Weyerhaeuser's Coastal British Columbia Habitat Structure Monitoring

David Huggard[1], Glen Dunsworth[2], Jeff Sandford[3], and Bill Beese[4]

Abstract

In coastal British Columbia, Weyerhaeuser monitors habitat structures, along with ecosystem representation and a range of organisms, to assess the biological effectiveness of a variable retention (VR) approach to forest management. The main challenge for a useful habitat monitoring program was developing a framework of core questions and comparisons, essential for the monitoring results to guide management. Priority comparisons included: 1) Different retention types (group, dispersed or mixed retention), 2) Retention versus unmanaged benchmarks, 3) Relationship between percent retention and retention of particular structures, 4) Edge effects into and out of retained patches, 5) Progress in operational effectiveness over time, 6) Riparian versus upland retention, and 7) Retention patch types. Monitoring to address these comparisons uses many operational blocks and, eventually, 15 experimental sites. We summarize some results of operational significance, and compare pros and cons of monitoring in operational and experimental blocks. Experimental blocks benefit from replication, randomization and controlled variation in single variables, while abundant operational blocks risk confounding with existing site conditions. Experimental sites can allow a greater range of treatments than operational blocks. However, limited experimental replicates means that designed operational sampling is required to make many of the comparisons informative to operations. Most practically, monitoring existing operational blocks provides immediate results, important with impatient funding sources, and makes monitoring an integral part of operations; experimental sites provide a scientific cachet that attracts researchers, promotes publications, and shows a corporate commitment to improving knowledge.

---

1 Consultant, 517 E.10th St., North Vancouver, BC, V7L 2E7
2 Glen Dunsworth Ecological Consulting, 7857 Shangri-la Road, Lantzville, BC, V0R2H0
3 Western Forest Products Inc., 118-1334 Island Highway, Campbell River, BC, V9W 8C9
4 Western Forest Products Inc., 118-1334 Island Highway, Campbell River, BC, V9W 8C9

Citation: Huggard, D., G. Dunsworth, J. Sandford and B. Beese. 2007. Weyerhauser's Coastal British Columbia Habitat Structure Monitoring . Paper presented at the "Monitoring the Effectiveness of Biological Conservation" conference, 2-4 November 2004, Richmond, BC. Available at: http://www.forrex.org/events/mebc/papers.html

Introduction

A primary reason for Weyerhaeuser's implementation of a variable retention (VR) approach to forest management in British Columbia (BC) Coastal Timberlands is to meet the company's objective of maintaining biological diversity across their tenure. To assess how well this objective is being met, VR is being implemented in an adaptive management framework. Biological diversity is indexed at three levels: the coarse filter of ecosystem representation, the medium filter of habitat and landscape structures, and the fine filter of indicator organisms (Bunnell et al. 2002, Kremsater et al. 2003). Monitoring habitat structures is a direct evaluation of the basic idea that VR retains structures not easily recreated in managed stands (Franklin et al. 1997, CSP 1995).

Animal ecologists have become accustomed to a standard set of habitat structures, stemming from Thomas (1979), which includes live trees (particularly large ones), snags, coarse woody debris (CWD), and canopy, shrub, herb and ground covers. Monitoring these canonical habitat elements has the advantages of allowing comparisons with other habitat monitoring programs and published relationships with particular species (primarily vertebrates; see Bunnell et al. 1999, Marcot et al. 2002). These elements are therefore the main part of Weyerhaeuser's habitat monitoring. However, these discrete elements are at odds with the more integrated view of habitat used by naturalists, who examine the whole suite of habitat elements at a larger scale, roughly 0.01-1ha. We try to include this view of habitat in our monitoring, though fewer measurable variables have been proposed: horizontal heterogeneity of trees and other elements, vertical diversity (MacArthur and MacArthur 1961) and gap structure are examples. We also recognize that the predominance of Thomas' habitat elements could limit how we perceive forest habitat. We are trying to overcome this limitation by reviewing natural history studies of organisms, particularly non-vertebrates, to gain some idea of what features they use to define "habitat", but this work has not yet been incorporated into Weyerhaeuser's field monitoring of habitat structure.

Field methodology for logistically efficient, objective measurements of Thomas' habitat elements are well-known and easily adopted to particular monitoring situations. Statistical techniques using pilot study results to optimize sampling designs are also readily available (Krebs 1989), though often neglected in monitoring programs. Efficient field methods, optimized sampling, and informative indicator variables are necessary, but not sufficient, for useful effectiveness monitoring. A study design that explicitly addresses one or more operationally important comparisons is also essential. This context of designed comparisons converts the information collected during field monitoring into knowledge that can guide management. Determining comparisons was a fundamental step in developing Weyerhaeuser's habitat monitoring. Because Weyerhaeuser's adaptive management program uses both operational cutblocks and designed experiments, part of the study design process was deciding which of these settings to use for which comparisons.

In this paper, we summarize the field methodology used for monitoring habitat structures, the comparisons and study design that define the monitoring program, and a few of the results to date. We then discuss more generally the pros and cons of operational versus experimental settings for this monitoring.

Methods

Field methods and sampling design

Two types of plots were used in the field:

1) Dispersed retention retains trees and other structures dispersed across the cutblock. In these blocks, a 25 m x 25 m quadrat was used to measure all stems, nested within a 50 m x 50 m quadrat in which snags and large trees were recorded (Figure 1). Two quadrats were used per block. CWD was measured along intercept transects of 50 m (all sizes) or 100 m (diameters >30 cm) on 2 perpendicular sides of each quadrat. Cover variables and dominant plants were recorded in five 0.01-ha circular sub-plots. The number of quadrats and sub-plots, and length of CWD transects were based on optimization analysis of a 1999 pilot study.

2) Group retention retains structures in unharvested retention patches, while mixed retention combines group and dispersed retention. In group and mixed retention, 2 transects were used across the edges of 3 retention patches, based on optimization results from the 1999 pilot study. The transects extended up to 50 m into the patch and 50 m into the opening (Figure 1). All stems were recorded within 2.5 m of the transect; snags and large trees were recorded within 5 m. CWD was recorded along the transect, and along perpendicular 10 m-long transects every 10 m along the main transect. Trees, snags and CWD were recorded separately by 10-m transect segment (i.e., 0-10 m from the edge, 10-20 m, 20-30 m, etc.) to allow examination of edge effects. Every 10 m along the transect, 0.01-ha circular plots were used for cover layers, dominant plants and site series. Transects were also used to sample riparian reserves, pre-harvest experimental blocks and unharvested benchmark sites, to allow comparisons of within-stand variability of habitat elements with group and mixed retention. Because measures of variability are affected by plot size and shape, direct comparisons of variability with dispersed retention are not possible. However, this comparison is of little interest, because dispersed retention clearly produces different variability within stands than group retention or unharvested benchmark sites.

Adaptive management comparisons

We identified seven primary stand-level comparisons that would be informative to management. Projects monitoring organisms address one or more of these comparisons, but the habitat structure monitoring, with more easily collected data, addresses all of them.

<u>1. Comparisons of retention types:</u> Comparison of operational dispersed, group and mixed retention in various BEC groupings is a basic part of decisions on which of these management options to favour. No one system will be best for all variables; this comparison measures what will be gained or lost with different possible mixtures of the systems. Operational settings provide many replicates for these comparisons in all ecosystem types. The far fewer experimental blocks, with no explicit comparisons of these types, will be of limited use. However, randomization of treatments in experimental blocks may help assess whether operational choice of retention type is severely confounded with stand characteristics, though pre-harvest measurement in the operational blocks would be more definitive.

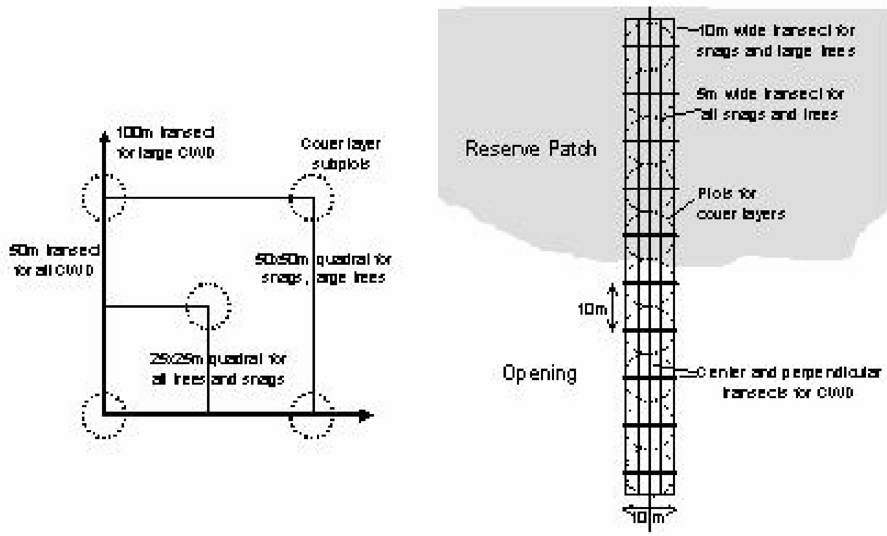

Figure 1: Layout of quadrats in dispersed retention (left) and transects in group retention (right).

<u>2. Comparisons of retention patches with unharvested benchmark sites:</u> VR blocks clearly differ from unharvested forest. The main reasons for this comparison are to determine weakest points in managed stands (which habitat elements are at the lowest levels relative to benchmark forests) and whether retained patches in group and mixed retention retain structures representative of unharvested forest. Operational sites and existing unharvested areas are the main focus, but experimental sites will be helpful. The experimental sites, which include unharvested units, will help overcome concern that existing unharvested areas may not be typical. (Some benchmarks may be less productive sites, others may have been reserved as parks or winter ranges because of outstanding habitat features). Again, pre-harvest measurements could be a more effective way of answering some of these questions.

<u>3. Edge effects</u>: The legal definition of the retention silvicultural system in BC assumes that retained trees affect adjacent harvested areas to a distance of one tree-height, but empirical data are limited. Edge effects into retained patches help determine desired sizes and shapes of retained patches. Operational blocks provide many patches for measuring edge effects, but risk confounding the location of the patch edge with a natural change in stand type or topography. This is particularly true because Weyerhaeuser emphasizes anchoring many retained patches on special features such as riparian areas or rock outcrops. Experimental sites could avoid confounding inherent and induced edge effects, if patches were randomly or systematically located. However, Weyerhaeuser's experimental sites are laid-out in standard operational ways, and do not have the advantage of unbiased edge locations.

4. Relationships with retention level in VR blocks: Percent retention in operational VR blocks is measured as the percent of basal area of live trees retained in dispersed retention, and the percent of cutblock area retained in groups. Depending which structures or areas are retained, this may result in greater or lesser percent retention of particular habitat elements. Developing these relationships requires monitoring the widest available range of percent retention in VR blocks. Experimental blocks can be particularly useful in extending the range beyond normal operational practices, without concern about confounding factors (e.g., high operational retention in only operationally difficult blocks). The form of these relationships, whether 1:1, concave, convex or threshold, has implications for the minimum and desired range of retention levels.

5. Operational blocks over time: Monitoring recent operational blocks over the years is essential to determine whether operational practices are improving. Progress is required under some forest certification systems and indicates that the adaptive management program itself is effective. We emphasize checking whether weak points identified in previous years have been improved in recent cutblocks. This comparison requires a randomly selected set of operational blocks.

6. Riparian areas: Riparian areas are usually managed under their own administrative rules, and have been only a secondary comparison for the habitat structure monitoring. However, they are the main variable in one set of experimental replicates, and the topic of separate research.

7. Anchor types: Wetlands and rock outcrops are favoured as anchor points for VR patches, for operational reasons and because of their associated species. Comparing structures in these patches to patches anchored on more typical mesic sites can help determine the desired mix of different anchor types. This comparison relies mainly on operational sites, because anchor type is not one of the experimental comparisons.

Weyerhaeuser's coastal B.C. tenure spans ecosystems ranging from dry Douglas-fir forest to coastal rain forest to subalpine. The main comparisons of retention types and benchmarks were conducted across all the ecosystem types, with AIC-based model selection (Burnham and Anderson 1998) used to combine ecosystems with similar habitat structures for summaries. Other comparisons were conducted in the dominant retention type in two or three ecosystems, typically dry, mesic and wet subzones.

Results

The 329 sites monitored to date mainly cover the three retention types and benchmark sites, across seven ecosystem types (Table 1). Each pre-harvest experimental site, with four or five experimental units, is counted as one benchmark site.

We give a brief summary of results for the seven comparisons; full results are in Huggard (2004).

Table 1. Sites monitored for habitat structure, 1999-2004.

Retention or other forest type

Subzone	Dispersed	Group	Mixed	Benchmark	Riparian
CDF	10	2	7	14	2
CWHxm	17	17	20	35	6
CWHdm	7	11	2	9	2
CWHmm	3	7	3	9	3
CWHvm/vh	9	49	6	39	7
CWHwh		7		5	
MH		2		1	

1. Comparisons of retention types: Dispersed retention retained substantially lower levels of many habitat elements than group retention, except in the CWHvm/vh subzones where the two types were more similar. Snag retention and deciduous structures were particularly low in dispersed retention. However, large trees, large (but short) snags and some types of large CWD had better retention levels in dispersed blocks. While group retention is better for many habitat elements, the importance of the distribution of habitat elements across the block and the need for a variety of stand types suggest not neglecting dispersed retention. Additional retention in the mixed retention matrix favours that system over group retention. Operational use of mixed retention has been increasing, with reductions in dispersed retention in most forest types.

2. Comparisons of retention patches with benchmark sites: Benchmark sites in several BEC variants had higher levels of several habitat attributes than retention patches, particularly large trees, overall basal area and tall snags. This probably reflects poor representation of large trees and higher productivity sites in retention patches, although it may also be that some benchmark sites are protected from harvesting because they have exceptional habitat attributes. Comparisons of pre- versus post-harvest experimental sites will help resolve this issue in the coming years. Deciduous trees were strongly favoured in retention patches compared to benchmarks in drier ecosystems. The increased deciduous, along with lower basal areas and fewer large trees, partly reflects many retention patches anchored on wetlands. Retention patches and benchmarks had similar levels of CWD and vegetation cover. Operational progress towards better retention of large trees, basal area and tall snags will be monitored in coming years.

3. Edge effects: We used AIC-based model selection to examine edge effects into retention patches and adjacent matrix for 10 main habitat variables in 7 ecosystem types. Half of the combinations showed no edge effects. Snags were usually reduced somewhat 0-10m into a patch compared to further into the patch, with a few minor reductions extending 10-20m. Other variables showed slightly different levels 0-10m into the patch and/or 0-10m into the adjacent harvested area. These edge effects, though small,

encourage use of some retention patches larger than the 0.25-0.5ha size that predominates in group retention. More pronounced edge effects may develop with time.

<u>4. Relationships with retention level in VR blocks</u>: We also used a model-selection approach to examine the relationship between retention of 19 main habitat elements and percent retention with dispersed, group and mixed retention in 3 subzones. For most live tree and snag variables in all retention types, the best relationship was a 1:1 line (i.e., *x*% retention retains *x*% of benchmark levels of the habitat element). Levels of well-decayed snags showed more variable relationships, because some blocks retained high levels of (very short) decayed snags, even in the harvested matrix. CWD levels showed no relationship to percent retention, because of abundant CWD in the harvested matrix, although decayed CWD was rarer in VR blocks than benchmarks. Shrub cover did not change with percent retention in the drier BEC groups, but increased in nearly a 1:1 relationship in the wetter subzones. The lack of threshold or non-linear responses suggests no particular minimum retention levels. Instead, increased overall retention retains proportionally more of structures that are affected by harvesting. However, if greater retention levels within blocks require more harvest blocks to maintain equivalent harvest, then no net gain in structural retention at the landscape scale is expected.

<u>5. Operational blocks over time</u>: Many habitat elements showed substantial increases from 1999, the initial year of VR, to 2000 and 2001. In the wetter subzones, positive trends continued in 2003, or habitat elements remained at 2001 levels. Trends were more mixed in the drier subzones, with some elements in 2003 declining back to 1999 levels, while others stayed at 2000-2001 levels. Elements previously emphasized as weak points, such as tall snags, did not show any pronounced improvement by 2003. However, these results do not yet indicate a lack of progress or ineffective monitoring feedback, because the time scale examined is short and few recent blocks have been sampled.

<u>6. Riparian areas</u>: Riparian areas differed from retention patches, providing opportunities to retain some elements that were at lower levels in retention patches compared to benchmarks, including greater basal areas, larger trees, large cedar snags, well-decayed snags and abundant herb-layer cover. Riparian areas also had abundant deciduous elements and higher volumes of CWD, though these are also retained well in VR blocks.

<u>7. Anchor types</u>: Compared to mesic patches, patches anchored on wetlands had more, but smaller, trees and snags, while patches anchored on rock outcrops had fewer, larger trees and very few snags. CWD did not differ between patches with different anchor types, but there were floristic differences, particularly in patches anchored on rocks. Overall, wetland patches generally had typical or higher levels of habitat elements, but patches centred on rock outcrops lack some structures. A range of patch types, not unduly favouring rock outcrops, is recommended.

Discussion

Habitat monitoring has influenced Weyerhaeuser's practices in several ways. A few deficiencies in retention, such as tall snags, have been identified and used as a focus for operator training. The edge effects results have been used to support the adoption in some blocks of retention in fewer, larger patches, though this change was mostly driven by operational concerns. The large body of information on habitat attributes, including benchmark values, has made an important contribution to regional evaluations of the effectiveness of different forest practices, and to development of provincial policy.

Almost all the useful information from habitat monitoring to date has come from operational blocks, or existing benchmark sites. Experimental sites have only contributed pre-harvest results, as additional benchmarks. This simply reflects the time required to plan and implement Weyerhaeuser's ambitious set of experimental sites. We have not conducted a full set of post-harvest habitat measurements in the experimental sites that have been harvested, because we are waiting for harvest of the replicate sites. A critical benefit of monitoring operational sites is that they can provide immediate results, important for satisfying corporate and external funding sources that increasingly have a one-year time-frame. Beginning monitoring of operational blocks as soon as a new management approach is started helps to make monitoring an integral part of management. In contrast, focusing on experimental sites that cannot produce information for several years gives the impression that monitoring is peripheral "research" and less relevant to operations. Keeping monitoring as an integral part of operations serves to emphasize the "adaptive" part of adaptive management, a reminder that current practices are not necessarily a final solution.

Despite these practical advantages, monitoring in operational blocks has several limitations that require experimental sites. A main limitation is the risk that operational treatments are confounded with existing site conditions. This applies to comparisons of different retention types, where particular systems are likely to be used on particular sites (e.g., dispersed retention in more uniform, possibly more productive, sites), comparisons with existing benchmarks that are rarely typical sites, and measurement of edge effects where edges of retention patches are located at natural boundaries. The many replicates in operational sites cannot overcome these potential biases, though informed choice of sampling sites can help. For example, benchmark sites can include areas reserved from harvest for a variety of reasons, such as parks or wildlife reserves in particularly productive sites, and inoperable areas in less productive sites. However, the opportunity to randomize treatments in experimental sites is the best way to overcome confounding effects. Realizing this benefit with large-scale, operationally-implemented experiments requires adherence to randomization, avoiding the practical temptation to assign treatments to certain sites (e.g., clearcut treatment on most productive unit, unharvested control on least accessible unit). The operational layout of retention patches in Weyerhaeuser's experiments lost the advantage of randomized edge locations, but made the overall treatment results more directly relevant to management.

A second limitation of operational sites is the limited range of variables important for comparisons. Operational retention levels, for example, cluster around 20%, with the occasional higher values likely to be on sites confounded with difficult operating conditions. Experimental sites can provide a greater range of these important individual variables, with their experimental status protecting practitioners from the professional risks of doing something far out of the ordinary. Weyerhaeuser's experimental sites push the range of important variables only to a limited extent, because of a trade-off with making the treatments directly relevant to current practices, necessary to retain company support for the experiments.

The expense and difficulty of implementing full experiments means that there will never be enough experimental replicates to deal with high natural variability, particularly with the many ecosystem types on Weyerhaeuser's tenure. Monitoring operational sites is required to cover this wide range, to make comparisons not included in the experimental design, and, of course, to directly monitor operational progress. We anticipate that the main scientific contribution of the experimental sites will be to help reveal biases in the much larger set of results from operational sites. For example, a different relationship between percent retention and retention of particular habitat elements in operational and experimental sites could indicate that operational retention levels are confounded with existing site conditions. (Discussions with operational foresters and pre-harvest measurements would also help reveal these biases). As part of the broader Adaptive Management Program, operational and experimental structural monitoring assist in determining compliance with results-based regulations, help inform and support sustainable forest management certification processes, and help land managers maintain social license to operate on public lands.

References

Bunnell, F.L., L.L. Kremsater, and E. Wind. 1999. Managing to sustain vertebrate diversity in forests of the Pacific Northwest: relationships within stands. Environmental Reviews 7:97-146.

Burnham, K.P. and D.R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer Verlag, Inc. New York, USA.

CSP (Clayoquot Scientific Panel). 1995. Sustainable ecosystem management in Clayoquot Sound: planning and practices. Victoria, B.C.

Franklin, J.F., D.R. Berg, D.A. Thornburgh and J.C. Tappeiner. 1997. Alternative silvicultural approaches to timber harvesting: variable retention harvest systems. In: Creating a Forestry for the 21st Century: The Science of Ecosystem Management. K.A. Kohn and J.F. Franklin (Eds.) Island Press, Washington, D.C., pp. 111-139.

Huggard, D.J. 2004. Weyerhaeuser BC habitat monitoring 1999-2004. Unpublished report to Weyerhaeuser BC, Nanaimo, BC.

Kremsater, L., F. Bunnell, D. Huggard and G. Dunsworth. 2003. Indicators to assess biological diversity: Weyerhaeuser's coastal British Columbia forest project. Forestry Chronicle 79:590-601.

Krebs, C.J. 1989. Ecological Methodology. Harper and Row, New York, USA.

MacArthur, R.H. and J.W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

Marcot, B., K. Mellen, S.A. Livingston and C. Ogden. 2002. The DecAID advisory model: wildlife component. USDA Forest Service General Technical Report PSW-GTR-181.

Thomas, J.W. (editor). 1979. Wildlife Habitats in Managed Forest in the Blue Mountains of Oregon and Washington. USDA Forest Service Agriculture Handbook 553.