

# Natural and Advance Regeneration of Engelmann Spruce and Subalpine Fir Compared 21 Years After Site Treatment

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## Abstract

The mean height of Engelmann spruce (*Picea engelmannii* Parry) advance growth<sup>3</sup> 21 years after release by overstorey harvesting and residual tree felling, was eight times that of natural regeneration established following brush blade scarification. Subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) advance growth was nine times taller than natural regeneration established on scarified soil. Mean current annual height increment of Engelmann spruce and subalpine fir advance growth was 39 and 34 cm, respectively, compared with only 7 cm for natural regeneration on scarified soil. The performance gap does not appear to be narrowing. The poor performance of natural regeneration on mineral soil exposed by blade scarification is attributed to removal of organic and top mineral soil horizons beyond the immediate reach of seedlings. These soil layers remained available to the advance growth. Consideration should be given to preserving advance growth when scarification may be inappropriate.

## Résumé

La hauteur moyenne de l'épinette d'Engelmann (*Picea engelmannii* Parry) considérée en tant que régénération pré-établie 21 ans après la récolte et une coupe résiduelle, s'est avérée 8 fois supérieure à celle qui suivit la méthode de scarification à lame.

Le sapin subalpin (*Abies lasiocarpa* (Hook.) Nutt.) de son côté, fournit une régénération pré-établie neuf fois supérieure à celle obtenue habituellement suite à la même méthode de scarification.

En effet, l'accroissement moyen annuel courant de ces deux espèces forestières respectives considéré en régénération pré-établie fut de 39 et de 34 cm alors que celui obtenu habituellement sur sol scarifié se chiffrait à 7 cm.

Les trouées ne semblaient pas être nuisibles. Aussi le piètre rendement de la régénération naturelle sur sol minéralisé exposé suite au passage du scarificateur dépend de l'enlèvement des horizons organiques et supérieurs des sols alors hors d'atteinte par les semis. Ces couches de sol demeurent disponibles pour la régénération pré-établie. L'auteur suggère de tenir compte de la conservation de la régénération pré-établie lorsque la scarification devient inadéquate.

## Introduction

Some form of natural regeneration is necessary in the Engelmann spruce/subalpine fir forest cover type of the British Columbia interior, because seed from suitable high elevation provenances may be too scarce to meet planting requirements. Scarification to expose mineral soil seedbed for natural regeneration is necessary because few germinants survive when seed falls on undisturbed duff (Dobbs 1972).

The effect of blade scarification on soil fertility, however, has been questioned (Revel 1976). In the short term at least, growth rates may be impaired when seedlings grow in exposed mineral soil (McMinn and Van Eerden 1977). Whether scarification of interior spruce sites is done with an angled blade or a toothed brush blade seems to make little difference. Once the roots of undergrowth vegetation are caught by the teeth of a brush blade, surface horizons are removed like rolling back a carpet. Little surface organic matter is left in place, accessible to germinants or freshly planted seedlings.

Information on the longer term effects of surface soil removal on the growth of spruce seedlings in the British Columbia interior is scanty. Re-examination of plots established

in 1953 to evaluate the cost of various site treatment alternatives (Clarke *et al.* 1954) fortuitously provided an opportunity to obtain data covering a 21-year period since harvesting. The growth rates of seedlings established as natural regeneration on bare mineral soil exposed by blade scarification could be compared with the performance of advance growth<sup>3</sup> released following clearcutting of all trees over 1.3 m tall. Duff layers in advance growth plots had been left essentially undisturbed.

## Study Area

The site treatment trials were conducted near Sock Lake, northwest of Clearwater, British Columbia. In the study area, parallel rocky ridges separate intervening depressions and small swamps on a low relief plateau, some 1,400 m above sea level. Mineral soil horizons are derived from granitic parent materials, which are generally shallow to bedrock. Soil textures are coarse (sandy loam to loamy sand) and stones, cobbles and boulders are common. Humo-ferric podzols (Agriculture Canada 1974) predominate. L-H layers are generally shallow (less than 10 cm deep), although deeper surface organic horizons occur on moist slopes and in depressions. A mature Engelmann spruce/subalpine fir stand occupied the area before cutting in 1950 to a 40 cm minimum diameter limit.

Two treatments in the original trial are of interest for this report: (1) blade scarification to obtain natural regeneration, and (2) residual tree felling without further treatment.

Duff and uppermost mineral soil were pushed aside in 4 m wide strips in 3 ha replicated blocks by TD-14 crawler tractor equipped with a 6-toothed brush blade. All advance growth and residual trees in the strips were destroyed, and duff removal was generally complete. The lower Ae or uppermost B horizons formed the new soil surface of scarified strips.

In the 1.5 ha residual tree felling blocks, all trees over 1.3 m were hand-felled preparatory to planned broadcast burning. Burning was not carried out. Cutting the residual trees to leave only stems less than 1.3 m tall inadvertently "sanitized" the remaining advance growth as well as completed their release from the residual overstorey. Studies at Sock Lake and elsewhere have shown that advance growth of Engelmann spruce and subalpine fir less than 1.3 m in height at time of release is generally free from decay (Smith and Craig 1970; Herring 1977).

## Methods

In the summer of 1975 and fall of 1976 sampling points were established at regular intervals along transect lines across three sample blocks in each of the two treatments to determine the present status of regeneration. The closest Engelmann spruce and subalpine fir to each sample point were measured. Total height to the end of the 1974 growing season was measured. Height increments for 1972, 1973 and 1974 seasons were used to obtain mean current annual increment. A basal section was collected from each sample tree for accurate determination of age. The height of advance growth at the time the overstorey was cut was determined by stem analysis.

Three soil pits were dug along transect lines in each of the six blocks sampled. Soil samples were collected from each horizon and mixed to form a composite sample of each

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<sup>3</sup>Regeneration established in the understorey of a stand prior to logging.

soil horizon present in scarified and untreated blocks. The exchange capacity, exchangeable calcium and potassium, base saturation, total nitrogen, phosphorus and carbon and pH of composite samples were determined.

## Results and Discussion

The height growth since 1953 of advance growth released by overstorey harvesting and residual tree removal was greater than that of natural regeneration established following blade scarification (Table 1). The mean heights of subalpine fir and Engelmann spruce advance growth were nine and eight times respectively, that of natural regeneration. The difference in current height increment suggests that the natural regeneration was still growing at only one-fifth the rate of the advance growth.

A small portion of the difference measured after 21 years can be attributed to the "head start" of the advance growth. In 1953, the mean height of the advance growth was 0.54 m (SE 0.06 m) for Engelmann spruce and 0.51 (SE 0.04 m) for subalpine fir. The average age of the regeneration in 1974 was only 14 years. The advance growth had probably been actively growing in height for most of the 21 years prior to 1974, since it may be assumed that a 3-year height-growth

response delay followed cutting of the overstorey in 1950 (Herring 1977). Notwithstanding these circumstances, the difference between the two forms of regeneration in 1974 was substantial.

Brush blade scarification had appreciably reduced the capacity of the site for growing trees, at least for the first two decades following treatment. Reduction of soil fertility following removal of surface organic horizons may be an important factor (Table 2). Although a new surface organic horizon had started to form from residues of pioneer plants (particularly *Polytrichum* moss), this new layer appears to be less fertile and thinner than the original duff. The low base saturation and nitrogen level of mineral soil horizons (Table 2) suggests that organic matter in surface horizons contributes substantially to the fertility of the soils on this site.

Soil compaction by scarification equipment and exposure of poorly structured subsurface soil by removal of surface horizons, are not considered to be major factors contributing to the poor seedling performance on scarified soils on this site because soil textures were coarse. Competing vegetation is also unlikely to have been a significant factor in reducing growth rates of naturally regenerated seedlings in scarified areas. Even by 1976, scarified strips were still sparsely revegetated.

**Table 1. Mean total height and mean current annual height increments of subalpine fir and Engelmann spruce regeneration 21 years after application of two regeneration treatments**

Species	Growth Performance					
	Advance Growth (residual-tree felling treatment)			Natural Regeneration (blade scarification treatment)		
	Number Sampled	Mean Total Height (cm)	Mean Current Height Increment <sup>1</sup> (cm)	Number Sampled	Mean Total Height (cm)	Mean Current Height Increment (cm)
Subalpine fir						
Blk. 14	28	554	31	Blk. 6	36	56
Blk. 15	28	678	40	Blk. 9	36	56
Blk. 18	28	484	31	Blk. 17	36	73
Mean <sup>2</sup>	—	572	34	Mean <sup>2</sup>	—	62 <sup>a</sup>
Engelmann spruce						
Blk. 14	17	601	32	Blk. 6	36	72
Blk. 15	17	647	46	Blk. 9	36	77
Blk. 18	17	640	38	Blk. 17	36	83
Mean	—	629	39	Mean	—	77 <sup>a</sup>

<sup>1</sup> Current annual increment was calculated by averaging annual increments for the 3-year period, 1972 to 1974.

<sup>2</sup> Mean values followed by the same letter are not significantly different ( $p \leq 0.01$ ).

**Table 2. Chemical properties of soils following site treatment by brush-blade scarification for natural regeneration, and overstorey removal and residual-tree felling to release advance growth**

Site Treatment Horizon/Depth (cm)	Chemical Properties							
	Exchange Capacity (me/100g)	Ca (me/100g)	K (me/100g)	% Base Saturation	Total N (%)	Total P (%)	Total C (%)	pH
Brush-Blade Scarification (natural regeneration)								
FH	1-0	37.9	9.45	0.89	32	0.74	24.5	11.9
Ae	0-6	5.7	0.49	0.12	13	0.45	3.8	1.0
Bfh	6-10	35.2	0.55	0.07	2	0.12	3.6	3.8
Bf1	10-17	12.7	0.37	0.08	4	0.06	6.6	1.3
Bf2	17-34	8.9	0.27	0.05	4	0.06	16.6	0.9
BC	> 34	10.4	0.39	0.08	5	0.03	21.3	0.5
Residual-Tree Felling (advance growth)								
FH	6-0	46.5	12.91	1.36	36	1.43	57.1	30.9
Ae	0-8	11.1	0.92	0.08	11	0.07	6.4	1.4
Bfh	8-12	42.6	0.82	0.08	2	0.16	6.2	3.7
Bf1	12-24	29.7	0.66	0.07	3	0.11	10.3	2.5
Bf2	24-40	25.0	0.52	0.09	3	0.10	7.4	2.0
BC	>40	17.0	0.34	0.06	3	0.05	21.0	1.7

## Conclusions

The disparity between the two types of regeneration 21 years after harvesting, in both total height and current annual height increment, suggests that the advance growth will be merchantable decades before the natural regeneration. The suggested use of advance growth for forest regeneration is not without constraints, however. The most obvious requirements are:

1. Quantity; an adequate quantity of advance growth of one or more species, ecologically suited to the site, must exist to meet desired stocking standards.
2. Quality; the advance growth must be of good quality to ensure vigorous, disease-free growth response.
3. Protection; the advance growth must be protected from destruction during overstorey harvesting.
4. Sanitation; post-logging sanitation treatments are usually required to eliminate defective advance growth and optimize site productivity. Residual tree felling and sanitation will, however, substantially increase the slash fuel accumulation resulting from the harvesting operation.

These requirements imply preharvest planning and ecological site evaluation, modification of harvesting techniques and additional stand treatments. The added costs these activities impose on the forest manager must be evaluated in relation to the cost of other regeneration alternatives.

The site degradation which followed blade scarification in the area studied justifies concern for this method of site treatment. Growth rates should eventually improve once

seedling roots reach the untreated margins of scarified strips or accumulations of organic matter within strips, restoring access to fertile soil horizons. The interim period could, however, be long where mineral soils are infertile or have a poor structure which inhibits root growth.

Monitoring of operational experience is suggested. Development of improved methods and machines for site preparation also seems to be warranted. Acceleration of site preparation programs should not precede a better understanding of the biological implications of site treatment techniques. In the meantime, consideration could be given to the use of advance growth for reforestation.

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