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DIRECT SEEDING BLACK SPRUCE ON PEATLANDS IN ONTARIO

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INTRODUCTION

Current economic conditions are motivating forest managers to develop lower cost renewal strategies. To evaluate different regeneration methods, managers must know their applicability by site type, as well as by effectiveness and cost. Clear-cutting followed by broadcast seeding is one reproduction method that offers the possibility of successfully regenerating large areas of peatland forests, where productivity is often low and summer access is frequently poor.

Traditionally, information on direct seeding black spruce on peatlands in northern Ontario was scarce and the data required to develop prescriptions for seeding rates and seedbed amounts were lacking. Therefore, in 1982, the Canadian Forest Service–Ontario initiated a study to examine these aspects of direct seeding. The objectives were: (i) to determine the suitability of peatland seedbed types for black spruce establishment from seed, and (ii) to compare black spruce stocking and density for different seeding rates and seedbed amounts (Groot and Adams 1994). This note presents the fifth-year results of the study.

APPROACH

Seeding experiments were established from 1982–1984 at four locations within the Northern Clay Section of the boreal forest in northeastern Ontario: Hanna Township, 25 km south of Cochrane; Williamson Township, 20 km east of Kapuskasing; Adanac Township, 40 km north of Smooth Rock Falls; and Sangster Township, 60 km northeast of Cochrane. At all locations the original forest was dominated by black spruce that occurred mainly on organic soils (i.e., organic depth 40+ cm). Preharvest Forest Ecosystem Classification (FEC) Operational Groups (OGs) (Jones et al. 1983) included OG 11 (*Ledum*), OG 12 (*Alnus*–herb poor), and OG 13 (*Alnus*–herb rich) with lesser amounts of OG 14 (*Chamaedaphne*) and OG 9 (conifer–herb/moss rich).

The harvesting method used at Hanna, Williamson, and Adanac was clear-cutting with tree-length logging; the Sangster site was clear-cut using full-tree logging. At each site, seed spot (Fig. 1) and broadcast seeding experiments were established in the spring following winter shearblading. Each seed spot consisted of six black spruce seeds (81% viable). Four replications of 50 seed spots were established on common seedbed types at each location during May or June, and a single set of 50 seed spots was established on some of the less common seedbed types.

Seeds from the same lot used in the seed spotting experiment were broadcast with a hand-operated cyclone seeder at rates of 0; 50,000; 100,000; and 150,000 viable seeds per ha (Groot 1988). Observations of seedbed type and number of advance growth stems were made prior to treatment. The number of seeded trees and advance growth stems were measured 2 and 5 years after the treatment. The total height and fifth-year height increment of the seeded trees and advance growth were measured after five growing seasons. Analysis of variance and other statistical techniques were used to assess the relationships between stocking, density, seedbed types, and seeding rates in a completely randomized block design.

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Figure 1. Black spruce seedlings established on poorly decomposed Sphagnum *peat.*

RESULTS AND DISCUSSION

Seedbed Receptivity

The most receptive seedbeds for black spruce on peatlands were poorly decomposed and undisturbed *Sphagnum* peat; sheared *Sphagnum*; and living, compact *Sphagnum* moss.

At each site, fifth-year seed spot stocking was greater than 74% and the establishment ratio was greater than 38 seedlings per 100 seeds sown on either poorly decomposed *Sphagnum* peat or sheared *Sphagnum*. These seedbeds differ mainly in the method by which they are created. Shearing produces a flat, uniform surface, whereas disturbance by harvesting or site preparation equipment creates a more variable and often rougher peat surface. Both seedbed types are good substrates for seed germination and establishment because they remain continuously moist.

Fifth-year stocking and establishment ratios for living, compact *Sphagnum* moss ranked third or fourth at three locations. Initial black spruce seedling establishment was good on this type of seedbed since it remains moist. However, because the moss can grow more rapidly than the germinants, the rate of mortality can be high (Johnston 1977).

Displaced, poorly decomposed *Sphagnum* peat and rotten wood usually showed intermediate stocking and establishment ratio values, but resulted in a poorer seedbed than the same substrate when undisturbed. Displaced peat is more prone to drying because there is a poor hydraulic connection with the moisture supply in the underlying peat.

Black spruce seedling establishment on well-decomposed organic matter was initially good, but mortality occurred later. This type of organic matter usually remains moist and allows for good initial establishment, but seedlings that germinate on this substrate are prone to a number of problems (e.g., flooding, frost heaving, erosion, and competition).

Litter, feathermosses, and poorly decomposed feathermoss peat, whether displaced or undisturbed, all showed consistently low seed spot stocking and establishment ratios. In contrast with *Sphagnum* moss or peat seedbeds, the surface layers of feathermosses and feathermoss peats (equivalent to organic matter in the F-layer of upland feathermoss sites) dry out rapidly even on peatland sites and are not favorable substrates for the establishment of black spruce from seed. Poorly decomposed *Sphagnum* peat; sheared *Sphagnum*; and living, compact *Sphagnum* should be considered as the main receptive seedbeds on peatlands.

Seedling Survival and Growth

Black spruce stocking and establishment ratios declined from the first to the fifth year on almost all seedbed types, but declines were especially marked on well-decomposed organic matter and pioneer mosses and were notable on rotten wood and living *Sphagnum* seedbeds.

Seedling heights on seed spots averaged from 2 to 4 cm after two growing seasons and from about 5 to 20 cm after five growing seasons. Fifth-year height of seeded trees in the broadcast seeding experiments averaged from 8 to 17 cm; fifth-year height increment averaged from 4 to 5 cm. Of note, black spruce advance growth averaged from 35 to 57 cm in height and height increment averaged from 6 to 9 cm in Year 5.

Although *Sphagnum* peat and *Sphagnum* moss are good seedbeds from the point of view of establishment, they do not provide good conditions for seedling growth. Seedlings establish poorly on feathermoss peat, but once established grow more rapidly than on *Sphagnum* peat (Jeglum 1981, Munson and Timmer 1989), perhaps because of nutritional differences. The small initial size of trees established by direct seeding and their slow growth will result in longer rotation periods than if the area is regenerated by planting or if the advance growth is preserved.

Seeding Rates

At each location the stocking and density of seeded trees generally increased with the seeding rate (Table 1).

Although a seeding rate of 150,000 viable seeds per ha resulted in a seeded tree stocking rate of 70% or greater at all four locations, it is imprudent to recommend a single seeding rate for black spruce on peatlands. This is because the seeding rate required to achieve a given level of stocking depends on the availability (amount and distribution) of receptive seedbeds.

Table 1. Fifth-year results for stocking and density to seeded black spruce trees for four study areas by seeding rates.

Study area	Seeding rate (000's of viable seeds per ha) 0	50	100	150
	Stocking to seeded trees (%)			
Hanna	17	63	76	76
Williamson	37	67	53	70
Adanac	22	58	72	75
Sangster	23	56	70	74
	Density of seeded trees (stems/ha)			
Hanna	575	3,675	7,675	8,225
Williamson	1,500	5,833	4,208	9,250
Adanac	708	3,375	6,458	8,167
Sangster	1,063	3,969	7,000	7,844

Table 2. Fifth-year results for stocking and density of all black spruce trees (seeded trees and advance growth) for four study areas by seeding rates.

Study area	Seeding rate (000's of viable seeds per ha) 0	50	100	150
	Stocking to all trees (%)			
Hanna	61	76	87	86
Williamson	37	70	55	70
Adanac	65	85	83	83
Sangster	84	96	94	93
	Density of all trees (stems/ha)			
Hanna	5,850	7,425	12,700	12,250
Williamson	1,500	6,167	4,417	9,708
Adanac	8,417	13,250	10,667	17,708
Sangster	22,250	26,938	25,563	24,781

The importance of well-distributed, receptive seedbeds is further illustrated by the relationships between stocking, density, and the effective seeding rate (the number of seeds per 4 m^2-quadrat that fall on receptive seedbeds). The number of seedlings per quadrat was linearly related to the effective seeding rate (number of seedlings = 0.98 + 0.22 x effective seeding rate, r^2=0.98). The relationship between quadrat stocking and effective seeding rate was strongly nonlinear (stocking = effective seeding rate / (1.572 + effective seeding rate , r^2=0.98). An effective seeding rate of six to seven seeds per quadrat is required to achieve a stocking level of 70% or greater.

Depending on desired black spruce stocking or density levels, the necessary seed application rate can be predicted from the amount and distribution of receptive seedbeds. A computer model that will calculate the seeding rates needed to achieve given stocking and density levels, based on seedbed measurements, is under development by the Canadian Forest Service–Ontario and will be integrated into a direct seeding guide to be published within the next year.

Advance Growth

It is important to consider advance growth when evaluating the need for direct seeding on any site. In this study, black spruce advance growth was abundant at all of the sites except Williamson. Fifth-year stocking to all black spruce trees, including the advance growth, exceeded 75% for all seeding rates at all of the sites except Williamson (Table 2).

Preservation of advance growth and direct seeding should be viewed as complementary regeneration methods on peatlands. Preservation of advance growth is preferable to regeneration by broadcast seeding because it is less risky and because advance growth has a large height and height growth advantage over trees established from seed. Seeding can be used to increase stocking in situations where advance growth stocking by itself is inadequate and where seedbed conditions are favorable.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

The stocking and density levels achieved from a direct seeding treatment depend on the amount and distribution of receptive seedbeds and on the seed application rate. The most receptive seedbeds for black spruce on peatlands were poorly decomposed *Sphagnum* peat *in situ*, sheared *Sphagnum*, and living compact *Sphagnum* moss. Depending on the amount and distribution of these seedbeds, seeding rates from 50,000 to 150,000 viable seeds per ha will yield good regeneration results on peatlands.

Site type is also an important consideration when developing direct seeding prescriptions. Site types with a high cover of *Sphagnum* moss (e.g., FEC Operational Groups 8, 11, 12, and 13) provide the greatest likelihood of seeding success. Competition from shrubs, herbs, and grasses and the growth rate of seedlings are also related to site type. Seedlings will grow faster on nutrient-rich sites but may require release from competing vegetation.

Harvesting and site preparation methods that increase the amount and improve the distribution of receptive seedbed cover will give the best results when direct seeding black spruce on peatlands. Full-tree harvesting will minimize slash and thus increase black spruce stocking and density above that obtained by tree-length harvesting (Johnston 1980). Creation of deep ruts during harvesting and site preparation should also be avoided in order to increase seedbed amounts and improve distribution. Matching the season of harvest and type of equipment to FEC operational groups will contribute to minimizing site damage (Groot 1987).

Treatments such as shearblading or burning can destroy significant amounts of advance growth. Therefore, it is important to determine whether there is sufficient advance growth through a pretreatment survey before investing in treatments that may be unnecessary. Where such growth is determined to be insufficient, further treatment may be recommended. Winter shearblading is an effective site preparation technique for direct seeding black spruce on peatlands since it redistributes slash and can create receptive seedbeds. An alternative method of site preparation is prescribed burning. Burning consumes slash, litter, and dry mosses; exposes receptive seedbeds; and reduces competition from shrubs, grasses, and sedges. Broadcast or natural seeding following burning has given good regeneration results in Manitoba, Newfoundland, and Minnesota.

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