67.31	- 1.69	H	- 2.17	- 2.93
CedarMed	CWHwm	54.58	- 1.06	M	- 1.54	- 1.84
HemBalHigh	CWHws2	45.78	- 2.39	M	- 2.96	- 5.04
HemBalHigh	CWHvh2	87.75	- 1.89	VH	- 2.13	- 4.00
HemBalHigh	CWHws1	46.07	- 2.01	M	- 2.64	- 3.78
HemBalHigh	CWHvm	82.37	2.10	**VH / H**	- 2.41	- 4.20
HemBalHigh	CWHwm	49.12	2.23	M	- 3.15	- 3.39
HemBalLow	CWHws2	18.54	0.24	VL	- 1.30	- 1.30
HemBalLow	CWHws1	58.89	- 1.11	M	- 1.22	- 1.25
HemBalLow	CWHvm	17.44	- 0.71	VL	- 0.96	- 1.03
HemBalMed	MHwh1	57.58	- 2.78	M	- 3.40	- 3.44
HemBalMed	MHmm2	40.01	- 3.68	**M/ L**	- 4.60	- 4.60

AU	BEC	VR2 Scaled Basecase	SBC minus 100RT VR2	Original / new risk	SBC minus 40RT VR2	SBC minus 0RT VR2
HemBalMed	CWHws2	52.28	- 2.56	M	- 4.09	- 4.97
HemBalMed	CWHvh2	61.49	- 2.31	**H / M**	- 2.96	- 3.27
HemBalMed	MHmm1	34.41	- 1.38	L	- 2.24	- 2.49
HemBalMed	CWHws1	76.47	- 2.87	H	- 3.53	- 4.49
HemBalMed	CWHvm	59.08	- 2.44	M	- 3.20	- 4.14
HemBalMed	CWHwm	51.35	- 1.32	M	- 1.95	- 2.38
SpruceHigh	CWHvh2	61.62	- 2.26	**H / M**	- 2.78	- 3.69
SpruceHigh	CWHvm	48.91	- 1.16	M	- 1.52	- 2.04
SpruceLow	CWHvm	35.13	- 0.80	L	- 1.27	- 1.58
SpruceMed	CWHvh2	65.72	- 2.70	H	- 3.42	- 4.45
SpruceMed	CWHvm	48.62	- 2.37	M	- 3.18	- 3.75

Sensitivity to recovery threshold (RT)

Short-term (20 years): with RT = 0, 3 ecosystems change risk by more than 1%. RT = 40 does not reduce risk over RT = 100.

Mid-term (50 years): with RT = 0, and 40 risk is reduced for 14 and 4 ecosystems (more than >1%,) respectively.

Long-term (150 years): with RT = 0 and 40, 29 and 25 ecosystems had risk reduced by >1% using the 40 and 0% RT respectively. In addition, the magnitude of risk reduction also increased, from 1.8 to 2.4 to 3.2% respectively (for 100, 40 and 0RT).

5.3.3. Key results from VR2 Scenario:

Application of VR2 (see table 1 for details) requires a 17.5% reduction in AAC. This results in a relatively small reduction in risk compared with the spatial basecase, but a larger reduction than seen in VR1 (18 of 48 ecosystems had reduced risk levels greater than 1%). Risk reductions are observed for a range of ecosystems, but they tend to be high or medium productivity, and ecosystems which are large enough to show a discernible effect of lengthening rotation (the effect of lowering the AAC). The magnitude of the changes is still relatively small, as explained for VR1 scenario (Section 5.2.3).

Application of variable retention alone does result in reduced risk, but at relatively low levels. As above, the effect is distributed across the entire landbase, so potential conservation benefit in specific ecosystems is relatively low. In particular, most VR occurs in the heli zone under the SELES model rules, and as a result tends to occur in lower productivity, and generally lower risk ecosystems. The variable retention results are quite sensitive to the assumptions regarding when recovering forest should be allowed to reduce the risk level.

5.4. Protected Areas 13 Scenario

We compared this scenario with the scaled basecase for VR1. This is not quite equivalent (10% AAC reduction for PA13 compared with 12.7% for VR1), however we did not have a scaled basecase for this PA run.

Short-term: reductions in risk at 20 years are relatively small, with no units having risk reduced by more than 1%, although overall risk is slightly lower (i.e. any changes are reductions). Although initially counter-intuitive (the protected area is in place at the beginning of the scenario), this result stems from the fact that most gains are made out in the future, when risk for many units would otherwise have become quite high.

Mid-term: reductions in risk at 50 years are also relatively small, however 10 ecosystems have risk reduced by >1% - primarily hemlock/ balsam high and spruce medium ecosystems.

Long-term: 29 ecosystems had risk reduced by more than 1% over the long term, with a magnitude of the reduction average reduction of 3.4%. This reduction is greater than the risk reductions associated with VR1, when a recovery threshold of 100 is used (average not area-weighted = 1.9%), but is similar to that when the least conservative risk threshold is used (RT = 0%, average risk = 3.4%).

Table 8. PA versus VR1 scaled basecase.

CH	BEC	Basecase VR1	Change in risk to PA scenario
CedarHigh	CWHvh2	86.16	-2.97
CedarHigh	CWHvm	87.45	-3.10
CedarLow	CWHws1	33.90	-1.25
CedarMed	MHwh1	38.45	-1.00
CedarMed	CWHvh2	50.73	-3.31
CedarMed	CWHvm	68.39	-3.55
CedarMed	CWHwm	55.43	-1.70
HemBalHigh	CWHws2	47.04	-4.22
HemBalHigh	CWHvh2	88.03	-2.53
HemBalHigh	CWHws1	47.66	-4.27
HemBalHigh	CWHvm	82.88	-3.40
HemBalHigh	CWHwm	49.16	-1.76
HemBalLow	CWHws2	20.69	-3.44
HemBalLow	CWHvh2	15.33	-1.01
HemBalLow	CWHvm	18.10	-1.61
HemBalMed	MHwh1	58.85	-4.27
HemBalMed	MHmm2	42.09	-5.74
HemBalMed	CWHws2	56.79	-8.60
HemBalMed	CWHvh2	63.03	-4.45
HemBalMed	MHmm1	36.34	-3.90
HemBalMed	CWHws1	77.90	-4.97
HemBalMed	CWHvm	60.91	-5.34
HemBalMed	CWHwm	51.72	-2.12
SpruceHigh	CWHvh2	62.74	-3.85
SpruceHigh	CWHvm	49.56	-2.37
SpruceLow	CWHvh2	21.06	-2.01
SpruceLow	CWHvm	36.39	-2.81
SpruceMed	CWHvh2	67.33	-5.30
SpruceMed	CWHvm	50.51	-4.84

***Note however, that it is difficult to make an exact comparison of each run using this methodology since it is not an area-weighted risk reduction, and nor does it account for minor differences in timber harvesting occurring in the different models.*

In addition, we looked locally (Landscape Unit level) at the effects of implementing the PA13 scenario:

All landscape units showed either no change, or decreased in risk as a result of the scenario, with two landscape units showing a decrease in risk of > 2% (Kwinamass and Khyex) which is quite large, given that this summarises over all ecosystems within each LU.

Table 9. Change in Risk in PA13 versus VR1 scaled basecase for the "protected" LUs at Years 100 and 150.

LU	Year	Basecase VR1	Change in risk
Campania	100	10.62	-2.97

Dundas	100	10.53	~ 0.0
Johnston	100	12.76	-0.031
Kshwan	100	18.75	-0.0003
Kwinamass	100	25.41	-2.0296
Stephens	100	10.68	0
Khyex	100	25.71	-2.5129
Banks	100	10.68	-0.0228
Hartley	100	12.22	-0.1348
Campania	100	10.64	-0.0072
Dundas	100	10.58	-0.0072
Johnston	100	15.45	-0.7649
Kshwan	100	18.70	~ 0.0
Kwinamass	100	25.22	-3.0971
Stephens	100	10.63	0
Khyex	100	26.1	-2.8581
Banks	100	10.68	-0.0308
Hartley	100	13.11	-0.4409

5.4.1. Key results for PA13 Scenario

The PA scenario results in lowered risk, equivalent to the VR scenarios when they are interpreted using the least conservative assumptions for counting recovered forest (i.e. 0% recovered, or 40% recovered).

The risk reduction for particular ecosystems will clearly depend upon the exact location of a protected areas scenario. In this case, a wide range of otherwise high risk ecosystems had risk levels reduced. Local risk levels are also reduced as a result of the scenario – which is unsurprising.

The difference in the risk estimates given for the Protected Areas example is that the risk reductions are not reliant on assumptions about biological contribution of area, or whether retention of true old forest attributes is possible. In this case, it is much more certain that the areas retained do contribute old growth values to the extent that the model says they do, so the uncertainty around the risk reductions in this case is much less.

5.5. Sensitivity Analysis: Variable Retention Assumptions

In this work we used recovery curves of variable retention harvested cutblocks to allow regrowing blocks to reduce coarse filter risk. The extent to which variable retention may in fact reduce risk will depend at least in part, with the actual attributes retained on the cutblock. In drawing the recovery curves and in modelling the output , **our assumption is that old forest attributes are retained that are fully representative of old growth forest in that ecosystem**. To test the outcome if this were not the case, we reduced the recovery curves by a percentage at each time period (0ld growth state was reached at the same time, but the earlier rates of recovery were lowered, see methods).

Sensitivity was examined using the VR2 scenario:

Short-term and Mid-term: the short-term VR gains were already small (section XX) and although risk is higher for individual ecosystems with the negative curves, the differences are within the uncertainty bounds of the model and so undetectable.

Long-term: the gains associated with VR are reduced by 1.5% (on average not area weighted), and on an individual ecosystem basis, risk was reduced by more than 1% for 26 of 48 ecosystems. As with other analyses, the ecosystems most affected by the change are high and moderate productivity ecosystems, with low productivity ecosystems in general unaffected by the assumption.

Table 10. Variable retention assumptions in VR2 – effect at 150 years.

AU	BEC	VR2 100% RT – base curves	VR2 100%RT – negative curves	Difference
CedarHigh	CWHvh2	83.84	84.87	1.03
CedarHigh	CWHvm	84.20	85.45	1.25
CedarLow	MHwh1	10.55	10.55	0.00
CedarLow	MHmm2	10.50	10.50	0.00
CedarLow	CWHws2	10.65	10.66	0.01
CedarLow	CWHvh2	10.50	10.50	0.00
CedarLow	MHmm1	11.51	11.51	0.00
CedarLow	CWHws1	32.76	33.44	0.67
CedarLow	CWHvm	10.92	10.99	0.07
CedarLow	CWHwm	34.74	34.74	0.00
CedarMed	MHwh1	37.74	39.03	1.29
CedarMed	CWHvh2	48.07	49.76	1.69
CedarMed	CWHvm	65.62	67.33	1.71
CedarMed	CWHwm	53.52	55.24	1.71
HemBalHigh	CWHws2	43.39	45.41	2.03
HemBalHigh	CWHvh2	85.86	86.72	0.85
HemBalHigh	CWHws1	44.06	46.31	2.25
HemBalHigh	CWHvm	80.26	81.35	1.09
HemBalHigh	CWHwm	46.89	50.15	3.26
HemBalLow	MHwh1	11.54	11.65	0.11
HemBalLow	MHmm2	10.50	10.50	0.00
HemBalLow	CWHws2	18.30	22.08	3.78
HemBalLow	CWHvh2	14.47	15.07	0.60
HemBalLow	MHmm1	14.37	14.40	0.03
HemBalLow	CWHws1	57.78	58.19	0.41

AU	BEC	VR2 100% RT – base curves	VR2 100%RT – negative curves	Difference
HemBalLow	CWHvm	16.73	17.63	0.90
HemBalLow	CWHwm	38.11	38.33	0.22
HemBalMed	MHwh1	54.81	57.05	2.24
HemBalMed	MHmm2	36.33	39.59	3.26
HemBalMed	CWHws2	49.73	55.17	5.45
HemBalMed	CWHvh2	59.18	61.46	2.29
HemBalMed	MHmm1	33.04	36.11	3.07
HemBalMed	CWHws1	73.60	75.95	2.35
HemBalMed	CWHvm	56.64	59.33	2.69
HemBalMed	CWHwm	50.03	52.26	2.24
Pine	MHwh1	10.50	10.50	0.00
Pine	CWHvh2	10.50	10.50	0.00
SpruceHigh	CWHvh2	59.36	61.19	1.83
SpruceHigh	CWHvm	47.75	49.05	1.30
SpruceHigh	CWHwm	21.53	22.00	0.47
SpruceLow	MHwh1	22.44	22.77	0.32
SpruceLow	CWHvh2	19.44	20.91	1.47
SpruceLow	MHmm1	42.83	42.83	0.00
SpruceLow	CWHvm	34.32	35.97	1.64
SpruceLow	CWHwm	65.04	65.17	0.13
SpruceMed	CWHvh2	63.02	65.55	2.54
SpruceMed	CWHvm	46.25	49.13	2.88
SpruceMed	CWHwm	70.74	73.13	2.39

6. Key Results and Discussion

Using natural disturbances as a guide for management at multiple scales is considered a key factor in implementing ecosystem-based management in coastal ecosystems (e.g. see CIT 2003 Handbook). As a result, a move towards variable retention in coastal ecosystems has been seen because as a harvesting approach it emulates natural disturbances in these ecosystems more than does traditional clearcut harvesting techniques.

Retaining structure within cutblocks has a number of benefits to biodiversity (section 2.0). In this analysis we make a number of hypotheses in order to quantify these potential benefits by summarising overall ‘old growth equivalent’ of a cutblock that has a mixture of retained old forest structure plus regrowing new forest. We can then compare the total amount of old forest (unharvested plus old forest equivalent) to the natural predicted amount, to determine a risk rating as previously explained in Holt and Sutherland 2003).

To date, variable retention has been implemented in a number of areas within the Pacific Northwest, and many short term experiments have commenced which attempt to quantify the implications of VR on a multitude of different aspects of old forest biodiversity. However, there are very few results yet available, and especially we have found no compilations of results that assess the overall implications to biodiversity, rather than to single species or specialised guilds. We therefore used expert opinion to draw some general recovery curves for different coastal ecosystems, and then made a number of modifying assumptions to alter the shape of the curves under different scenarios. Although we feel this is a reasonable general approach, we point out that these are only hypotheses, and as yet real data are unavailable to test them. However, this would be an interesting approach to test as data does appear from the range of experiments currently underway.

This analysis is the first attempt that we are aware of, to attempt to quantify and compare the coarse filter biodiversity gains possible from implementing variable retention over a large geographic area such as the North Coast LRMP area.

Given the pace of the LRMP tables set by government, it is extremely difficult to carry out detailed technical analyses of the sort being attempted by the North Coast planning table. Ideally, the results presented should be explored in additional detail, however, this timeframe precludes that.

Key results are summarised below:

- Reducing the AAC in order to implement the VR scenarios (12.7 and 17% for VR1 and VR2) had smaller impacts on risk than initially predicted. In particular, the VR1 reduction had almost no discernible change to ecosystem risk at the regional scale[9], while the VR2 reduction resulted in a relatively small reduction in risk for a number of ecosystems. This low level of effect can be explained by the relatively low *difference* in old forest harvested *within each ecosystem* over the total landbase in the different scenarios. Although the rate of harvest is changed, the location of harvest does not, and the AAC reduction results primarily in an effective long rotation in the timber model – the transition from old to managed forest in VR1 is 140 to 160 years. The VR1 AAC reduction appears too small on this constrained yet diverse landbase to significantly impact *regional* risk for ecosystems. The VR2 AAC reduction is approaching the order of magnitude where reductions in risk are observed.
- Variable retention did result in lower risk levels, compared with clearcut harvesting, though the reduction differed with the scenario (VR1 / VR2), the ecosystems involved, and the assumptions being applied:
  - Ecosystems with high operability and high levels of past harvesting (e.g. most cedar high ecosystems) see generally low risk reduction occurring as a result of VR. This is because risk is already high or very high, and the amount of area available remaining to ‘reduce risk’ by implementing VR is very small. Although VR generally results in lower risk in these ecosystems than does clearcut harvesting, the reduction in risk is very small and these ecosystems remain at high risk into the future.
  - Variable retention had very little influence on risk levels for lower productivity ecosystems because relatively little harvesting occurs there, and overall risk is dominated by the large area of inoperable forest, generally maintaining low risk. In the scenarios examined, much of the VR was modelled to occur in the designated “heli- zone”. These areas tend to be lower productivity sites in many cases (A. Fall pers. comm.). The potential biological gains associated with VR may therefore have been lost when the most benefit could likely have been garnered from higher productivity sites which were lower risk but move to high risk over time and under conventional management.
  - Ecosystems with high operability, but relatively low levels of past harvesting (e.g. some cedar/ hemlock medium, hemlock/ balsam medium and spruce ecosystems) do have a reduced risk as a result of variable retention. Even the most conservative assumption of recovery (100% RT) results in lowered risk for these ecosystems, at least in the long-term. Short-term gains are considerably lower, and occur only for a very limited number of ecosystems.
  - Comparing the two scenarios, risk is reduced for the same ecosystems, except that the VR1 scenario also reduces risk for an additional 5 ecosystems over VR2 in the long-term. We cannot determine whether this is a result of different levels of retention, or different placement of VR harvesting in each scenario. The results highlight the need to target variable retention

[9] I.e. risk is still considered at the level of ecosystems, but ecosystems at the regional, not local scale.

application, if the intention is to reduce risk. A generic guideline for application of VR (such as those given in the SELES model) may, or may not, result in the desired effect – depending on their specificity.

- Variable retention (at least for VR2 over the long-term) does result in lower risk levels compared with clearcutting. However, the magnitude of the risk reductions was relatively small. There are a number of reasons why this may be the case:
  - the percentage of the landbase being impacted by variable retention is relatively low, and distributed across a range of ecosystems. Hence the actual level of VR per ecosystem is quite small, and does not dramatically affect risk.
  - The VR scenarios are compared to their scaled basecase – i.e. a scenario that has the same harvest rate, but is applied by clearcutting rather than partial harvest. So, while on any particular VR cutblock trees are retained, an equivalent number of trees are removed from an adjacent block. The risk is therefore *distributed* over a larger area and time frame and overall risk stays relatively even. In addition the extra roads required to implement the ground-based (not heli) VR resulted in increased landbase loss over the 150 years, and so further increased risk for some units.
- The scale at which we are investigating risk – at the level of the subregion – affects the apparent result. At the scale of individual landscape units or watersheds variable retention can result in lower risk values, but at the level of the region, the benefit can be offset by the increased harvest in an adjacent watershed / landscape. Our analysis does not say that local benefits are not obtained from VR, rather than without more specific planning rules, the overall benefits may be cancelled out over the landscape.
- The direction of the changes is in some cases contrary to expected, for example some ecosystems increased in risk even with application of the VR scenario. This is due to a number of factors:
  - Arbitrary placement of VR. The VR was not targeted to particular ecosystem types, rather it was applied across all units[10], and so did not necessarily impact those units of concern (e.g. those which are low / moderate risk now, but increase in risk in the future).
  - Ecosystems at high risk currently will continue to rise in risk, whether clearcut or variable retention harvesting techniques are applied
- The protected areas scenario was not a true comparison with the others, because we had to compare it with a similar, but not identical basecase. However, the comparison provides an overview of the relative risk reduction. Long-term risk was reduced by this scenario to an equivalent extent to that seen in the variable retention scenarios (VR1 and VR2) but only when the least conservative assumptions regarding retention are used (0RT and full old forest retention). Short or mid term risk were not greatly affected, because either ecosystems are at high risk and protection now cannot bring back old forest (which is what is required to lower risk), or because ecosystems were moderate or low risk and variable retention needed to be applied through time before risks were reduced. When the most conservative assumptions are used (e.g. the forest must be fully recovered before it can reduce coarse filter risk) VR has apparently fewer conservation benefits. However, the level of reduction is more certain for the PA13 scenario simply because we are more certain what old forest attributes are being maintained over time, and the interpretation does not rely on recovery assumptions, or assumptions regarding the quality of the stand structure retained on site.
- Risk reductions associated with variable retention are reliant on assumptions regarding the recovery rates of the forest and the ‘quality’ of the retained attributes. These two assumptions are discussed below:

[10] Harvest is applied using two rules: a) oldest first modified by b) accessibility (the model prioritises harvest in areas that are already roaded).

Assumption: That biologically, a stand with a particular recovery level (e.g. 40%) can be converted into an old growth equivalent area (40% * 100ha = 40ha old forest). This assumption will be false particularly where unique old growth attributes accumulate through time – i.e. where a 50% recovered stand never contains particular elements of 100% recovered true old growth stand.

In all the runs presented, we used a recovery threshold of 100% as the base comparison. This means that an area of forest must be 100% recovered before it can be counted a equivalent old forest. In addition, we also examined the implications to risk of using different recovery thresholds (40 and 0% - i.e. an area must be 40, or 0% recovered before it can contribute to lowering risk). As expected, the benefits of implementing variable retention are quite sensitive to this threshold.

We can hypothesise that the assumption is more likely to hold at higher levels of recovery, and less likely at low levels. It is quite likely that 5% recovery of a block towards old growth conditions does not provide any of the structural or biotic values present in 5ha of old forest. However, at 80% recovery, it is much more likely that the unique attributes of old forest will be present at least at some level.

Using thresholds of 40% and particularly 100% recovery in the VR2 scenario, many of the regional scale gains associated with VR are lost and the scenario becomes a similar risk level than the scaled basecase at the regional scale.

Assumption: that all retention is representative / fully functioning old growth forest, spreading 'old forest influence' throughout the cutblock.

This assumption may not hold under the following circumstances:

i) Where non-representative trees or patches are retained

ii) Where there is selective (non-representative) harvest of a particular species, such as red or yellow cedar

iii) Where retention is lost due to windthrow (at a higher probability than seen in unharvested forest stands)

iv) Where retention is on the edges of patches, not contained within its boundaries (i.e. there is no forest influence effect)

v) Where wildlife / dead trees are lost due to worker safety concerns

vi) Where understory or other attributes (e.g. coarse woody debris or microclimate) are not retained in concert with retained trees (e.g. particularly in dispersed retention where standing structures are retained, but all other old forest attributes are lost)

To 'model' the influence of this, we reduced the recovery curve for 30% dispersed retention, and examined the change in risk levels for ecosystems. Short-term and mid-term effects were small (because not much VR had occurred, or recovered in any scenario in the Short-term), but in the long-term the gains associated with VR were reduced by 1.5% (on average not area weighted), and on an individual ecosystem basis, risk was reduced by more than 1% for 26 of 48 ecosystems. As with other analyses, the ecosystems most affected by the change are high and moderate productivity ecosystems, with low productivity ecosystems in general unaffected by the assumption.

The implication from this sensitivity analysis is that the values associated with variable retention cannot be fully predicted (or expected) unless there is certainty about the actual attributes being retained. Retention that is not representative of the old forest within a particular ecosystem will not provide the risk reductions observed in some of these scenario runs.

6.1. References

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