Evaluating the Effects of Partial Cutting on Wildlife Trees and Coarse Woody Debris[1]

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Abstract

In the wet forests of interior British Columbia, Canada, partial cutting can be used to produce stands that resemble natural uneven-aged forests. We have begun a long-term study of the effects of several partial cutting prescriptions on structural attributes and ecosystem processes in these forests. We employ a new classification of functional types of wildlife trees and coarse woody debris. A "Type" is a configuration of habitat features required by one or more wildlife species for specific functions. We present preliminary data on the occurrence of Wildlife Tree and Coarse Woody Debris Types before and after partial cutting in a fir-spruce stand.

Introduction

The existence of a major conference devoted to the ecology and management of dead wood indicates a recognition of the ecological importance of dead wood, and a desire to maintain in managed stands the functional processes that it supports. This is part of a larger recognition that the structures and processes that occur naturally are important to maintaining the biodiversity and productivity of forests, and furthermore that those structures and processes will not necessarily survive in managed stands unless special efforts are made to maintain them.

Using selection silvicultural systems in forests that are naturally uneven-aged is one approach to maintaining natural structures and processes in managed stands. The interior wetbelt of British Columbia, Canada, is an area of high precipitation and low fire frequency located on the windward side of the Rocky Mountains. It is dominated by western red cedar *(Thuja plicata* Donn) and western hemlock *(Tsuga heterophylla* [Raf.] Sarg.) at low elevations and Engelmann spruce *(Picea engelmannii* Parry) and subalpine fir *(Abies lasiocarpa* [Hook.] Nutt.) at higher elevations. Many stands are naturally uneven-aged. In the interior wetbelt there is increasing interest in selection silvicultural systems both for ecological reasons and to meet specific management objectives, such as conserving habitat for mountain *caribou (Rangifer tarandus caribou* Gmelin) or protecting scenic quality.

A research group at the University of Northern British Columbia has begun a long-term replicated study of the effects of several partial cutting systems on a

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variety of structural attributes and ecosystem processes, including the loss and creation of wildlife trees and coarse woody debris (Jull and others 2001). That component of our study focuses on comparing the occurrence of damage agents and of structural attributes that are important to wildlife in undisturbed and post-harvest stands. We employ a new classification of functional types of wildlife trees and coarse woody debris. Our objectives in this paper are to describe the new classification system of wildlife habitat features associated with standing and fallen trees, and to present preliminary results of a pilot project that evaluates the short-term effects of partial cutting on those habitat features.

Background

In recent years, increased scientific understanding of the ecology of natural disturbances has led to a paradigm shift in forest management (Rogers 1996). Forest managers have often viewed disturbances negatively and tried to suppress them. Many of those attempts, such as fire suppression and insecticide application, have had unanticipated negative consequences of their own (Rogers 1996). The disturbances themselves have been shown to have a key role in supporting the ecosystem processes essential to forest productivity and biodiversity. Increasingly, managers have come to view disturbances as natural processes that must be maintained if we wish to maintain ecological integrity.

Furthermore, many scientists and managers today see natural disturbance regimes not only as natural processes of value, but as models for forest management regimes. British Columbia's *Biodiversity Guidebook* states as its first principle, "The more that managed forests resemble the forests that were established from natural disturbances, the greater the probability that all native species and ecological processes will be maintained" (Ministry of Forests and British Columbia Environment 1995).

In the interior wetbelt of central British Columbia, stand-initiating fires occur infrequently. The common means of natural forest regeneration are small disturbances in which one or a few trees are killed by insects, disease, or windthrow. The resulting canopy gaps, standing dead trees, and coarse woody debris have a pervasive influence on the ecology of wet forests, including tree recruitment, understory vegetation dynamics, wildlife habitat, stream structure and dynamics, biomass dynamics, and carbon budgets (Lertzman and others 1996). Whereas clearcut silvicultural systems can mimic the effects of stand-destroying fires, partial-cut silvicultural systems are better suited to maintain the uneven age- and size-class distributions and the structural attributes that result from a natural disturbance regime dominated by small-scale mortality events.

However, selection harvested stands differ from natural stands in several important ways, some of which may affect the stands' ability to provide important structures and processes. Felled trees are removed from the block rather than remaining on the forest floor. For economic reasons, it is often necessary to remove more trees in a single entry than would die naturally at any one time. Trees that could be dangerous to forest workers must be felled, even if they are unmerchantable. Over time, there is likely to be an increase in the amount of young wood and a decrease in the amount of old or dead wood.

The landscape pattern that results from logging may be conceptualized as a secondary mosaic of disturbance overlaying nature's disturbance patterns (Ripple and others 1991). Regardless of whether or not the human-caused disturbance pattern resembles the natural disturbance pattern, the natural agents of disturbance continue to operate. However, the frequency, severity, and character of those natural disturbances may be affected by forest harvesting.

Although disturbance ecology is currently an active area of research, we are aware of little work on the effects of harvesting on natural disturbance agents in the residual stands after partial cutting. Relationships have been documented between silvicultural systems and the occurrence of specific disturbance agents, such as western spruce budworm (Carlson and Schmidt 1989), windthrow (Coates 1997), and decay organisms and insects (Nevill and Whitehead 1996). But there seems to be little information on how the overall assemblage of disturbance agents is affected by partial cutting.

In the interior wetbelt of central British Columbia, trees that have been damaged by disturbance agents provide a rich variety of habitats for the 61 vertebrate species that are obligate or frequent users of wildlife trees, and the 51 vertebrate species that are obligate or frequent users of coarse woody debris (Keisker 2000). The habitat values of these trees and logs are linked to the damage agents that have affected them. If different silvicultural systems result in different levels of occurrence of various damage agents, they may also result, over time, in different levels of occurrence of the wildlife habitat attributes associated with damaged or dead trees. One of the objectives of the research of Jull and others (2001) is to find out how various partial-cutting prescriptions affect the assemblage of disturbance agents and the occurrence of standing trees and coarse woody debris with wildlife habitat attributes.

Study Area

The study area for the pilot project is located at Pinkerton Mountain, about 90 km east-southeast of Prince George, British Columbia, Canada, in the Engelmann Spruce-Subalpine Fir zone (Meidinger and Pojar 1991). The mesic to subhygric site is on a southwest-facing slope at 1,350-1,470 m a.s.l. Pre-harvest basal area was approximately 35 m^2/ha, composed of 78 percent subalpine fir and 22 percent Engelmann spruce.

Harvesting Methods

The study area comprises a 40-ha single tree selection unit, a 59-ha group selection unit, and a 25-ha unharvested control area. The target level of volume removal in both units was 30 percent. In the group selection unit, the trees were removed in openings that ranged from 0.1 to 0.4 ha. In the single tree selection unit, trees to be cut were marked to leave a target diameter distribution with relatively high retention of large trees. The block was logged in early 1998 on a late winter snowpack by mechanized harvesting machines. The harvesting was described in more detail by Stevenson and others (1999).

Study Methods

Sampling was based in and around 14 systematically located permanent sample plots, 7 in each of the 2 treatment areas. At each location, a 0.05-ha plot was nested inside a 0.10-ha plot. In the inner plot, all standing trees $\geq$ 10 cm dbh were assessed, and in the outer plot all trees $\geq$ 25 cm were assessed. In addition to standard mensurational data, we recorded damage agents, evidence of wildlife use, and Wildlife Tree Types and two Coarse Woody Debris Types for each sample tree.

Coarse woody debris was tallied along at least two 24-m transects associated with each permanent sample plot. For each piece, we recorded various standard data (Ministry of Forests 1997) and Coarse Woody Debris Types.

Trees and coarse woody debris were assessed in summer 1997 and again in summer 1998, after logging was completed. Some trees that were standing after the harvest were potentially dangerous to workers and should have been removed according to the safety regulations of the Workers' Compensation Board (WCB) of British Columbia (Stone and others 2001). To ensure that the data represented realistic conditions, such trees were omitted from the analysis.

Because of unequal sample sizes between treatment units and before and after logging, results are shown as percentages of the number of sample trees or logs in each treatment unit exhibiting a given attribute. The log-likelihood ratio *G* (Sokal and Rohlf 1995) was used as a test statistic to compare the frequency distributions of the number of Types associated with each sample tree or log in the two treatment units. Assessments carried out in the control area are not reported here.

Wildlife Tree and Coarse Woody Debris Types

Our classification system of habitat features associated with wildlife trees and coarse woody debris is based on the concept of the "Type"—a configuration of habitat features that appears to be required by one or more wildlife species for specific functions (Keisker 2000). The classification developed from a project in which available information on wildlife habitat requirements involving wildlife trees and coarse woody debris in the north-central interior of British Columbia was reviewed and presented in a summary format that would be useful to managers (Keisker 2000). For that purpose, information was condensed by including only those habitat features that have functional significance to wildlife and by delineating sets of these features, termed "Types," that serve specific functions for groups of wildlife.

Ten Wildlife Tree (WT) Types and six Coarse Woody Debris (CWD) Types were described by Keisker (2000) and are summarized in *tables 1* and *2*. The term "wildlife tree" refers to a standing dead or live tree with special characteristics that are valuable for wildlife and that distinguish it from most other trees in the forest. The sets of features that define the Types are often not mutually exclusive. A single tree or CWD piece may have 0, 1, or more Types. Although the Types were developed for wildlife species and ecosystems occurring in the north-central interior of British Columbia, we believe that both the approach and the results have a broader geographic applicability.

CWD Types 1, 2, and 3 may apply to standing trees as well as logs. We included CWD-1 and CWD-3 in our assessments of standing trees, but not CWD-2, because it applied to almost every tree.

Table 1—*Types of Wildlife Trees required by wildlife of north-central British Columbia (Keisker 2000).*

Main function		Type	Main users
Reproduction/resting:			
Substrates for cavity excavation	WT-1	Hard outer wood surrounding decay-softened inner wood	Woodpeckers (stronger excavators)
	WT-2	Outer and inner wood softened by decay	Woodpeckers (weaker excavators), chickadees, nuthatches
Existing cavities	WT-3	Small, excavated or natural cavities	Chickadees, nuthatches, swallows, bats
	WT-4	Large, excavated or natural cavities	Ducks, owls, bluebirds, swallows, bats, squirrels, mustelids
	WT-5	Very large natural cavities or hollow trees	Swifts, owls, bats, mustelids
	WT-6	Cracks, loose bark, or deeply furrowed bark	Creepers, bats
Large open-nest supports and other non-cavity sites	WT-7	Witches' brooms	Diurnal raptors, owls, squirrels, mustelids
	WT-8	Large branches, multiple leaders, or large-diameter broken tops	Herons, diurnal raptors, owls
Foraging:			
Feeding substrates	WT-9	Arthropods in wood or under bark	Woodpeckers
Hunting perches	WT-10	Open-structured trees in or adjacent to open areas	Diurnal raptors, owls

Table 2—*Types of coarse woody debris (CWD) required by wildlife of north-central British Columbia (Keisker 2000).*

Main function		Type	Main users
Reproduction/resting /escape:			
Concealed spaces	CWD-1	Large concealed spaces	Grouse, hare, woodrat, porcupine, fox, cats, some mustelids, bears
	CWD-2	Small concealed spaces (or soft substrate allowing excavation of such spaces) at or below ground-level beneath hard material	Salamander, toad, treefrog, snakes, wrens, shrews, voles, deer mouse, golden-mantled ground squirrel, chipmunk, jumping mice, weasels

	CWD-3	Small concealed spaces above ground-level	Treefrog, Yellow-bellied Flycatcher, wrens, Townsend's Solitaire, some wood warblers, some sparrows
Travel:			
Concealed runways	CWD-4	Long concealed spaces (or soft substrate allowing construction of runways)	Salamander, some snakes, wrens, shrews, voles, deer mouse, weasels
Exposed, raised travel lanes	CWD-5	Large or elevated, long material clear of dense vegetation	Tree squirrels, chipmunk
Foraging:			
Feeding substrates	CWD-6	Invertebrates in wood, under bark or moss-cover, or in litter/humus accumulated around CWD	Salamander, treefrog, woodpeckers, wrens, some sparrows, shrews, deer mouse, skunk, bears

Results and Discussion

Two of our main interests in this pilot project were to learn about the frequency of occurrence of the various WT and CWD Types in a high-elevation fir-spruce stand, and to obtain a preliminary indication of the different effects of group and single tree selection. We expected that the two different partial cutting prescriptions would have different effects on the occurrence of WT Types, but not necessarily CWD Types. According to worker safety regulations, if work in a forestry operation will expose a worker to a dangerous tree, that tree must be removed (Stone and others 2002). Harvesting is dispersed throughout a single tree selection unit, and many of the danger trees are potentially subject to removal. In a group selection unit, work activity is more concentrated, and more of the danger trees are likely to be located away from work areas. Because wildlife tree attributes are often associated with damage or decay that could make a tree dangerous, we expected that fewer trees with WT Types would be retained in the single tree selection unit than the group selection unit.

Most WT Types were uncommon in the study area before harvesting, occurring with a frequency of less than 5 percent *(fig. 1)*. Fifteen to 20 percent of the sample trees had large concealed spaces at or below ground-level (CWD-1), possibly because they had originated on nurse logs which had subsequently rotted away. Loose bark or wide cracks (WT-6) were also common (15-20 percent). Hunting perches (WT-10) were moderately common (5-10 percent) in this high-elevation stand, which had many natural gaps. WT-10 was recorded more often in the unit assigned to group selection than the unit assigned to single tree selection (G = 11.114; df = 1; p = 0.001), although refinements to the identification criteria for that Type that were made during sampling may have contributed to the difference. No other differences were found between the pre-harvest occurrence of the other Types in the two treatment units.

Because the planned level of volume removal was 30 percent throughout the harvest block, we expected that the proportion of sample trees remaining after harvesting would be similar in the two treatment units. In fact, however, harvested areas were overrepresented in the group selection sample plots. Of those seven plots, one was completely logged, one was completely unlogged, and five were partly logged, but only 42 percent of the original sample trees were still present. In the single tree selection unit, some trees had been felled in all the plots except one, which was located on a short, steep slope; and 67 percent of the sample trees remained after logging. Because of the difficulty of obtaining adequate representation of harvested and unharvested areas in non-uniform treatment units, we will use a stratified sampling scheme in future studies.

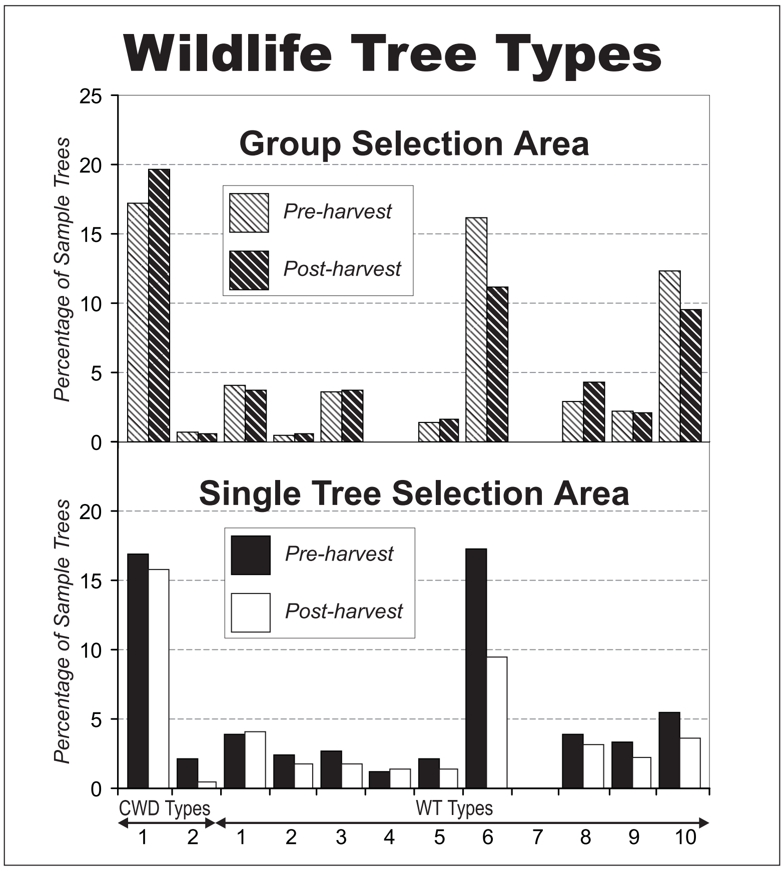

Figure 1—Occurrence of 10 WT and 2 CWD Types associated with standing trees before and after group selection and single tree selection logging at Pinkerton Mountain, British Columbia.

Our primary interest was not in the number of trees that remained after logging, but in the habitat attributes of those trees. The proportion of sample trees with Types did not change as much after harvesting as we had expected, nor was there a pronounced difference between the two treatment units. The most conspicuous reduction was in the occurrence of WT-6. In our study area, loose bark or wide cracks were usually associated with hard subalpine fir snags that had been dead for some time (Stage 4 of Thomas 1979). These trees were commonly dangerous and often had their full height, which made them more likely than shorter trees to affect work areas. Aside from WT-6, occurrence of Types was similar or only slightly reduced after harvesting.

The results shown in *figure 1* are inconvenient for statistical analysis because the number of observations in some categories is very small, the categories are not ordered, and it is not reasonable in most cases to increase the number of observations by grouping categories. We used the number of Types associated with each sample tree as a single variable to characterize the habitat value of that tree, and the frequency distribution of the number of Types to characterize the stand. Before the harvest, 35.8 percent of the 776 sample trees in the 14 plots exhibited one or more Types, and the frequency distributions of number of Types in the two treatment units did not differ (G = 3.995; df = 4; p = 0.407). After harvesting, 30.6 percent of the 409 remaining sample trees had one or more Types, and the frequency distributions were still not significantly different (*fig. 2;* G = 5.900; df = 4; p = 0.207).

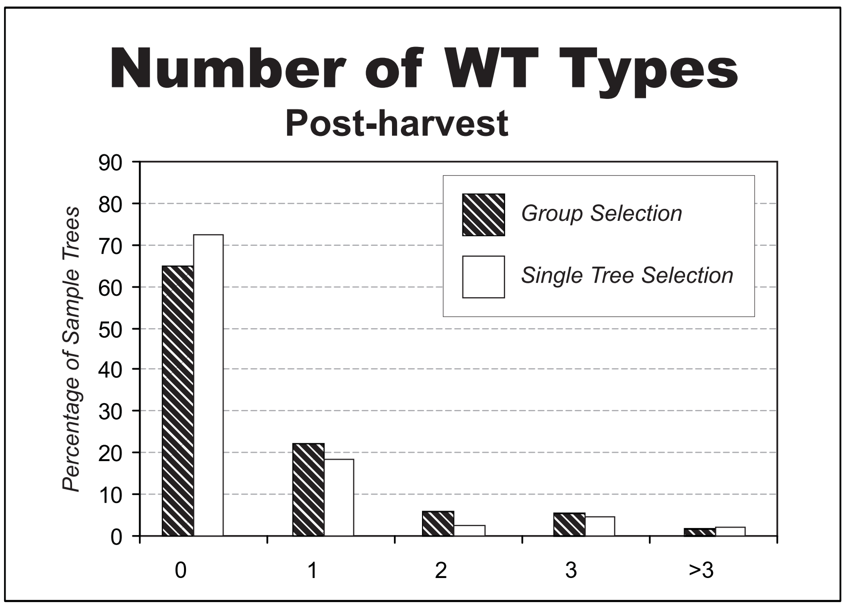

Figure 2—Frequency distribution of the number of WT and CWD Types associated with standing trees after group selection (GS) and single tree selection (STS) at Pinkerton Mountain, British Columbia.

The relatively high retention of trees with Types after partial cutting and the small differences between the group selection and single tree selection units were unexpected. We found that some Types occurred in trees that were not dangerous to workers, either because the attribute was not associated with any structural defects that made the tree hazardous, because the tree was short enough that it would not affect any work areas, or because a tree that was otherwise hazardous was buffered from work areas by healthy green trees that would break its fall. Also, we found that even in the single tree selection unit, there were areas where no logging took place, either because they could not easily be accessed or because initial basal area was low and no trees had been marked for cutting.

Unlike WT Types, CWD Types are very common. Ninety percent of the 397 pieces that were tallied in pre-harvest plots had one or more CWD Types. CWD Types 1, 2, and 4 were the most common, occurring consistently in more than 20 percent of the sample pieces. Occurrence of the various Types was similar before and after harvest in both treatment units, except for an apparent increase in CWD-1—large concealed spaces—after harvesting in both units. There may have been more spaces around and under logs where logging residue had been piled.

Because CWD Types are common, the frequency distribution of number of CWD Types *(fig. 3)* has a different shape from that of the WT Types *(fig. 2)*. Frequency distributions of CWD Types did not differ between treatment units either before harvesting ($G = 7.358$; df = 5; p = 0.195) or after harvesting ($G = 3.079$; df = 5; p = 0.688).

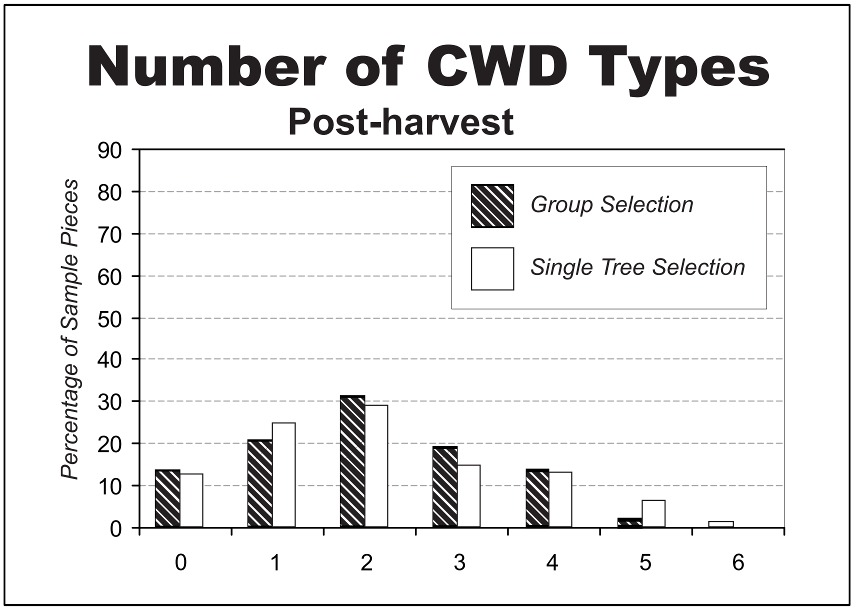

Figure 3—Frequency distribution of the number of CWD Types associated with down logs after group selection (GS) and single tree selection (STS) at Pinkerton Mountain, British Columbia.

The results of this pilot project have limitations that restrict their generality: only one site was studied, sample sizes were small, and the treatments were not randomly assigned. The results described here should not be extrapolated to other sites. However, the approach has broad applicability when used in a larger, replicated experimental design.

Conclusion

The preliminary results of this pilot project suggest that, at least in some cases, selection harvesting may have little impact on the percentage occurrence of the attributes of standing trees and coarse woody debris that are most important to wildlife. However, it would be premature to base any conclusions on an unreplicated study in which sample sizes were small and methodological problems were still being resolved.

The classification system of WT and CWD Types described here appears to be a useful tool with which to evaluate the effects of various silvicultural systems in both the short-term and the long-term. We would expect that with larger sample sizes we might find that some Types, such as WT-6, are more likely than others to be substantially reduced by partial cutting. Different methods of partial cutting, such as helicopter logging, cable logging, and hand-felling, may affect the occurrence of WT and CWD Types differently. We would also expect that the patterns of occurrence of the various Types will vary with the age and species composition of forest stands. Eventually, the results of these studies should help managers to plan how to maintain the full array of structural attributes that are critical to wildlife.

Acknowledgments

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References

Carlson, C. E.; Schmidt, W. C. 1989. **Influence of overstory removal and western spruce budworm defoliation on growth of advance conifer regeneration in Montana.** Res. Paper. INT-RP-409. Ogden, UT: Intermountain Research Station, Forest Service, U.S. Department of Agriculture; 14 p.

Coates, K. D. 1997. **Windthrow damage 2 years after partial cutting at the Date Creek silvicultural systems study in the Interior Cedar-Hemlock forests of northwestern British Columbia.** Canadian Journal of Forest Research 27: 1695-1701.

Jull, M.; Stevenson, S.; Rogers, B.; Sanborn, P.; Eastham, A. 2001. **Northern wetbelt silvicultural systems project: a study of alternative silvicultural systems in Northern Wetbelt ICH and ESSF forests.** Establishment report. Prince George, B.C.: University of Northern British Columbia.

Keisker, D. G. 2000. **Types of wildlife trees and coarse woody debris required by wildlife of north-central British Columbia.** Working Paper 50. Victoria, BC: British Columbia Ministry of Forests; 92 p.

Lertzman, K. P.; Sutherland, G. D.; Inselberg; A.; Saunders, S. C. 1996. **Canopy gaps and the landscape mosaic in a coastal temperate rain forest.** Ecology 77(4): 1254-1270.

Meidinger, D.; Pojar, J. 1991. **Ecosystems of British Columbia.** Spec. Rep. Ser. No. 6. Victoria, BC: British Columbia Ministry of Forests.; 330 p.

Ministry of Forests. 1997. **Ground sampling procedures.** Victoria, BC: British Columbia Ministry of Forests Resources Inventory Branch, Ministry of Forests and Resources Inventory Committee.

Ministry of Forests and British Columbia Environment 1995. **Biodiversity guidebook—Forest Practices Code of British Columbia.** Victoria, BC: British Columbia Ministry of Forests and British Columbia Environment; 68 p.

Nevill, R. J.; Whitehead, R. J. 1996. **Potential loss due to decay and insect attack following selective harvest in coastal montane forests.** FRDA Rep. 265. Victoria, BC: Canada-British Columbia Partnership Agreement on Forest Resource Development II; 11 p.

Ripple, W. J.; Bradshaw, G. A.; Spies, T. A. 1991. **Measuring forest landscape patterns in the Cascade Range of Oregon, USA.** Biological Conservation 57: 73-88.

Rogers, P. 1996. **Disturbance ecology and forest management: a review of the literature.** Gen. Tech. Rep. INT-GTR-336. Ogden, UT: Intermountain Research Station, Forest Service, U.S. Department of Agriculture; 16 p.

Sokal, R. R.; Rohlf, J. F. 1995. **Biometry.** 3rd ed. New York: Freeman and Co.; 887 p.

Stevenson, S. K.; Jull,, M.; Coxson, D. S. 1999. **Selection silvicultural systems in mountain caribou habitat: logging and learning at Pinkerton Mountain.** Forest Research Note #PG-19. Prince George, BC: Prince George Forest Region Forest Resources and Practices Team; 8 p.

Stone, J.; Parminter, J.; Arsenault, A., Densmore, N.; Manning, T.; Davis, G.; MacKinnon A. 2002. **Dead tree management in British Columbia.** In: Laudenslayer, William F., Jr.; Shea, Patrick J.; Valentine, Bradley E.; Weatherspoon, C. Phillip; Lisle, Thomas E., technical coordinators. Proceedings of a symposium on the ecology and management of dead wood in western forests. 1999 November 2-4; Reno, NV. Gen. Tech. Rep. PSW-GTR-181. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; [this volume].

Thomas, J. W. 1979. **Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington.** Agric. Handb. 553. Washington, DC: Forest Service, U.S. Department of Agriculture; 512 p.