Accounting for stand-level retention: background material

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[1] This paper is not intended to be a full literature review due to time constraints. Instead, it relies on the literature collections and knowledge of the authors.

Disclaimer

This report was commissioned by the Ecosystem-Based Management Working Group (EBM WG) to provide information to support full implementation of EBM. The conclusions and recommendations in this report are exclusively the authors', and may not reflect the values and opinions of EBM WG members.

Purpose of the paper

The current Land Use Objectives include landscape level retention targets, and a minimum stand level retention target (15%). This paper was requested by the EBM WG to provide recommendations around:

- If, and under what circumstances stand level retention could 'count' towards landscape old growth targets; and what attributes must it have to meet old growth criteria?
- And how changes in species composition created through partial cutting should be addressed in old growth representation accounting.

Investigation of these questions raised a number of issues around implementation of retention under EBM that also pertain to revision of the LUOs. For simplicity, we present our main findings with short rationale upfront. More detailed science summaries are found in the main section of the paper.

Summary of Assumptions and Recommendations

The Coast Information Team (2004) made EBM recommendations that included a variable stand level retention target of 15 – 70% within stands. However, the current Land Use Objectives (LUOs) only require a minimum retention level of 15%, and there are no incentives to encourage the full range of stand level retention. We use a number of guiding principles, or assumptions, in writing this paper, including:

- We reiterate that the full range of stand level retention as outlined by the EBM Handbook **is** biologically appropriate (15 – 70%); we would expect that over a large area the average level would not fall close to the low end of this range;
- That conservation biology principles require stand level retention levels to reflect local landscape context – in particular, where landscape retention levels are low and harvesting continues, **higher** stand level retention should be used to attempt to minimise any additional increases in risk;
- After reviewing the functions of stand and landscape level retention, even where functions overlap, it is unlikely that stand level retention ever fulfills the goals of 'landscape retention' as effectively as real landscape retention. Making a trade-off between these levels therefore is difficult to justify unless the landscape is at low risk (see following discussion for rationale).
- That 'trading off' stand for landscape level retention is being promoted as an incentive or mechanism for creating appropriate levels of stand retention. However, science suggests there is a very limited series of circumstances where this trade-off is ecologically appropriate (see following discussion for rationale). Therefore, alternative mechanisms to promote good stand level retention should be found.

The following recommendations[2] are therefore made:

- The LUOs should reflect the ecological need to promote a range of stand level requirements. This requires more than a minimum 15% retention level. We suggest including a requirement for a full range of retention levels. [R1].

[2] Note that this list of recommendations sometimes encompasses multiple recommendations from the text. The individual recommendation number is noted in brackets after each.

- Where landscapes have seen significant harvesting to date and where ecosystems (or, until appropriately defined, SSS) are at high risk today, a considerably higher stand level minimum is appropriate. There is little science to promote a single target number, but information on useful stand level retention levels (see rest of paper) suggests greater than a 30% minimum would be ecologically appropriate. [R3].
- Counting stand towards landscape-level retention targets is only strictly ecologically appropriate when stand level retention meets the same function as landscape level retention. This only occurs only for interior habitat conditions (i.e. when a patch is >7ha. [R4].
- When the landscape is at low risk (i.e. with a 70% of natural old growth landscape level target), AND when stand level retention can be considered 'excellent' (i.e. when it is >30% retention and mirrors the profile of the pre-harvest stand and provides forest influence within the cutblock), counting could occur with ecological benefits that outweigh the costs. [R2,5,6,8,9].
- Retention should never be double-counted. [R10].
- Acknowledging uncertainty, focus on identifying the most sensitive species, so that monitoring can be focused and useful. Then apply a variety of retention levels and check whether the most sensitive known species are maintained in landscapes with various combinations of stand versus landscape level retention. [R11].

<u>Key for application</u>

We suggest that these limited circumstances are the only occasions when stand level retention should be counted at the landscape level, under an ecological rationale for EBM.

→ Is the landscape unit at low risk (i.e. do all ecosystems or SSS have targets of 70% of natural old-growth).
No = no counting
Yes. Continue

→ Does the stand level retention create interior habitat? – i.e. is it a patch >7ha?
Yes – count the interior portion towards landscape level targets as 1:1.

→ Does the stand level retention meet excellence standards – i.e. is it >30% retention **and** does it reflect the profile (no high-grading), **and** is it mapped and permanent **and** is it within or directly adjacent to the cutblock.
No = no counting
Yes – count some portion as per suggested accounting rules below.

<u>Accounting proposal [R7].</u>

- Interior portions of patches larger than 7ha could be counted as equivalent to landscape-level retention.
- Retention that matches the Recommendations above may be counted in the following proportions (i.e. interior forest patches and 'excellent' retention):

- Retention between 30 and 80% should count at half or quarter value (i.e. 2 ha of 50% retention = 0.5 ha of old forest).
- Retention between 80 and 100% counts as proportional value (i.e. 1 ha of 80% retention = 0.8 ha of old forest););.

The remainder of the paper provides a discussion of the science background that has lead to these recommendations.

Discussion of Science and Recommendations

1. Should stand-level retention count towards old growth representation targets?

The CIT Handbook recommended variable retention levels of 15 – 70% within stands. However, currently there is no requirement to provide that range of retention levels, nor any requirement that average retention levels fall within that range, and no guidance where the higher levels (or lower) levels are appropriate. Rather, there is simply a legislated minimum of 15% stand level retention. There is sound evidence to suggest that there is an ecological benefit to a range of retention levels, and to levels of retention substantially beyond this minimum level.

Mechanisms (legal directions or some type of incentives) should be found to encourage a full range of retention from 15 – 70%. It has been suggested that one possible mechanism is allowing some levels of stand retention to 'count' towards landscape level targets thus providing an incentive for stand level retention above the 15% minimum. However, counting stand-level retention towards lowering landscape old growth targets is likely not the best vehicle to encourage a range of retention. First, stand level and landscape level retention function for largely different purposes, hence tradeoffs are not straightforward and seldom appropriate. Not straightforward, because even when stand-level retention may address some of the same objectives as landscape-level retention, it usually doesn't address them as effectively as landscape level retention would; and seldom appropriate, because the two approaches to representation are intended to be complementary, to work together in addressing conservation goals. Second, there is some minimum level of landscape reserves we consider necessary to meet a low risk goal—and so 'counting' stand level retention towards landscape targets would only be possible when landscape reserves are well above that minimum level. Hence, even in situations where stand level retention could philosophically be considered to be contributing somewhat to the goals of landscape level retention, counting stand-level representation towards landscape-level targets will only be appropriate where landscape retention is high. In addition, encouraging appropriate stand level retention by trading off against landscape level targets will work counter to the ecological premise that stand level retention should be higher when landscape level reserves are low, since this is exactly the situation when all landscape reserves should be maintained AND stand level retention should be higher.

In this paper we outline a narrow range of situations where we consider stand level retention **might** count towards landscape targets. We suggest strongly that more practical means of encouraging ranges of retention be explored. Ideally stand retention should be planned in the context of characteristics of the landscape and adjacent stands[3], and not be calculated by how much landscape requirements can be reduced.

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[3] Conservation planning theory suggests that ideally a range of stand-level retention would be practiced, leading to a variety of stand conditions suitable for a wide range of species. The range of levels of within-stand retention should reflect conservation objectives, current landscape condition, and the character and extent of existing cutblocks. Where a landscape unit is dominated by cutblocks that have had low levels of retention, higher levels of within-stand retention should be planned to moderate the effects of additional harvesting. In areas of low levels of *landscape* retention, higher levels of stand retention also should be encouraged. Where landscape reserves are a large proportion of the area, higher levels of within-stand retention are likely to be less important.

Recommendation 1: Develop direct mechanisms to encourage appropriate stand level retention within EBM other than reducing landscape requirements (e.g. modify legal objectives to be consistent with the original intent). This should include managing to the original range (15-70%), and selecting specific retention levels that reflect conservation objectives, current landscape condition, and the character and extent of existing cutblocks.

2. When should it count?

2.1 Goals of retention at different scales.

The following section discusses roles of retention and how much retention is functional for different species at different scales. In general, landscape-level representation and stand-level retention serve different ecological functions and are designed to meet different goals. There are ecological benefits from both levels of retention.

At the landscape scale, retention of unmanaged areas is generally intended to provide habitat for a variety of species and space for ecological functions to continue without significant ongoing management intervention. In an EBM context, landscape-level retention is usually in larger blocks and is primarily intended to maintain focal ecosystems (e.g. late seral and interior conditions, special habitat types, rare ecosystems and hydroriparian ecosystems) and to represent all ecosystems at a level at which they can maintain ecological functions. Landscape-scale retention functions to provide habitat for focal species that are known to be associated with old forest structures (e.g. Marbled Murrelet) and for those species and communities averse to edges and openings.

At the stand scale, retention serves three primary functions (Franklin et al. 1997): 1) maintaining ('lifeboating') species and processes through the disturbance process that would otherwise be absent from early seral stands, 2) enriching re-established forest stands with structural legacies, so that they develop complex structures and begin to function as older stands sooner than they otherwise would; and; 3) enhancing landscape connectivity by providing a habitat mosaic in which organisms can move over small scales[4]. Lifeboating implies a persistent occupancy of the cut stand by some species through the whole disturbance, establishment, and stand development process. Structural enrichment is intended to allow re-establishment by other organisms which may be initially extirpated locally during the disturbance process or in the early seral stages thereafter. Connectivity maintains a habitat mosaic that not only provides direct habitat for some organisms, but facilitates dispersal of others between old forest patches. Additionally, and of critical importance, stand level retention serves to protect specific small features or ecosystems such as swampy areas, bear dens, nest trees, and other localized features. These typically occur at scales too fine to be represented at the map scales used in landscape planning and are often only identified in on-the-ground mapping and planning of stand-level treatments.

Stand-level retention will never provide most of the roles for which landscape-level retention is intended. It will never provide ecosystem representation (although it may contribute protection for small pieces of ecosystems it will never represent all ecosystems at a level at which they can maintain ecological functions); it will not maintain focal ecosystems; and, for the most part, it won't provide habitat for the full range of species that are known to be associated with old forest structures and for those species and communities averse to edges and openings. It is possible that stand-level

[4] Although maintaining connectivity can be a function of stand level retention, we don't address connectivity issues here due to the complexity of defining and measuring connectivity for different organisms at different scales and resulting confusion how stand level connectivity may be "traded off" for landscape level connections.

retention could include patches large enough to provide forest interior habitat for focal species and communities averse to edges and openings. Stand level retention should count towards *landscape targets* when it plays this *landscape* type role.

We suggest that, *to the extent that ecological goals overlap*, stand level retention could 'count' towards landscape-level targets for old growth. The only clearly overlapping function is providing forest interior.

Basically, we believe that stand and landscape retention are serving mostly different functions. However, we also acknowledge that there are multi-scaled relationships where efforts at the stand-level alter the characteristics of landscapes. Also, we are aware that our definitions of "stands" and "landscapes" are based on our perception as humans, and that many organisms perceive "stands" and "landscapes" at an entirely different scales. We hypothesize that stand level retention that is very successful at fulfilling stand-level roles may make a difference at the landscape level. The main stand-level roles are 1) lifeboating and 2) enriching stands with structure from the former stand. Although we would prefer to see a more direct way of promoting those higher retention levels, one way ***may*** be to give credit towards landscape targets. However, because of the very different roles of landscape and stand retention, such tradeoffs should never compromise basic levels of landscape representation.

Recommendation 2: If landscapes are managed to low risk, trade-offs between stand and landscape level retention may provide more benefits than costs.

2.2 Allocation of retention between landscape and stand

It is not possible to provide guidance on the optimal mixes of landscape reserves and stand retention. In fact, an optimal mix *cannot* be determined, even theoretically – there are too many species with too many differing requirements. For example, Huggard (2006) documented response curves of different bird species to varying retention levels. He found that a full range of responses: some species were generalists and do not respond negatively to forest management; others would benefit more from stand-level retention than by allocating the same amount of uncut forest as landscape level reserves; yet others were negatively affected by even small amounts of harvest and would be better accommodated by having landscape level reserves even if retention levels were high. A similar mix of response curves can likely be found for most groups of organisms. This finding supports Rosenvald and Lohmus's (2007) recommendation to create a mix of retention levels within stands, and also shows the importance of having both stand and landscape-level retention.

Most theoretical and empirical studies agree that total amount of habitat is more important than habitat pattern except at low levels of habitat abundance (McGarigal and McComb 1995, Fahrig 1997, 2002, Schmiegelow and Mönkkönen 2002). If the amount of habitat across the landscape is too low, organisms are absent even from patches of suitable habitat (e.g. Gibbs 1998, Hargis et al. 1999, Carson 2000, Lennartsson 2002). Bird communities in small old growth reserves, surrounded by managed forest of various ages in Scandinavia, were more similar to those in young forest than to those in ecologically similar large reserves (Vaisanen et al. 1986, Virkkala 1991). The conclusion from these studies is that simply reserving suitable habitat (in patches within harvested stands or corridors between old growth patches) does not guarantee success if habitat representation over the landscape is insufficient. Retention in patches and corridors can be an effective **supplement** to large areas of old growth forest in the landscape for maintaining biodiversity, but are not sufficient in isolation (Perault and Lomolino 2000). This supports the principle that stand and landscape retention fill fundamentally different roles, yet act together to affect landscape characteristics. These studies suggest that where little unmanaged forest remains, the amount of landscape level retention should not be reduced to promote stand level retention. We know that some sensitive species need large blocks of unmanaged area, and landscape level reserves are likely to maintain attributes with higher certainty.

In addition, in those landscapes with little remaining old forest, it is even more important to use stand level retention to create habitat. It is especially in these areas with low landscape reserves that high levels of within-stand retention can have high benefits.

Recommendation 3: If harvesting occurs in high risk landscapes, higher levels of stand retention should be required[5]. It is critical to find mechanisms to increase the minimum 15% retention in landscapes where representation is at or near 30%.

2.3 So when does stand retention meet landscape level goals?

In this section we discuss how stand retention could provide the 'landscape-type role' of providing forest interior. We then discuss the levels of retention that would be necessary for a stand to provide 'excellent stand-level function' for lifeboating and structural enrichment. Note that although most stand retention will not meet requirements for forest interior, smaller patches will contribute to lifeboating or structural enrichment functions and may contribute (at least partially) to landscape retention targets.

2.3.1 Interior forest: a landscape-level function

We suggest that to the extent that stand level retention provides forest interior conditions, it should count towards landscape retention targets. Interior old forest conditions occur at the point where edge influence ends. This point varies by species and process. Microclimatic effects of edge (temperature, air and soil moisture, wind speed, light) are well documented, and can extend 1 – 3 tree heights (or to about 150 m) into forests, depending on aspect and specific type of effect (e.g. Chen et al. 1995, review in Kremsater and Bunnell 1999). Biotic edge effects tend to concentrate mostly within the first 50 – 100 m, although reported biotic edge effects range to hundreds of metres (Kremsater and Bunnell 1999, Harper et al. 2005, Lindenmayer and Franklin 2002) depending on organism and characteristics of edges. A detailed study of edge effects is currently underway by Marcot (pers. comm.); preliminary data suggest a very wide range of species-specific patterns and no one "depth of edge influence" defining a specific core area of interior forest environments or species' habitats.

Forests with rare to infrequent natural stand-replacing disturbances will have more interior old forest under natural disturbance regimes than will more frequently disturbed ecosystems. Consequently, they may have more pronounced and ecologically important edge effects (Harper et al. 2005).

Based on a distance of 150 m (a conservative depth, although not the largest recorded, for microclimatic effects), patches 7 ha or less would include little or no interior forest conditions. Patches 16 ha in size would include 1.8 ha of forest free of edge influence. Therefore, to count towards old forest retention for the forest interior goal, in-stand retention patches should be at least 7 ha. Based on the smallest average edge effects of 50m (some effects are smaller), a 0.75 ha patch has no interior. At a depth of 100 m, patches need to be more than 3 ha to have any interior. At 7 ha, patches could be considered to provide forest interior habitat from a microclimatic perspective. Whether this patch size provides suitable habitat for species depends on many other requirements than forest interior. We propose that the interior portion of stand-level patches could be counted towards landscape representation targets. We recognize this is conservative as smaller patches likely provide interior conditions for some organisms.

[5] This type of landscape/ context-specific modification of planning is based on basic conservation biology principles.

These smaller patches may contribute to landscape targets because of meeting either the 'lifeboating' or 'earlier functioning forest' roles discussed below.

The 7 ha estimate may not be that conservative for values other than microclimate, however. An ongoing, unpublished study has found that 22 ha old forest patches maintain only a fraction of all species found in unfragmented old forest cover nearby (B. Marcot, personal communication). Note that it is difficult to critique this study; it is not yet published and we cannot assess whether a species area/relationship is responsible for the result, or if the finding indicates that very large forest blocks are beneficial for some species for reasons that are not yet clear.

Recommendation 4: Interior portions of patches larger than 7ha could be counted towards landscape-level representation targets even if landscape-level representation is low. Make sure only at low risk landscapes

2.3.2 Lifeboating: a stand-level function

Life-boating is an important role for stand-level retention and, if done well, acts to create habitat for some species over a landscape. According to the literature retention levels need to be fairly high to provide lifeboating for a wide-range of organisms. The "Scientific Background to EBM" (CIT 2004) suggests that a minimum of 30% retention of old growth stand structure within stands would serve as life-boating for some late-seral organisms. We looked for new information to update that preliminary estimate and found a recent comprehensive review of 214 studies examining the effects of retention on lifeboating in forests from North America and Europe (Rosenvald and Löhmus 2007). We believe it to be the most recent, relevant review of the topic and summarise the findings of their meta-analysis below.

Rosenvald and Löhmus (2007) found that stand-level retention provides lifeboating to some organisms but not others. For instance, ectomycorrhizal fungi, epiphytic lichens and small ground-dwelling animals such as carabid beetles, salamanders, and the vole *Clethrionomys gapperi* benefited the most from stand level retention across a wide range of forest types (review in Rosenvald and Löhmus 2007). However, even at high levels of retention, most sensitive and rare liverworts, some bryophytes and most forest-interior saproxylic beetles still disappeared (for a period at least) soon after harvest (refs in Rosenvald and Löhmus 2007). Immediate post-cut survival of various forest taxa increased not necessarily linearly, with the amount of retention (Rosenvald and Löhmus 2007). For example, for ground-dwelling bryophytes, late-seral vascular plants and flying squirrels, retention of less than 20% did not improve the value of the stand relative to clearcutting, while shelterwood stands (34 - 50% retention) resembled undisturbed forests for these species (refs in Rosenvald and Löhmus 2007). Because most studies are short-term, knowledge about the long-term effectiveness of lifeboating is severely lacking.

We consider that the review of Rosenvald and Löhmus (2007) supports our preliminary finding that 30% retention is a minimum to achieve lifeboating for that subset of species that respond to it. They acknowledge that not all species respond to lifeboating, even at high levels of retention (i.e. 50% does not represent unharvested forest for all species). Clearly, for lifeboating, there are benefits to providing a variety of retention levels over the landscape.

Recommendation 5: Only retention levels above 30% should be considered for any type of tradeoff with landscape targets.

2.3.3 Providing Forest that Functions as Late-Seral Forest Earlier in its Development: a stand-level function

Although, for some species, retention may not serve as a lifeboat immediately after harvest, it can create suitable stands for those species over time. The main effect of structural enrichment is due to the use of retention trees as substrata or microhabitats, but the trees also create microclimate, and affect species and structural changes in the surrounding forest (Rosenvald and Löhmus 2007).

Studies in stands which were harvested with retention many years ago are few, so it is difficult to assess the impacts of retention on creation of older forest attributes, but some effects of retention are reasonably well-known. Bryophytes – poorly surviving on the cuts in the short term – were able to re-occupy young stands in the presence of substrata and source populations nearby (Löhmus and Löhmus , in press, Baldwin 2000). As well, carabid beetles in older remnant patches included forest specialists (Pearsall 2003). Epiphytic lichens and forest bird communities in 60 – 80-year old harvested stands resembled similarly-aged (not old) naturally disturbed stands most when more structure had been retained at harvest (Price et al. 1998). Just when retention patches appear to be treated functionally as older forest is not clear: for some species it is right away after harvest, for some it may be quite late in the rotation and may depend on proximity to other old forest. For some species, structural enrichment is not sufficient even over a full management rotation: small (< 1 ha), 120-year-old stands with 25% retention, within an oldgrowth matrix still did not support the same epiphytic lichen communities as paired oldgrowth stands (Price and Hochachka 2001).

In their review, Rosenvald and Löhmus (2007) also analysed the success of retention at enriching structure—and noted significant benefit in terms of species using the stands earlier than might otherwise be expected. They noted that the current state of knowledge does not yet provide an answer to the optimum amount of retention. In their meta-analysis, the highest levels of retention they considered (16 – 33% and 34 – 50% classes) had significantly different species richness and abundance when compared with clearcuts, whereas the lowest retention levels (< 15% dispersed retention and < 20% group retention up to 1 ha) did not differ. These results are supported by Huggard's (2006) analyses of structure and birds responses to variable retention. However, Rosenvald and Löhmus (2007) were unable to detect differences between 16 and 50%, likely because of high inter-species variability. Because species vary in their response, they note that there is a need to vary retention levels across the landscape to meet the needs of different species. Small, young trees do not function for lifeboating epiphytes and play little role as structural enrichment for many years (Lohmus et al. 2006).

Guidance arising from this discussion suggests that

a) retention below 15 – 20% (the lowest classes in Rosenvald and Löhmus 2007) has very limited value for structural enrichment; retention above this level has value for some species;

b) data are currently insufficient to provide an ecological basis for an optimum level for structural enrichment above the 15 – 20% minimum; optima vary among species and hence there are benefits to varying retention level.

Recommendation 6: Because retention below the 15 – 20% class benefits only a few species to a significant degree, retention below 20% should not be considered as fulfilling

the potential of stand-level retention and thus should not be considered for tradeoffs against landscape targets for old growth[6].

2.3.4 What level of retention provides a functioning 'unmanaged' stand?

Whether a partially harvested stand functions as an uncut stand will vary for individual species. In this context the most appropriate species to consider are therefore the most sensitive. Research has shown that even small levels of removal (20%) (i.e. 80% retention) alters bird communities from unmanaged communities (Huggard 2006). In a review of landscape-level thresholds, we found some support that 60% retention of a species' habitat at a landscape scale (i.e. 70% of natural old forest in coastal BC) posed low risk to most species (Price et al. 2007). This result can theoretically be applied equally well to the stand level. That is to say that organisms for which a "stand" represents their ecological landscape (i.e. small organisms that perceive a stand as a mosaic of habitat patches), may show that same rough pattern—60% stand retention could represent an unmanaged condition for them.

We know very little about long-term effects of retained structure: impacts might decrease as stands recover; conversely, full impacts may not be detectable for generations due to extinction debt. In their review, Rosenvald and Löhmus (2007) used 50% as an upper limit for what they considered stand-level retention and note that above 50% plant community structure changes significantly (Deal, 2001) to become more like intact forest.

Some organisms will be missing or have considerably reduced abundance even from the highest retention blocks (for example Brown Creeper seems to drop off suddenly when stands are harvested). Therefore 2 hectares of 50% retention are not equivalent to 1 hectare of old forest because the same sensitive species may be absent (or almost absent) from all 50% retention stands.

Recommendation 7: Because even at 80% retention some species will not respond to the stand as unmanaged, harvested stands should count only partially towards landscape representation targets even at high levels of retention. And, because 2 hectares of 50% retention is not equivalent to 1 ha of 100% retention, it is not appropriate to count retention towards old forest targets at the proportion retained (see Accounting Section).

3. Characteristics of stand –level retention necessary to be considered excellent retention.

As well as meeting the percentage requirements discussed above, stand-level retention must meet several other attributes before it can be considered excellent retention and hence a candidate for supplementing landscape-scale function. Consideration of 'excellence' includes considerations of level of retention, location, tree species composition and implementation issues around mapping and permanence.

Partial harvest, particularly in high retention blocks may increase shade-tolerant species, but this change would occur similarly in naturally disturbed stands. Almost all harvesting shifts tree species composition from late seral species to an early seral assemblage – and perhaps, if it is an early seral stand, that is appropriate. This becomes an issue in terms of landscape context – if the shift is in all or most of the

[6] Note in the final recommendations we use 30% as the basic cut-off for excellent retention, rather than 20%, due to the significant additional benefits apparently associated with this higher level of retention (i.e. lifeboating).

stands across the landscape, it matters a lot. If it is in a few patches in the landscape mosaic, it doesn't matter at all. Where we need more information to make recommendations is where the transition between the two cases occurs. The requirement for representation ensures a certain amount of old natural forest. That other parts of the landscape have early seral species for a time is not likely an issue.

We do know that harvesting biased towards one species (e.g. western redcedar), however, could reduce the ecological value of the remaining stand for some species. Among the studies reviewed by Rosenvald and Löhmus (2007), tree species appeared the most influential factor in the effectiveness of retention. They suggested that the most important tree species to maintain included rare species, those with particular qualities and species with high future value for biodiversity (resulting from low mortality and development of ecologically important features). Their findings confirm that to meet the criteria for excellent stand-level retention, harvesting should not change the species profile of the pre-harvest stand. Landscape-level effects again depend on the extent of the change over the landscape.

If EBM is being correctly implemented (ecologically and economically – see FPB 2008), systematic changes in species composition should not occur. We recommend that EBM guidance be followed and species shifts in stand composition be avoided.

Retention must capture the profile of the stand, that is, it must represent the site series, species composition and structure of the pre-harvest stand. Because larger structural elements have higher ecological value for more species, bias towards larger tree size is encouraged. Retention that has low basal area or low productivity sites compared to the preharvest stand are not acceptable as excellent examples of retention.

Recommendation 8: To be considered as excellent retention, in-stand retention should be greater than 30%, match the profile of the pre-harvested stand for site series and species composition, and should either match the profile for structural elements or be biased towards larger structures.

To provide ecological benefit, retention must add forest influence to the block. In general, this means that retention must be within the block. Retention directly adjacent to the edge of the block would be acceptable, if it is mapped, permanent and meets profile criteria.

Recommendation 9: To be considered as excellent retention, in-stand retention should also be within a block, or adjacent to a block, and mapped and permanent.

Retention can be counted as **either** landscape or stand-level retention. If riparian zones, or oldgrowth management areas or wildlife habitat areas have already been counted as landscape features they cannot then also be counted as stand level retention (that could then reduce landscape level requirements). Alternatively, if those areas are counted as stand-level retention, they then should not also be counted as landscape level retention. The decision must be made for although those features may add forest influence to the block, the double counting masks the actual overall retention levels. Riparian features are sometimes stand level and sometimes landscape level. While we agree that riparian corridors are features of landscapes, narrow stand-level buffers don't maintain intact streamside habitat (see Hydroriparian Planning Guide and background documents). Thought needs to be given as to when riparian buffers actually contribute to unmanaged forest (we suggest 1.5 tree height buffers).

Recommendation 10: Retention should not be double-counted.

4. Suggested pattern of accounting.

The recommendations listed above suggest that stand-level retention can count "partially" towards ecosystem representation under a narrow range of conditions. We recognize there is a need for rules about how to count retention, but also realize any rules will make us seem more certain than we are about how stand and landscape retention function together. Nonetheless, we suggest a working protocol, with the important proviso that any precise numbers will be wrong (we have no unequivocal reasons for choosing 50 vs 45% or 70% vs 80%, etc), that learning and improving is more important than getting the numbers 'right' (and there are no unequivocally 'correct' numbers for the array of species and functions). This section provides some specific accounting guidance about how much each level should count (a continuous function could also work).

- Interior portions of patches larger than 7ha could be counted as equivalent to landscape-level retention.
- Smaller patches of 'excellent' stand level retention may only be counted towards landscape targets for old growth under certain conditions:
    - when landscape old growth targets reflect a low risk threshold (i.e. 70% of natural);
    - when the retention matches the profile of the stand for site series and species composition and matches or exceeds the profile for structure;
    - when the retention provides forest influence (i.e. is within or directly adjacent to the block);
    - when retention is permanent and mapped;
    - when they are not double-counted
- Retention that matches the above criteria may be counted in the following proportions:
    - Retention between 30 and 80% should count at half or quarter value (i.e. 2 ha of 50% retention = 0.5 ha of old forest).
    - Retention between 80 and 100% counts as proportional value (i.e. 1 ha of 80% retention = 0.8 ha of old forest);).

We repeat that although counting stand level retention towards landscape targets will encourage a range of retention under the narrow range of conditions noted above, it is not the best vehicle for encouraging a range of retention. Means should be found to encourage a range of retention in all landscape, and encourage higher retention in areas where landscape retention is low, or where harvesting has not left much retention in historical blocks.

5. Learning versus Adopting Rules

We expect that the EBM Working Group wanted us to develop simple rules to govern how stand retention could count towards landscape targets. We have provided some of these rules above, but stress that they remain hypotheses. The difficulty with adopting rules that specify, for example, 30% retention (or 80% retention, or 7 ha patches, or a sloping function between 30 and 70%, etc.) counts as landscape representation, is that these rules imply we are certain of the exact shape of species responses, or at least certain enough that we are confident that the numbers and shapes of relationships lead to clear, quantitative recommendations. The tremendous variety among species, paucity of studies on local ecosystems, and lack of research on natural disturbance, indicates that, though we have a good understanding of the problem, and a sense of the general nature of the solutions, we still have substantial uncertainty regarding the quantitative targets for management.

It is crucial that we learn more about which species benefit from different levels of stand versus landscape retention. So far, studies on effects of retention have not generally focused on the most sensitive organisms. For example, in Rosenvald and Löhmus (2007), 29% of case studies on pre- versus post-cut occupancy of forest stands were about birds, and short-term benefits of retention are very clear for them. However, given their good dispersal abilities, birds do not require the continuous occupation of particular stands and landscape-scale planning of cuttings and the resulting mosaic of stands in different succession phases is much more relevant (Welsh, 1987; Angelstam et al., 2004). For them, the main role of retention could be its potential to create suitable stand structures in post-cut areas, notably the old-growth features in young forests, which would extend the duration of suitable phase in stands managed on a rotational basis. However, the long-term structural effects were actually the least explored in avian studies, and the effect of landscape context on stand occupancy has not been investigated.

Recommendation 11: Focus on identifying the most sensitive species, so that monitoring can be focused and useful. Then apply a variety of retention levels and check whether the most sensitive known species are maintained in landscapes with various combinations of stand versus landscape level retention.

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