

# Partial cutting in root disease infected stands in the Interior Cedar–Hemlock biogeoclimatic zone

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## INTRODUCTION

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In the summer of 1993, the Nelson Forest Region's Forest Sciences section initiated an interdisciplinary research project (EP 1186) to test the use of partial cutting and root disease treatments in root disease infected stands in two Interior Cedar–Hemlock (ICHmw2 and ICHmk1) subzones. This study is being conducted on two sites:

- Mount Seven near Golden, B.C., which is infected with *Tomentosus* root disease; and
- Ice Road near Burton, B.C., which is heavily infected with *Armillaria* root disease.

Conventional or pushover harvesting techniques were implemented in 1-ha treatment units prescribed as clearcuts, light-retention shelterwoods, or heavy-retention shelterwoods. Logging was completed at the Mount Seven site during the winter of 1994/95; treatment units were planted in the spring of 1995. Establishment and first, second, and third growing season measurements are now complete. The Ice Road site was logged during the winter of 1995/96; therefore, activities at the site occur one year behind those at Mount Seven.

This summary outlines initial findings of the understorey light evaluation completed over the summer of 1997, preliminary results of the decomposition component, and preliminary results of the regeneration component after three growing seasons. For more detail about study objectives, project design, harvesting operations, and post-harvest assessments, see DeLong (1995) and Nelson Forest Region (1996).

## UNDERSTOREY LIGHT

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Fisheye photographs were taken at selected locations at the Ice Road site to characterize light conditions following harvesting (understorey light at the Mount Seven site was not studied). Locations included one clearcut, two light shelterwood, two heavy shelterwood, and two control treatment units. A program called GLI-C was used to analyze the images and estimate growing season light conditions at a height of 1 m above forest floor. This program provides estimates of the global light index (GLI), which is a measure of total growing season light (i.e., direct and diffuse) for each treatment type.

Results show that, as expected, light levels increase as a stand becomes more open. However, total stand basal area was not a great predictor of understorey light levels because of the variation in crown

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### CITATION —

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TABLE 1 *Understorey light levels at Ice Road site*

Treatment	BA (m <sup>2</sup> /ha) <sup>a</sup>	Open (%) <sup>b</sup>	GLI (%) <sup>c</sup>
Control	110.3	11.0	14.96
Control	103.8	13.08	21.95
Shelterwood; heavy conventional	91.5	32.15	43.24
Shelterwood; heavy pushover	98.1	37.67	53.21
Shelterwood; light conventional	53.2	44.81	59.34
Shelterwood; light pushover	62.3	48.34	63.71
Clearcut	0	71.82	92.04

a BA = residual basal area (all species).

b Open = percent of sky visible through canopy openings.

c GLI = percent of total (direct plus diffuse) radiation that penetrates through the canopy (relative to open sky).

shapes, sizes, and densities in mixed species stands (Table 1). Results suggest it is better to use the basal area of each species as separate, independent variables when estimating light levels.

Light levels in the control units were lower than those required for growth of most conifer species. However, post-harvest light levels in all the treated units, including heavy-retention shelterwoods, were acceptable for conifer growth.

Additional photographs will be taken at other locations at the Ice Road site. Quantum sensors will be installed to provide data for local calibration of results (i.e., to calibrate estimates from fisheye photographs with actual measured light levels).

## DECOMPOSITION

The rate of decomposition of several types of litter is under study at both the Mount Seven and Ice Road sites to determine the effects of various silvicultural systems and harvest methods on decomposition. Mesh bags containing pre-weighed amounts of various types of litter were placed on the ground in a number of treatment units, and left for 1–2 years before collecting and reweighing.

Results from the Mount Seven site show no significant differences between the treatments after 1 year of decomposition. After 2 years, significant differences were evident in the mass of Douglas-fir needle litter remaining compared to the other four litter types under study (aspen leaf litter, forest floor litter, lodgepole pine needle litter, and green spruce needles).

Litter loss from mesh bags in control units (unharvested) at Mount Seven was less than losses from most of the harvested plots. Litter may decompose faster on pushover plots (where bags were located on mineral soil) than on conventionally harvested plots (where bags were located on forest floor); however, no significant differences were evident.

At the Ice Road site, three different types of litter were studied: lodgepole pine needles, western larch leaves, and aspen leaves. Unlike the Mount Seven results, mass loss after 1 year tended to be greatest in the control units and least in the clearcuts. However, this difference was only significant for the pine needle litter. No consistent trend was evident in differences between pushover and conventionally harvested plots at the Ice Road site, and no significant differences existed between these treatments.

In an additional analysis combining both sites, significant differences were evident between the two sites, but no overall treatment differences were noted. The study is ongoing.

## REGENERATION

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The regeneration component of EP 1186 assesses survival and growth of planted, advanced, and natural regeneration (i.e., germinants). The following information summarizes third growing season results from the two study locations.

### Mount Seven: Planted Seedlings

**Survival** Douglas-fir, larch, and spruce seedlings were planted in sample plots at the Mount Seven site. Average mortality of planted seedlings after three growing seasons was 13% (see Figure 1). The annual mortality rate was lower in 1997 than 1996 and remaining seedlings generally show good vigour.

Results showed little difference in total mortality between treatments and no apparent trends; however, spruce had significantly lower mortality than either larch or fir. Larch and fir both showed moderate mortality regardless of treatment (though larch mortality increased slightly with increasing overstorey), which may indicate poor planting stock, or, in the case of larch, poor site suitability.

**Vigour** Surviving seedlings generally have good vigour and the data showed no trend in seedling vigour between treatments. Douglas-fir seedlings were not quite as vigorous as larch and spruce; however, they averaged more than 70% in good condition.

**Damage** None of the seedling damage observed to date is considered serious, and seedlings will likely outgrow most of it (i.e., forked stems and chlorotic foliage). The most common type of damage—forked leaders—occurred in all species, but was most frequent in Douglas-fir. This problem was observed across most of the treatment types and is likely related to stock or other factors, rather than treatment.

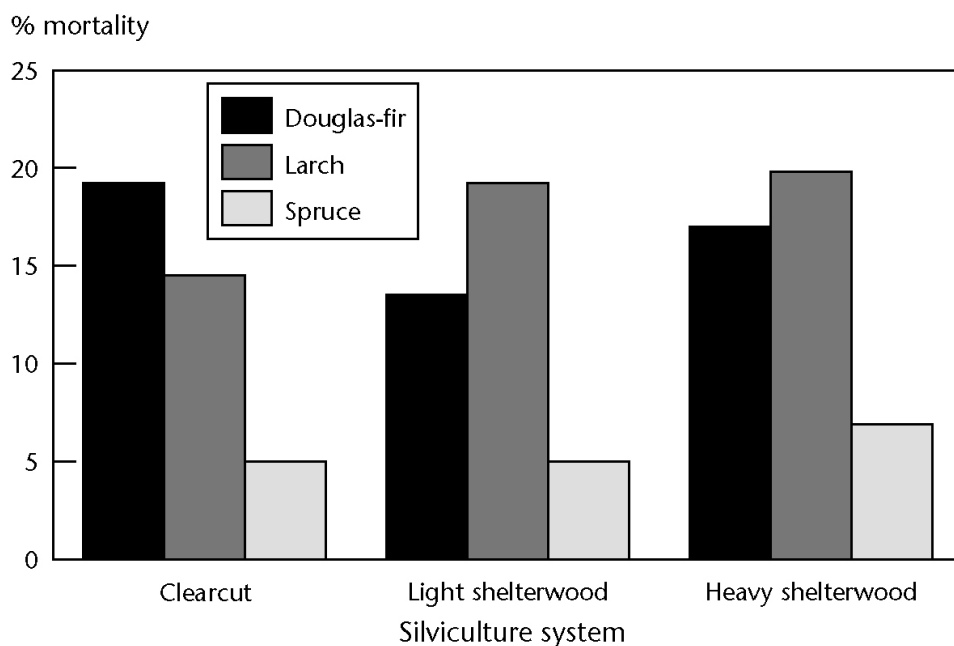


FIGURE 1 Cumulative mortality of planted seedlings 3 years after harvest at the Mount Seven site.

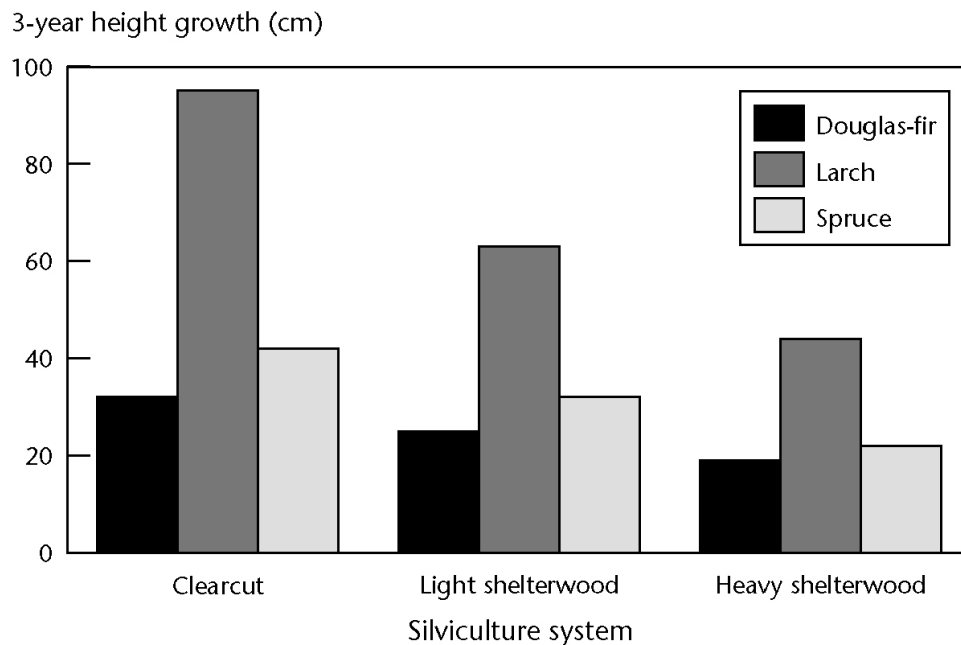


FIGURE 2 Height growth after three growing seasons at the Mount Seven site.

**Growth** Statistically significant differences were observed in height growth between species (Figure 2). Height growth of larch was greater than that of either spruce or Douglas-fir, even in the heavy-retention shelterwoods. This trend is, at least in part, the result of larch growth form. The slightly drier climate and more exposed location compared to the Ice Road site may be contributing to the relatively good growth of larch, and absence of larch needle cast.

Differences in height increment between treatments are not yet significant, but seedlings are beginning to differentiate. It is likely that by the 5-year re-measurement period, differences between treatments will be significant. Analysis of seedling diameter growth showed similar results.

#### Mount Seven: Advanced Regeneration

Height increment of advanced regeneration will be analyzed after the fifth growing season. Current height of advanced regeneration was compared by species for the different treatments. Results show that species heights between treatments are reasonably similar, so it should be possible to determine treatment-based differences over time.

#### Mount Seven: Germination

Germination frequency at this site shows considerable variation from year to year, and between treatment types. Both second- and third-year results show an apparent trend towards increasing germination frequency with increasing level of overstorey retention (with the exception of control blocks). In addition, a slight trend was evident towards increased germination on pushover blocks compared to conventionally logged blocks. Heavy-retention shelterwoods had substantially greater germination than other blocks, possibly reflecting the readily available seed supply overhead.

#### Ice Road: Planted Seedlings

**Survival** Douglas-fir, western larch, and western redcedar seedlings were planted in sample plots in each

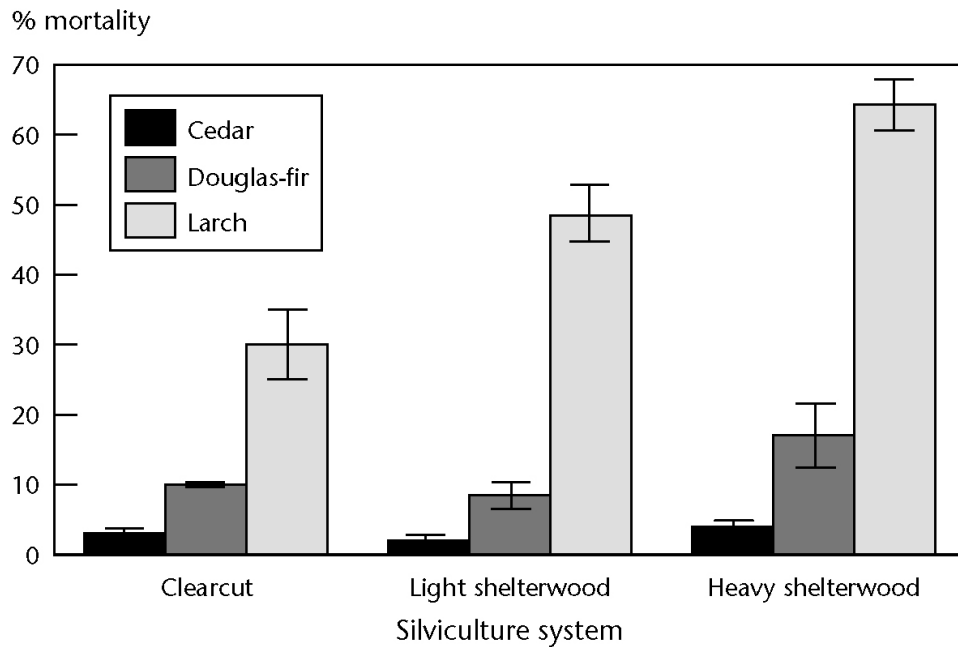


FIGURE 3 Cumulative mortality of planted seedlings 3 years after harvest at the Ice Road site.

of the treatment units (except controls) at the Ice Road site. Mortality, vigour, damage, and growth were analyzed after three growing seasons. Results showed statistically significant differences in mortality for the three species, with larch suffering by far the greatest amount (45%), followed by Douglas-fir (11%) and cedar (1%) (Figure 3). Statistically significant differences in mortality were evident between clearcut units and heavy shelterwoods, although no differences between conventionally and pushover-logged units were apparent.

Larch mortality was not consistent across treatment types and the variability suggests that the problem is environmental (treatment-related) rather than stock-related. The likely cause is a foliage disease—probably larch needle cast—observed on most of the surviving seedlings after the second growing season. The seedlings in the shelterwood blocks may have been under stress because of the reduced light conditions and larch needle cast. Therefore, the seedlings may have been more susceptible to mortality over the summer of 1998, especially given the relatively hot, dry weather. The incidence of foliage disease was much lower following the 1998 growing season, so most of the remaining larch seedlings may survive.

**Vigour** Seedlings of all species show a trend of increasing vigour with decreasing levels of overstorey retention, but the trend is much more pronounced for larch. Western redcedar vigour was predominantly good regardless of treatment type. Douglas-fir vigour was generally good or medium, depending on level of overstorey retention. Only a small proportion of seedlings showed poor vigour. Larch vigour, although still often poor, was greatly improved from 1997 results. The reason for this improvement is likely twofold. In part, it may be due to the high level of mortality over the 1998 growing season (i.e., many of the stems which were previously in poor condition died). In addition, the seedlings were beginning to acclimatize to their new environment.

**Damage** No serious damage or stress indicators were found on the planted seedlings after three growing seasons, with the exception of thin foliage on some of the larch. This may be related to the larch mortal-

ity at the site. Some additional mortality will likely occur in the larch over the next growing season, as many still show poor vigour and signs of stress (thin foliage); however, mortality is expected to be substantially reduced. Only minor browsing was noted in the third-year assessment.

**Growth** After three growing seasons, statistically significant differences in seedling growth were evident between species and silvicultural systems, but not between logging method. Seedling height increment was significantly different for all three silvicultural systems. In general, height increment increased as the level of overstorey retention decreased. Results also showed a significant difference in height increment for western redcedar compared to Douglas-fir or larch, with cedar generally showing greater height increment than the other two species.

Figure 4 shows the effects of both species and silvicultural system on height growth, illustrating the effect of poor larch vigour on height growth especially well. Under better conditions, larch should have surpassed Douglas-fir in total height (i.e., given its faster growth form). However, the average height increment of larch is slightly less than that of both Douglas-fir and cedar on the shelterwood sites. Larch was not growing as well as would be expected, even on the clearcut blocks. When larch seedlings are located in favourable microsites they grow very well, but as light levels decrease and other factors such as larch needle cast come into play, growth is substantially reduced.

Diameter growth showed the same trends as height growth, with average diameter growth decreasing as the level of overstorey increased. Differences in diameter growth were statistically significant between all three silvicultural system treatments, and there were significant differences between larch and the other two species.

#### Ice Road: Advanced Regeneration

A subset of advanced cedar regeneration was used as the sample set for analysis of advanced regeneration at this site. Analysis of variance shows a significant effect of silvicultural system on height increment. Height increment in control blocks is significantly different from that of clearcut and light

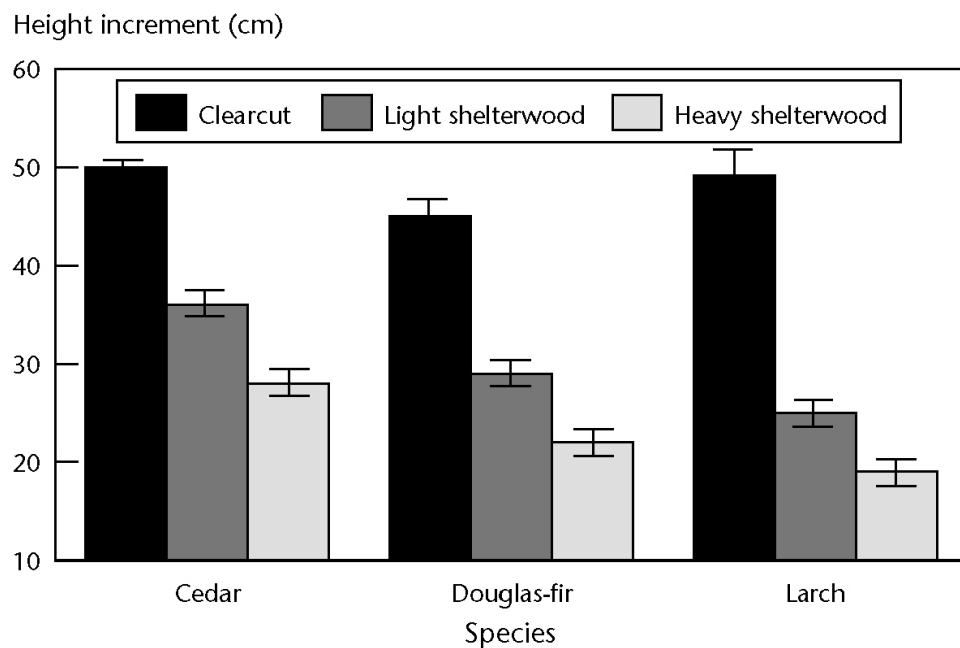


FIGURE 4 Height increment of planted seedlings 3 years after harvest at the Ice Road site.

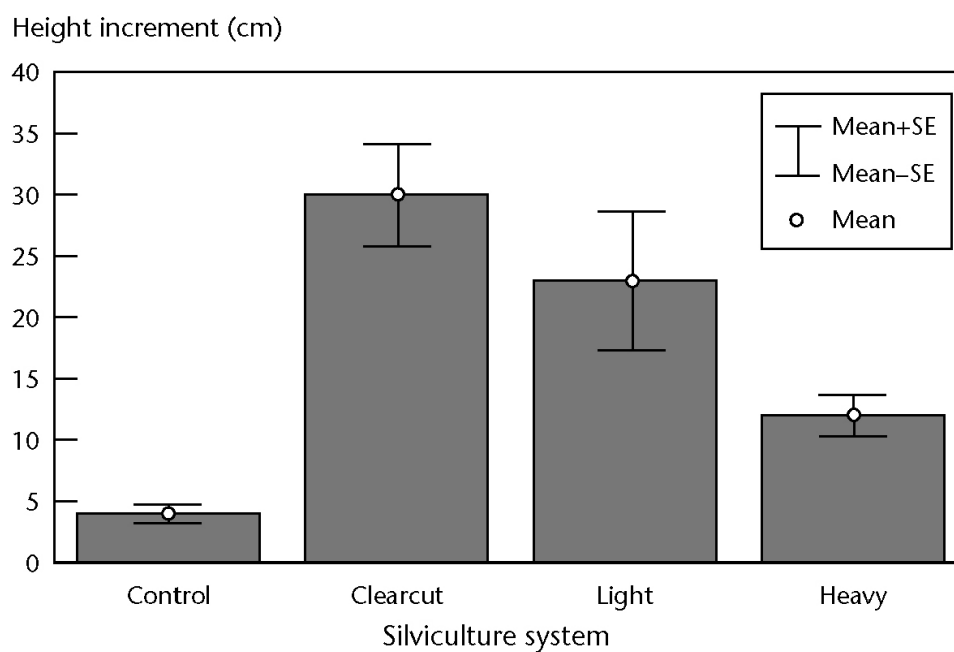


FIGURE 5 Three-year height increment of advanced cedar regeneration at the Ice Road site.

shelterwood blocks, and height increment in heavy shelterwoods is significantly different from that in clearcuts (Figure 5).

#### Ice Road: Germination

No trends are obvious to relate germination occurrence to either logging method or level of overstorey retention. Substantial variation was evident in germinant occurrence within each treatment.

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