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LOGGING SLASH CAN PRECLUDE BLACK SPRUCE REGENERATION ON PEATLAND CUTOVERS

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INTRODUCTION

On typical peatland black spruce (*Picea mariana* [Mill.] B.S.P.) cutovers, logging debris that covers otherwise receptive seedbeds has often been blamed for poor regeneration success (Vincent 1965, Haavisto 1979). Furthermore, logging debris can cause severe damage and even mortality to well-established stems of advance growth (Vincent and Haavisto 1967, Groot 1987).

The amount of logging slash left on a cutover site is dependent on the harvesting system used. Advantages and disadvantages for the removal of this logging slash have been controversial subjects for many years. Morrison and Foster (1979) studied the nutrient capitals that exist in stands and suggested that depletions may occur on some sites if all logging slash is removed during harvesting. The disadvantages of full-tree harvesting systems include a net drain of elements from the site, removal of decomposable organic matter, soil destabilization, destruction of microsite created by slash, and removal of cone-bearing slash (Morrison 1980). In the absence of full-tree logging, however, Atkinson (1978) stated that "logging debris left on the ground after harvesting is probably the main obstacle encountered by site preparation machinery used to obtain better planting conditions and more receptive seedbed." Saltarelli (1980) summarized some of the physical problems associated with logging slash in reference to black spruce regeneration, including a pilot study done by Haavisto, which showed that growth suppression problems may occur as a result of leachates from fresh logging slash.

The purpose of this note is to show the effect of different depths of logging slash on the establishment of black spruce seedlings on peatland cutovers. Postharvest seedbed changes (Fig. 1), slash subsidence, and moss growth over time are also addressed. This information is derived from a study established in the Kennedy Township Black Spruce Area (an experimental forest about 18 km northeast of Cochrane, Ontario) by the Canadian Forest Service–Ontario. The results after five growing seasons are reported here.

SITE CONDITIONS

The site supported a typical OG13 (*Alnus* – herb rich) (Jones et al. 1983) black spruce stand that had an average age of 133 years, and had been classified as "open-merchantable", with a 54% crown closure and a basal area of 27.5 m^2/ha. The stand had been harvested during the winter of 1964/65, but

Figure 1. Sphagnum *mosses over-growing logging slash.*

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all foliage was intact on the slash. Four seedbed types were chosen: loose growing *Sphagnum* moss; compact growing *Sphagnum* moss; *Hylocomium splendens* (Hedw.) BSG. feathermoss; and *Pleurozium schreberi* (Brid.) Mitt. feathermoss. Forty-eight 4-m^2 quadrats, established to provide measurements in four slash depth classes (0, 30, 60, and 90 cm), were placed where these slash depths occurred. The slash accumulations were comprised of branches, tops, and broken stems of various sizes. The thicker accumulations occurred in slash windrows. Randomly chosen 2-m x 2-m plots for all seedbed types and slash loadings were seeded to black spruce at a rate of 250,000 viable seeds/ha. Periodic seedling influx assessments were made, and the encroachment of other species of vegetation was assessed over a 5-year period.

RESULTS

Most seedbeds changed considerably over time (Table 1). Much of the original, loose-growing *Sphagnum* mosses (mostly *S. girgensohnii* Russ.) prevalent under tree and/or shrub cover suffered from shock of exposure subsequent to harvesting, and died. By the fifth year, all loose *Sphagnum* seedbeds had converted to compact *Sphagnum* seedbeds, except where 90 cm of slash cover occurred. Understandably, where slash was deep and/or dense no living vegetation was present; where slash was diffuse some *Sphagnum* development had occurred. Compact *Sphagnum* seedbeds, with a predominance of *S. nemoreum* Scop., remained unchanged except under the deepest and most dense slash loadings. *P. schreberi* feathermoss seedbed surfaces became quite dry when they were exposed to full sunlight after harvesting, but this species retained its predominance over the duration of the study in all except the deepest slash loadings. On the slash-free *Pleurozium* feathermoss seedbeds, there was evidence of some *Sphagnum* moss encroachment. Regardless of slash depth, *H. splendens* feathermoss seedbeds parched very quickly following harvesting, and the mosses died. However, some regrowth occurred under open and lightly shaded conditions. *Sphagnum* mosses that inhabited the low areas very quickly encroached on these seedbeds. Loose-growing *Sphagnum* mosses developed in the slash covered areas and compact *Sphagnum* developed where the slash was either diffuse or nonexistent.

Slash settles over time, but 1 year after placement it had subsided only about 20% (Fig. 2). However, by the fifth year slash depths were only about 50% of the original levels. Except for the 90-cm depth, significantly greater slash subsidence occurred on *Sphagnum* moss seedbeds than on feathermoss. It is postulated that the moisture retained in *Sphagnum* permits the slash to remain pliant, thus allowing the weight of the encroaching *Sphagnum* mosses, winter snow, and the debris itself to compress the mass. Much of the logging slash is preserved for long periods in this wet, acidic environment. Conversely, slash on feathermoss sites becomes very dry and unyielding, and decomposition commences only where the slash is in contact with the soil.

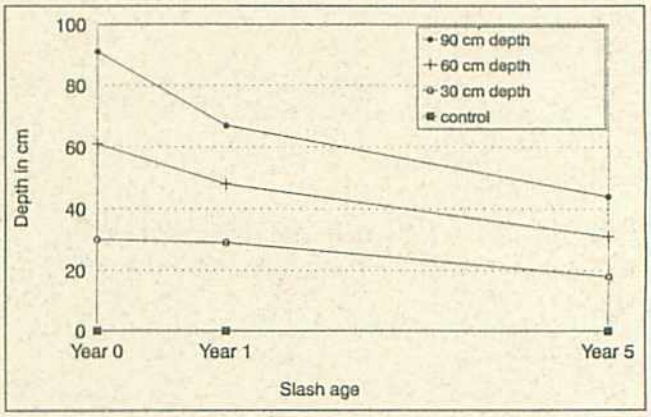

Figure 2. Subsidence of different depths of black spruce logging slash over a 5-year period.

Sphagnum mosses are often seen over-growing debris on the ground (Fig. 1). Measurements made in the fifth year of the study showed that all original *Sphagnum* seedbed types, with no logging slash coverage, averaged net accumulations of only 1.7 cm (Table 2.). Even though alive, *Pleurozium* seedbeds showed no measurable net accumulation, thereby suggesting that humification occurs very rapidly. The small net accumulation of the *Hylocomium* seedbeds after 5 years is a result of the buildup due to *Sphagnum* moss encroachment.

Table 1. Change in seedbed vegetation under four slash depths (0, 30, 60, and 90 cm) 5 years after harvesting.

Original seedbed	Original slash depth (cm)			
	0	30	60	90
Loose *Sphagnum*	Compact *Sphagnum*	Compact *Sphagnum*	Compact *Sphagnum*/ loose *Sphagnum*	No vegetation
Compact *Sphagnum*	Compact *Sphagnum*	Compact *Sphagnum*	Compact *Sphagnum*	No vegetation
Pleurozium	*Pleurozium* (*Sphagnum*)[a]	*Pleurozium*	*Pleurozium*/ compact *Sphagnum*	No vegetation
Hylocomium	Compact *Sphagnum*/ *Hylocomium*	*Hylocomium*/ *Pleurozium*/ loose *Sphagnum*	*Pleurozium*/ *Sphagnum* (loose *Sphagnum*) (compact *Sphagnum*)	No vegetation

[a] Parentheses indicate secondary moss species.

Table 2. Net 5-year moss growth (cm) on plots with different original slash depths.

Original seedbed type	Original slash depth (cm)			
	0	30	60	90
Loose *Sphagnum*	1.7	10.2	8.5	5.1
Compact *Sphagnum*	1.7	7.6	11.9	3.4
Pleurozium	0.0	3.4	1.7	0.8
Hylocomium	1.7	8.5	7.6	3.4

In plots that originally had 30 cm of logging slash, the net moss accumulation after 5 years averaged as high as 10.2 cm where loose growing *Sphagnum* converted to compact *Sphagnum*. On one compact *Sphagnum* seedbed with a diffuse 60 cm of slash, which allowed some light penetration but retained a moist microclimate, the net moss accumulation was 11.9 cm. Surprisingly, some net accumulation occurred on all original *Hylocomium* seedbeds where slash depths were 30 and 60 cm (8.5 and 7.6 cm, respectively) and where *Sphagnum* and *Pleurozium* mosses were encroaching. This suggests that diffuse slash cover provides sufficient shade and moisture retention not only to encourage the encroachment of *Sphagnum* species, but also to retain Schreber's feathermoss as an integral part of the forest floor following the harvest.

Following harvesting and removal of the canopy, feathermoss seedbeds become parched. Dry seedbed surfaces are not suitable for the germination of black spruce seed. No seedlings became established on *Pleurozium* seedbeds during the first 5 years, regardless of the depth of logging slash or whether direct seeding had been done (Fig. 3). On the 12 *Hylocomium* seedbed quadrats, only two black spruce seedlings became established and in both cases this occurred on parts of the seedbed that had converted to either loose or compact forms of *Sphagnum* moss. Seeding 250,000 viable black spruce seeds per hectare did not improve seedling establishment on feathermoss seedbeds.

Sphagnum mosses proved to be good seedbeds, but slash was definitely detrimental (Fig. 3). On the slash-free, compact *Sphagnum* seedbeds, an average of 3.5 black spruce seedlings/m^2 (35,000/ha) had become established by the fifth year on the naturally seeded control plots. Direct seeding at 250,000 seeds/ha resulted in an average of 66,000 seedlings/ha (an establishment ratio of 26%). With 30 cm of slash covering the seedbed, 15,000 black spruce seedlings per hectare were recorded after 5 years; about 22,500 seedlings/ha (an establishment ratio of 9%) were found on direct seeded seedbeds. Where logging slash measured 60 cm deep, 10,000 naturally seeded seedlings per hectare became established, but only in areas where slash was diffuse.

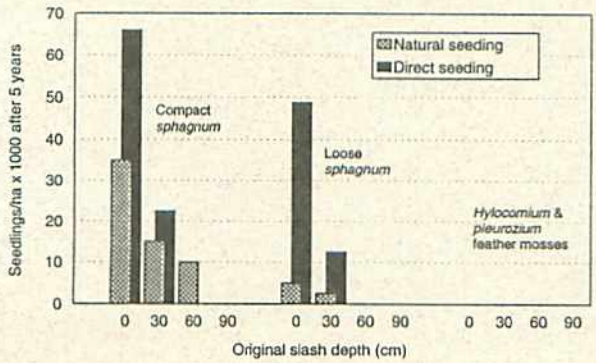

Figure 3. Effect of slash depth and seedbed type on black spruce seedling establishment after 5 years.

On loose growing *Sphagnum* seedbeds with no slash covering, and only on areas where the seedbed had converted to compact *Sphagnum*, about 5,000 black spruce seedlings/ha were recorded by the end of the fifth year (Fig. 3). When seeded at 250,000 seeds/ha, 48,800 seedlings/ha (a 19% establishment ratio) became established on these seedbeds. On the loose growing *Sphagnum* seedbeds with an original slash loading of 30 cm, only about 2,500 naturally regenerated seedlings per hectare were found. With seeding, about 12,500 seedlings/ha become established (a 5% establishment ratio). With deeper slash cover, no black spruce regeneration developed on loose *Sphagnum* seedbeds.

DISCUSSION

Deep slash is detrimental to the development of competing vegetation and mosses, and also to the establishment of black spruce seedlings. By the end of the fifth growing season no black spruce seedlings had become established in plots with 90 cm of slash, regardless of the seedbed type. Following harvesting, feathermoss seedbeds on peatland cutovers, whether *Pleurozium schreberi* or *Hylocomium splendens*, were not conducive to the establishment of black spruce seedlings, even at a seeding rate of 250,000 seeds per ha. Original *Hylocomium* seedbeds did become receptive due to the encroachment of *Sphagnum* mosses during the initial 5 years following harvesting.

Even though loose growing *Sphagnum* moss seedbeds may be adequate for seed germination, they are somewhat inhospitable for early seedling survival because the mosses can outgrow the black spruce seedlings. With direct seeding, acceptable results were obtained. Fortunately, loose growing *Sphagnum* species usually succumb following exposure and compact species of *Sphagnum* mosses quickly become established. Compact growing *Sphagnum* moss species proved to be very good seedbeds, even where some logging slash was present.

Many species of *Sphagnum* mosses (e.g., *Sphagnum girgensohnii)* seem to proliferate under partial shade in a moist microclimate. This study showed that such conditions can be provided by slash layers up to about 30 cm deep, or deeper if slash is diffuse enough to let some light through.

SILVICULTURAL IMPLICATIONS

Slash depths found on cutovers are primarily a function of the logging method used and on the age, density, and condition of the stand. Shortwood operations and tree-length logging systems leave most of the branches and tops at the stump. Full-tree systems remove the complete tree to the landing, where processing takes place and slash is deposited. Slash depths on cutovers can, therefore, range from nil to considerable.

Feathermoss seedbeds dry excessively and are not conducive to the germination and early survival of black spruce seedlings in peatland cutovers. Logging slash does not afford adequate shade to permit satisfactory seedling establishment on these

types of seedbeds. Since loose growing *Sphagnum* mosses can outgrow black spruce seedlings, these seedbeds are not very satisfactory. Compact *Sphagnum* seedbeds are very good for seed germination and for early seedling survival.

Dense logging slash is detrimental to the establishment of black spruce seedlings because seedbeds are effectively covered. Stems of well-established advance growth can also be physically damaged or even buried.

If there are insufficient advance growth stems to restock the cutover, or when prescribed fire is not intended as the site preparation treatment, full-tree logging is the recommended harvesting method for most peatland black spruce sites in the boreal forest if clear-cutting is to be practiced.

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Graydy Atkinson, who worked as a silviculture technician with the Canadian Forest Service–Ontario before his retirement in 1993, was involved in the study of techniques for the management of black spruce, especially the procurement of cones and seeds.

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