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A Comparison of Natural Regeneration Patterns in Old-growth Stands and Clearcuts in the Mountain Hemlock Zone of Southern British Columbia

Introduction

Regeneration patterns on British Columbia's (BC) coast change with increasing elevation. At low elevations in the Coastal Western Hemlock (CWH) zone, trees regenerate primarily in gaps (Spies et al. 1990; Lertzman et al. 1996). At high elevations in the parkland Mountain Hemlock (MH) subzone, deep snow restricts regeneration to tree islands where snow melts earliest (Brooke et al. 1970; Franklin and Dyrness 1973). At elevations between these two systems, in the forested MH subzone, the lack of understanding of regeneration patterns hampers forest management. We therefore compared regeneration patterns on six old-growth sites and six adjacent sites that were clearcut 11-12 years prior to sampling. All sites were in the moist maritime (MHmm1) variant of the forested MH subzone (Green and Klinka 1994). They were uphill of Sechelt, BC at elevations from 1060-1195 m. Three sites each in old-growth stands and clearcuts were 'flat' (17-25% slope), and three sites were 'steep' (45-53% slope). Four sites in each occupied warm aspects (190-222° azimuth) and two sites occupied cool aspects (24-64° azimuth). Site conditions for the old-growth stands and clearcuts were matched as closely as possible. Soils were nutrient-poor and ranged from fresh to very moist (Green and Klinka 1994).

Results and Discussion

Mountain hemlock (*Tsuga mertensiana*) and Alaska yellow-cedar (*Chamaecyparis nootkatensis*) dominated the old-growth canopy, but Pacific silver fir (*Abies amabilis*) dominated the sub-canopy and understory layers (Figure 1). Canopy trees were 319-1404 years old and averaged 488 years to recruit to the canopy layer (a diameter at breast height of 40 cm). Virtually all regeneration was located on the undisturbed forest floor rather than on decaying wood or mineral soil. Mounds covered only 28% of the ground surface but supported 41% of understory trees and 61% of sub-canopy trees. Regeneration was statistically unrelated to overhead canopy cover (i.e., gap versus non-gap), which likely reflected the openness of the canopy in these stands and the relatively homogeneous light levels below the canopy. Distance to the nearest canopy tree, however, was related to regeneration patterns: there were 14% more understory trees and 56% more sub-canopy trees than expected on microsites <2 m from the nearest canopy tree. This pattern was apparently related to snowmelt patterns since snow melted earliest on microsites closest to a canopy tree.

Overall, regeneration patterns in old-growth stands resembled those in tree-island systems more than those in gap-phase systems since trees were more likely to survive to the sub-canopy layer on microsites close to canopy trees and on mounds. This tendency was most apparent on flat and cool-aspect sites where snow remained into June. The steep snow gradient at the transition from the CWH zone to the forested MH subzone is reflected by the change from western hemlock (*Tsuga heterophylla*) to mountain hemlock (Brooke et al. 1970) and from gap-phase to tree-island regeneration patterns. An example of this steep gradient is the gap-phase structure of stands dominated by Pacific silver fir and western hemlock (Lertzman and Krebs 1991) that are at only slightly lower elevations than our study stands.

Clearcutting of old-growth stands on sites that were edaphically similar to those described above apparently caused changes in species composition, stand structure, and regeneration patterns. Virtually all trees >1.3 m tall on clearcut sites established two or more years before cutting. The

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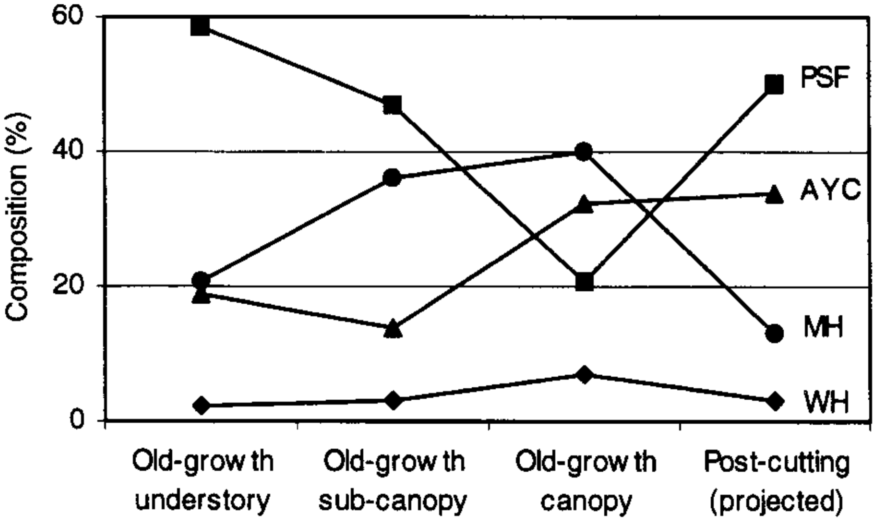

Figure 1. Species composition (in percent) of old-growth stands compared to the projected canopy composition of second-growth stands on edaphically-similar clearcuts. Only trees >1.3 m tall are included in the old-growth understory class. Abbreviations: PSF = Pacific silver fir; AYC = Alaska yellow-cedar; MH = mountain hemlock; WH = western hemlock.

mean height of these 'residuals' at the time of cutting was 0.5 m. Pacific silver fir comprised the majority of residuals (76%) which was consistent with its proportion in the sapling layer (trees 0.1-1.3 m tall) in adjacent old-growth stands (79%). An unexpectedly high proportion (45%) of trees established in a three-year window from one year before cutting to one year after cutting. Ingress two or more years after cutting accounted for only 20% of all regeneration. There were far fewer seedlings <10 cm tall of all species on clearcut sites (1233/ha) than on old-growth sites (187,000/ha) which suggests that most future canopy trees are already established. These results highlight the important role of trees and germinants from the previous old-growth stand, especially where there is not an adequate source of seeds for continued ingress after cutting.

We projected the future canopy composition of these second-growth stands by applying the growth rate of Pacific silver fir to all species. Based on this assumption, and compared to the composition of adjacent old-growth stands, we project that Pacific silver fir will be much more common, Alaska yellow-cedar will maintain its relative importance, and mountain hemlock will be far less common. In contrast to the wide range of canopy tree ages in adjacent old-growth stands, these future stands (if left uncut) will likely remain a single-storied cohort for many centuries.

Although undisturbed forest floor covered only 46% of the ground surface on clearcut sites (compared to 80% on old-growth sites), it supported 86% of all trees. Regeneration in clearcuts was scarcest on the most disturbed substrates: friable forest floor (usually found around disturbed stump mounds), exposed decaying wood, and logging slash. Mounds were less important microsites for regeneration than in adjacent old-growth stands, though this may change as the stands develop and snowmelt patterns are affected by taller trees.

Management Implications

Regeneration patterns that resemble those in tree-island ecosystems reflect the influence of deep snowpacks. Our results show that late snowmelt restricts most regeneration to raised microsites that are underneath a canopy tree, even where there are no distinct tree islands. Any form of cutting is therefore undesirable on late-snowmelt sites where tree-island regeneration patterns are pronounced; e.g., at higher elevations, but also on benches and cool-aspect sites at lower elevations. Since it is difficult to schedule site visits to determine the exact date of snowmelt, indirect indicators of late snowmelt can be substituted. Some indicators include a clumped pattern of canopy and sub-canopy trees, large gaps containing no snags or other evidence of past tree growth, and snow-tolerant species such as pink mountain-heather

(*Phyllodoce empetriformis*) and white-flowered rhododendron (*Rhododendron albiflorum*).

The clearcuts that we surveyed were at the lowest elevations of the MH zone, where snowpacks are shallowest. Although trees are re-populating these sites, clearcutting has resulted in a shift from mountain hemlock to Pacific silver fir and in greatly reduced diversity in structure and age compared to adjacent old-growth stands. Where cutting is appropriate in the MH zone, many of the negative features of clearcutting could be avoided by retaining sub-canopy trees and live and dead canopy trees during cutting.

Acknowledgements

We thank the BC Ministry of Forests and the family of Donald S. McPhee for financial support, and two anonymous reviewers for helpful comments on the manuscript. We also gratefully acknowledge help in the field from L. Daniels, M. Dee, M. Goosens, T. Higgins, D. Manning, J. Millen, A. Smits, P. Varga, and C. Wildburger.

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