Effectiveness Monitoring on Weyerhaeuser's B.C. Coastal Tenure

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Abstract

We discuss progress on monitoring three indicators of biological diversity on Weyerhaeuser's coastal tenure: 1) ecosystem representation, 2) habitat structure and 3) organisms. We summarize the characteristics of the non-harvestable landbase (indicator 1), and then we outline how variable retention (VR) is maintaining habitat structures (indicator 2). For organisms (indicator 3) we limit our discussion to two of the key questions that focus our monitoring program: 1) How does VR type and retention level affect organism abundance? 2) Are edge effects apparent? For each indicator, monitoring has progressed to different stages. Ecosystem representation has been calculated at the biogeoclimatic variant level and for some areas at site series level (or groupings of site series). Results from the representation analyses clearly show that drier east-side Vancouver Island variants have little unmanaged forest. Covenants on some of that land are being pursued; restoration has been attempted on small areas. For indicator 2 (habitat structures), results from comparing group and dispersed VR have helped decide appropriate mixes of VR types. Comparisons to uncut benchmark stands have shown where retained structures differ most from natural conditions and that has helped focus efforts to improve retention of some attributes. For indictor 3 (organisms), several studies are underway addressing different comparisons (e.g., different types of VR, different amounts of retention; effects of edges) in a variety of operational and experimental settings. Results so far indicate some edge effects and some increases of forest associated species as retention levels increase. Results of the organism studies and monitoring of indicators 1 and 2 need to be combined to provide coherent information to managers. Assessing ecosystem representation, projecting landscapes and habitat structures then linking these to the needs of a few indicators species is ongoing as a part of a project this year. Further work on linking habitat to organisms will continue in subsequent years.

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Introduction

In 1998, under pressure from environmental groups, markets and the public, MacMillan Bloedel (prior to acquisition by Weyerhaeuser) announced a phase-in of variable retention (VR) harvesting from predominately clearcutting. This shift was accompanied by designation of stewardship zones to address public concern about old growth. Stewardship zones include areas with an emphasis on timber production (Timber Zones - 65% of the tenure), providing habitat in managed stands (Habitat Zones - 25%) and areas maintaining old growth conditions (Old Growth Zones - 10%). We are assessing the effectiveness of stand-level practices and landscape zoning at meeting the ecological objective of sustaining biological richness throughout the tenure with a monitoring program embedded in an adaptive management framework (Kremsater et al. 2003). Biological richness is evaluated by means of three filters: the coarse filter that assesses ecological representation in non-harvestable areas, a medium filter examining habitat and landscape structures, and a fine filter addressing indicator organisms from a range of taxonomic groups. This paper outlines preliminary results of monitoring of the three filters. The rationale for using these filters or indicators is discussed by Bunnell et al. (2003). Reports that provide more detail on results of individual projects are available from Cascadia Forest Products.

Indicator 1: Ecological Representation of Non-Harvestable Land

Keeping examples of each ecosystem in an unmanaged state can help to sustain poorly known species and ecological functions, allow a buffer against management error and provide baselines for comparing effects of management to unmanaged areas (Lindenmayer et al. 2000; Margules and Usher 1981; Scott et al. 2001). The critical question for monitoring non-harvestable land is its distribution across ecosystem types. Ideally a given amount of non-harvestable land would be distributed relatively evenly across all ecosystem types. However, operational or policy constraints that determine the location of non-harvestable areas in managed forests often lead to some ecosystem types having a disproportionately low percentage of non-harvestable area. Because many poorly known organisms are likely associated with a limited range of ecosystems, poor representation of some ecosystem types could greatly reduce the contribution of non-harvestable areas towards maintaining the entire suite of biological diversity (Austin and Margules 1986; McKenzie et al. 1989; Margules and Pressey 2000).

In addition to how well they encompass the variety of ecosystems, other characteristics of unmanaged areas can affect their ecological contribution, including the proportion of edge versus interior area, the size of unmanaged patches, and their geographic distribution.

We assess ecological representation in non-harvestable lands across Weyerhaeuser's tenure at the level of ecosystem variant (see Pojar et al. 1987) and, where mapping is available, site series groupings. We briefly summarize results and implications fully presented in Huggard et al. (in press).

Results

On Weyerhaeuser's entire coastal tenure, areas wholly constrained from harvest represent 25.7% of the forest. Old Growth stewardship zones contribute an additional 3% area not already constrained. Partially constrained areas, having 50% to 90% of the timber volume constrained, occupy 7.3% of the forest area. The proportion of non-harvestable falls within many recommendations in conservation literature. However, drier ecosystems on southern Vancouver Island and highly productive sites are under-represented. Potential edge effects are also a concern, with 62% of non-harvestable area within 50 m of harvestable stands, reflecting the narrow or highly convoluted shapes of many reserves (e.g., riparian, steep slopes, sensitive soils and inoperable areas). The area of unmanaged forest near edges is higher in the drier ecosystem types, where constrained areas are smaller, and riparian reserves predominate. Only a small percentage of non-harvestable land is greater than 200 m from the edge.

Two obvious weak points in representation on the Weyerhaeuser tenure should clearly be the focus of management actions: 1) under-representation of drier, southerly variants on Vancouver Island, several of which are conservation priorities for Weyerhaeuser based on high responsibility in the province and low percentages of legally protected areas, and 2) limited amounts of non-harvestable forest that is "interior"--distant from potentially harvestable stands. Lack of interior area is most pronounced in the poorly-represented dry, southerly variants, exacerbating concern about those ecosystem types.

Three main avenues are available to improve the first weak point. The most certain would be to designate Old Growth stewardship zones or other reserves in ecosystems poorly represented in the on-harvestable landbase. A less certain option is to increase the level of retention in managed stands in the drier zones, including more large retained patches. A third possible solution being developed is active restoration of old growth characteristics in some of the abundant second-growth stands in these ecosystems. Recovery of some timber value through commercial thinning as an initial restoration step could offset some costs of subsequently setting these restoration areas aside as reserves (Krcmar 2002).

Some progress has been made towards establishing smaller, better distributed Old Growth zones, allowing a modest increase in non-harvestable area in a few variants that had moderate representation. However, no old growth zones or other reserves have yet been established in the small remnant areas of old forest in the dry southerly variants, nor in larger areas of mature second-growth forest in these ecosystem types.

So far little progress has been made in increasing stand-level retention in the poorly-represented variants.

The essential difficulty is that dry variants within Weyerhaeuser's tenure are mainly private land. It is mostly easily accessed, lacks some of the operational constraints of public land and is the most profitable for timber harvesting. Designation of reserves or increasing stand-level retention, therefore, has the greatest economic consequences in these zones. Although the incremental value of conservation actions is also highest in these poorly-represented ecosystem types, there are few market mechanisms to reflect this value. Conservation covenants purchased by environmental groups or government are being pursued to reduce costs of creating permanent reserves in these high-value areas.

The problem of low proportions of interior non-harvestable forest can be improved in several ways that have less direct conflict with economic objectives. VR retention patches can be located adjacent to non-harvestable areas as buffers. In some cases, foregoing harvesting in a few small harvestable areas embedded in larger non-harvestable areas would produce disproportionately large increases in amount of non-harvestable interior. Areas reserved from harvesting to meet the objectives of partially constrained areas can also be preferentially located adjacent to non-harvestable areas. At a larger scale, harvest locations and timing can be planned to avoid isolating non-harvestable areas with young managed stands. To date, some progress has been made in using stand level reserves to buffer small or narrow non-harvestable areas, but larger scale planning to mitigate edge effects in the larger non-harvestable landbase has not yet been implemented.

Maintaining ecological representation is intended to be a coarse-filter approach to maintaining biological diversity, to be used in conjunction with finer-filter monitoring of habitat and landscape structures and indicator organisms. Monitoring structures and organisms can be used to test assumptions of this indicator (e.g., definition of ecosystem types, extent of edge effects), while monitoring at the overall tenure level tests that harvest practices and the non-harvestable landbase, when combined, are meeting the objective of sustaining species on the tenure. Representation monitoring also helps to focus finer-scale monitoring into poorly represented ecosystems (such as drier forests on the east side of Vancouver Island) where effective stand-level practices are most critical.

Indicator 2: Habitat Structures

Variable retention is expected to help maintain biodiversity by improving the supply of habitat attributes compared to past practices. Examples of habitat attributes include different types of snags, coarse woody debris, shrub cover--each required by a number of well-known vertebrate species and other poorly-known groups of organisms (e.g., Thomas 1979; Rose 1976). From 1999 to 2003 Weyerhaeuser conducted surveys to monitor habitat structure in VR blocks, benchmark unharvested sites (including pre-harvest experimental sites), riparian reserves and several other types (Table 1). Measured habitat attributes included live trees (species, diameter at breast height (DBH), height), snags (species, DBH, height, decay class), coarse woody debris (CWD; species, diameter, decay class), cover layers (canopy, small tree, shrub, herb, moss, litter, mineral soil) and dominant shrub and herb species.

The monitoring design allows several types of comparisons identified as priorities in Weyerhaeuser's Adaptive Management Framework:

- comparisons of VR types;
- comparisons of VR with benchmark sites;
- edge effects;
- the relationship of retention of habitat elements to the percentage of VR retention in a block;
- habitat attributes in riparian areas; and
- effects of different ecological "anchors" for VR patches.

Table 1. Habitat structure sampling effort.

BEC Group	Dispersed	Group	Mixed	Control	Clearcut	Remnant	Scrub	Riparian
CDFmm	11	2	7	5				2
CWHxm	16	17	19	15	3	2	1	6
CWHmm/dm	11	18	5	12	3			5
CWHvm/vh	9	50	6	18	3	17		7
CWHwh1		7		5				
MHmm1		2		1			5	

A key interest of the monitoring program is to know if retention practices are improving over time, that is, are better choices being made about which structures to retain in harvested blocks as we learn? To assess improvement we evaluating new operational blocks each year. Huggard et al. (in press) provides detailed results for many habitat elements for the comparisons above.

Habitat monitoring results identified several weak points in structural retention. Through operational training, this led to some improvement after the initial year and limited improvement thereafter. For example, dispersed retention was found to retain larger trees than group retention and group retention was retaining smaller basal area than the same sized patches of uncut benchmark forest. In response, dispersed retention was continued as an important portion of VR and group retention was adjusted to capture more larger trees (thus increasing basal areas relative to benchmarks). Edge effects (specifically finding some reduction in snags near edges) were used to support use of larger retention groups or patches in some settings. More generally, the results have helped inform government policy on wildlife tree and downed wood retention. In particular monitoring in uncut stands has helped establish benchmarks for sizes and densities of snags and volumes of down wood and thus has helped government compare effectiveness of retention practices by several forest companies.

Anticipated connections between the habitat and organism monitoring, including refining habitat measurements for specific organisms' needs and developing habitat models, have not yet occurred. The habitat monitoring will also be used to test that non-harvestable areas (indicator 1) are structurally similar to stands available for harvest.

Indicator 3: Organisms

Ultimately VR is expected to help sustain organisms, thus organisms are the third and finest indicator. Monitoring for indicator 3 includes organisms that show a range in habitat associations and taxonomy (lichens, fungi, bryophytes, vascular plants, invertebrates and vertebrates) that are affected by forest practices and that are practical to monitor. The initial years of monitoring were used for pilot studies to refine which organisms to monitor for which questions, to test field methods and to optimize sampling design (Table 2). As expected, some organisms proved unsuitable for monitoring. Red squirrels, for example, occurred at very low densities over the tenure including young stands and so were not included in further monitoring.

Some of these pilot studies have returned information on a few of our monitoring questions (Bunnell et al. 2003) including the two questions we focus on here:

1) What is the effect of VR type and level of retention on organisms?
2) What edge effects exist? (Edge effects can be used to suggest appropriate sizes for retention patches)

Table 2. Pilot studies by year.

Organism Group	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Vascular plants	x	x	x	x	x	x
Bryophytes	x				x	
Epiphytes/lichens		x	x	x	x	x
Songbirds	x	x	x	x	x	x
Aquatic amphibians	x	x	x	x	x	x
Gastropods	x	x	x	x	x	
Carabid beetles			x	x	x	x
Red squirrels		x				
Breeding bird surveys	x	x	x	x	x	x
Mycorrhizal fungi			x		x	x

In the following sections, we summarize initial answers to these questions from monitoring of carabid beetles (Pearsall 2003), forest birds (Preston and Harestad 2004, Preston and Campbell 2004, Chan-McLeod et al. 2004), mycorrhizal fungi (Outerbridge and Trofymow 2004), gastropods (Sopuck and Ovaska 2004), and bryophytes (Sadler 2004).

Carabid beetles

Carabid beetles were captured by pitfall trapping in a variety of retention types including transects into and out of retention patches to measure edge effects (methodology can be found in Pearsall, this volume). Some beetles clearly favor open areas, while forest specialists are more abundant when retention levels increase. For a similar level of retention, group retention was more effective than dispersed retention at maintaining the forest specialist species. The by-catch (spiders, millipedes, etc.) also showed a clear difference among treatments and will eventually be analyzed further.

Edge effects were apparent for some species, particularly the forest specialist *Zacotus matthewsii* and Staphylinid beetles, which were all particularly abundant at the edges. The reason is unclear – they may prefer that location, or accumulate there due to unwillingness to travel into the opening. When all beetle species were considered, edges had greater numbers, greater species richness and greater evenness than found within patches or in the harvested matrix.

Forest birds
Two studies examined effects of VR type, level and edges on forest birds (Chan-McLeod et al. 2004, Preston and Campbell 2004, Preston and Harestad 2004). The reports document overall species richness in different VR types and, more interestingly, the effects of VR and edges on individual species. Four species that are often reported to prefer old forest were examined for this paper: winter wren, chestnut-backed chickadee, golden-crowned kinglet and Pacific slope flycatcher. Abundance of winter wrens increased at 30 to 40% retention but old forest benchmarks had high natural variability in abundance. Chestnut-backed chickadees increased in abundance after about 20% retention but benchmark values were highly variable. Golden-crowned kinglet observations were few and variable. One 40% retention area had numbers similar to benchmarks. Pacific-slope flycatcher was also very variable in benchmark sites. Observations from different VR levels showed a general increase in Pacific Slope Flycatcher abundance after 20% retention.

The results to date seem to suggest that for these four species, increasing retention increases abundance. No thresholds are apparent. The abundance of these species will be influenced more by the total amount of retention in the landscape than the distribution of that retention.

Mycorrhizal fungi
Outerbridge and Trofymow (2004) compared ectomycorrhizal (EM) fungi on roots of planted 1-year-old Douglas-fir seedlings sampled at 5, 15, 25 and 45 m along transects into and out of old growth or second growth patches into VR openings. In 4 of the 5 sites, the farther the seedlings were from the residual stand or patch edge, the lower the percentage of root colonization and number of EM species. Abundance of EM fungi dropped after 5 to 10 m into the opening and then continued to decline.

Stands that were originally second growth had lower EM abundance and diversity than those that were old growth. At present, the researchers are examining the effects of individual dispersed trees on EM diversity and abundance.

Gastropods
There was some indication that VR type influenced gastropod species (Sopuck and Ovaska 2004). For example, western flat whorl decreased from uncut controls to VR patches to harvested matrix. For tight-coil species, the differences were less noticeable, and variation between locations was greater than the effect of VR type, reflecting their clumpy distribution and specificity to moist sites. Because of high spatial variability, pre-harvest measurements are being taken in areas where VR levels will be manipulated experimentally (5, 10, 20 and 30% retention in group and dispersed VR).

Bryophytes and vascular plants
The study looking at effects of stand age and edge on vascular plant and bryophyte cover found no effect of edges on vascular plants in young second growth stands adjacent to mature forest (Sadler 2004), but reported a 5 to 15 m edge effect where abundance of bryophytes was reduced. Bryophytes decline further in abundance 35 to 60 m into the opening, which may reflect colonization limitations. The same trend was detected when only ‘bryophytes restricted to logs’ were examined. As stands aged, bryophyte cover increased but the patterns around edges remained.

Combining Information from Studies and Indicators

Weyerhaeuser's goal is to maintain all species on their tenure. Evaluating how effective practices are at meeting this goal requires integrating the three indicators. This challenge necessarily involves long time frames and large areas. Ultimately, we should be able to provide an account of how all species, or broad taxa, will be maintained on the tenure. Our general approach to projecting and linking the three indicators is shown in Figure 1.

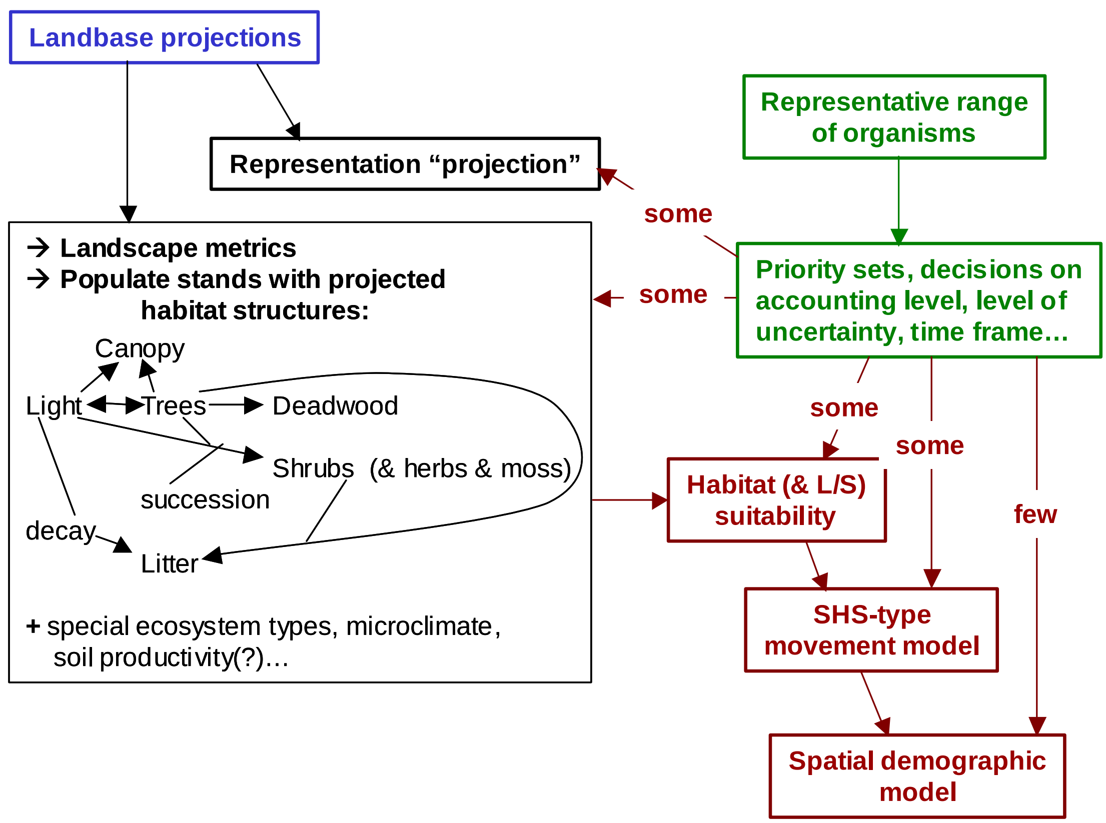

Figure 1. Schematic approach to integrating the three indicators.

We project the landbase, including stand types and age with realistic harvesting and, eventually, natural disturbances, given the different ecosystem types, harvest constraints and past histories. From that base model we can assess characteristics of the non-harvestable landbase (indicator 1). Some parts of the representation analyses change over time and so need to be modeled, especially possible future development or expansion of the non-harvestable landbase.

From the base model we can also calculate landscape indices (part of indicator 2). Projections of stand-level habitat structures are being driven mainly by projections of live trees and associated modeling of light. Projecting indicator 2 is a basic part of accounting for many organisms but it is also essential in itself because we use these structural indices to evaluate effectiveness of practices. For instance, all else being equal, a harvest system that maintains some decayed snags in perpetuity is better than one that does not. Similarly, a land use plan that retains more “interior” old forest is better than one that retains less, even if we do not explicitly tie those structures to particular organisms.

Depending on what information is available for the organisms and how certain or detailed we want to be, we will account for an organism by different means (in a gradient of increasing detail and effort):

1. Ecosystem representation
1a. Adequate amounts or unmanaged forest of suitable ecosystem types.
1b. As above, but also considering stand-age requirements, edge/interior and distribution.
1c. As above, but with addition of area contributed by suitable managed stands (combination of age and harvest type).

2. Habitat suitability
2a. Adequate amounts of suitable habitat. This requires habitat suitability models (simple HSI, statistical model, etc.) and projections of habitat structures in different stand types.
2b. As above, modified for edge/interior effects (within and between “stands”) and roads, and spatial distribution (e.g., not counting isolated patches).

3. Spatial habitat supply
This involves mapping habitat suitability and applying movement rules to predict how organisms would use that distribution of habitat.

4. Population modeling
The most detailed level adds explicit demographic modeling of organisms to the spatial habitat supply approach.

An important element of this approach is careful documentation of the assumptions in each component. We also include estimates of the uncertainty of the predictions due to uncertainty in the model parameters, and perhaps structural uncertainty about how to model the organism. Beyond a basic acknowledgment of uncertainty, including this analysis could help guide the monitoring program to focus where uncertainty can be reduced most effectively

Clearly the monitoring effort requires long-term commitment, a means of conveying results, deciding when action is appropriate and corporate will to implement action in response to findings. These crucial elements are items we strive to create and maintain.

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