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Effects of Partial Cutting on Forage Lichens for Caribou in a Subalpine Forest: The Pinkerton Mountain Silvicultural System Trial Revisited 10 years After Harvesting.

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Abstract

Partial cutting systems have often been proposed as a means of maintaining canopy lichen abundance and diversity in managed forests. However, most assessments of the effectiveness of specific harvest practices in maintaining canopy lichens are based on immediate post-harvest measurements. Fewer assessments extend beyond the immediate 2-3 year post-harvest period. We anticipate that changes in lichen community composition will occur for many decades after harvesting, as lichens respond over time to changes in canopy microclimate and substrate availability. We can now report on the response of canopy lichen communities 10 years after partial cutting at Pinkerton Mountain, in B.C.'s central interior, where 30% of the timber volume had been removed in a side-by-side comparison of two partial-cut harvesting treatments: one in which trees were removed in patches, as part of a group selection silvicultural system, and one in which trees were removed singly from throughout the harvest unit, as part of a single tree selection silvicultural system. Our measurements show a shift in canopy lichen genus composition, with the proportion of *Bryoria* – the preferred winter forage of the red-listed mountain caribou – gradually increasing in relation to *Alectoria.* However, it will still be many decades before overall forage lichen loading in the partial cut harvest stands approaches that of uncut adjacent old-growth forests. Thus, although partial cut harvesting is an effective strategy for maintaining winter forage for mountain caribou, it cannot substitute for maintaining core habitat in a natural state.

Introduction

High-elevation Engelmann-spruce Subalpine-fir (ESSF) forests in the central interior of British Columbia were historically dominated by old-growth stands. DeLong (1998) estimated that fire return intervals in montane forests of the upper Fraser River watershed ranged from 244 years to over 1600 years – depending on slope position, absolute precipitation levels, and aspect. These old forests represent a major winter foraging area for populations of the red-listed mountain caribou (*Rangifer tarandus caribou*), which feed on arboreal hair lichens, primarily a number of species of the dark-brown genus *Bryoria* and secondarily, the less preferred yellowish green species *Alectoria sarmentosa* (Rominger et al. 1996, Terry et al. 2000).

Where forest harvesting occurs within the range of mountain caribou herds, there are several impacts. One is the direct loss of habitat, particularly winter forage availability. As it takes many years – longer than a normal harvesting cycle – for arboreal lichens to reach biomass loadings attractive to caribou after stand-destroying events, retention of arboreal lichens in old-growth forests is critical to providing continued habitat availability for mountain caribou. The second major impact of forest harvesting applies primarily to low-elevation forests and is less direct, but just as important. Forest harvesting within or adjacent to mountain caribou habitat at low elevations provides abundant winter forage for moose, which in turn allows regional wolf populations to reach much higher levels than would otherwise have been the case. Although mountain caribou are not the major prey species for these wolves, the increased predation on caribou that results from higher wolf numbers is a major factor in the decline of mountain caribou populations (Wittmer et al. 2005). The third impact is the creation of access roads, which can increase disturbance to caribou from human activities (Seip et al. 2007), and probably the vulnerability of caribou to predation by wolves in winter.

The most prudent approach to management of B.C.'s mountain caribou populations would be to minimize all of these impacts in core mountain habitat areas by curtailing forest harvesting activities. Steps were taken in this direction with the designation of areas in which logging is not permitted due to high habitat values for mountain caribou in the Prince George area (British Columbia Ministry of Forests 1995) and in the Quesnel Highland (Cariboo-Chilcotin Land Use Plan Caribou Strategy Committee 2000). Major additions to no-harvest zones throughout the range of mountain caribou were announced in February 2009 under B.C.'s Mountain Caribou Recovery Implementation Plan (British Columbia Ministry of Environment 2009). In some areas, the no-harvest strategy is supplemented by the designation of modified-harvest zones, often in lower-value caribou range or as buffers around no-harvest zones. In modified-harvest areas, harvesting must be done in a way that is as compatible as possible with maintaining caribou habitat, as through the use of selection harvesting techniques. Where low volume removal partial cutting is done in subalpine forests, some canopy lichens are retained as a winter forage source for caribou. Snow depths at that elevation generally preclude use by moose in winter, so the potential enhancement of moose browse is not an issue. However, access management may be necessary where there is a risk of recreational use of the road system during winter, especially where caribou habitat overlaps desirable snowmobiling areas.

The assessment of canopy lichen response to partial cut harvesting in modified-harvest zones requires long-term ecological studies. Immediate post-harvest retention of canopy lichens on remaining trees is no guarantee that canopy lichens will remain in place under the altered conditions of canopy microclimate brought about by harvesting. Indeed, our previous studies have demonstrated that there may be a pulse of lichen litterfall from retained trees after harvesting (Stevenson and Coxson 2003). The important question, therefore, is what long-term equilibrium develops for the growth and establishment of arboreal hair lichens under the new conditions of canopy microclimate that occur in harvested stands.

We have been addressing the need for long-term monitoring in a set of experimental plots at Pinkerton Mountain, a silvicultural systems trial site in the Cariboo Mountains. Changes in the composition and abundance of canopy lichen communities have been monitored in group and single tree selection harvesting units at this experimental silvicultural systems site, logged in 1998. Our initial studies of canopy microclimate and lichen response at this site indicated that growth rates of individual sample clumps of both *Alectoria* and *Bryoria* species were reduced in the most exposed location – along the edges of the group selection openings – but not in the single tree selection or control areas (Coxson et al. 2003, Stevenson and Coxson 2003). Our data suggested that over time, we would see a shift in composition toward more *Bryoria* and less *Alectoria* on trees that were in more exposed locations. We have now conducted a series of follow-up measurements, some 10 years after harvesting, to determine if these trends continued, allowing further assessment of the efficacy of these harvest treatments in maintaining canopy lichen populations.

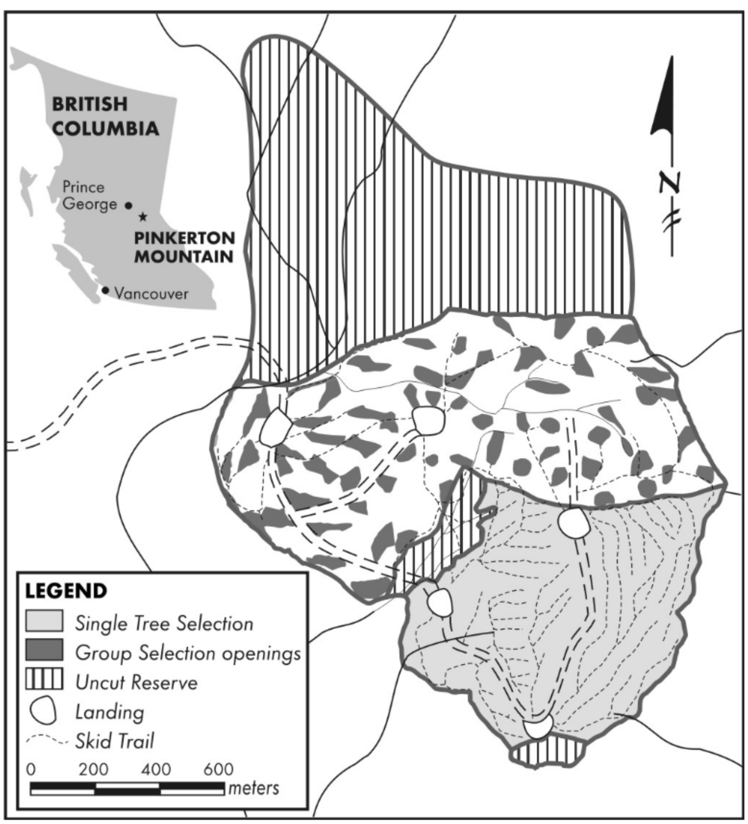

Figure 1. Location of the Pinkerton Mountain study area and layout of the harvest block.

Methods

The Pinkerton study area (53°38′7″N, 121°25′33″W) is located in the Cariboo Mountains approximately 90 km east-southeast of Prince George, British Columbia (. 1), at an elevation of 1350 to 1470 m, in the wet cold subzone of the Engelmann Spruce – Subalpine Fir Zone (Meidinger and Pojar 1991). Mean annual precipitation in this subzone is 1408 mm, of which approximately 56% falls as snow (DeLong et al. 1994).

The Pinkerton Mountain silvicultural systems trial utilized two uneven-aged silvicultural systems: group selection and single tree selection (Fig. 1 and 2). In the 59-ha group selection (study) area, trees were removed in discrete groups with a mean opening size of 0.25 ha. As much as possible, naturally occurring clumps of trees were either removed entirely or retained, resulting in irregularly shaped harvest openings. In the 40-ha single tree selection (study) area, trees were removed in specified proportions from a range of diameter classes to achieve a target diameter distribution; trees larger than 52.5 cm diameter at breast height were retained unless they had to be felled to clear skid trails. A 25-ha area immediately adjacent to the block was designated as a control area and left unlogged. The prescription for both harvest units was for 30% timber removal. The resulting post-harvest basal area ranged from 23 to 27 $m^2 \cdot ha^{-1}$ in both treatment units. Harvesting took place in March and April 1998 on a settled snowpack. Operational details of the planning, prescription and harvesting are given in Stevenson et al. (1999).

In summer 2008, 10 years after logging, we reassessed forage lichen abundance on trees in the single tree selection area, the group selection area and a nearby unharvested

Figure 2. Edge of a group selection opening at Pinkerton Mountain 10 years after partial cut harvesting.

control area. We used a photo guide (Armleder et al. 1992) to rate the abundance of the forage lichens on a 7-point scale and the percentage (by 10% intervals) of the forage lichens composed of *Alectoria sarmentosa*, as opposed to *Bryoria* spp., on trees that had previously been assessed before and soon after the harvesting. The photo-based estimates were done from the ground and considered only the lower 4.5 m of each tree – the portion of the canopy that is generally available to foraging caribou during winter. We used log-likelihood *G* tests in SYSTAT ver. 10.2 (SPSS Inc., Chicago) to compare the frequency distributions of changes in lichen classes in the treatment areas.

We also used detailed branch-level estimates to quantify forage lichen abundance on a smaller group of trees that had been assessed immediately after the harvesting. The branch-level estimates were done by a research tree-climber who used a rope system to access the entire canopy. The number of "clumps" of lichen on each branch was estimated, at the genus level, with reference to sample clumps used as standards for comparison (see Coxson et al. 2003 for more a more detailed description of methods). Although several of our sample trees had been lost to windthrow or spruce beetle, two sample trees remained that were immediately adjacent to group selection openings. For these trees, we used t-tests on log-transformed data to compare the number of clumps of *Alectoria* and of *Bryoria* on the branches facing the group selection opening with those on the branches facing away from the opening. As well, we established new sample trees so that we would have a more robust sample size for future comparisons.

Results and Discussion

Ground-based estimates of overall forage-lichen abundance on sample trees done before and immediately after the harvest had not differed significantly from one another (Coxson et al. 2003). In 2008, that was still the case – most trees were given the same rating in 2008 as in 2001, and the numbers that went up and down were similar in all three treatment units (Figure 3). However, the frequency distributions of changes in the percent *Alectoria* classes (each class representing a 10% interval) from 2001 to 2008 differed significantly from one another (log-likelihood $G = 18.730$, df = 6, $p = 0.005$). In the group selection area, and especially in the single tree selection area, more trees decreased than increased in percent *Alectoria*.

At a finer scale, we examined branch-level lichen loading on two trees located on the edges of group selection openings (Figure 4). In 2000, two years after logging, there was no significant difference in biomass of the two groups of hair lichens between exposed and protected branches. Eight years later, there was significantly more *Bryoria* on the exposed branches than on the branches facing away from the opening ($p = 0.008$). When examined individually, both trees showed the same pattern, although the difference in *Bryoria* loading was not statistically significant (p = 0.177) in one case. While the observed branch-level differences are not large, they are consistent with the predicted changes and with the changes in ground-based estimates.

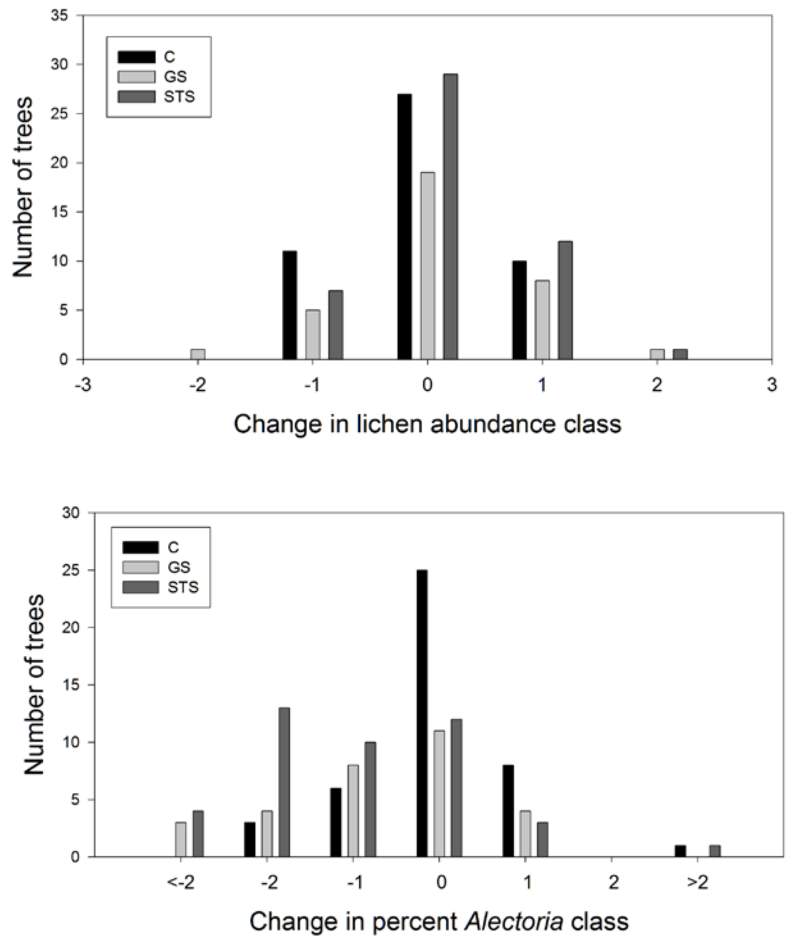

Figure 3. Frequency distributions of changes in lichen abundance class (above) and percent *Aelctoria* class (in 10% intervals) (below) from 2001 to 2008 in the unharvested control area (C), the group selection area (GS), and the single tree selection area (STS) at Pinkerton Mountain. N= 131.

Maintaining canopy lichen communities in subalpine forests depends on the ongoing balance between processes of lichen dispersal, establishment, survival, and growth. Our results reflect, primarily, the survival and growth of lichens that had previously been established. It is not clear to what extent the trends in our data result from a decrease in *Alectoria* loading or an increase in *Bryoria* loading. The long pendulous thalli of *Alectoria* have been found susceptible to wind scouring in other ecosystems (Esseen and Renhorn 1998), and this may have been taking place along the edges of group selection openings at Pinkerton. At the same time, *Bryoria* prefers well ventilated canopy exposures (Goward 1998) and has a demonstrated intolerance to prolonged exposure to wet conditions (Coxson and Coyle 2003). These factors, when taken together, may predispose *Bryoria* to attaining greater

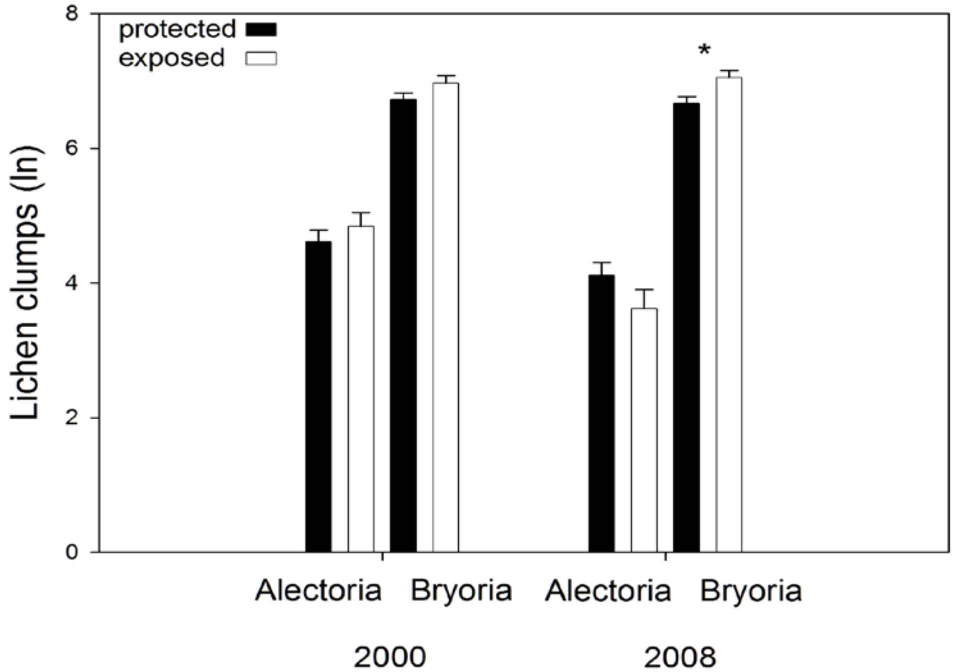

Figure 4. Estimated number of clumps per branch (natural log scale) of *Alectoria sarmentosa* and *Bryoria* spp. on protected and exposed portions of two trees on edges of group selection openings at Pinkerton Mountain, 2000 (n = 294) and 2008 (n = 303). Asterisk indicates a statistically significant difference.

biomass accumulation on retained trees in the more open partial-cut forest canopies. Ten years after harvesting, the regenerating trees are still too small to reduce the effects of exposure, and the trends we observed in the canopy lichens are likely to persist for some time. Eventually, as regenerating trees in surrounding harvest openings attain greater size and edge effects are reduced, the proportion of *Alectoria* in relation to *Bryoria* on retained trees should increase. At the same time, the regenerating trees should begin to gain lichen biomass through the processes of dispersal and establishment, and stand-level biomass of forage lichens should increase.

Conclusions

Ten years after partial-cut harvesting at Pinkerton Mountain, there appears to have been no net loss of forage lichens for caribou at the tree level, and we are beginning to see the expected shift in genus composition toward more *Bryoria* and less *Alectoria*. This shift is not detrimental to caribou, which prefer *Bryoria* when both genera are available (Rominger et al. 1996). However, stand level lichen loading within the partial-cut harvesting areas remains about a third lower than that of adjacent (uncut) old-growth forests -- based on the original level of basal area removal – as the regenerating trees have not yet grown enough to accumulate substantial biomass of forage lichens.

The changes in the lichen community that are occurring at the Pinkerton site are consistent with patterns that have been observed at other partial cut sites in the Engelmann Spruce – Subalpine Fir Zone, reviewed by Stevenson and Coxson (2007). As the understory residual trees develop and begin to shade the lower canopies of the larger residual trees, there are likely to be further changes in the lichen community. As the residual stand grows, it will be important to monitor not only the lichens on the large trees, but also the developing lichen communities on the younger trees.

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Further Reading or Resources

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