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MANAGEMENT OF INTERIOR DOUGLAS-FIR STANDS IN BRITISH COLUMBIA: PAST, PRESENT AND FUTURE

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ABSTRACT

The extensive Douglas-fir forests of interior British Columbia are highly valued for timber, range, wildlife habitat, and recreational uses.

In the drier ecological subzones and on drier sites, Douglas-fir is the principal species and occurs in uneven-aged stands. These stands have been partially-cut at least once and as many as four times in this century. Foresters have expressed concern about the extent, intensity, and selectivity of cutting practices at frequent intervals, and various forms of administrative and technical controls have been proposed and adopted over the years. Current timber harvesting licenses almost always require some form of individual tree selection and this is controlled in a variety of ways.

On moister sites, Douglas-fir is a productive seral species. Early partial cutting did not regenerate the species and foresters turned to clearcutting in large patches. When natural regeneration was slow and unreliable, site preparation and planting were added to the prescription. This has proved successful, but concerns about non-timber values have led to a renewed interest in natural regeneration. Current practices employ a mix of seed-tree, uniform shelterwood, and group shelterwood methods.

On both site types, timber is removed by using a variety of machines and techniques.

The extent and form of future practices will be influenced by timber harvesting tenure issues, the rate at which growth projections are improved, investment levels, and productivity, bio-diversity, and pest management issues.

Keywords: *Pseudotsuga menziesii* var. *glauca*, Douglas-fir, silviculture, forest management practices, British Columbia

INTRODUCTION

Forests of Douglas-fir (*Psuedotsuga menziesii* var. *glauca* [Beissn]) spread over the rolling plateaux, and skirt the lower slopes of mountain ranges, in the southern interior of British Columbia. Over much of this area Douglas-fir is the dominant and climax tree species. It is moderately shade tolerant, and reproduces profusely following small scale disturbances to the overstory. Shade is not required, except possibly at germination, and best stem growth occurs in well spaced stands. The distribution of the species appears to be limited by length of growing season and summer frosts.

These forests are the representative vegetation type of the Interior Douglas-fir biogeoclimatic zone (Lloyd *et al.* 1990). The distribution of the zone is shown in Figure 1. It is the second warmest and driest of the forested biogeoclimatic zones in the province (Figure 2). The climate is classed as continental with warm summers, cool winters and a relatively long growing season. Precipitation is low, ranging from 300-600 mm annually, and is strongly influenced by the rain shadow effect of the Coast and Columbian mountains.

Throughout the central portion of the Interior Douglas-fir zone, ponderosa pine (*Pinus ponderosa* Laws) is the seral and sometimes co-dominant species in the savannah-like forests at lower elevations. Lodgepole pine (*P. contorta* var. *latifolia Engelm.*) occupies the same position at higher elevations and in the northern part of the zone. Toward the eastern mountain ranges, western larch (*Larix occidentalis* Nutt) forms part of the dry belt stands. As precipitation increases toward the edges of the zone, Douglas-fir decreases in domination. Species such as interior spruce (*Picea glauca* x *engelmanii*), sub-alpine fir (*Abies lasiocarpa* [Hook] Nutt), and western red cedar (*Thuja plicata* Donn) occur with increasing frequency on mesic sites.

The Douglas-fir stands and mixtures on dry sites are easily recognized. Their structure is complex, with an intricate mosaic of size classes. There is often a well developed overstory of many-aged mature and over-mature trees, with crowns ranging from full to ragged. Typically, either an intermediate story of pole sized trees, or a regeneration layer of Douglas-fir can be found beneath. In some places, all three layers of trees are found together, and in others, only one. The tree ages range upwards to 350 years and their maximum size reaches 35 m in height, and 100 cm in diameter. Trees often have sweeps and crooks, and heavy limbs, especially when widely spaced on southerly aspects.

On moister sites the stands are usually even-aged with a greater mix of species. The stems are usually straight and the branches small in contrast to the drier sites.

Fire and insects were the predominant shaping factors in stand development before logging commenced. On the dry sites, fire scars are common and ground fires appear to have played a major role by destroying patches of pole sized stems, permitting new regeneration to develop. Forest survey photos from the 1920's show park-like stands of mature stems with no understory. This condition was especially prevalent adjacent to the lower elevation grasslands and higher elevation meadows. Lightning strikes and Douglas-fir bark beetle (*Dendroctonus pseudotsugae* Hopk.) created gaps in the canopy of the overstory, permitting patches of new regeneration to establish in partial shade. Where seral species became established as the result of widespread destructive fires, Mountain pine beetle

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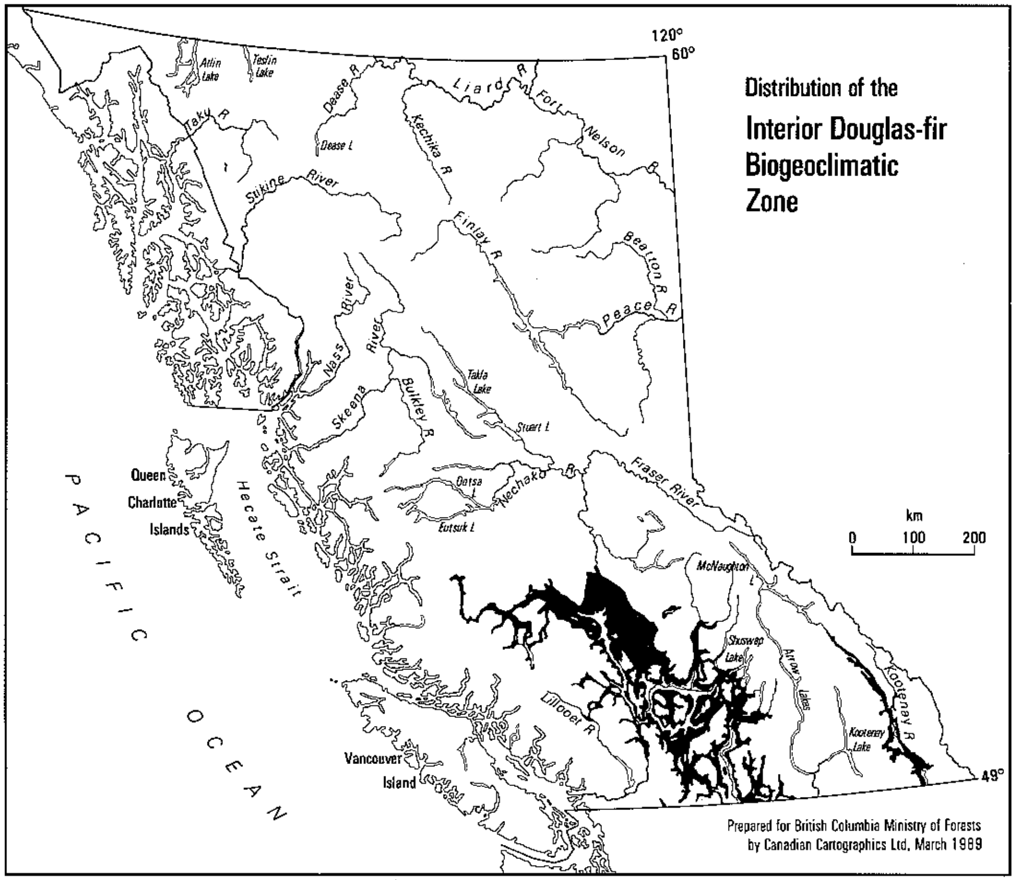

Figure 1.—Distribution of the Interior Douglas-fir biogeoclimatic zone in British Columbia.

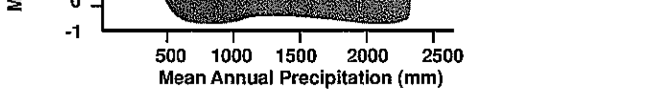

Figure 2.—Mean annual temperature and precipitation in the Interior Douglas-fir zone and in adjacent zones.

Dendroctonus ponderosae Hopk.) played a significant role in releasing Douglas-fir regeneration. This sequence of events was particularly prevalent on the wetter sites.

After logging began on a significant scale, fire control efforts increased, and both factors had the effect of encouraging regeneration. In the dry-belt, Douglas-fir bark beetle attacks increased as a result of careless utilization practices and further encouraged new stems. As a result, stocking levels in most stands are very high. This has provided ideal conditions for Douglas-fir tussock moth (*Orgyia pseudotsugata* McD.) and western spruce budworm (*Christoneura occidentalis* Freeman) attacks in the southern part of the zone over the past thirty years.

The Douglas-fir forests of British Columbia's interior are a highly valued resource for timber, wildlife, range and recreation. They have been the mainstay for many interior sawmill operations since the 1940's, and supply much summer forage to the extensive cattle ranching industry. Large portions of the forest type adjacent to grasslands and on southerly aspects are winter range for populations of mule deer. Small mammal and bird populations are high. Forest roads provide an access network to hunting opportunities, favored fishing lakes, and viewpoints for local inhabitants.

PAST PRACTICES

The Douglas-fir forests were first exploited for timber when the Interior of the province was settled in the 1860's by entrepreneurs riding the wave of fortune generated by the Fraser and Cariboo gold rushes. As the transportation networks improved, the early settlements shifted and then consolidated. Railway ties, piles, beams, and sawn boards were in rising demand. The early loggers soon moved beyond the grassland fringe in the major valleys and into the wilderness. Control over

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exploitation in this period was minimal. Forestry efforts were restricted to timber surveys, fire control, and revenue collection. And the pattern didn't change much until after World War II. By then, some valleys' stands had been picked over three or even four times, with low volumes removed every 10-15 years (Clark 1952). Other areas, principally on the northern plateau, had never been logged.

After World War II, the pace of economic development in the province accelerated rapidly, and with it, the rate of logging. The typical operations were run by local loggers and businessmen who learned on the job. The sawmills were located in the forest and sawn wood was trucked to the railhead for export. Only the best logs were felled, and the "bush" mills relocated frequently, leaving sawdust and reject piles to mark their passing.

The foresters of the time, reinforced by an influx of freshly graduated servicemen, began to express concern about the logging practices, the quality of the residual stands, and the lack of regeneration. They began to press for harvesting controls. The earliest form of control specified that 60% of the volume should be cut and 40% left. This "rule" was implemented by cruising the stands to be sold, developing a stand and stocking table, and devising a diameter limit to meet the 60/40 target. It soon met with dissatisfaction because the logger was permitted to select the choicest stems. Further regulations for marking stems were drawn up and implemented amid much controversy according to a report of the time (Benteli 1955).

The objectives of the marking crews were to:

- achieve an economic harvest
- reserve a vigorous growing residual stand
- retain a seed source where regeneration was lacking
- retain or improve scenic values
- improve or safeguard water potential

Laudable aims, indeed, forty years ago! A stand treatment guide was produced to help gain some consistency in marking operations across the province (B.C. Forest Service 1955). But it became apparent that marking-to-cut was an expensive proposition. Diameter-limit cutting regained popularity, and seed tree marking was combined with the use of diameter-limits in an attempt to achieve the same objectives.

Three reviews of Douglas-fir harvesting practices were produced in the 1960's (Clark 1962; Glew and Cinar 1964; Glew and Cinar 1966). All reported that the harvesting results were generally acceptable, even with low diameter limit cuts. Advance regeneration and large residual stems were responding to release of competition, but post-logging regeneration was slow to develop, especially on southerly aspects. There were stocking voids, and patches of poor quality residual stems, but these deficiencies were not thought to be serious.

Ironically, at about the time that these reports were issued, the logging industry went through a major financial and physical reorganization. Truck transportation had improved to the point that large sawmills located at railheads became economic, and this trend was further encouraged by the dramatic growth of an Interior pulp industry based on sawmill waste woodchips. The bushmill era disappeared almost overnight. Logging operations became more highly mechanized, production rates increased, and the area cut each year expanded.

Harvesting controls did not keep pace with these changes. By the early 1970's, silviculturists were once again expressing concern about the quality of residual stems, logging damage to those stems, and lack of regeneration following diameter limit cutting on the drier sites. Some of these concerns turned out to be exaggerated. For example, a recent review of logging in the 1960's and 1970's carried out by Mather (1986) arrived at much the same conclusion as the earlier reviews:

- patches of stocking voids were less than 10% of total area;
- residual stems were releasing at an encouraging rate;
- openings created by the removal of all overstory trees were regenerating slowly, particularly on south slopes, and where grass cover was high,
- residual patches were often dense and contained many poor quality stems.

However, some advances were made in response to the concerns. Efforts were made to modify the worst features of diameter limit cutting without increasing the costs of logging by introducing marking. "Faller selection" was introduced in the Kamloops area. The major objective was to develop uneven-aged stands by cutting throughout the range of diameters, and to remove sufficient volume to ensure an economic harvest. Fallers were trained to meet these objectives, and to include special wildlife habitat concerns, such as providing escape cover, increasing shrub growth, and saving snags. Spacing operations followed the harvest to achieve density control and remove residual stems damaged during logging.

There was general satisfaction with the result of these operations and the ideas began to spread. They were amended to meet local needs and guidelines for limiting logging damage, particularly where mechanical falling was used. However, careful inspection of some examples of faller selection logging plus density control shows that they are unlikely to meet the goal of uneven-aged stand structure (Figure 3). They will have to be managed as even-aged stands and regenerated via the shelterwood method, or carefully thinned to create an uneven-aged stand.

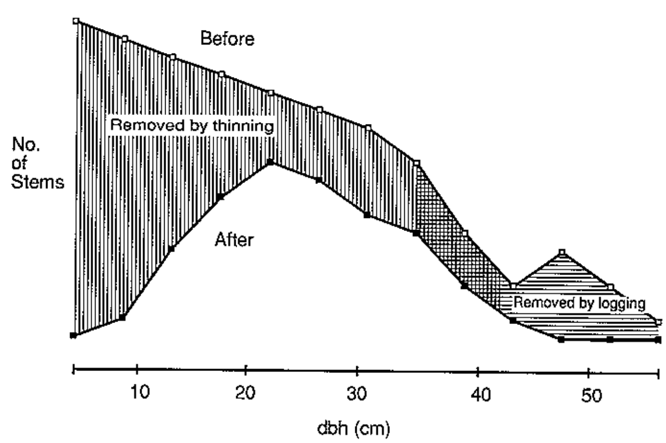

Figure 3.—Example of the effect of faller selection logging and subsequent thinning on dry-belt stand structure.

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On moister sites with mixed species stands, partial cutting failed to regenerate the more productive and valuable seral species and was replaced by clearcutting in the 70's. At first, natural regeneration was far from satisfactory. More and more areas were planted, primarily with Douglas-fir, until clearcutting, slash burning and planting on large areas became the standard silvicultural option. This trend has now been reversed in response to public pressures. Foresters are beginning to experiment with various forms of partial cutting, from seed trees to group shelterwood techniques.

In both dry-belt and moist mixed species stands, there has been a slow, cyclical evolution of Douglas-fir silviculture in the last fifty years. The objectives of the early foresters are little different from our own, but as the value of the resource has increased so has our ability and our mandate to manage. Examples of this capability are discussed in the next section.

PRESENT PRACTICES

Present day practices in the interior Douglas-fir stands vary considerably. The variation is a product of such factors as the type of timber cutting rights granted to companies and individuals, regional Forest Service policy, attitudes of forest managers, and site conditions. There are examples of good and bad practices to be found in almost every situation. Our aim in this section is to describe the best practices in the "dry-belt stands" where Douglas-fir is the dominant species, and in "mixed stands" where Douglas-fir is the leading but not dominant species.

"Dry-belt" Stands

The most common prescription in the dry Douglas-fir types continues to be single tree selection (Figure 4). Forest managers usually have well-defined residual stand structure goals. The more conservative retain 50-75% of the stand volume, with diameter distribution "q" values from 1.3-1.5 and residual basal areas from 15-25 m²/ha. The less conservative managers often retain 30-40% of the stand volume with "q" values of 1.5-1.7 and residual basal areas below 20 m²/ha. An example of a stand with a high residual basal area follows:

	Volume (m³/ha)	Basal Area m²/ha	No. of Stems 15 cm. dbh+ (stems/ha)	Diam. distrib. (q)
Pre-Harvest	181	36.1	657	1.2
Post-Harvest	123	26.8	484	1.4

The stand was marked to cut. The maximum diameter was set at 50 cm, but in reality many of the trees greater than 50 cm were reserved to maintain wildlife habitat and the wind firmness of the stand. Following harvesting, the non-merchantable portion of the residual stand was spaced to remove damaged and undesirable trees. The anticipated cutting cycle is 25 years. The harvesting effort was concentrated in the high risk stems and trees which over-topped regeneraion were marked for cutting to minimize the spread of spruce budworm from the overstory to the understory.

Figure 4.—Single tree selection cutting controlled by marking in dry-belt Douglas-fir stand near Monte Lake, Vernon Forest District.

There is still much controversy over the need for marking. Some forest managers have had considerable success training fallers to carry out tree selection. Others are less convinced, preferring to retain a greater degree of control over the end result. Our experience has been that whatever the methods chosen, the forester is challenged to translate the stand prescription into easy to follow instructions for the faller or the marker. Some examples include:

1. Visual comparison of target stand with desirable stands is combined with instructions to remove a proportion of the volume over the full range of diameters. Additional instructions might include requests to avoid enlarging existing openings in the canopy, and to concentrate cutting in poor quality stems. This works well in uneven-aged stands with experienced fallers.
2. The target residual basal area is translated into target inter-tree spacing intervals. This method works best in fairly even-spaced homogenous stands. It is also used for cutting in uniform shelterwood prescriptions.
3. The diameter distribution to be removed is summarized by diameter class. For example:

Diameter Class	Remove
45 cm +	1 from each 2
30 to 40	2 from each 3
20 to 30	2 from each 5
15 to 20	3 from each 5

Basal area control is accomplished using periodic prism sweeps. This system is the most accurate, but it is difficult to implement in stands that are not fairly homogeneous.

Variations of the above three methods are often used. For example, there has been good success using a prism sweep for basal area control, combined with visual assessment for diameter distribution.

In some stands the forest manager may prefer a "clumpier" approach to felling and marking. This complicates the marking even further and relies heavily on experience and leadership from the person making the prescription. Such an approach is thought to have several advantages over the uniform single tree selection system:

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- more forage production for wildlife (in openings);
- more thermal cover for wildlife (in thickets);
- improved conditions for natural regeneration within the opening;
- easier slash disposal; and
- reduced risk of pest damage through improved ability to stump (root rot) and more vigorous regeneration (defoliators).

Whatever the method chosen for implementing prescriptions, the key is to start the fallers, or markers, on the right foot by marking part of the stand personally in order to anticipate problems and also leave a visual comparison for the crew to follow.

Mixed Stands

In mixed stands with Douglas-fir as the leading species, the preferred silvicultural system is still clear-cutting in patches of 20 ha or more. Stands with a high proportion of lodgepole pine are naturally regenerated. All other stands are planted following site preparation by fire or mechanical piling. There is, however, a high level of interest in natural regeneration of Douglas-fir using partial cutting methods. Seed trees are most commonly used, but shelterwoods are becoming quite common especially where non-timber values have been emphasized.

Seed Trees

Southern Interior prescriptions range from 8-80 trees per ha (Figure 5). Regeneration results from Douglas-fir and larch seed trees have been variable, with very good results to the south in the Kettle Valley area and mixed results elsewhere. Performance in the Vernon Forest District, for example, has been very poor over the last 5 years. Some foresters suggest that more seed trees should be left, while others blame the problem on a lack of seed crops.

Figure 5. – Seed tree cut with Douglas-fir and western larch seed trees on Silver Star Mountain near Vernon, Vernon Forest District.

There is general agreement that seed tree success is highly dependent on adequate site preparation. Blade scarification is the most popular treatment, but some success has been reported for track scarification.

Many of the disagreements about numbers of seed trees have centered on the problem of salvaging timber once regeneration is established. With current pressures to maintain mature stems as nesting sites and perches for raptors, and future snags for cavity nesting animals, it seems inevitable that many seed trees will be left standing in our second growth forests.

Shelterwoods

There are many different ideas on the number of residual stems that are required to provide shelterwood conditions (Figure 6 and 7). Prescriptions run from as far as 40 stems/ha (basal area of 5 m^2 per ha with an average dbh of 40 cm) to 200 stems/ha (25 m^2 per ha with average dbh of 40 cm). There is general agreement, at least, that the residual stand should be comprised of the best dominant and co-dominant trees.

Figure 6. – Low density shelterwood with Douglas-fir and western larch reserved from cutting on Silver Star Mountain near Vernon, Vernon Forest District.

Figure 7. – High density shelterwood with Douglas-fir and western larch reserved from cutting on Silver Star Mountain near Vernon, Vernon Forest District.

Particularly good results were obtained when a mixed species stand on the slopes of Silver Star Mountain near Vernon was logged in 1985. All species except Douglas-fir and larch were removed from the stand reducing the basal area from 46 m^2

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to 20 m^2. The stand is now fully stocked. A neighboring stand was logged in much the same way one year later, but the results were less satisfactory because of poor seed supply.

The most contentious aspect of uniform shelterwood logging involves the timing and method of overstory removal. If natural regeneration was the only consideration, many operators would prefer to remove the overstory on a snowpack when the regeneration averaged less than 45 cm height. The expectation is that the young seedlings can tolerate the sudden increase in frosts and solar radiation. But rapid removal may not be acceptable because of the need to protect other resource values. One alternative is to remove the overstory in two stages beginning when the regeneration is 3 m. Some stems may have to be retained through the light of the regenerating stand.

One of the advantages of applying a uniform shelterwood system to suitable stands is that it provides many options for future long-term management. If timber production is the primary focus, an even-aged stand is usually the preferred option. Where maintenance of high forest cover is a priority, the stand can gradually be converted over to a multi-aged forest. The group shelterwood technique can be used to accomplish the same objective.

Group shelterwoods consist of very small clear cut openings that generally remove no more than 25-35% of a given area of timber. The size of each opening is dependent on the desired environment for regeneration, but rarely exceeds 1-3 tree-lengths in width. Spatial arrangement of the openings is dependent on the logical skid trail pattern and operability of the area, but must also consider windthrow risk and the need to provide cold air drainage. A proportion of any diseased or insect infested trees within the reserved areas may also be harvested if they can be felled into the openings. Logging safety is improved and slash disposal is simplified in comparison with uniform single tree selection or shelterwood systems.

Shelterwood prescriptions have often been approached simplistically in the past by applying a diameter limit or simply reserving all Douglas-fir and larch. This has often resulted in portions of the stand being too open and other portions too dense to achieve the desired objectives. More prescriptions are now making use of other species such as cedar and spruce to help fill in the gaps, and where the Douglas-fir and larch are too thick, they are being thinned out to a target spacing interval.

Harvesting Methods

Traditionally, small harvesting equipment was used for partial cutting and large equipment for clear-cutting in interior Douglas-fir stands. This trend is rapidly changing. Major companies are now using feller-buncher machines on a regular basis to apply selective cutting prescriptions although smaller operators still use smaller, slower machines, and even horses.

Large Machine Operations

Good results have been achieved with large machines in partial-cut operations. A tractor-mounted feller-buncher first cuts out the skid trails and any obvious trees that can be reached along the route are also cut. The trees are bunched behind or off to the side in any available opening as the machine moves through. A grapple equipped rubber-tired skidder then pulls each of the bunches into a landing.

In the next phase trees are hand-felled to the final desired stand structure. The trees are felled with tops to trails, and yarded out with a rubber-tired line skidder. The advantages of this system are that the operator achieves maximum productivity with the large machine on some portions of the block. The trails provide openings for safe hand falling and the feller-buncher can be used to fell dangerous trees or work in windy conditions.

Small Machine Operations

On timber sales for small business operators, the B.C. Forest Service often specifies small machines in partial cut prescriptions. This is the result of good success in the past plus the fact that many small operators do not have large equipment.

In fairly open stands, with sufficient room to maneuver, small skidders and crawlers up to 100 flywheel horsepower and with maximum overall widths less than 3 m are permitted for skidding and trail construction. In these operations random skidding is often preferred, except for main access routes where the machine must stay on trails. Random skidding can produce the desired site preparation results, as long as it does not cause excessive compaction.

In denser stands, especially when there is a lot of regeneration, "narrow gauge" restrictions are used to limit the skidding equipment to less than 1.85 m wide. On the most sensitive sites, the skidding may be restricted to horses or an "iron horse".

Horse Logging

Horse logging is still active in parts of the province on a small scale. It is especially suited to partial cutting in Douglas-fir stands. Although more costly than mechanical loggings, damage to regeneration and to the soil is minimized. Operators use Percheron or Belgian draft animals in their horse teams.

Steep Slopes

Partial cutting on slopes greater than 50% has not been considered feasible, but recently several operations using small portable skyline towers have been successfully completed (Figure 8). Logging quality has been excellent with almost no damage to residual stands after removing up to 60% of the original basal area. Target diameter distributions have been achieved.

Prescriptions called for the yarding trails to be kept free for future stand entries (every 20-25 years) and for the remainder of the stand to be managed on an uneven-aged basis. Alternatively the yarding trails could be shifted each cutting cycle to protect regeneration and to convert the stand into a series of even-aged strips.

FUTURE MANAGEMENT ISSUES

Until very recently, silviculturists managing interior Douglas-fir stands have concentrated on controlling harvesting operations to achieve healthy productive residual stands and ensure satisfactory regeneration. This goal now appears to be accepted.

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There is much debate about how to reach the goal but the basic silvicultural principles are accepted and applied. The only exception is on private land where logging proceeds without the guidance of Provincial legislation.

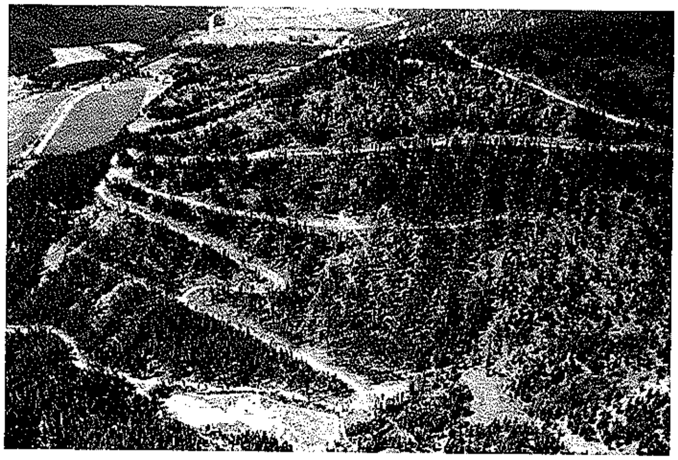

Figure 8. -- Single tree selection cutting on a steep slope near Falkland, British Columbia, Vernon Forest District. A sky-line system was used.

To make further progress toward the traditional goal and to meet changing public expectations of the forest we predict that some action will be needed on each of the following issues:

- tenure management on partial-cut lands
- improved growth projections
- increased investment in thinning
- possible loss of long-term productivity
- possible loss of biological diversity
- improved pest management

Tenure Management

Most of the publicly owned timber in British Columbia is logged under a form of land tenure called a Forest License. Forest licenses are issued for substantial volumes over 15 years and are replaceable every 5 years. The licensees are responsible for most forms of forest management on the land including achieving satisfactory regeneration. Provincial regulations now require that before any area is logged a pre-harvest prescription must be prepared. The prescription describes how the area will be regenerated and to what standards, and must be signed by a professional forester.

For prescriptions that specify clearcutting this is a relatively straight forward procedure, but there is much less experience with partial cuts. How should the treatment be described? Are the indicated goals likely to be achieved? What monitoring procedures should be used? All of these questions are under discussion at present. Their resolution will require clear thinking, some compromise, and patience, while much needed research on growth in partial-cut stands is funded and results are made available to guide decisions.

Growth and Yield Projections

Current projections of growth in Douglas-fir stands in British Columbia are based on the assumption that the stands will always be managed on an even-aged basis (Johnstone 1985). Clearly this is not the case in either the dry-belt or mixed species stands. In effect, our ability to manipulate stand structure has run ahead of our ability to foresee the impact of those manipulations, either at the stand level of planning, or at the forest level. This is not an issue of minor consequence. Partially cut stands cover sizeable areas in several of the Province's yield planning units and contribute a substantial volume to the allowable cut.

Johnstone (1985) has suggested two steps to improve the situation:

1. improve site productivity evaluation methods; there is a big difference between methods used in British Columbia and those recently published by Monserud (1984); and
2. develop local stand stocking guidelines by examining the growth response of existing partially-cut stands and by establishing long-term growth plots in operationally and experimentally treated stands.

Work is already underway on each of these steps and the resulting information should result in much improved prescriptions.

Increased Investment in Thinning

Thinning of the dense clumps of Douglas-fir regeneration that are often found on dry-belt sites would produce substantial benefits in terms of increased timber production. These benefits would come in the form of increased growth of individual stems and some unknown level of protection from the effects of spruce budworm attacks. Thinning would also create many years of employment.

Current rates of harvesting in the Interior Douglas-fir zone are creating cut-overs that require some amount of thinning at the rate of several thousand hectares per year. But this amount is far outweighed by the cost of treating the backlog of 15-20 years of accumulated cut-overs. The costs of keeping up with current logging (approximately $2 million/year) will be paid by timber tenure holders under the terms of their licenses. However, a substantial public investment program will be required to clear the backlog.

Possible Loss of Long-term Productivity

Interior Douglas-fir forests grow on soils that are relatively young and infertile (Mitchell and Green 1981). Organic horizons are shallow, especially in the drier areas, and the soil parent materials are often compact, fine textured, and stony. Rooting zones may be no more than 50 cm. Under these conditions logging operations can have a major effect on long-term productivity if operators are not carefully controlled. General guidelines are now in place to reduce soil degradation through compaction or removal of upper horizons but much needs to be done to increase operator awareness.

In addition, the work on organic horizons and the role of large woody debris in Intermountain forests summarized by Harvey *et al.* (1987) suggests that we should be looking beyond the logging phase and paying more attention to the long-term management of organic inputs to the soil.

Managing for Biological Diversity

Today, managers of interior Douglas-fir are expected to pay much more attention to wildlife habitat than in the past. Timber harvesting and stand treatment prescriptions are required to adjust plans in favor of maintaining or improving habitat for large game animalsprimarily deer and moose. For instance, Armleder *et al.* (1986) have produced guidelines for identifying, protecting, and managing mule deer winter range in relatively deep snow areas. In the drier Kamloops Forest District the creation of spring range in stands with dense regeneration by thinning is given high priority. But the effect of thinning on small mammals is far from certain (Waterhouse *et al.* 1990).

The future will see much more attention given to smaller mammals, birds, and even reptiles, following the trends established in the United States. The job of the silviculturist has been made much easier by the recent publication of the Wildlife Habitat Handbooks for the dry Southern Interior (Harcombe 1990), but much remains to be done to train people to apply the information available and to fill crucial information gaps. The case of the flammulated owl provides an example. Until recently, the owl was thought to be rare in the valleys of the Okanagan and South Thompson. A logging moratorium was placed on an area containing a concentration of these birds and a small research program started. As a result it soon became apparent that there were more owls in the valleys than anyone had realized and that they had survived logging in earlier decades. The challenge now facing local managers and researchers is to understand enough about the owl to ensure its continued survival while maintaining a reasonable flow of logs to local mills.

Pest Management

Pests threaten the achievement of management objectives no matter what those objectives are. Indeed, non-timber resources may be more at risk because there is often some prospect that the timber can be salvaged. If pests destroy one of the few remaining patches of high quality winter range for mule deer in the heavy snow belt of the Douglas-fir zone for example, there may be a substantial long-term reduction in the deer population.

Future management of interior Douglas-fir will be complicated by three groups of pests: bark beetles, defoliators, and root rots. The danger of Douglas-fir bark beetle has already been recognized by Armleder *et al.* (1986). They point out that one of the keys to successfully integrating timber and mule deer management is to avoid adding to the supply of bark beetle host material by following simple prevention measures spelled out over thirty years ago by Lejeune *et al.* (1957).

Coping with defoliators is going to be a far more challenging task. The present day impact of the western spruce budworm is largely restricted to growth losses, mortality in lower canopy classes, some mortality in mature stems on poor quality sites, and short lived visual effects (Alfaro *et al.* 1982). Douglas-fir tussock moth on the other hand can cause extensive mortality in lower elevation stands if left unchecked (Brookes *et al.* 1978). Future impacts are likely to be more severe as the intensity of management increases to meet public demands on the forest. More managers are thinking about moving toward partial-cut methods, and more shelterwood and uneven-aged stands will be created, thus putting more regeneration at risk and increasing the difficulty and cost of replacement in the event of severe defoliations.

Root rots have only just been recognized as a major force in Douglas-fir stand development by operational staff. *Phellinus* and *Armillaria* are present throughout the zone (Wallis 1976; Morrison 1981). They contribute to the canopy gaps found in dry-belt and mixed stands alike. Insect attacks promote their incidence and future management practices are also likely to increase root rot levels. Partial cutting in dry-belt stands, for example, has been found in some areas to increase mortality in the residual stems (Hagle and Goheen 1988). And in wet-belt areas, brushing operations which remove competing hardwood stems from Douglas-fir plantations are also thought to increase the risk of infection to the crop trees. Future operations will have to be based on a much deeper understanding of the ecology of root rots if management objectives are to be met.

Future pest management is highly unlikely to rest on the foundation of direct control. The emphasis is more likely to be placed on prevention and the creation of healthy forest. The challenge will be to identify the silvicultural conditions which best meet this goal while meeting other demands.

CONCLUSIONS

Douglas-fir management in British Columbia has improved significantly since the high grading days of the two-man power saw and the bush mill. Regeneration problems have been solved to a large extent, and forest managers are now confronting the challenge of creating forests which meet a wide variety of public demands. This has to be done while facing economic constraints and threatening pests. The prospects are good, given flexible administrative procedures and a continuing flow of information on the ecology of the Douglas-fir forests and their response to management.

Forestry practices and the forestry profession in British Columbia are facing unprecedented levels of criticism at the present time. Undoubtedly some of the negative comments are justified. We believe that the management of the interior Douglas-fir forests offers a positive example of what has been achieved, and what can be achieved in the future.

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