Prince George Forest Region

Forest Resources & Practices Team

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Note #PG-20

FOREST RESEARCH NOTE

Group Selection in Old Cedar Hemlock Forests:
Five-year Results of the Fleet Creek Partial-cutting Trial

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Is group selection feasible in old-growth cedar-hemlock forests?

Introduction

Increasingly in British Columbia, forest managers are seeking to use a greater variety of silvicultural system options, and reduce reliance on clearcutting. In BC and the Pacific Northwest, the shift in forest practices in response to changing environmental and land use attitudes is well-documented (Kohm and Franklin, 1997). There has been much work on different silvicultural systems in many parts of BC in the last decade. A major unsolved challenge, virtually unique to British Columbia, is the development of viable partial-cut silvicultural systems for very old unmanaged or "old-growth" forest types (Weetman, 1996). To succeed, such old-growth systems must be both ecologically appropriate and operationally feasible.

To date, few silvicultural system trials have tested partial-cut silvicultural systems for the very old, multi-aged cedar-dominated mixed forests and productive rich sites typical of the wet-belt Interior Cedar-Hemlock (ICH) biogeoclimatic zones in the northern Rockies and Cariboo Mountains. Forest management objectives for wet-belt ICH stands in the east-central Interior and northern Rocky Mountain Trench have changed in the last decade, and now include a diverse array of resource values (Jull *et al*, 1998). Changes in forest practices, however, have been slow, hindered by scant past experience with alternatives to clearcutting in this forest type.

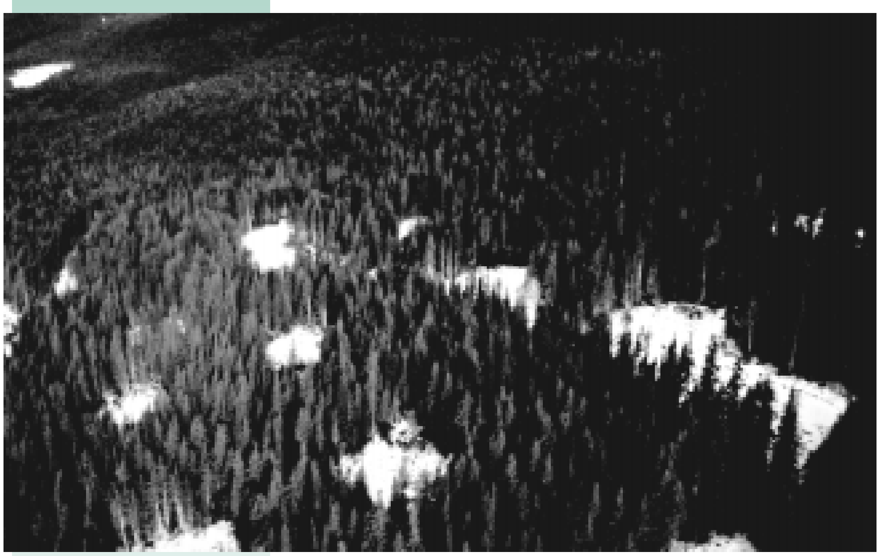

FIGURE 1. Aerial view of the Group Selection openings, Fleet Creek.

The first five year results of the Fleet Creek trial provide some useful insights into the potential benefits and risks of group selection silvicultural systems in old-growth ICH forest types. The Fleet Creek group selection trial (Silvicultural Systems Project SS054, and EP 1119.02), established in 1994, is located in 350-year-old Interior Cedar-Hemlock forest northwest of McBride, BC. We originally designed this operational test of group selection methods with a focus on maintaining low-elevation habitat for mountain caribou (*Rangifer tarandus*). However, these group selection methods are also potentially useful for combining timber harvesting objectives with the management of old-growth ICH forests for many other non-timber objectives. These include high scenic values, old-growth forest attributes, and maintenance of stand-level biodiversity.

The purpose of this research note is to present the preliminary results of the Fleet Creek group selection trial to the public, operational forest managers, and forest scientists.

Project Objectives

The overall goal of the Fleet Creek trial is to test the feasibility of group selection partial-cutting in wet-belt cedar-hemlock ICHwk3 forests. The group selection system was chosen for testing in this pilot study because of it is thought to be a potentially low-impact partial-cut harvest method in low-elevation caribou ranges in the ICH zone.

Specific study objectives are:

1. To assess the effects of group selection harvesting on stand habitat attributes thought to be important to mountain caribou (such as arboreal lichen litterfall, snow interception, abundance of low evergreen plants) and to other ungulates such as moose (such as abundance of browse species);
2. To assess the feasibility of regeneration of several conifer species within the group selection silvicultural system in the ICHwk3, specifically:

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a) *Survival and growth of planted western redcedar, spruce, and Douglas-fir;*
b) *Post-harvest survival and release growth of advance regeneration of cedar, spruce, subalpine fir, and western hemlock, within group openings;*
c) *To evaluate post-harvest establishment and species composition of natural regeneration;*

3. To assess the effect of group selection partial-cuts on windthrow incidence in ICH stands;
4. To provide forest managers with information that will help them use partial-cut silvicultural systems to reduce the impacts of timber harvesting on non-timber resource objectives, including caribou habitat, visual quality, and biodiversity;
5. To provide data and information that can be compared to similar partial-cutting studies in British Columbia.

Study Area

The Fleet Creek site (Figure 2) is located in the Goat River Wet Cool Interior Cedar-Hemlock (ICHwk3) biogeoclimatic subzone, in the Robson Valley Forest District in east-central BC (53° 30' degrees N, and 120° 27' degrees W). The stand is located 1 km east of Fleet Creek, on the Mountainview Forest Service Road about 40 km northwest of McBride, British Columbia. The ICH zone here is frequently used as low-elevation range and travel corridor by mountain caribou in early spring and late fall. We have sighted caribou, and signs of caribou use in the area on several occasions. Also, the general area is included in the Robson Valley Land and Resource Management Plan (LRMP). Here, in the northern Rocky Mountain Trench, the LRMP emphasizes the use of partial-cutting over clearcutting to meet visual quality objectives.

The study area is an approximately 300 to 350-year-old stand of (by basal area), 70% western redcedar (*Thuja plicata*), 15 to 20% western hemlock (*Tsuga heterophylla*), 10 to 15% subalpine fir (*Abies lasiocarpa*), 5% interior spruce (*Picea glauca* x *engelmannii*) and less than 1% scattered Interior Douglas-fir (*Pseudotsuga menziesii*). Average stand height is 30 to 34 metres, with taller spruce and Douglas-fir up to 45 metres.

FIGURE 2. Location of Fleet Creek ICH Group Selection Trial in British Columbia

This sloping, 46 hectare block ranges from 900 to 1040 metres in elevation, and faces southwest into the Rocky Mountain Trench and the upper Fraser River valley. The site is moist (mesic to subhygric) with much seepage from upslope. Slopes range from about 20 to 45%. Soils are silty loams. Coarse fragment content is about 15 to 45%, and rooting depths are generally 40 to 70 cm. Common understorey species are black huckleberry (*Vaccinium membranaceum*), oval-leaved blueberry (*V. ovalifolium*), Devils Club (*Oplopanax horridus*), and false azalea (*Menziesii ferruginea*) in the shrub layer; and oak fern (*Gymnocarpium dryopteris*), lady fern (*Athyrium filix-femina*), foamflower (*Tiarella unifoliata*), bunchberry (*Cornus canadensis*), and wild sarsaparilla (*Aralia nudicaulis*) in the herb layer.

The stand is multi-storied, and has a wide range of diameter classes, from regeneration to trees over 100 cm in diameter. Basal area is about 85 m^2ha^{-1}. About 90% of overstorey trees sampled by increment boring have some degree of internal stem decay (Hoggett, 1998). While the total stand volume is about 800 m^3ha^{-1}, the cruised net merchantable volume was about 325 to 400 m^3ha^{-1} when allowing for existing defects, internal decay, and estimates of waste and breakage. In places, the stand was very lightly "poled" for cedar stems in the 1930s and 1940s using horse-logging techniques which removed less than 10% of the volume.

Sapling and seedling layers less than 10 cm dbh are abundant in the stand, and are generally composed of 60% cedar, 20% hemlock, 5 to 20% subalpine fir, and less than 1% spruce.

In general, cedar appears to be a very long-lived and self-regenerating overstorey species in the stand. Few dead cedar were observed, either as standing cedar snags or treefalls. There is abundant and continuous recruitment of cedar in all canopy layers. In contrast, subalpine fir, and hemlock appear to be persistent but much shorter-lived tree species which reach smaller sizes and lower abundance than cedar. Spruce can grow taller than cedar and be almost as long-lived but is much less common in the stand.

Treatments

Prescription Objectives

For mountain caribou habitat, stand management objectives in this trial are to maintain:

- stand characteristics that include an abundance of large, old trees, to promote the production and availability of arboreal lichens;
- a dense mature forest canopy over most of the block to maintain snow interception, and;
- a late seral understorey plant community suitable for caribou habitat, including retention of the pre-harvest low shrub/herb layer, and minimal increases in tall shrubs which are browse species for moose.

For short- and long-term timber management, silvicultural objectives used here are:

- unevenaged management of the stand through a group selection system, using area regulation methods to control current and future harvesting.
- reforestation of harvested areas to planted or natural regeneration of acceptable species, stocking, and quality. Cedar, spruce, and Douglas-fir are preferred species, and;
- to minimize logging damage to leave trees and leave areas.

Target Residual Stand Structure

Based on the above caribou habitat and silvicultural objectives, several post-harvest structural targets were set for the stand. These included:

1. *Percent removal and cutting cycle*:
   20% of the total stand area will be harvested at each stand entry; this provides for cutting cycles of 50 years, and maintains a minimum of 40% of the area in age-classes 150 years of age or greater in the long-term. (A shorter cutting-cycle option would result in more rapid conversion of the stand to uneven-aged second-growth, while opting for a longer cutting cycle would emphasize very gradual harvest and maintenance of more old trees and old-growth characteristics in the stand.)

2. *Minimum opening size*:
   Harvest opening widths were set to a width of at least one mature tree length (30 m or more), to allow fallers to safely fell large old cedar trees, and to promote regeneration of a mixture of both shade-tolerant and intolerant species similar to that found in the existing stand.

3. *Maximum opening size*:
   Harvest openings were limited to a maximum dimension of two mature tree lengths (2 x 30 = 60 metres) or less, to help partially shade the interior of the harvest openings, and to limit the growth and vigour of highly light-demanding early seral brush species.

4. *Stand access / infrastructure*:
   Skid road access layout and the distribution of the first harvest openings were designed to ensure suitable access for future harvest stand entries throughout the block.

Layout and Costs

Harvest groups and skid trails were described in the prescription, and were flagged in the field in the fall of 1992 by an experienced local forestry consultant. Our block layout (Figure 4) followed a "total resource" planning approach, which considered not just the current stand entry, but all future stand entries as well. Layout for our initial harvesting stand entry was designed to aid future access to other harvest groups at future stand entries. Selection of harvest groups at the first entry was spatially well-distributed, without bias, so as to maintain comparable timber volumes and quality in the future.

First, the layout crew determined the location of the main haul road into the block and landings. Based on the location of the main access routes in the block, locations of proposed skid trails were ground-checked, and flagged in the field. Once skid trail locations were established, the boundaries of 40 m x 60 m harvest openings were located, and harvest boundaries traversed and marked. The layout crew spaced harvest openings at regular intervals of +/- 60 m along the skid trails. Skid trails for this first pass are located at an average spacing of about 80 m.

Layout of the ± 1900 metres of skid trails and 23 openings took approximately 6 days with an experienced 2-person field crew. Of the 6 days, the crew needed about 1 day for skid road layout, 4 days for layout of harvest openings, 0.5 days for office planning, and 0.5 days for mapping. This work was in excess of that normally required for basic pre-development tasks (e.g., lay out of boundaries, haul roads, cruising, etc.) to be expected for conventional clearcut logging.

Based on a current typical going rate of +/- $ 600 per crew day for such layout work, total estimated cost of the layout was about $ 3600, to access about 1800 cubic metres (not including volume from haul road right-of-way). This works out to an added cost of about $2 per cubic metre for group selection, over an equivalent clearcut harvest area.

In about half the harvest groups, a clump of 2 or 3 large cedar leave-tree reserves were marked-to-leave within each harvest group. We consulted directly with harvesting staff during this task to ensure that marking and retention of reserves did not conflict with operational falling and skidding activities.

Data are not available on incremental costs of the group selection block on other harvest phases such as felling

FIGURE 3: Pre-harvest tree diameter distribution (stems > 7.5cm dbh)

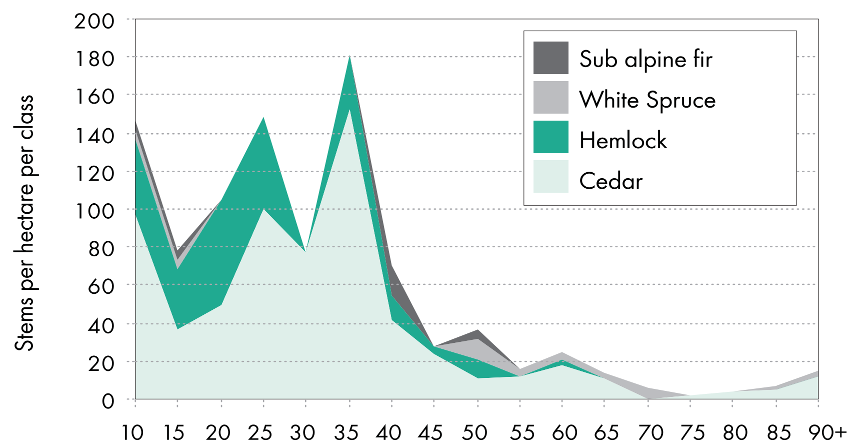
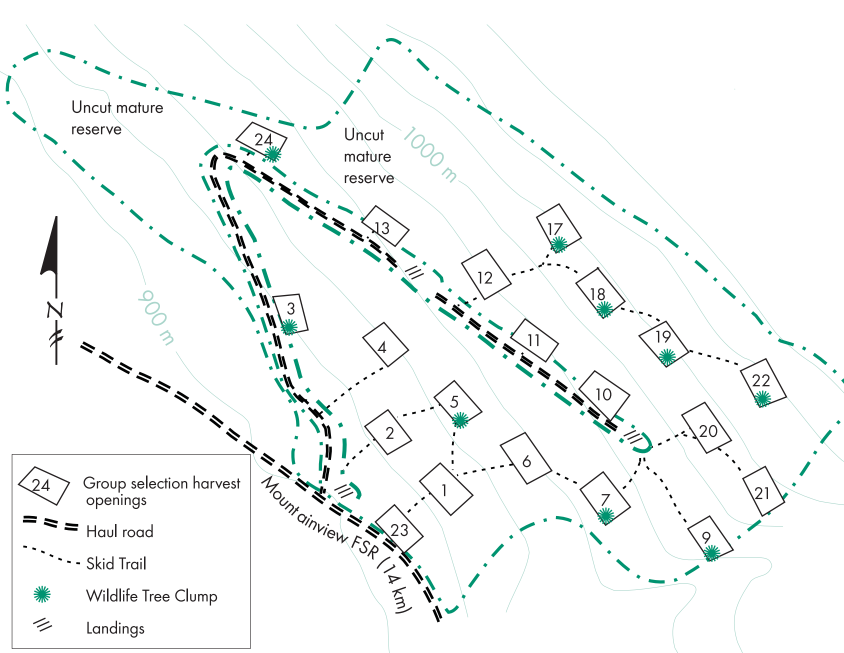


FIGURE 4. Group Selection Block Layout



and skidding, and in this case, adjacent clearcut harvesting was not available for comparison. Comparative studies will be conducted in future ICH silvicultural system trials, some of which are now being planned.

Harvesting

This group selection sale was sold competitively under the Robson Valley Small Business Program (TSL A43654), and harvested in January and February, 1994. The cedar was primarily sold to a local McBride cedar mill, generally for post and rails and other cedar products. The bulk of the remaining species and logs were of sawlog quality, except for large hemlocks which tended toward pulplog quality.

The selected harvested groups were logged using hand-falling, and ground skidded using Clark 668B tracked line skidders. Snowpack at time of logging was 50 to 100 cm. Weather conditions during harvest were variable, ranging from around freezing to minus 20° C. Before the start of active log skidding, skidder operators packed the snow on skid trails in milder weather by driving skidders over the routes several times. Cold weather in late January solidly froze all landings, skid trails, and haul roads.

On this moist sub-hygric site, logging crews encountered some water seepage at the soil surface during partial-cutting operations, despite ample snowpack. Colder weather was required to freeze up on-block access routes, and some care had to be taken during skid road layout to avoid very wet seepage areas, and avoid redirection of surface and subsurface drainage patterns.

At the Fleet Creek site, the estimated maximum area occupied by semi-permanent haul road and landings under the prescription is 3.2 hectares (7%). More recent improvements in haul road design probably could reduce this total impact by several percent. Regionally, operational trends since the mid 1990s indicate a steady reduction in the percent of cutblocks used for access structures (Paul Sanborn, MoF Regional Soil Scientist, pers. comm.).

FIGURE 5. A large spruce tree is hand-felled into a group selection opening at Fleet Creek.

The block includes twenty 0.24 hectare groups, totalling 4.8 hectares. The total area (including roads) harvested in this first stand entry was 8.0 hectares out of 46 hectares total, or 18.2%. Winter skid trails, at a width of 3 metres, accounted for an additional removal of no more than 1.2%. At 19.4%, this was slightly less than the goal of 20% removal for a stand entry under this group selection prescription. Total merchantable volume removal within the block was about 2532 m^3.

Regeneration Methods

White spruce, Douglas-fir, and western redcedar were planted in June 1995, in six randomly-selected harvest openings. The planting pattern exposed all three species to the same wide range of microsites and growing environments. As the study progresses, we will be able to assess differences in growth and survival of each species throughout the harvest openings. For site preparation, we used a "planter screef" only. We used the same seedling stock type for all species: 1+0 PSB 415. Seedlots used included Interior white spruce seedlot #8583, Douglas-fir seedlot # 28676, and western redcedar seedlots # 5490 and 31499.

We assessed and measured pre-harvest advance regeneration before logging, in fixed plots, which also allowed reassessment of surviving damaged and undamaged trees on the same plots following harvesting in 1994. Advance regeneration is periodically reassessed to determine vigour, quality, and growth response since logging.

Findings to Date

Climate

A weather station was established in a clearcut adjacent to the Fleet Creek site in 1994. Climate monitoring continues to the present. Microclimate monitoring in one harvested group selection opening was carried out for four years, including the 1994 through 1997 growing seasons. Climate and microclimate data were collected each year from approximately the 15th of June to the end of September.

At this location, estimated total growing season precipitation averages 399 mm, (including 278 mm from June 15th to September 30th). Monthly growing season precipitation averages 80 mm, with little apparent moisture deficit on these sites, especially with the contribution of seepage from upslope. Total annual precipitation, based on growing season measurements, is about 1000 to 1100 mm per year. Average growing season temperature is 14°C, with average daily maximums of 20 to 24°C, and average daily minimums of about 6.5°C. Relative humidity during the growing season averages 77%, ranging from 45 to 100%.

Microclimate of Group Selection Openings

Average air temperatures at 30 cm and 100 cm height above the ground surface in the group selection openings were similar to those measured in the adjacent clearcut. In general, average temperatures in the uphill, northwest sides (southerly exposures) of the harvested openings are nearly identical to air temperature in clearcut conditions. The more shaded southwest sides of the opening were measurably cooler, with average air temperatures about 0.2 to 0.8°C lower than the opposing side of the opening, or the adjacent clearcut.

At 77% (range of 40 to 100%), average relative humidity was also very similar in clearcut and group selection cut environments. This, combined with the presence of seepage from upslope locations on these sites, makes it likely that moisture availability is neither limiting nor affected significantly by harvest patterns on these sites.

The most obvious difference between the micro-environment of the 0.24 hectare group selection openings relative to the clearcut opening is light availability (Figure 6). Light availability above understorey vegetation in the group selection opening as a percent of full sunlight (as measured under clearcut conditions) averages 63.8% for total solar radiation, and 56.2% for photosynthetically active radiation (PAR). As expected, there was a modest difference between the uphill "sunny" side of the group selection-harvest openings (62.4% PAR), and the sensors located on the downhill "shady" side of the openings (49.6%).

Regeneration

Planted Regeneration

Over 1000 planted trees (more than 300 of each species) have been remeasured and monitored since planting.

Four-year survival rates (1995 to 1998) of the three species planted in the group selection openings (western redcedar, Interior spruce, and Douglas-fir) ranged from an average of 94.7% for spruce, 93.1% for fir, to 86.3% for cedar (Figure 7). In general, seedlings for all three species display good to moderate vigour four years after planting, and seem to be keeping pace with vigorous understorey vegetation of thimbleberry *(Rubus parviflorus)*, ferns, and Devils club on these productive sites. These four-year survival statistics reflect mortality during the initial seedling establishment phase.

Four years after planting, western redcedar seedlings are the tallest of the three planted conifer species at a average height of 88 cm (Figure 8) and have the highest proportion of exceptional seedlings exceeding 100 cm in height. Average heights for Douglas-fir and white spruce are about 20% or 16 cm shorter after 4 years. 35% of western redcedar are greater than 100 cm, with some reaching 150 to 160 cm in height. In contrast, only 8 to 9% of fir and spruce exceed 100 cm, with a maximum size of 125 to 130 cm.

Interestingly, as shown by Figure 8, all three conifer species have a similar average height growth increment for the last three years between fall 1995 and fall 1998, ranging from 30 and 31 cm for spruce and cedar, to 35 cm for Douglas-fir. Based on these recent growth rates, it appears that the light intensities and growing environment in these group selection openings are still well within the range of suitable growing conditions for all three species. Neither cedar, Douglas-fir, nor spruce presently appear to be at any growth disadvantage in this size of harvest group. So far, there appears to be no obvious difference in seedling performance in different locations in the openings.

Advance Regeneration

Before logging, high densities of young conifer seedlings and saplings in this ICH stand were observed (5100 trees per hectare in regeneration greater than 30 cm height and less than 17.5 cm dbh). Species composition was about 60% cedar, 18% hemlock, 20% subalpine fir, and 2% spruce. Approximately four-fifths of this total (4000 sph) was less than 4.0 cm dbh.

After logging, survival of this "advance" regeneration" is quite variable in harvested openings. The proportion of advance regeneration less than 1.3 metres height that survives harvest activities in moderate to good condition (light or no logging injury) was about 40% overall. This surviving advance regeneration will provide significant stocking of young trees for harvested areas. The pattern of advance regeneration survival is closely linked to the spatial pattern of felling and skidding within the harvest unit, as well as the size of the seedlings. Logging slash, branches, and logs crush or smother some advance regeneration. In general, advance regeneration survival is highest in the smallest size classes for all species (Tables 1 and 2). It appears that small size classes less than 1.3 metres in height are reasonably well protected by winter snowpacks during harvesting. As well, the flexibility and low stature of small seedlings and saplings reduce both the incidence and severity of stem breakage, foliage loss, or bark scarring, during skidding operations.

Results also suggest that western redcedar is relatively more resistant to logging damage than western hemlock, especially in large size classes greater than 1.3 m in height. In addition to direct logging damage, western hemlock advance regeneration appears to be particularly prone to damage or mortality from post-harvest sun-scalding following harvesting.

Post-harvest Natural Regeneration

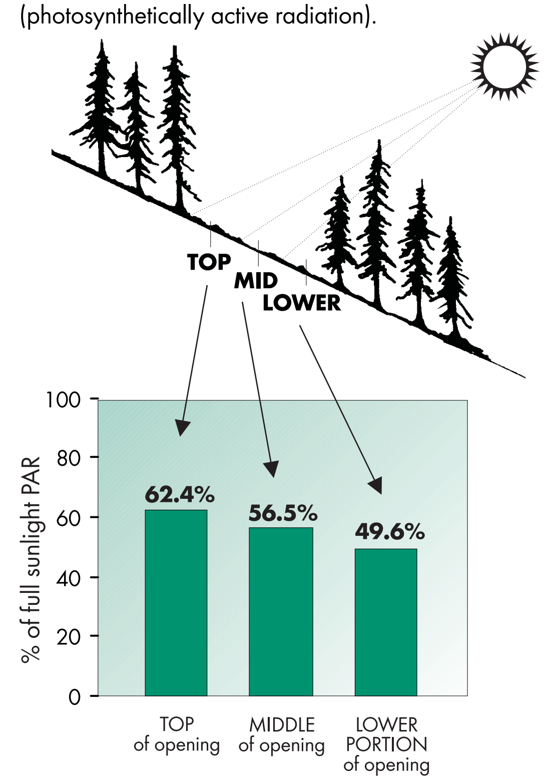
Although not reported in this research note, we are tracking the seeding-in and establishment of young conifer seedlings in this study. Much redcedar and hemlock natural regeneration has been observed to be establishing after harvest on disturbed mineral and organic (rotting wood) seedbeds. The overall contribution of new natural

Table 1. Post-harvest advance regeneration percent survival by size class and species within Fleet Creek harvested groups as a proportion of pre-harvest densities.

Advanced Regeneration Size Class	Cedar	Hemlock	Spruce	Sub-alpine fir	All species
0.3 - 1.3 m height	43%	53%	41%	49%	46%
1.3 m height - 3.9 cm dbh	46%	31%	33%	48%	43%
4.0 - 7.4 cm dbh	44%	29%	*	*	38%
7.6 - 12.4 cm dbh	37%	15%	*	*	30%
12.5 - 17.5 cm dbh	37%	13%	*	*	28%

** Insufficient pre-harvest sample size (<15 trees)*

FIGURE 6: Comparison of average light levels across a 40 metre-wide group selection opening (photosynthetically active radiation).



regeneration to future stocking of reforested harvested areas will be determined in future surveys.

Understorey Vegetation Response

If group selection harvesting causes subsequent changes in the understorey plant community in old-growth ICH stands, such changes would be likely to affect mountain caribou habitat in several ways. One potential change could be a shift in the abundance of the forage plants used by caribou in early winter — mainly dwarf shrubs and perennial herbs with persistent green leaves. A second type of change could be changing abundance of woody browse plants that are preferred by moose and deer but not by caribou; an increase in woody browse has the potential of increasing winter use of the area by moose and deer, and subsequently by predators, to the detriment of caribou. Thirdly, potential stand structural changes that result in poorer visibility and more obstructions to movement would also be expected to affect caribou adversely.

Before harvesting, the understorey vegetation in the study area was dominated by western redcedar, western hemlock, subalpine fir, false azalea, and oval-leaved blueberry, and the herb/dwarf shrub layer by oak fern, bunchberry, foamflower, and ladyfern.

We are monitoring cover, height, vigour, and utilization of understorey species in openings with site preparation, openings without site preparation, and in the unlogged control area. As well, we use a cover pole — a 2 m survey pole marked into 10 cm bands — to assess visibility and obstructions. These assessment methods were designed to allow us to compare the relative contribution of the opening of the canopy and soil disturbance to changes in the vegetation.

As of summer 1997, the overall herb cover is at about the same level in the openings as it is in the unharvested "control" area, but the species composition has changed in logged areas. Some of the pioneer herb species that have invaded the openings, such as fireweed *(Epilobium angustifolium)*, are being used as forage, but this summer use is unlikely to affect caribou. Of the species in the herb/dwarf shrub layer that are most likely to be important to caribou, bunchberry cover has been unaffected by harvesting, and foamflower cover has increased.

The post-harvest low-shrub cover is similar to that in the unharvested stand, while the tall-shrub cover is much lower. Species such as raspberry (*Rubus idaeus*) and thimbleberry have increased in abundance, while false azalea and oval-leaved blueberry have declined. The harvested openings have not yet reached the successional stage at which a large increase in browse species would be expected. So far, cover of important browse species such as the willows (*Salix* spp.), Douglas maple (*Acer glabrum*), and red-osier dogwood (*Cornus stolonifera*) has increased since harvesting, but is still very low. Frequency and intensity of browsing have increased only slightly.

Despite the structural changes that have occurred since logging in the harvest groups, overall visibility and level of obstruction in the harvested openings is currently still similar to that in the unharvested stand.

FIGURE 7: Four-year survival rates of planted cedar, Douglas-fir, and spruce in Fleet Creek Group Selection openings.

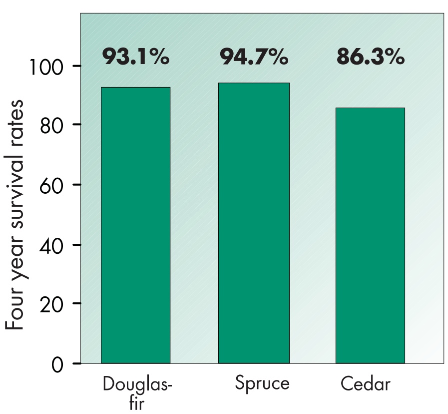
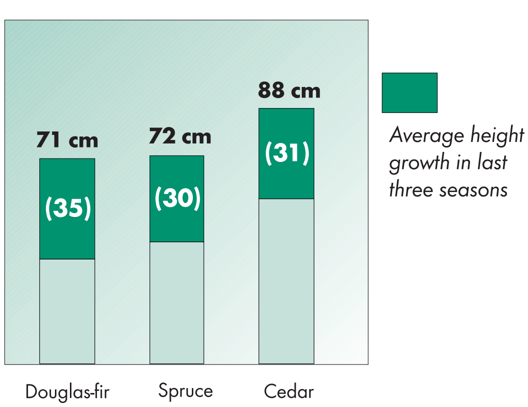


FIGURE 8: Comparison of cedar, spruce, and Douglas-fir height growth in Group Selection openings (0.24 ha), Fleet Creek.



Windthrow Monitoring

As local residents know well, the northern Rocky Mountain Trench has a very windy climate, and high wind events are quite common throughout the year. Based on 1995 to 1997 windspeed monitoring at an exposed weather station located about 1.5 km from the study site at an identical elevation and similar topographic location, daily maximum one-minute windspeeds exceeding 10 m/s (or 36 km/hr) occur on about 50 days per year, or 13.8% of recorded days in the Fleet Creek area. Daily maximum one-minute windspeeds exceeding 15 m/s (54 km/hr) occur on about 2 days per year (0.50% of recorded days). Peak 1-second wind gusts in the Fleet Creek area typically range from 20 to 23 m/s (72 to 85 km/hr). Higher wind gusts than this no doubt occur, but more rarely.

In the group selection treatment unit, the rate of windthrow (including windfalls due to root failure or stem snap) between harvest in January 1994, and October 1997 was 0.3% of all trees 20 cm dbh and larger within 20 metres of the edges of harvested openings. Up to the latest data collected (October 1998), windthrow continues to be ex-

Table 2. Total stems per hectare density of moderate to good-quality surviving advanced regeneration by size class and species following a winter group selection harvest.

Advanced Regeneration Size Class	Cedar	Hemlock	Spruce	Sub-alpine fir	All species
0.3 - 1.3 m height	854	236	44	434	1564
1.3 m height - 3.9 cm dbh	286	46	14	84	430
4.0 - 7.4 cm dbh	122	50	0	6	178
7.6 - 12.4 cm dbh	36	6	4	0	48
12.5 - 17.5 cm dbh	14	4	2	0	20

tremely light in these stands. In the unharvested control area, this wind damage or tree fall rate is 0.33%, nearly identical to that observed near the edges of the harvested openings. This suggests that the openings have had no significant effect on the rate of windthrow in the stand.

Windthrow rates at Fleet Creek in both uncut stands and group selection areas are very similar to rates found in a small-patch harvesting trial in old-growth ICH stands in the northern Revelstoke Forest District (Waters, 1997). Similarly, Coates (1998) found no significant difference between wind damage rates in partially cut and uncut ICH stands in northwestern BC, following high wind events.

Arboreal Lichens

The major forage lichens in the study area are *Bryoria* spp., a genus of dark brown beard lichens that dominate the upper canopy, and *Alectoria sarmentosa*, a light green beard lichen that grows most abundantly in the lower canopy. The canopy lichens are out of reach of caribou until they fall onto the snowpack as litterfall, or become available on fallen trees. Distribution and abundance of the lichens differ among tree species. Overall lichen abundance is greatest on spruce. Cedar trees are dominated by *Alectoria* on this site, whereas the other tree species support more *Bryoria.*

The creation of small harvest openings within a mature forest has a number of potential effects on the lichen forage resource, in addition to the obvious effect of reducing the overall standing crop of lichens in proportion to the area harvested. Reserve trees and trees along edges of openings are exposed to an altered microclimate. The growth rates of the lichens on the exposed trees may be affected. The effects may differ among lichen genera, eventually altering genus composition. Increased exposure to wind may result in increased litterfall, and this effect may extend into the adjacent unlogged forest. Increased litterfall may or may not be balanced by increased productivity.

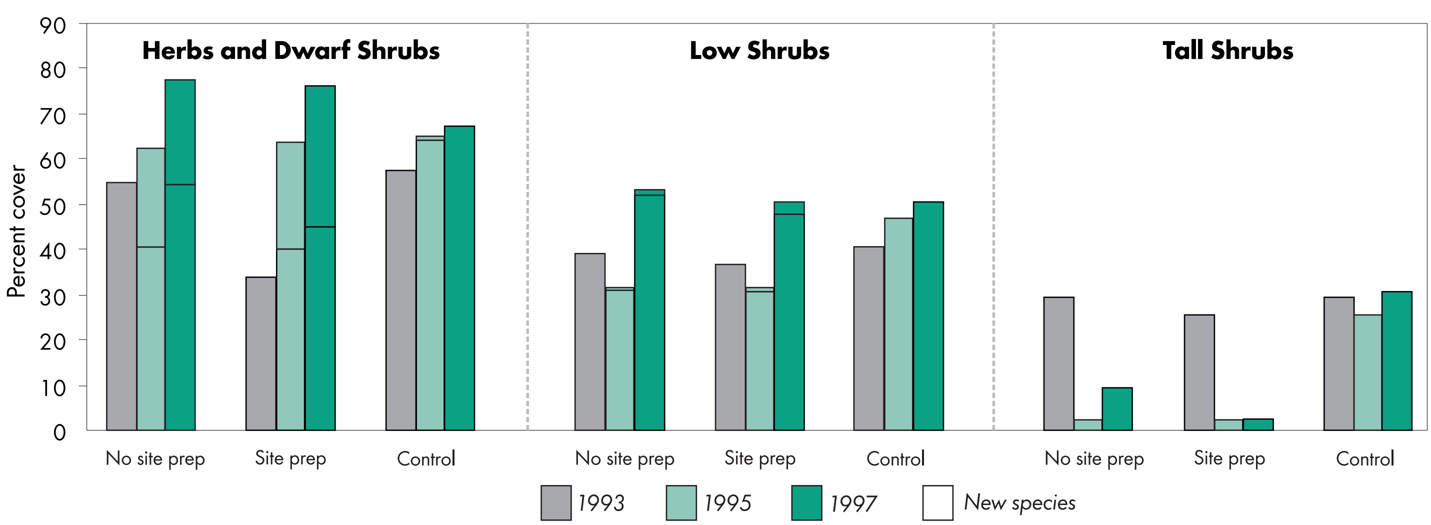
Effects such as these can only be assessed over extended periods of time. So far, litterfall has been measured during the winter before harvesting and the winter after harvesting, and is being remeasured in 1998/99, the fifth winter after harvesting. The abundance and relative proportions of *Bryoria* and *Alectoria* on edge trees and reserve trees were visually assessed in summer 1994, and summer 1998. The rating system is unlikely to detect changes due to altered growth rates over as short a period as four years, but could detect major changes due to wind effects.

Lichen litterfall from the canopy was measured in openings with and without reserve trees, in the uncut stand between openings, and in the uncut forest outside the block. Lichen litterfall rates for the May to October period ranged from 1.5 kg/ha in the openings without reserves to 30.2 kg/ha in the stand between openings. Lichen litterfall was significantly greater in openings with reserve trees than those without. It is not yet clear whether this is a short-lived effect of newly-exposed trees, or whether reserve trees within openings continue over time to contribute significantly to litterfall.

The only significant change in abundance or genus composition of the lichens on edge trees detected so far was an increase in the proportion of *Alectoria* on southwest edge trees. This may have occurred because the wind blew more *Bryoria* than *Alectoria* off the newly-exposed trees, as *Bryoria* lichens are known to fragment more easily.

FIGURE 9. Decked cedar logs at the upper landing in the group selection block.

FIGURE 10. Percent cover of shrubs and herbs at Fleet Creek before harvest, 1 ½ years after harvest and 3 ½ years after harvest.



Conclusions to Date

Although monitoring of the Fleet Creek group selection trial is ongoing, some preliminary conclusions may be drawn from the results five years following the initial harvest.

In general, the group selection harvest method used here appears to be a reasonably efficient and cost-effective operational method for partial-cutting in this forest type, and maintaining the desired stand structural conditions. Additional layout costs were modest, in the order of $2 per cubic metre. Equipment designed for clearcut logging seemed to be readily adapted to group selection methods. The logging crew seemed to adapt to group selection equally readily, once the objectives were made explained. Harvest cost impacts are not known.

The environments created within the quarter-hectare harvested groups so far appear to be favourable for good survival and vigorous growth of planted seedlings of Douglas-fir, spruce, and western redcedar. Although western redcedar displays the best average height growth to date after four years, differences between species to date are modest. Advance and natural regeneration of cedar, hemlock, and subalpine fir will substantially add to the final stocking of regenerating group selection-harvested areas. However, it seems clear that regeneration methods for group selection cuts in the ICHwk3 subzone should not rely solely on natural and advance regeneration due to high variability in survival rates of advance regeneration and establishment and survival of post-harvest natural regeneration.

Five years after group selection cutting, the uncut edges of the mature stand adjacent to harvested groups are windfirm. The 0.24-hectare harvested areas themselves provide adequate cover and composition of understorey plant species for mountain caribou, while not unduly promoting shrub species for moose or reducing within-stand visibility. Arboreal lichen litterfall rates in unharvested portions of the old-growth stand are relatively unaffected by harvesting of adjacent groups. Lichen litterfall into the harvested openings is about 5% of pre-harvest levels. It remains to be seen whether this litterfall rate is sufficient to initiate eventual recolonization of regenerating immature areas by arboreal lichens.

Future Work

Further results of the Fleet Creek trial will be reported on an ongoing basis, and especially at project milestone years (years 7, 10, 15, and 20 post-harvest, for example).

The group selection trial at Fleet Creek has spurred further operational trials in wet-belt Interior Cedar-Hemlock forests in the Revelstoke Forest District (Waters, 1997). More locally, in the Robson Valley and Prince George Forest Districts, the Fleet Creek investigators and the University of Northern BC are currently planning a more extensive series of wet-belt ICH partial-cutting trials for harvest in the near future. These "second-generation trials" will include several geographic locations, several different replicated partial-cutting treatments, and monitoring of adjacent unharvested old-growth stands.

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