Biodiversity and Wildlife Habitat Considerations for Opportunity Harvesting

Prepared for:
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Preface:
This document was prepared for the Silviculture Working Group (SWG) of the Coast Region Implementation Team (CRIT), to provide preliminary considerations for biodiversity and wildlife habitat values during their development of a discussion paper on opportunity harvesting in the Coast Forest Region. This document was originally submitted as electronic correspondence to Don Heppner, Forest Entomologist, Coast Region Forest Stewardship member of the SWG, on 8 March, 2008. It was subsequently revised for submission to the SWG on 22 May 2008, and was edited by Kathi Hagan on 27 October 2008 for potential inclusion as an appendix to the draft opportunity wood discussion paper.

A. INTRODUCTION

When evaluating the biodiversity and wildlife habitat implications of conducting opportunity cutting of individual and small groups of higher value stems and species, such as cedar and spruce, from "constrained" areas defined by the draft discussion paper (SWG, Oct 27, 2008) (e.g., constrained by low site productivity, sensitive terrain, etc.) in either the timber harvesting land base and/or the non-contributing forest, two main questions arise.

Question 1: To what degree does forest planning rely on these types of sites and the non-contributing forest to help meet biodiversity and wildlife habitat objectives, and what is the "intent" with regard to reliance on these constrained areas, particularly, the non-contributing forest, for biodiversity and wildlife habitat values?

Many forest planning initiatives (e.g., Timber Supply Review (TSR); land-use plans; Coast Ecosystem-based Management (EBM); recovery plans; Forest and Range Practices Act (FRPA) strategies such as the Identified Wildlife Management Strategy (IWMS)) assume that biodiversity and/or wildlife habitat "values", such as old-growth or high-value habitat types, are captured within constrained areas, and in fact, rely on those constrained areas when those values become temporarily or permanently unavailable within the timber harvesting land base.

Quick reviews of various types of documentation within the Coast Region show a reliance on these constrained areas to:

- contribute directly to wildlife habitat and biodiversity objectives;
- off-set timber harvesting land base impacts to wildlife and biodiversity values and objectives;
- provide refugia for re-colonization of the timber harvesting land base; and to
- provide unmanaged benchmarks against which to monitor and evaluate management within the timber harvesting land base.

Reliance on constrained areas to do the above requires the implicit assumption that they are "intact"; i.e., unmanaged, or managed in a way that protects values and maintains attributes that these areas have and/or are anticipated to likely decline in supply on the managed timber harvesting land base.

It therefore becomes extremely important to be able to define what "intact" means, particularly if interested in meeting biodiversity and wildlife habitat objectives within these constrained areas whilst still aiming to harvest some wood volume within them.

Question 2: What does "intact" mean for biodiversity and wildlife habitat values, such as old growth and associated ecological processes, or habitat quality?

The corollary question to this is: what are the implications for biodiversity and wildlife habitat values, of modifying constrained areas and the non-contributing forest through limited harvest (e.g., single tree removal)?

Whilst most policy and planning acknowledges the potential to remove small amounts of wood from constrained areas (e.g., "no, or very little" is how the *EBM Handbook* describes it (CIT 2004)), there is insufficient information and planning in place to identify the **quantity** (e.g., 'very little') and **quality** (tree species, tree size, decay class,

etc.) that can be removed without compromising the biodiversity and habitat values, nor how that harvesting should be **spatially distributed** across a range of geographic scales (e.g., stand, landscape, region).

The definition of 'intact' can vary greatly, depending on the values and attributes protected or conserved within the constrained area (e.g., old growth, high-value habitats, rare plant communities, etc.). The definition is therefore not as simple as setting some arbitrary threshold of volume or basal area removal (e.g., 30%) for broad application across a range of scales (from patch to stand, watershed, landscape, and region); nor is this simplistic approach ecologically sound across scales.

To my knowledge, there is no scientific guidance available to define the quantity and quality that can be removed with any certainty. Therefore, to proceed with opportunity harvest requires the need for an assessment of risk. Again, to my knowledge, there is no adequate compendium of research, nor level of assessment and planning detail in place, to guide, or to evaluate the biological and ecological implications of, limited harvest of specific trees (species and size) in constrained areas. Further, we do not yet understand the biology and ecology of our forests well enough to set low-risk thresholds for potential harvest within these constrained areas. There are already a large number of assumptions made, with very wide margins of uncertainty, when taking on the risk of relying on constrained areas to supply and offset biodiversity and wildlife habitat impacts within the timber harvesting land base. Risk to biodiversity and wildlife habitat values will be further compounded and increased by the incremental assumptions and uncertainty associated with the removal of trees from within these constrained areas.

Additional detail is provided below regarding the concepts of "intent" and "intact". This is not a thorough review of the scientific literature or planning available in the Coast Forest Region, but an initial discussion of the issues of concern and the need for a more comprehensive review of these topics.

B. INTENT

Many planning initiatives rely on constrained areas (i.e., the non-contributing forest, non-productive sites, and set-asides (stand and landscape)), and their associated attributes, to meet biodiversity and wildlife values and objectives. In some cases, **explicit** statements are made regarding those attributes and values expected to be provided by the both the non-contributing forest and other types of constrained areas.

For example, the *Landscape Unit Planning (LUP) Guid*e (Province of BC 1999) explicitly directs planners to identify the non-contributing as a source of representativeness at the BEC sub-variant scale. Planners are to look to the non-contributing land base first when identifying old-growth attributes for capture in OGMAs at the landscape scale, and representative wildlife tree attributes to be captured by wildlife tree retention (WTR) at the stand level. In its "Factors to consider when managing for wildlife tree retention", the LUP Guide states "*Where the non-contributing land base contains the appropriate wildlife tree attributes, it must be used to the fullest extent possible before locating wildlife trees in the timber harvesting land base*." This implies that those wildlife tree attributes in the non-contributing will remain there, allowing for less retention within the timber harvesting land base.

In other planning initiatives, the presumed value provided by the non-contributing forest and constrained areas is **implicit** in the differential treatment of the non-contributing

and/or constrained areas during analyses for timber supply and risk assessment (e.g., reporting on constrained areas separate from the timber harvesting land base, or attributing different rates of disturbance to constrained areas).

A quick review of a random selection of planning documents for the Coast Region provided examples of both explicit and implicit intent. Examples include Allowable Annual Cut (AAC) determinations (in particular the Chief Forester's rationale with regard to wildlife and biodiversity); Species at Risk (SAR) recovery plans (e.g., the current Marbled Murrelet recovery plan); IWMS and Section 7 Notices; land-use planning risk assessments; and land-use plans that assume baseline legislative and regulatory contributions before they start making incremental recommendations for biodiversity and wildlife.

i) AAC Determinations

I selected three of the more recent AAC determinations and randomly looked at either biodiversity or wildlife values. In all three, there are assumptions that biodiversity and wildlife values are provided by the non-contributing forest and reserves thereby offsetting impacts to the timber harvesting land base.

Strathcona Timber Supply Area (TSA) (AAC Rationale, Snetsinger 2005, p.38)

- TSR 2004 applied a 200-m timber harvesting land base buffer adjacent to otherwise constrained forest (e.g., riparian reserves) in which they modelled no Wildlife Tree Patches (WTP) required because the wildlife tree value is presumed to come from the constrained areas.
- This amounts to 133,315 hectares of timber harvesting land base requiring no WTPs because that stand structure value is determined to be sitting in existing areas outside the timber harvesting land base.
- *The analysis appears to assume that **all** wildlife trees in the constrained areas are intact and available, since it is using a direct trade off of' none in the timber harvesting land base' for 'all in the constrained areas'.*
- "In conclusion, in determining the requirements for stand-level biodiversity it is clearly appropriate to include contributions from otherwise constrained areas, including riparian areas (Snetsinger 2005)."
- The previous TSR to this one assumed that 75% of the wildlife tree value required would come from "inoperable" areas.

Fraser TSA (AAC Rationale, Pedersen 2004, p. 44)

Same assumptions for stand level biodiversity accounting as Strathcona:

- "In the analysis, a spatial exercise identified all areas of the timber harvesting land base lying within 200 metres of forest stands not considered part of the timber harvesting land base, where the proximity to this **existing forest would meet retention requirements without further wildlife tree contributions**. The exercise showed that for the timber harvesting land base 145 000 hectares are already within 200 metres of suitable stand structure, while 115 000 hectares will need the full wildlife tree retention requirement (Pedersen 2004)."
- "In conclusion, I consider that this analysis provides more refined examination and modelling of wildlife tree retention requirements than earlier analyses, by

accounting for the contributions from the edges and perimeters of forest areas outside the timber harvesting land base in their spatial relationships to cutblocks, rather than by assuming the full impact of required retention on the entire timber harvesting land base (Pedersen 2004)."

Sunshine Coast TSA (AAC Rationale, Pedersen 2002)

This AAC rationale assumes wildlife habitat values will be provided by areas outside of the timber harvesting land base, including constrained and unmerchantable areas.

- p. 36 "Staff note that older Sitka spruce-leading stands, as well as those stands with a significant spruce component, provide high capability grizzly bear habitat. All stands with less than 300 cubic metres of volume per hectare, including sitka spruce-leading stands, were excluded from the timber harvesting land base in the analysis as discussed under *unmerchantable forest types*. BCFS staff estimates that between 200 and 300 hectares of sitka spruce-leading stands remain in the timber harvesting land base after accounting for these exclusions. These areas also overlap to a certain extent with riparian habitat, for which exclusions were applied . . . (Pedersen 2002)"
    - *This assumes that high capability bear habitat will come from unmerchantable forest types and exclusions from the timber harvesting land base.*
- p. 37 "It is expected that most of the needed Marbled Murrelet habitat can be found within the non-contributing (to timber harvesting land base), constrained (from harvesting) and partially constrained land base (Pedersen 2002)." (See more detail below in Species at Risk comments.)
- p. 38 "A total of 86,000 hectares has been identified as ungulate winter range in the mapping process, primarily to address goat habitat needs. ... Of the mapped area, 465 hectares are entirely located within the timber harvesting land base, and a further 5910 hectares partially contribute to the timber harvesting land base (Pedersen 2002)."
    - *That leaves 79,625 hectares of high-value habitat coming from **outside** the timber harvesting land base.*

ii) Species at Risk (SAR) and Identified Wildlife Management Strategy (IWMS)

I reviewed **one** high-profile, broad ranging, old-growth-associated wildlife Species at Risk for which recovery planning and FRPA Wildlife Habitat Areas (WHA) are integrally linked.

Marbled Murrelet (MaMu) Example

- Murrelet recovery planning assumes that constrained areas, such as protected areas and Old Growth Management Areas (OGMA), as well as the non-contributing forest, are sources of intact suitable MaMu habitat, and provide what murrelets need —large tall trees, presence of potential platform limbs, and epiphyte cover on branches (Burger 2002).
- According to the CMMRT (2003, p.14), "The areas of nesting habitat maintained in each conservation region include areas of suitable habitat currently under some form of protection (e.g., national and provincial parks, ecological reserves, **old-growth management areas**)."

- As summarized by Louise Waterhouse (Coast Region Research Wildlife Habitat Ecologist, pers. comm.), an examination of suitable habitat contained within legally protected areas, conducted using strategic level habitat maps derived from GIS-based habitat models, suggests approximately 30% of the required 1.4 million ha of suitable available murrelet habitat required to meet the current recovery goal may already be protected, while a further **10 to 20% may be available in the non-contributing land base** (based on preliminary estimates using several Landscape Unit case studies). The remainder may be required from the timber harvesting land base to meet the recovery goal.
- Burger (2002) reports that habitat attributes generally decline with increasing elevation. Steventon (2003) reports that birds can successfully nest on steeper slopes and at higher elevations than previously believed using tall trees with large mossy limbs **which can occur patchily in forest inventory polygons of lower height or even non-forest polygons**.
    - *Therefore, when in higher elevation non-contributing stands of lower habitat quality, the tallest and largest mature and old trees are likely the most suitable for potential murrelet nesting opportunities and must be preserved, particularly when considering the assumption that the non-contributing and other constrained areas are relied on as sources of suitable habitat, taking the pressure off of the timber harvesting land base.*
- WHAs are an important tool for achieving recovery objectives (CMMRT 2003). However, the development of WHAs and Ungulate Winter Ranges (UWR) must consider the locations of, and contributions from, OGMAs and the non-contributing forest.
- According to the Ministry of Sustainable Resource Management (MSRM in Warren 2001), the delineation of potential WHAs involves guidelines such as a 200-hectare minimum size, **a non-contributing land base** and suitable habitat for the birds, based on a habitat suitability model.
- Section 7 Species at Risk Notices for Marbled Murrelet, such as that for the Sunshine Coast Forest District (DSC) (MOE 2006), clearly stipulate the direct contribution of the non-contributing and OGMAs to the "Amount" of MaMu habitat required, and the "Attributes" section of the notice identifies species such as **yellow-cedar, western hemlock, sitka spruce, Douglas-fir and western red cedar** as more likely to provide large horizontal platforms suitable for nesting.
- The supporting information for the DSC Section 7 Notice states, "Amounts included in the Notice for Marbled Murrelet are considered additive to one another. ... The Notice identifies 495 ha of mature timber harvesting land base impact that is to be used to manage suitable nesting habitat. It is anticipated that this amount will address the timber supply impacts of potential and proposed wildlife habitat areas within the Sunshine Coast Forest District as well as **compliment high-quality smaller patches within the non-contributing land base (or existing patches in OGMA)** to provide high-quality large polygons (MOE 2006)."

iii) Land-Use Plans

I randomly selected a few land-use planning documents (actual plans as well as supporting documentation such as environmental risk assessments and the *EBM Handbook*) and very quickly reviewed both the biodiversity and wildlife habitat sections. I provide some examples of content that address the intent to use set-asides and the non-contributing land base to meet biodiversity and wildlife habitat objectives.

Vancouver Island Land-Use Plan

In Section 3.1.5 Biodiversity (Province of BC 2000), both Basic Biodiversity and General Biodiversity Conservation Management Goals are achieved by the following strategy for old seral retention and representativeness in Enhanced Development Zones:

- "the old seral forest contribution will be primarily from lands withdrawn from the timber harvesting land base or managed for non-timber resource objectives (riparian reserves, sensitive soils, wildlife habitat areas, gully management areas, inoperable areas, visually sensitive areas, etc.)."

North Coast Land and Resources Management Plan (LRMP)

In the risk assessments conducted for biodiversity and wildlife, the non-contributing forest and constrained areas were consistently treated differently in analyses, with both explicit and implicit assumptions that the non-contributing provides different values than the timber harvesting land base because it has no harvesting within it.

Environmental Risk Assessment: Base Case Coarse Filter Biodiversity (Holt and Sutherland 2003)

p. 13 "Old forest is further separated into two strata: (i) percent in the Timber Harvesting Land Base (THLB) and (ii) percent in the Non-contributing (NC) Land Base.

THLB is the operable forest land base. The non-contributing land base is the remainder of the forested land base excluding protected areas, and is primarily the physically and economically inoperable areas, plus other retention areas (riparian zones etc.). Because much of the landscape is physically inoperable, this separation gives an indication of physical distribution of old forest on the land base through time (Holt and Sutherland 2003)."

p. 17 "Note that although the vegetation in all ecosystems grows back during the analysis period, if the ecosystem is located in the timber harvesting land base it is harvested multiple times in the future, and never allowed to return to old forest conditions (hence risk never decreases for a unit) (Holt and Sutherland 2003)."

In risk modelling of trends in amount and distribution of old forest, inoperable and other retention areas are explicitly identified as a source of old forest over time, as no harvesting is assumed to occur in these areas.

Environmental Risk Assessment: Baseline Scenario Mountain Goats (Pollard 2003)

Section 3.2 Indicators "To assess the risk to winter range in the NC LRMP area three indicators were selected. The most direct, and ultimately most reliable indicator of risk, is the direct impact on winter range through the reduction of forest cover. … the potential forest cover loss due to harvesting has been assessed

in terms of the overlap between the timber harvesting land base (THLB) and the identified winter range."

This risk assessment uses the degree of overlap of goat range with the timber harvesting land base as an indicator of risk; the implicit assumption is that goat range within the non-contributing is assumed to be not at risk.

Central Coast Land and Resource Management Plan (CCLRMP)
EBM Handbook (CIT 2004) (p. 6)

The handbook explicitly lists what is expected to be provided by different scales of reserve.

"In practice these [conservation planning] strategies are implemented by establishing:
. . .

- Landscape, watershed, and site reserves, which are areas where no, or very little, extractive resource use takes place, but the land is not formally designated under legislation. Reserves are established to:

  – protect specific resource values or biophysical features (e.g., cultural heritage resources and features, unstable terrain, scenic areas, and recreation features), and

  − achieve objectives to maintain ecosystem representation, wildlife habitat, movement corridors, riparian forest, and other landscape design elements.

- Site/stand retention and management, in which individual trees, groups of trees, plant communities, wildlife habitats, or other features are retained or managed on the site to sustain ecological structures in the unprotected landscape (e.g., wildlife habitat, old forest structure). Site planning and management should focus on:

  – maintaining biological legacies (e.g., coarse woody debris, snags, understory plants)

  – maintaining connectivity between landscape and watershed reserves

  – providing for seasonal and critical wildlife habitat, and

  − protecting special ecological elements (e.g., bear dens, red-listed plants, small wetlands)."

C. INTACT

What constitutes "intact" old-growth, wildlife tree habitat or high-value wildlife habitats? Can specific types of trees (e.g., large cedar or spruce) be removed from a non-contributing stand or set-aside without significantly modifying the biodiversity or wildlife habitat value either protected or presumed to be present within the constrained area?

Current legislation, regulation, policy and guidebooks refer to "attributes" used to define the value of interest, whether that be old-growth or wildlife tree or wildlife habitat value. Attributes are likely to be the basis on which to define how intact a constrained area is after any type of harvest removal'.

What's an attribute?

It is important to recognize that attributes are not restricted in definition to just structure (e.g. tree height). Compositional features such as tree species and tree/stand age are also important attributes of old-growth, wildlife trees and high-value habitats. An intact old-

growth stand will not just contain old-growth structure, but a tree and vegetation composition representative of 'natural' old forest. High-value wildlife habitat will contain both structure and vegetative composition required by the wildlife species of interest. In addition, but less clearly defined and understood at this point, are functional attributes, including processes and pathways that are integrally linked with the composition and structure of an ecosystem, habitat type and/or habitat element (e.g., wildlife tree or CWD).

In some cases, attributes are clearly defined in policy or legislation. For example, the IWMS and Section 7 Notices clearly articulate what wildlife habitat attributes are required. To return to the MaMu and the DSC example (MOE 2006, p.2), these attributes are both structural (e.g., tree size and limb features) and compositional (e.g., stand age and tree species more likely to provide suitable nesting habitat).

With regard to wildlife tree attributes, the LUP Guide (Province of BC 1999) directs planners to identify representative wildlife tree attributes to be captured by wildlife tree retention (WTR) at the stand level. In its "Factors to consider when managing for wildlife tree retention" the LUP Guide states "Areas designated for wildlife tree retention should consist of a mix of species and stand characteristics representative of the pre-harvest stand."

To my knowledge, there is no clear definition of the attributes of wildlife trees specific to the Ministry of Forests and Range (MoFR) Coast Forest Region or overlapping Ministry of Environment (MOE) regions. But other jurisdictions, such as the MOE Omineca Region within the MoFR Northern Interior Forest Region, have defined attributes of wildlife trees that are structural, compositional *and* functional (MWLAP 2005):

> "Appendix A - Wildlife Tree Characteristics
>
> Wildlife trees (WTs) are important components to stand structure and are characterized by a number of factors including:
>
> 1) trees considered **large size** for site. Trees from the top 10% of the diameter distribution for the stand should be included as WTs. The minimum size of suitable wildlife trees is 25 cm in diameter for deciduous trees and 35 cm in diameter for conifers at breast height (DBH).
>
> 2) **evidence of wildlife use** (e.g., nesting cavities or dens) or tree structure suited for wildlife use (suitable for large nest, hunting perch sites, etc.).
>
> 3) species type. While wildlife tree patches (WTPs) should be representative of the harvested stand, some trees have better general qualities as WTs, especially to serve as dispersed wildlife trees. The **preferred species list** is:
>
> A) Large Douglas-fir "veterans" or large Cottonwood trees.
>
> B) Mature Douglas-fir, preferably with some surrounding trees left intact to help protect the root integrity and windfirmness of the Douglas-fir.
>
> C) Subalpine-fir, preferably with some surrounding trees left intact to help protect the root integrity and windfirmness of the subalpine-fir.
>
> D) Clumps of aspen containing individual aspen greater than 25 cm DBH.
>
> E) Windfirm individual conifers or deciduous trees.
>
> F) Coniferous or deciduous stubs.

4) declining or dead condition. **Indicators of decay** include:

- internal decay (heart rot or natural/ excavated cavities present)
- crevices present (loose bark or cracks suitable for bats)
- large brooms present (mistletoe)
- current insect infestation

5) relative scarcity of tree species. While not the primary purpose of WT retention, and sometimes at odds with the representation objectives, **"rare" or uncommon trees** should be retained on the block."

For a more local, but less detailed example, the South Central Coast Order (MAL 2007) lists some of the attributes that should be included within stand retention. Note that the order refers to structural, compositional and functional attributes:

"**16. Objectives for stand level retention**

(2) To the extent practicable, include the following within stand retention:

(a) habitat elements important for species at risk, ungulate winter range, and regionally important wildlife;

(b) representation of ecosystems and plant communities that are red-listed or blue-listed in the watershed and landscape;

(c) functional riparian forest adjacent to active fluvial units, forested swamps, fen and marsh wetlands and upland streams with unique climate and other characteristics;

(d) Western red cedar and Yellow cedar in a range of diameters and species representative of the preharvest stand; and

(e) wildlife trees and coarse woody debris."

With regard to old growth, the LUP Guide defines old growth/old seral as "forests of a certain age or forests with the appropriate old forest attributes". The term "old forest attribute" is not defined in the *Guide*, but a recent literature review of old growth definitions and management (Hilbert and Wiensczyk 2007) indicates that old growth can be defined structurally, compositionally, and in some cases, functionally, using process features (e.g., relatively low rates of biomass accumulation). Old-growth attributes can include tree species as well as live and dead tree height, size and decay state (i.e., wildlife tree class), CWD, and other attributes such as canopy structure and gaps.

What can you remove before a stand or an area is no longer intact?

As discussed above, this question has to consider more than just the quantity of trees (e.g., number, volume, basal area) but also the quality of those trees (e.g., tree species, structural characteristics, tree age, state of decay, etc.) and, potentially, the functional role of those trees.

Hilbert and Wiensczyk (2007) note that "It is thought by some managers that old-growth forest stands and their associated structural attributes can be maintained while still harvesting some timber. … The difficulty is in determining how many trees can be removed before old-growth values are compromised." They conclude "It is important to

recognize that, while limited harvesting may maintain some aspects of old-growth structure, other attributes associated with old growth are likely to be impacted. Potential changes include damage to residual stems and understory vegetation, soil compaction during the harvest operation, reduction in coarse woody debris, and changes in species composition."

Knowing how much wood can be taken by means of opportunity cutting from an already constrained area within or outside of the timber harvesting land base, without compromising a biodiversity or wildlife habitat objective, requires a complex evaluation of those attributes required to maintain the constrained area in an "intact" state relative to the objective; i.e., structurally intact, compositionally intact, functionally intact. Then there's the question of the spatial extent across which such removal of trees is applied on stands and landscapes. How often and where such removal is applied can be as critical as how much (quantity) and what (quality) is taken.

And as discussed, attributes to consider can be, but are not always obviously structural. For Bald Eagles, those vets that extend above the canopy (and are likely targets for opportunity cutting) are critical habitat elements for perch and nest trees. But for mountain goats, the functional attribute of value is the absence of disturbance. As pointed out by Pollard (2003) during the risk assessment for goats in the non-contributing LRMP, the difference between helicopter harvesting and ground based harvesting was not considered. This has potential significance because helicopter harvesting could significantly increase level of disturbance and could access wood in currently inoperable areas, normally unavailable to ground based methods. Helicopter disturbance associated with opportunity cutting would effectively reduce the value of a constrained area intended to contribute to high-value goat habitat.

A more comprehensive list of biodiversity and wildlife habitat objectives tied to constrained areas is needed in order to identify all the attributes at risk from opportunity cutting.

Compositional, structural, and functional attributes contributing to biodiversity and wildlife habitat values all need to be considered when evaluating the removal of specific types of wood by means of opportunity cutting, such as the preferentially large and tall trees of specific species (e.g., cedar, spruce, Douglas-fir). If removed from particularly low site index stands, where they tend to be rarer in occurrence and therefore more prominent and unique attributes of the stand, this will have a profound impact on the functional diversity of these sites.

The impact of the removal of wood, by means of opportunity cutting, on the functional attributes of constrained areas are not well-understood, but can be presumed to include effects on biotic communities (vegetation, invertebrate, vertebrate), species richness, functional diversity, and trophic cascades mediated by structural and compositional changes such as:

- changes in tree species diversity resulting in changes in biotic communities within the stand;
- changes in canopy complexity (i.e., removal of the largest trees, generally in A1 or A2) resulting in shifts in canopy communities;

- changes in spatial heterogeneity as single and small group tree removal increases the frequency of gaps canopy gaps with concurrent shifts in light regime and microclimate; or
- reduced recruitment potential for the critical biodiversity components and habitat elements of snags and CWD, likely to be affected by the removal of the larger trees within a stand, as well as by the shifting profile of tree species eventually recruited into the dead wood cycle (i.e., fallen tree species and size influences decomposition rate).

Concepts around thresholds beyond which habitat or old-growth value is lost need to be explored. A 2007 EBM Working Group Forest Representation Workshop examined a review of this topic in detail (Price et al. 2007). Whilst the workshop concluded that at a **sub-regional scale** "it is likely that ecological integrity can be maintained with 70% of natural representation for each ecosystem unit …", it also concluded "Notwithstanding the value of the existing evidence and our consensus regarding the 70% of natural old target hypothesis, there is a significant need for a program of research and monitoring to provide more, better quality, and local information." Important to note is that this recommendation is particular to the sub-regional scale only, and is not relevant at the scale of the site, stand, or high-elevation sub-basin in the non-contributing forest.

Concepts around replacement principles for attributes or area lost due to harvesting within constrained areas, and the ecological basis for and implications of these concepts need to be further explored.

D. CONCLUSION

A structured approach is strongly recommended for assessing the risks of opportunity cutting to biodiversity and wildlife habitat values in constrained areas outside the timber harvesting land base. It should consider the context of the intended role of these constrained areas in providing biodiversity and wildlife habitat value within and across managed landscapes.

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