

OPERATIONAL DIRECT SEEDING TRIALS  
WITH BLACK SPRUCE  
ON UPLAND CUTOVERS

J. W. FRASER

GREAT LAKES FOREST RESEARCH CENTRE  
SAULT STE. MARIE, ONTARIO

REPORT O-X-321

CANADIAN FORESTRY SERVICE  
DEPARTMENT OF THE ENVIRONMENT  
JANUARY 1981

*Copies of this report may be  
obtained from:*

*Information Office,  
Great Lakes Forest Research Centre,  
Canadian Forestry Service,  
Department of the Environment,  
Box 490, Sault Ste. Marie, Ontario  
P6A 5M7*

## ABSTRACT

Spring and fall operational direct-seeding trials with untreated and coated black spruce (*Picea mariana* [Mill.] B.S.P.) seeds on site-prepared boreal forest upland cutovers are documented and discussed. Although all trials were unconditional failures with respect to achieving acceptable stocking by province of Ontario stocking standards, the most germination and the best stocking occurred on either mineral soil or mixtures of mineral soil and humus. Failure of the trials is attributed mainly to improper and inadequate site preparation.

## RÉSUMÉ

Des essais opérationnels de semis direct au printemps et à l'automne avec des graines enrobées non traitées d'Épinette noire (*Picea mariana* [Mill.] B.S.P.) sur des surfaces de coupe en montagne dans la forêt boréale après préparation de la station sont documentés et discutés. Encore que tous les essais aient été des échecs incontestables en ce qui concerne le matériel sur pied selon les normes de la province de l'Ontario à ce sujet, le maximum de germination et l'optimum de matériel sur pied ont été obtenus soit sur le sol minéral, soit sur des mélanges de sol minéral et d'humus. L'insuccès des essais est attribué principalement à la préparation incorrecte et inadéquate de la station.

#### ACKNOWLEDGMENTS

I am indebted to former research technician, J. M. Shoup, and to forest research technician, M. J. Adams, who conducted the field work on the Mooseskull and Chickenfarm cutovers, respectively. I also wish to acknowledge the cooperation and assistance of Ontario Ministry of Natural Resources staff from Toronto headquarters, the Terrace Bay District, and the Angus Tree Seed Plant in implementing these trials. My thanks also to A. Radvanyi, Canadian Wildlife Service, for applying the R-55 treatments, and to Ontario Paper Company foresters at Manitouwadge for providing technical assistance and mechanical services as requested throughout the trials.

## TABLE OF CONTENTS

	<i>Page</i>
INTRODUCTION . . . . .	1
<i>Schedule of Trials</i> . . . . .	1
<i>Plot Location</i> . . . . .	3
<i>Plot/Area Descriptions</i> . . . . .	3
<u>Mooseskull Area 1</u> . . . . .	6
<u>Mooseskull Area 2</u> . . . . .	6
<u>Chickenfarm</u> . . . . .	6
METHODS AND PROCEDURES . . . . .	6
<i>Site Preparation</i> . . . . .	6
<i>Seeding</i> . . . . .	10
<i>Assessment</i> . . . . .	10
<i>Analysis</i> . . . . .	12
<i>Weather Measurements</i> . . . . .	12
RESULTS . . . . .	12
<i>Germination</i> . . . . .	12
<i>Stocking</i> . . . . .	16
<i>Stocking and Vegetation</i> . . . . .	26
DISCUSSION AND CONCLUSIONS . . . . .	29
LITERATURE CITED . . . . .	34



## INTRODUCTION

Pilot-scale operational direct-seeding trials with black spruce (*Picea mariana* [Mill.] B.S.P.)<sup>1</sup> seeds were initiated in 1973 on the Ontario Paper Company license, Manitouwadge (49°8'W and 85°50'N), in the Ontario Ministry of Natural Resources' Terrace Bay District in the Central Plateau Section of the Boreal Forest (Rowe 1972) (Fig. 1). These were cooperative trials among the Ontario Ministry of Natural Resources (OMNR), the Canadian Wildlife Service (CWS) and the Great Lakes Forest Research Centre (GLFRC).

OMNR provided the seeds, applied one of the seed treatments (Arasan) and did the hand seeding on cutovers they selected and site prepared (scarified)<sup>2</sup> to their prescription. CWS applied the second seed treatment (R-55), conducted rodent-census field studies on the trial areas and controlled-feeding laboratory studies. GLFRC coordinated the trials, conducted assessments and evaluated results. Although not a formal participant in this cooperative venture, Ontario Paper Company (OPC) contributed appreciably to it by providing accommodation, mechanical facilities, and field assistance.

Readers are referred to a previous paper (Fraser 1975) for the rationale behind these field trials to help resolve the controversy about direct seeding black spruce, particularly the role of rodents in the outcome of such seeding operations. A more recent report (Fraser 1980) documents how the two seed treatments (Arasan and R-55) used in these field trials influence the germination of black spruce seeds. Details concerning methods and materials included in the earlier paper (Fraser 1975) are omitted intentionally from this report, the main objective of which is to document the end results of the trials reported initially at the Black Spruce Symposium held in Thunder Bay in 1975.

### *Schedule of Trials*

Initially, the seeding phases of the trials, consisting of fall and spring seeding with untreated, Arasan-coated and R-55-coated seeds, were scheduled to begin with fall seeding (September-October) in 1972 and to end with spring seeding (May-June) in 1975. In the event, unforeseen complications related to availability of suitable areas and inability to scarify otherwise acceptable ones necessitated rescheduling twice. Initially, also, the trials were to have been assessed annually for five years. The actual schedule of harvesting, scarification, seeding and assessment was as follows:

---

<sup>1</sup>Throughout this report, unless otherwise specified, "seeds" means black spruce seeds.

<sup>2</sup>Within the context of this report "site preparation" and "scarification" are synonymous and mean mechanical disturbance of the surface of the cutovers.

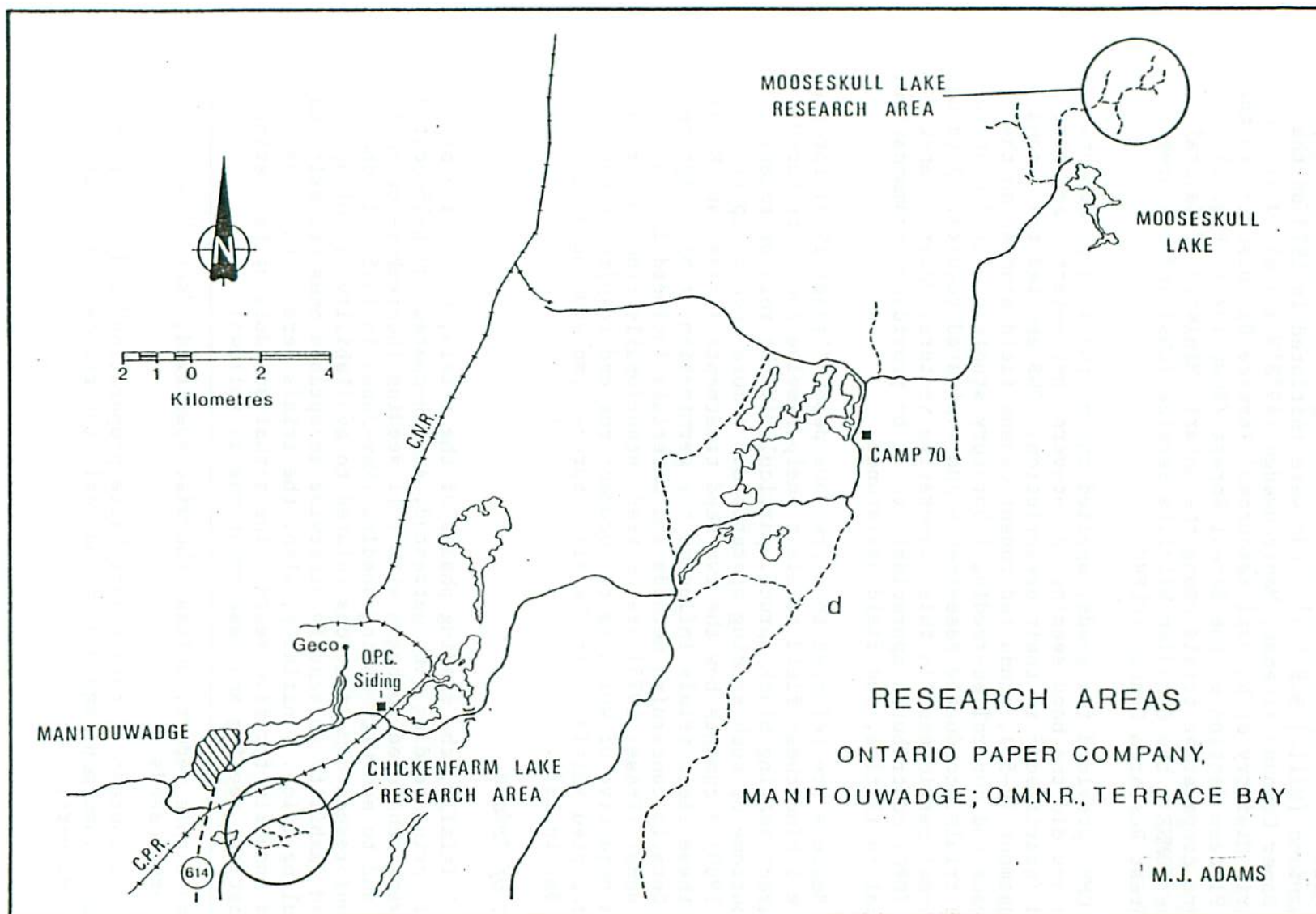


Figure 1. Location of the Mooseskull and Chickenfarm research areas relative to Manitouwadge and Ontario Paper Company Camp 70, Terrace Bay District, OMNR.



Area designation	Harvested <sup>a</sup> season/year	Site prepared <sup>b</sup> season/year	Seeded <sup>c</sup> season/year	Assessed season/year/method
Mooseskull Area 1	Winter/ 72/73	Summer/73	Fall/73 Spring/74 }	Fall/74, Fall/75/ Contract and Fall/ 76/GLFRC
Mooseskull Area 2	Winter/ 73/74	Summer/74	Fall/74 Spring/75 }	Fall/74/Contract and Fall/75/GLFRC
Chickenfarm Lake	Winter/ 75/76	Summer/76	Fall/76 Spring/77 }	Fall/77 and Fall/78/GLFRC

<sup>a</sup>Clearcut by cut-and-skid methods.

<sup>b</sup>Scarified using shark-fin or flanged barrels and spiked anchor chains.

<sup>c</sup>Spot seeded using R+S Einzelkorn hand seeders (see Fraser 1975 for further details).

#### *Plot Location*

Prior to site preparation, cutovers in each of the research areas, Mooseskull Lake areas 1 and 2 (Fig. 2), and Chickenfarm Lake (Fig. 3) (hereafter referred to as Mooseskull and Chickenfarm) were divided arbitrarily into six plots approximately equal in size, each large enough to accommodate 1000 seedspots roughly 2 m apart along scarified furrows about 2 m apart. Each area was delineated using 5 x 5 cm wooden stakes with CFS aluminum boundary plaques.

We soon recognized our naiveté in establishing as our criterion for selecting the plots that they be on similar sites representative of upland black spruce cutovers, and we had to settle for plots on cutovers that had been in the black spruce working group (60% black spruce) and *could be site prepared*. Even with these constraints, site conditions varied remarkably (often from one extreme to another) within as well as between plots and, not infrequently, from one seedspot to the next.

#### *Plot/Area Descriptions*

Reference has already been made to the remarkable variation in site conditions (soil depth over bedrock, boulder content, bedrock outcrop, moisture, topography, drainage) within plots, which, in the author's opinion, preclude meaningful descriptions of individual plots. It is even doubtful whether the following superficial descriptions of areas serve any useful purpose other than to draw attention to the misnomer "representative upland black spruce sites" and to indicate

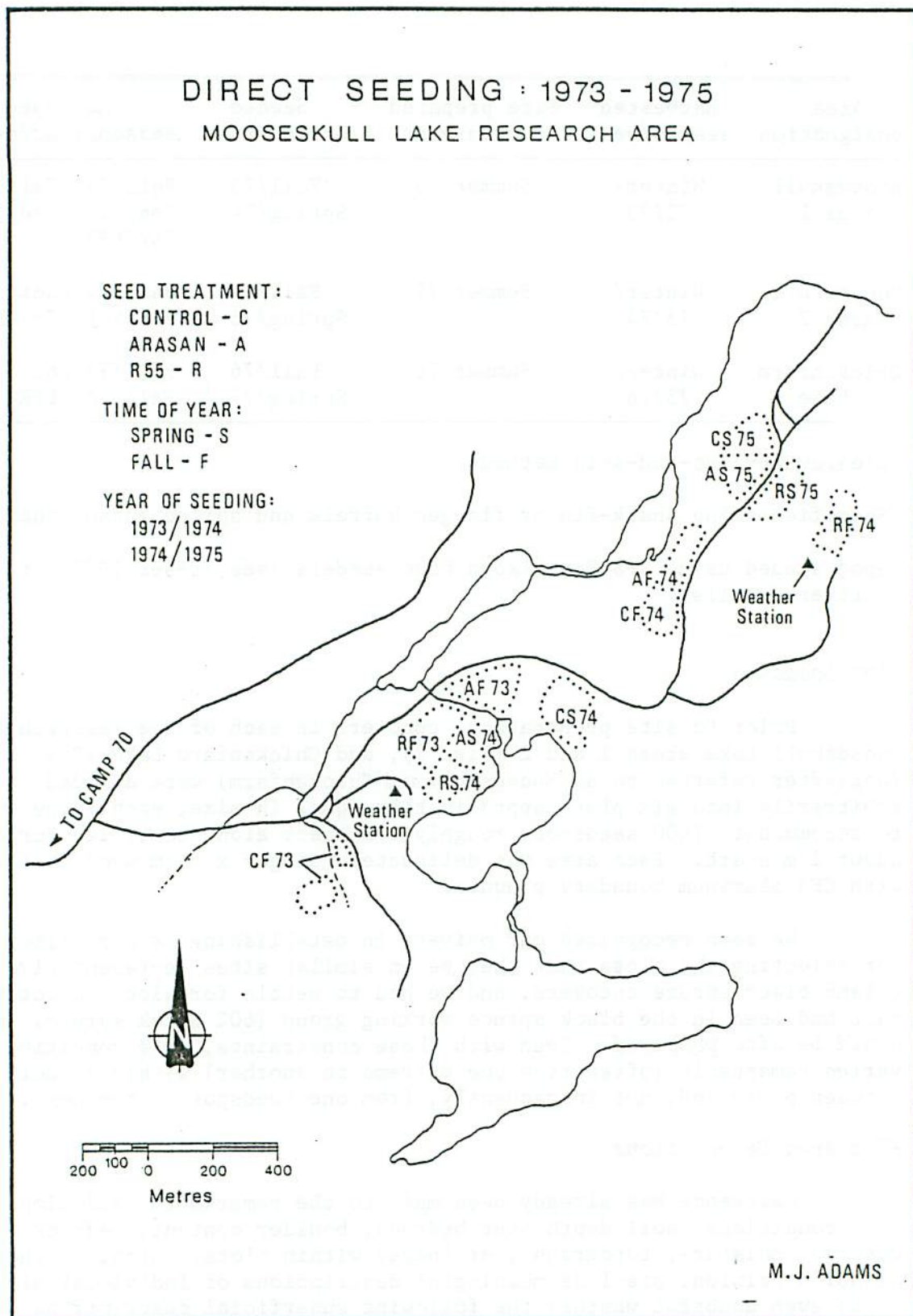


Figure 2. Direct-seeding trial plots in the Mooseskull upland cutovers.  
cutovers.



# DIRECT SEEDING : 1976 - 1977 CHICKENFARM LAKE RESEARCH AREA

## SEED TREATMENT:

CONTROL - C

ARASAN - A

R55 - R

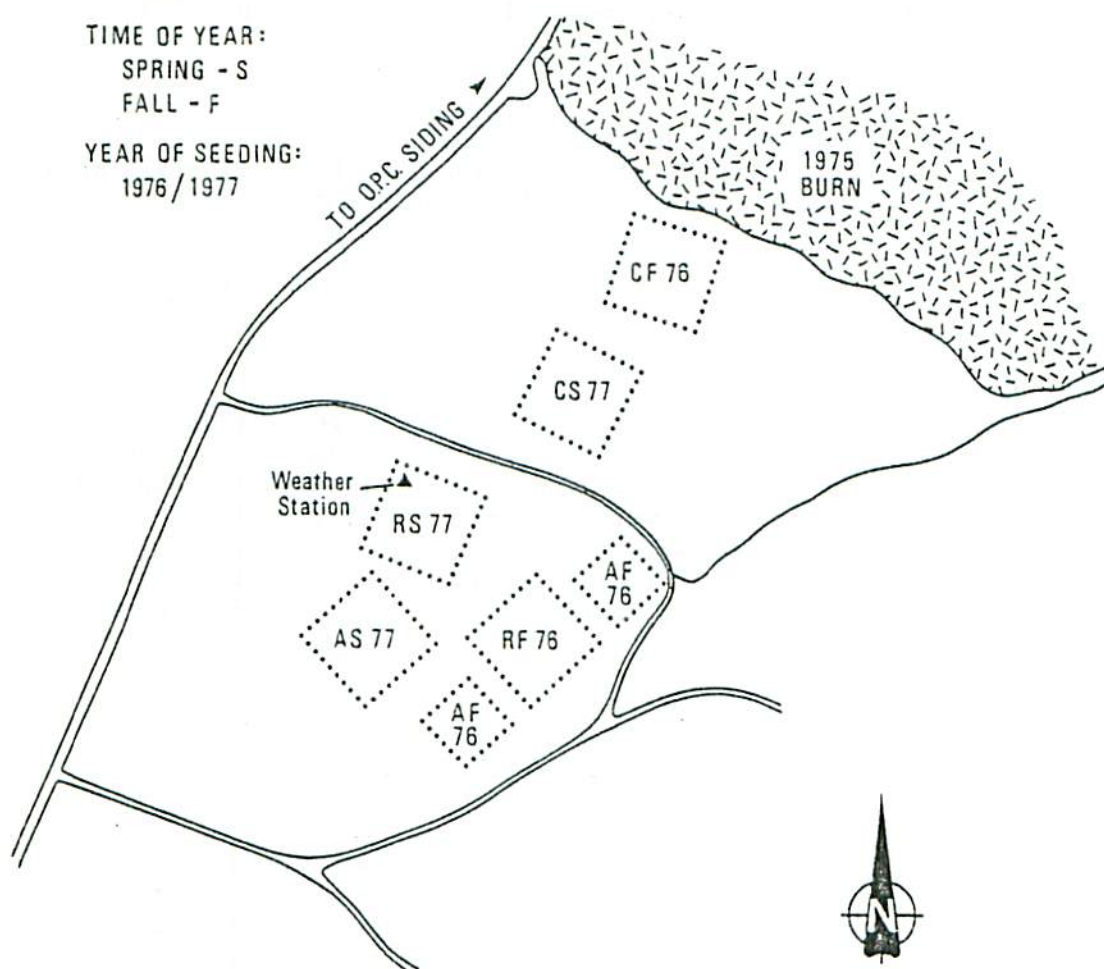
## TIME OF YEAR:

SPRING - S

FALL - F

## YEAR OF SEEDING:

1976/1977



M.J. ADAMS

Figure 3. Direct-seeding trial plots in the Chickenfarm Lake upland cutovers.

why uniform, good-quality site preparation on many upland cutovers is well nigh impossible, at least with current equipment and techniques.

The only common denominator on these scarified upland cutovers when they were seeded was an almost total absence of living vegetation.

Mooseeskull Area 1 (Fig. 2 and 4): Although it is not readily apparent from these black and white photographs, the overall area of the 1973-1974 seedings was a hotchpotch of steep rocky pitches and bedrock outcrop with local patches of reasonably stone-free soil varying in depth (0 to 100+ cm) over bedrock, and some low, moist depressions and occasional swampy areas.

Mooseeskull Area 2 (Fig. 2 and 5): The topography was gently rolling with only occasional medium pitches. The soil varied from a deep, medium sand to sandy clay loam. There were occasional moist depressions but this 1974-1975 area was, in general, neither moister nor drier than the first area seeded the previous year.

Chickenfarm (Fig. 3 and 6): In effect this was a long medium slope (0.4-0.8 km), which varied greatly in steepness of local pitches, depth of soil (generally very shallow over bedrock) and bedrock outcrop (very extensive). Soils varied from coarse sandy till at the top of the slope through clay loams to clay downslope. Haphazardly among the local pitches and bedrock ridges and shelves there were plateau-like flats and/or depressions of various sizes. These areas were generally moister than those immediately above and/or below them, probably because they were catchments for both soil and water from upslope. Post-scarification erosion on the Chickenfarm cutovers was inordinately severe (see *Site Preparation*).

## METHODS AND PROCEDURES

### *Site Preparation*

One of the conditions of the cooperative agreement was that the trials be *operational*, not *experimental*. In other words, the trial areas were selected by OMNR District staff, then site prepared to OMNR specifications (under OMNR supervision) for planting or seeding.

The quality of the *operational* site preparation left much to be desired--certainly for seeding black spruce. With little or no attempt to control the depth and/or degree of scarification by parting the slash or altering the type, size, weight, spacing and/or combination of barrels and chains the quality of site preparation was unduly dependent upon ruggedness of terrain, rock outcrop, boulder content, depth of soil over bedrock, and amount and type of slash.





4A: 1973



4B: 1974

Figure 4 (A and B). Representative views of Mooseskull cutovers (Area 1) seeded to black spruce in the fall of 1973 and spring of 1974. Black and white photos like these fail to show adequately the variability in terrain and bedrock but do convey the complete absence of vegetation following clearcut harvesting on such sites. (Shoup 1973/74)





5A: 1974



5B: 1975

Figure 5 (A and B). Representative views of Mooseskull cutovers (Area 2) seeded to black spruce in the fall of 1974 and spring of 1975. Note the generally flatter topography and absence of bedrock and boulders in comparison with Area 1 (cf. Figure 4), but the same absence of vegetation following clearcut harvesting. (Shoup 1974/75)



Figure 6. A representative view of the Chickenfarm Lake cutover seeded to black spruce in the fall of 1976 and spring of 1977. As in Figure 4, the black and white photo fails to do justice to steepness of slope, amount of exposed bedrock indicative of very shallow soil, and overall barrenness of this large clearcut. (Fraser 1976)

The resultant site preparation on Mooseskull 1 was of the "hit-and-miss" variety, i.e., either too severe (furrowed to bedrock or deep into the mineral soil) or inadequate (not even disturbing the surface litter). On Mooseskull 2 with its gently rolling terrain and generally deep, mainly sandy soil, the site preparation was, by and large, too extreme, with furrows scarified deep into mineral soil, not infrequently into the "B" horizon.

On Chickenfarm the site preparation was probably even more questionable for at least two reasons. Much of the area is in the "fragile site" category: fragile because the soils are generally very shallow over bedrock, and also because of the slope which predisposes the area to erosion of the shallow soil once it is disturbed. Furthermore, safety regulations dictated that scarification must be up and down the slope rather than across it. This in effect exposed much of the area to severe down-slope drainage, and it is conjectured that much



of the seed sown in seedspots was either washed away or buried too deeply, or many seedlings that did originate on seedspots were subsequently buried or washed out. These phenomena were observed many times.

Good conditions for germination, growth and survival of black spruce *were* created on these cutovers, namely exposure of the Ah horizon or some reasonable approximation thereof (Winston 1975), but by happenstance rather than by design.

### *Seeding*

Although the *method* of seeding was detailed in Fraser (1975), some clarification about the *sequence* of seeding is probably in order. On each of the three areas (Mooseskull 1 and 2, and Chickenfarm) the six plots to be seeded were located and established after the areas were harvested but before they were scarified. The six combinations of kind of seeds to be sown, i.e., untreated (control), Arasan-coated and R-55-coated, and the two seasons and years of seeding, e.g., fall/73 and spring/74, on Mooseskull Area 1, were allocated randomly among the six plots (see Fig. 2 and 3 for details).

All seeds used in these trials were from the same seed lot (Seed Zone 3E) reserved for these trials and stored at the Ontario Tree Seed Plant, Angus, Ontario. Just prior to each of the six seeding trials enough seeds to accommodate the trial and associated germination tests at GLFRC<sup>3</sup> were treated (coated) with Arasan (OMNR) or R-55 (CWS) and shipped to GLFRC for delivery to the seeding crews supervised by OMNR district staff.

### *Assessment*

There was a 100% tally of seedspots at each assessment. A 45-cm-diameter metal ring was centred on the pin marking where the seeds were sown<sup>4</sup> and the following information was coded for each seedspot:

---

<sup>3</sup>Laboratory germination tests paralleled each field seeding trial to ensure that the germinative capacity of the seed had not depreciated with storage.

<sup>4</sup>Wherever erosion of one kind or another had moved seeds away from where they were initially sown, the metal ring was centred where the seeds had germinated.



---



---

Aspect	Slope
1. Flat	1. 0- 5% (level)
2. North (quadrant)	2. 6-25% (gentle)
3. East (quadrant)	3. 26-50% (moderate)
4. South (quadrant)	4. 51-75% (steep)
5. West (quadrant)	5. >75% (precipitous)

---

The futility of trying to assign any of these categories of aspect or slope to *seedspots* (where the seeds were sown) which ranged from less than 5 cm to 15 cm in diameter was soon apparent. To categorize the seedbeds within the 45-cm circle was almost equally meaningless relative to microsites where the seeds actually came to rest and germinated--if and when they did so.

*Slash cover* was coded according to the aerial cover it provided over the seedspot<sup>4</sup> or the area where seedlings--if any--occurred, as 1 (0-5%), 2 (6-25%), 3 (26-50%), 4 (51-75%) and 5 (>75%).

*Vegetation cover*, coded in the same five percentage classes as slash cover, pertained to aerial cover, not stem density. It included all species, as an indication of shading.

*Vegetation type*, by one of six strata, i.e., that stratum of vegetation which was predominant on a seedspot, was coded as 1) none, 2) mosses and lichens, 3) grasses and sedges, 4) herbs, 5) low shrubs and 6) high shrubs. For the Chickenfarm assessments, a seventh category was added to deal with the vast numbers of white birch (*Betula papyrifera* Marsh.) seedlings on much of this cutover.

*Seedbeds*. Seven classes of seedbed were recognized: 1) mineral soil, 2) humus, 3) mineral soil/humus mix, 4) bark, 5) decayed wood, 6) dead moss and 7) "others". For these assessments "humus" included partly and fully decomposed litter but excluded raw litter which was identified as such under 7). The initial intention to code seedbed at each successive assessment was abandoned after the second assessment on Mooseskull 1 area revealed the futility of doing so. In retrospect, even the validity of the seedbed coding

at the first assessment on any area, i.e., 5 to 12 months *following* the seeding, may be questionable, even misleading.

*Height classes.* Seedlings were tallied in one of five classes:

1. Up to 1 year old, < 5 cm high
2. Up to 1 year old, > 5 cm high
3. >1 year old, < 5 cm high
4. >1 year old, > 5 cm but <10 cm high
5. >1 year old, >10 cm high

### *Analysis*

All field data were coded for computer analysis but, as will be evident from the results, the need for factorial analyses envisioned when the trials were set up was obviated by the end results which, in the author's opinion, warranted only the simplest Chi-square analysis for this report.

### *Weather Measurements*

Readers will have noted the location of weather stations on each of the two Mooseskull areas (Fig. 2) and on the Chickenfarm area (Fig. 3). None of these stations functioned according to specifications. Sporadic mechanical breakdowns and power failures, and intermittent failure of sensing elements and/or associated recording devices resulted in unacceptable discontinuous records. This, in the author's opinion, precluded using the data from the stations to describe weather conditions during these trials.

## RESULTS

### *Germination*

Laboratory germination tests paralleling the field trials and using seeds from the same seed lot indicate no appreciable loss of germinative capacity in this seed lot during the trials. The statistically significant differences in Table 1 have no practical significance in operational seeding.

In field germination tests (all seedbeds combined), germination<sup>5</sup> for all seed treatments combined and for individual seed treatments was disastrously and unacceptably low (Table 2). Hence, the statistically significant differences have no practical significance other than to *indicate*, perhaps, that germination from spring seeding was better than or as good as that from fall seeding in two of three instances.

---

<sup>5</sup>"Germination" is based on those germinants found on the seedspots at the first assessment 5-12 months after seeding. Conceivably, there may have been other germinants that died before this assessment.



Table 1. Percent laboratory germination\* of untreated and coated black spruce seeds after 28 days at 21C.

Season and year of seeding	Seed treatments		
	Control	Arasan	R-55
Fall 1973	2 198 a	195 a	197 a
Spring 1974	199 a	197 a	198 a
Fall 1974	2 198 a	198 a	196 a
Spring 1975	2 197 a	196 a	197 a
Fall 1976	2 198 a	197 a	2 90
Spring 1977	2 95 a	195 a	2 91

There is no significant difference ( $p = 0.05$ ) between seed treatments with the same lower case letter for any given season and year of seeding, nor between season and years with the same number(s) for any given seed treatment.

\*All percent data in this table and others in this report are rounded to the nearest whole number.

With one exception (spring 1977) (coating treatments combined) more coated seeds than control seeds germinated, and again with one exception (fall 1973) more Arasan-coated than R-55 coated seeds germinated.

Coated seeds always germinated better than control seeds in fall seeding and in two out of three instances in spring seeding. Germination from spring-sown Arasan-coated seeds was as good as or better than that from R-55-coated seeds. When seeds were sown in the fall, germination from one coated treatment was better than that from the other in one instance and there was no difference between them in the third. Readers are cautioned not to attach any practical significance to these indications.

Of all seeds that germinated, regardless of season and year of seeding, 94% or more germinated on one or other of three seedbeds, i.e., mineral soil (MS), humus (H), mineral soil/humus (MSH) (Table 3). There were two seedlings per stocked seedspot in all treatments combined, and two, three, and two per stocked seedspot in the control, Arasan, and R-55 treatments, respectively. Since less than 6% of all germination that occurred was on the other four seedbeds combined, it and they are excluded (arbitrarily) from further consideration.



Table 2. Percent germination on all seedbeds for all seed treatments combined and by seed treatments, based on five seeds per spot\* on 1000 seedspots for each seed treatment.

Season and year of seeding	All treatments	Control	Arasan	R-55
Fall 1973	11	10 a	9 a	14
Spring 1974	20	19	26	15
Fall 1974	22	10	27 a	28 a
Spring 1975	10	9	13	6
Fall 1976	16	12 a	24	12 a
Spring 1977	25	36	22	16

There is no significant difference ( $p = 0.05$ ) between seed treatments with the same lower case letter(s) for any given season and year of seeding, nor between seasons and/or years of seeding with the same number(s) for individual seed treatments or all treatments combined.

\*Hand seeders were calibrated to deliver 5 to 8 seeds on each spot. These data are calculated using the lower number (arbitrary choice by author). With numbers greater than 5, the germination data are even more discouraging.

Table 3. Percentage of all seeds germinating at each seeding which germinated on mineral soil, on humus, or on a mixture of mineral soil and humus, and the mean number of seeds germinating\* per stocked seedspot.

Season and year of seeding	All treatments		Control		Arasan		R-55	
	%	No.	%	No.	%	No.	%	No.
Fall 1973	97	2	98	2	94	2	96	2
Spring 1974	96	2	94	2	96	3	97	2
Fall 1974	99	2	99	2	99	3	99	2
Spring 1975	100	2	100	2	100	3	100	2
Fall 1976	96	2	96	2	96	3	96	2
Spring 1977	95	2	97	3	98	3	95	2

\*Germination is based on the number of germinants found on seedspots at the first assessment, i.e., 5-12 months after seeding.

Consider the germination summarized by seedbeds in Table 4, bearing in mind that these data are percentages of percentages of the germination that *actually* occurred. For example, only 11% (1651) of all the seeds sown in the fall of 1973 (15,000) (Table 2) actually germinated, and 97% (1610) of these were on one or other of three seedbeds (Table 3). Of these, 43% (699), 18% (286) and 39% (625) were on mineral soil, humus, or mineral soil/humus (Table 4). Readers are cautioned again to view these data with restraint and not be misled by numbers.

Table 4. Percentage of all seeds germinating\* *at each seeding* which germinated on mineral soil, on humus, or on a mixture of mineral soil and humus, and the mean number of seeds germinating *per stocked seedspot*.

Season and year of seeding	Seedbed	All treatments		Control		Arasan		R-55	
		%	No.	%	No.	%	No.	%	No.
Fall 1973	MS	43	2	37	2	46	2	47	2
	H	18	2	30	2	6	2	16	2
	MSH	39	2	33	2	48	2	37	2
Spring 1974	MS	63	2	74	2	53	3	67	2
	H	11	2	7	2	12	2	12	2
	MSH	26	2	19	2	35	3	20	2
Fall 1974	MS	34	2	56	2	12	2	47	3
	H	32	3	13	2	52	3	21	2
	MSH	34	2	31	2	36	3	32	2
Spring 1975	MS	48	2	20	2	59	3	64	2
	H	6	2	2	2	9	2	5	1
	MSH	46	2	78	2	32	2	31	2
Fall 1976	MS	9	2	26	3	4	2	2	2
	H	23	2	18	2	28	2	20	2
	MSH	68	3	56	2	68	4	78	2
Spring 1977	MS	17	4	9	4	36	4	7	2
	H	28	2	36	3	11	2	32	2
	MSH	55	4	55	4	53	4	61	3

MS = Mineral soil    H = Humus    MSH = Mixture of mineral soil and humus

\*Germination is based on the number of germinants found on seedspots at the first assessment, i.e., 5-12 months after seeding.



If we assume that the more favorable seedbeds are those on which there was the most germination, i.e., the greatest percent, the data in Table 4, when ranked in Table 5, indicate that, for all treatments combined, mineral soil and/or mineral soil/humus provided more favorable conditions than humus for germination. The sole exception was the fall trial in 1974 (Table 4) following which more Arasan-coated seeds germinated on humus than on either mineral soil or mineral soil/humus.

### Stocking

If we assume that the objective of operational seeding is to achieve desirable stocking in 7 years, initial stocking must exceed, quite considerably, the criterion for *desirable* stocking to allow for subsequent mortality. *Desirable* stocking for black spruce in Ontario is 60% and stocking below 40% is considered a failure (Robinson 1974).

Table 5. Frequency of seedbed types ranking first, all trials combined, for all treatments combined and individually.

Seedbed	Seed treatments			
	All treatments combined	Control	Arasan	R-55
Frequency of ranking first				
MS	3	3	2	4
MS/H	2	3	3	2
MS/(MS/H)*	1	0	0	0
H	0	0	1	0
	6	6	6	6

\*Indicates number of trials in which MS and MS/H were equally favorable seedbeds for germination of black spruce seeds.

For all treatments and all seedbeds combined, initial stocking in these six trials (Table 6) was considerably below the failure level (40%) in three of them, and barely above it in the other three. Stocking in the first two trials deteriorated progressively at the second and third assessments and when stocking in the subsequent four trials was also well below the failure level at the second assessments the trials were terminated. Despite these abysmal data, stocking from spring seeding was significantly better (relatively) than that from fall seeding in two of the three pairs of spring and fall seeding.

When one looks at stocking by seed treatments (Table 7), the picture is not appreciably more encouraging. Stocking never reached, let



alone exceeded, the desirable level (60%) on any treatment in any trial. However, in 5 of the 16 combinations (control and Arasan, spring 1974; Arasan and R-55, fall 1974; control, spring 1977) initial stocking was above the failure level (40%). Nevertheless, all stocking was at the failure level (control, spring 1977) or well below it at the second assessment.

Table 6. Percent stocking\* to black spruce, all seed treatments combined, on upland cutovers spot-seeded by hand.

Year seeded	Season seeded	Year of assessments (Fall)				
		1974	1975	1976	1977	1978
1973	Fall	30	22	19	No further assessment	
1974	Spring	43	30	27		
1974	Fall		46	23	No further assessment	
1975	Spring		22	17		
1976	Fall				32	28
1977	Spring				41	34

\*Within each pair of fall and spring seedings each stocking value is significantly different ( $p = 0.05$ ) from the adjoining one, vertically and horizontally.

Significant differences are indicated should any reader wish to speculate about relative effects of various combinations of treatments, seasons, and years of seeding. However, the data do not indicate any consistent trends. For example, in the 1973 fall seeding, germination from R-55-coated seeds was significantly better than that from control and Arasan-coated seeds: in the 1974 fall seeding there was no difference between germination from Arasan-coated and R-55-coated seeds and in both cases germination was better than that from control seeds: in the 1975 fall seeding, germination from Arasan-coated seeds was better than that from control and R-55-coated seeds. Similar mismatches are apparent in the spring seeding results.

As might perhaps be expected following barrels-and-chains scarification most of the seedspots were on mineral soil, humus, or mineral soil/humus (100% of them in the Mooseskull 2 Area) (Table 8)

In this respect, if in no other, the seeding plots on each area were remarkably similar (cf. fall/73 and spring/74 data on Areas 1, 2 and 3, Table 8). Because the great majority of seedspots were on the above three seedbeds only these are considered from the standpoint of stocking.

Table 7. Percent stocking\* to black spruce, by seed treatments, on up-land cutovers spot-seeded by hand.

Season and year of sowing	Seed treatment	Year of assessment				
		1974	1975	1976	1977	1978
Fall/73	Control	128	18 a	117 a		
	Arasan	126 a	124 a	2 22 a	No assessment	
	R-55	37	123	2 119		
Spring/74	Control	44	31 a	130 a		
	Arasan	49	36	130	No assessment	
	R-55	36	23 a	21 a		
Fall/74	Control		28	13		
	Arasan		152	130	No assessment	
	R-55		158	127		
Spring/75	Control		121	17		
	Arasan		25	21	No assessment	
	R-55		120	12		
Fall/76	Control				128	23
	Arasan				37 a	34 a
	R-55				131 a	27 a
Spring/77	Control				42	30
	Arasan				134 a	131 a
	R-55				136	130

\*Within each season of seeding and year of assessment there is no significant difference ( $p = 0.05$ ) between treatments with the same subscript number(s). Within each season of seeding, by seed treatments, there is no significant difference between stocking values with the same lower case letter(s).

For all seed treatments combined, stocking at the first assessment was anything but encouraging and varied considerably on the three principal seedbeds (Table 9). In two instances (on mineral soil, spring 1974 and on mineral soil/humus, spring 1977) it reached or exceeded slightly the criterion for desirable stocking (60%). Otherwise stocking was either "marginally acceptable" (Fraser et al. 1976) (i.e., >40% and <60%), or below the failure level (40%). With one exception (fall 1974) stocking on humus was always below the failure level and always inferior to stocking on mineral soil and on mineral soil/humus.

At first glance, stocking by seedbed and seed treatment appears somewhat more encouraging (Table 10). In nine sub-plots (combinations of seedbed and seed treatment) initial stocking equalled or exceeded



Table 8. Percentages of 1000 seedspots, by seedbed types, on hand-seeded upland cutover. Seedbed types are arbitrarily combined into "major" and "minor" seedbeds according to their combined predominance.

Seedbed types	Mooseskull												Chickenfarm					
	Area 1						Area 2						Area 3					
	Fall/73			Spring/74			Fall/74			Spring/75			Fall/76			Spring/77		
	C	A	R	C	A	R	C	A	R	C	A	R	C	A	R	C	A	R
Mineral soil	19	29	33	58	29	34	48	18	37	26	42	50	10	2	1	6	24	4
Humus	39	8	24	9	20	33	17	47	30	8	15	11	41	46	34	51	41	47
Mineral soil/humus	29	36	28	20	28	21	35	34	33	66	43	39	30	34	41	31	24	27
"Major"	87	73	85	87	77	88	100	100	100	100	100	100	81	82	76	88	89	79
Bark	0	2	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Decayed wood	4	7	1	5	4	6	0	0	0	0	0	0	7	6	3	6	3	4
Dead moss	7	4	3	0	4	0	0	0	0	0	0	0	1	0	0	1	0	0
Others	2	14	6	8	14	6	0	0	0	0	0	0	11	12	21	5	8	18
"Minor"	13	27	15	13	23	12	0	0	0	0	0	0	19	18	24	12	11	22

C = control (untreated) seeds      A = Arasan-coated seeds      R = R-55-coated seeds



*desirable* stocking (60%), in 17 it was *marginally acceptable* and in the remaining 28 it was below the failure level (40%). Within a year, stocking had deteriorated to the point where only one sub-plot (control, spring 1977) was *desirably* stocked (only just), only 10 were even *marginally* stocked and 43 were outright failures (stocking <40%). A further breakdown of the percentage of these sub-plots on the three principal seedbeds (Table 11) leaves no doubt that most of the stocking, poor as it was, was on mineral soil or on mineral soil/humus.

In view of the continuing deterioration in stocking at the third assessment on the first pair of fall and spring seedings (Table 7), it would appear that very few of the subsequently seeded plots would have been even *marginally* stocked three years after seeding.

Table 9. Percent stocking\* by seedbed types, all seed treatments combined, at the initial assessment.

Season and year of seeding	Year of initial assessment								
	1974			1975			1977		
	M	H	MH	M	H	MH	M	H	MH
Fall 1973	45	25	35						
Spring 1974	60	27	46						
Fall 1974				48 a	44 a	44 a			
Spring 1975				27	13	20			
Fall 1976							50 a	22	52 a
Spring 1977							48	30	69

\*There is no significant difference ( $p = 0.05$ ) between values with the same lower case letter(s) in any given horizontal line nor between pairs of values joined by the same vertical line.

Anyone wishing to speculate further on relationships among treatment combinations and stocking should note that these stocking data indicate only the relative effectiveness of the different seedbeds and seed treatments. For example, the 48% stocking value for the 1974 assessments of the 1973 fall seeding (Table 10) is arrived at as follows:

Of the 1000 seedspots seeded with control seed in the fall of 1973, only 869 (87%) were classified as MS, H or MSH (Table 8). Of these, 186, 369 and 294 were on MS, H and MSH, respectively. Although 89 (48%) of these 186 on MS were stocked at the first assessment, this could also be interpreted to mean that only 89 (9%) of the mineral soil seedspots out the entire 1000 seeded were stocked.

Table 10. Percent stocking\*, by major seedbed types, from spring and fall seed spotting with untreated and coated black spruce seeds.

			Year of assessments														
Area	Season and year of seeding	Seed treatment	1974			1975			1976			1977			1978		
			MS	H	MSH	MS	H	MSH	MS	H	MSH	MS	H	MSH	MS	H	MSH
Mooseskull	Area 1	Control	48 <sub>1</sub>	24 <sub>2</sub>	30 <sub>2</sub>	33	14	20									
		Fall 1973	Arasan	38 <sub>1</sub>	23 <sub>2</sub>	30 <sub>2</sub>	35	18	28								
		R-55	50 <sub>1</sub>	28 <sub>2</sub>	45 <sub>1</sub>	32	15	32								No assessments	
		Control	52 <sub>1</sub>	39 <sub>2</sub>	40 <sub>2</sub>	37	21	27									
		Spring 1974	Arasan	76 <sub>1</sub>	36 <sub>3</sub>	58 <sub>2</sub>	56	30	42								
		R-55	62 <sub>1</sub>	19 <sub>3</sub>	37 <sub>2</sub>	43	10	22								No assessments	
Area 2	Fall 1974	Control				30 <sub>1</sub>	20 <sub>2</sub>	24 <sub>2</sub>	15	9	11						
		Arasan				45 <sub>2</sub>	54 <sub>1</sub>	51 <sub>1</sub>	23	33	28					No assessments	
		R-55				69 <sub>1</sub>	43 <sub>3</sub>	58 <sub>2</sub>	33	22	26						
	Spring 1975	Control				20 <sub>1</sub>	7 <sub>2</sub>	24 <sub>1</sub>	14	5	20						
		Arasan				34 <sub>1</sub>	18 <sub>2</sub>	19 <sub>2</sub>	30	14	16					No assessments	
		R-55				24 <sub>1</sub>	9 <sub>3</sub>	17 <sub>2</sub>	17	1	9						
Chickenfarm	Area 3	Fall 1976	Control									49 <sub>1</sub>	16 <sub>2</sub>	46 <sub>1</sub>	34	13	29
			Arasan									63 <sub>1</sub>	28 <sub>2</sub>	61 <sub>1</sub>	67	26	55
			R-55									38 <sub>1</sub>	23 <sub>2</sub>	50 <sub>1</sub>	31	20	45
	Spring 1977	Control										64 <sub>1</sub>	42 <sub>3</sub>	80 <sub>1</sub>	50	33	60
		Arasan										44 <sub>2</sub>	16 <sub>3</sub>	66 <sub>1</sub>	31	20	45
		R-55										55 <sub>1</sub>	28 <sub>2</sub>	61 <sub>1</sub>	40	26	47

MS = Mineral soil      H = Humus      MSH = Mixture of mineral soil and humus

MS = Mineral soil H = Humus MSH = Mixture of mineral soil and humus

\*For the first assessment only of each seeding, subscript numbers indicate the rank and significance of stocking by seedbed types, i.e., there is no significant difference between values with the same subscript number(s) in any given horizontal line.

With these trials classified as failures two years after seeding, seedling growth is scarcely relevant. However, a brief summary, by height classes, of the living black spruce seedlings at the second assessment on each area indicates that the majority were less than 5 cm in height (Table 12). A reasonable inference is that stocking, albeit a failure, for the most part was by seedlings less than 5 cm tall.

Table 11. Summary of seedbed/seed treatment combinations for all seasons and years of seeding combined (54) in each stocking category and the percentage of these by seedbed types.

Stocking criteria (%)	First assessment				Second assessment			
	No. of Sub-plots	Percent			No. of Plots	Percent		
		MS	H	MS/H		MS	H	MS/H
>60 (desirable)	9	56	0	44	1	0	0	100
>40 <60 (marginal)	17	41	18	41	10	50	0	50
<40 (failure)	28	21	54	25	43	30	42	30
	54				54			

Table 12. Percentage of living black spruce seedlings by height classes, two years after seeding.

Area	Height class				
	1	2	3	4	5
Mooseskull 1	<1	<1	75	22	3
Mooseskull 2	2	0	87	11	<1
Chickenfarm	4	0	71	18	7

Since, with one exception (control plot, spring/75: 4%), 2% or fewer of the seedspots had more than 50% aerial cover from slash (Table 13), the two top categories of slash cover (51-75% and >75%) are excluded from further consideration.



Table 13. Percentage of 1000 seedspots by slash-cover categories on hand-seeded upland cutovers. Slash-cover categories are arbitrarily combined according to their obvious predominance.

Percent slash cover	Mooseskull												Chickenfarm					
	Area 1						Area 2						Area 3					
	Fall/73			Spring/74			Fall/74			Spring/75			Fall/76			Spring/77		
	C	A	R	C	A	R	C	A	R	C	A	R	C	A	R	C	A	R
<5}																		
6-25}	98	99	99	99	98	99	99	98	99	96	99	98	100	100	100	100	100	100
26-50}																		
51-75}	2	1	1	1	2	1	1	2	1	4	1	2	0	0	0	0	0	0
>75}																		

C = control (untreated) seeds      A = Arasan-coated seeds      R = R-55-coated seeds

For all seed treatments combined, aerial cover (shading) from slash does not seem to have had any significant effect on stocking (Table 14) except perhaps in the fall 73 seeding where stocking was significantly better in the 0-5% category than in either of the others (34% vs 28% and 26%). When all stocking was below failure level (40%) the 6-8% statistically significant difference had no practical significance.

Table 14. Percent stocking\* to black spruce, all seed treatments combined, on three predominant slash-cover categories.

Season and year of seeding	Season and year of assessment	Percent stocking					
		Percent aerial cover - slash					
		0-5%		6-25%		26-50%	
Fall 1973	Fall 1974	(1009)	34	(1674)	28 a	(289)	26 a
Spring 1974		(1075)	44 a	( 684)	42 a	(249)	47 a
Fall 1974	Fall 1975	(1031)	47 a	(1480)	47 a	(454)	41 a
Spring 1975		( 833)	22 a	(1604)	23 a	(489)	20 a
Fall 1976	Fall 1977	(2794)	32 a	( 185)	31 a	( 19)	21 a
Spring 1977		(2788)	41 a	( 181)	36 a	( 30)	47 a

\*Numbers within parentheses represent seedspots in the slash category. Percent values are percentages of those seedspots stocked to black spruce. There is no significant difference ( $p = 0.05$ ) between values with the same lower case letter in any given line, or between values joined by the same vertical line in any slash category.

How reliable these data are as an indication of slash cover on the three areas is questionable as they relate to slash on the seedspots in the scarified furrows where the slash had been disturbed by the scarification. However, in view of the actual numbers of seedspots in the three categories, there was relatively less slash on the Chickenfarm cutover than on the Mooseskull cutovers.

Stocking on 15 of the 18 sub-plots (seed treatment x season and year of seeding combinations) (Table 15) confirms that shading had no effect.<sup>6</sup> On the remaining four sub-plots stocking decreased significantly with increased slash cover (shading)--progressively on two of

<sup>6</sup>The reliability of the \*\* data (Table 15) is questionable because there were too few seedspots in this category on the Chickenfarm area to satisfy requirements for valid Chi-square testing.

them (control and R-55 in the fall/74 seeding)--but only up to 6-25% shading on the other two (control and Arasan in the fall 73 seeding).

Table 15. Percent stocking\* to black spruce by seed treatment and slash cover.

Season and year of seeding	Year of 1st (fall) assessment	Seed treatment	Percent stocking		
			Percent aerial cover - slash		
			0-5%	6-25%	26-50%
Fall 1973	1974	Control	140	128 a	123 a
		Arasan	131	122 a	118 a
		R-55	136 a	35 a	43 a
Spring 1974	1974	Control	140 a	145 a	153 a
		Arasan	53 a	147 a	145 a
		R-55	137 a	35 a	142 a
Fall 1974	1975	Control	33	26	13
		Arasan	49 a	153 a	151 a
		R-55	66	158	147
Spring 1975	1975	Control	119 a	123 a	119 a
		Arasan	125 a	125 a	124 a
		R-55	121 a	120 a	117 a
Fall 1976	1977	Control	128 a	126 a	110 a **
		Arasan	37 a	43 a	129 a **
		R-55	132 a	123 a	150 a **
Spring 1977	1977	Control	53 a	145 a	86 a **
		Arasan	134 a	135 a	138 a **
		R-55	136 a	130 a	129 a **

\*Percent stocking values are percentages of seedspots in the given slash category which are stocked to black spruce. There is no significant difference ( $p = 0.05$ ) between values with the same lower case letter in any given line, or between those with the same subscript number within any given seeding period.

\*\*Unreliable owing to small numbers of seedspots in this slash category on these sub-plots.



*Stocking and Vegetation*

Table 16. Percentages of seedspots with more than 50% aerial cover (shading) from vegetation.

Area	Season and year of seeding	Year of assessment	
		1974	1975
Mooseskull 1	Fall 1973	14	18
	Spring 1974	28	47
Mooseskull 2		1975	1976
	Fall 1974	7	13
	Spring 1975	4	9
Chickenfarm		1977	1978
	Fall 1976	0	6
	Spring 1977	0	8

The small percentage of seedspots with more than 50% aerial cover from vegetation in 1974 indicates that more than one year after harvesting there was little, if any, significant shading by vegetation. With one exception, the number of seedspots with more than 50% aerial cover increased by less than 10% in the second year after harvesting, indicating generally slow regrowth and/or ingrowth of vegetation on these severely exposed cutovers. The exception, 19% increase (spring seeding, 1974), is attributed primarily to aspen (*Populus* sp.) sucker growth.

Shading from vegetation undoubtedly increased the second year after harvesting as is evidenced by the decreased percentage of seedspots in the lower categories of aerial cover (Table 17) and the increased percentage of them in one or more of the higher ones. Generally, however, the decrease in the percentage of stocked seedspots suggests that shading had little, if any, significant impact on stocking (survival) in the second growing season, and costly factorial analyses are irrelevant in view of the failure of *any* of these trials to achieve stocking above the failure level even two years after seeding.

The lower percentage of seedspots without any vegetation on them at the second assessment (Table 18) is evidence of [minimal] vegetation regrowth or ingrowth on these cutovers. The greatest change on the Mooseskull 1 cutover was the increased percentage of seedspots dominated by grass, herbs and low shrubs, whereas on the second Mooseskull cutover, the greatest change was the increase in the percentage of seedspots dominated by herbs and shrubs with no change in the grass/sedge category.

Table 17. Percentages of seedspots, by aerial-cover categories, and percentages of those which were stocked to black spruce at the first and second assessments.

Mooseskull 1								
Vegetation categories in % aerial cover	Seeded fall 1973				Seeded spring 1974			
	% of seedspots		% seedspots stocked		% of seedspots		% seedspots stocked	
	1974	1975	1974	1975	1974	1975	1974	1975
0- 5	38	36	27	16	21	9	41	30
6-25	29	29	32	22	27	20	42	32
36-50	19	17	34	29	24	24	43	29
51-75	9	10	32	26	17	22	50	33
>75	5	8	21	29	11	25	36	27

Mooseskull 2								
	Seeded fall 1974				Seeded spring 1975			
	1975	1976	1975	1976	1975	1976	1975	1976
0- 5	35	28	39	16	48	39	17	10
6-25	38	34	49	19	37	32	24	18
26-50	20	25	48	31	11	20	31	25
51-75	5	11	52	34	3	8	25	29
>75	2	2	61	26	1	1	38*	32*

Chickenfarm								
	Seeded fall 1976				Seeded spring 1977			
	1977	1978	1977	1978	1977	1978	1977	1978
0- 5	99	58	32	22	94	39	40	23
6-25	1	24	21	35	4	26	59	33
26-50	0	11	67	36	1	16	56*	42
51-75	0	4	0	41	1	10	60*	48
>75	0	2	0	34*	0	8	0	51

\*As the stocking percentages are percentages of the percentages of seedspots in given categories it is doubtful whether the footnoted percentages are meaningful as they are based on too few seedspots.



Table 18. Percentage of seedspots on which a given stratum of vegetation was dominant\* (contributed most of the shade) and percentages of those which were stocked to black spruce at the first and second assessment.

Mooseskull 1								
Vegetation by strata	Seeded fall 1973				Seeded spring 1974			
	% of seedspots		% seedspots stocked		% of seedspots		% seedspots stocked	
	1974	1975	1974	1975	1974	1975	1974	1975
None	38	27	27	15	21	7	41	60
Moss/lichen	43	20	31	26	20	6	54	48
Grass/sedge	12	26	36	26	9	10	47	38
Herbs	4	22	30	21	37	60	38	28
Low shrubs	1	4	30*	23	9	17	41	9
High shrubs	2	1	33*	29*	4	0	24	0

Mooseskull 2								
Vegetation by strata	Seeded fall 1974				Seeded spring 1975			
	1975		1976		1975		1976	
	1975	1976	1975	1976	1975	1976	1975	1976
None	24	4	40	61	38	9	17	5
Moss/lichen	2	3	64*	70	1	3	49*	47
Grass/sedge	35	32	49	66	13	13	42	36
Herbs	35	46	51	43	21	41	25	17
Low shrubs	3	15	31	47	18	34	15	11
High shrubs	1	0 (<1)	30*	100 a	8	<1	16	6*

Chickenfarm								
Vegetation by strata	Seeded fall 1976				Seeded spring 1977			
	1977		1978		1977		1978	
	1977	1978	1977	1978	1977	1978	1977	1978
None	54	27	15	15	68	35	33	28
Moss/lichen	2	16	34*	37	1	11	73*	49
Grass/sedge	12	18	50	39	19	23	65	47
Herbs	10	27	32	27	8	21	49	32
Low shrubs	6	4	16	11*	2	3	35*	28
High shrubs	0	1	0	21*	1	1	52*	30*
Others	16	7	78	46	1	6	50*	32

\*Percent stocking (percentage stocked of percentage of seedspots in given categories) based on 2% (60) or fewer of the actual seedspots considered unreliable (the 2% cutoff was arbitrary).



On Chickenfarm, most of which was practically barren one year after harvesting, the greatest change was in the percentage of seedspots on which moss, grass, or herbs predominated. The "other" category on Chickenfarm (Table 18) was added to provide for the recording of seedspots on which white birch was the predominant cover. The subsequent percentage decrease in this category is attributed to ingrowth of faster-growing vegetation of other than the moss categories during the second post-harvesting year.

## DISCUSSION AND CONCLUSIONS

As stated in the introduction, the main objective of this report was to document the end results of direct seeding trials, preliminary results of which were reported previously (Fraser 1975). Since none of the seeded areas was *desirably* stocked (60%) to black spruce even one year after seeding and none was even *marginally* stocked (40%-60%) two years after seeding, these trials must be considered *unconditional failures* in terms of regenerating the areas to current standards. However, some useful *inferences* can be drawn even from such results as these, which, along with field observations throughout the trials, may be worth consideration.

Although the seeding trials extended over four years and laboratory tests revealed some statistically significant difference in germination indicative of decreasing germinative capacity during this period (Control and R-55: Table 1) there is no reason to suppose that these were of any practical significance in the universally poor germination (Table 2). Practically all the seeds that germinated (>95%: Table 3) did so on mineral soil, humus, or mineral soil/humus seedbeds. With one exception, fall seeding in 1974 with Arasan-coated seeds, germination was always better on mineral soil and on mineral soil/humus seedbeds than on humus (Table 4).

That germination following spring seeding was better than it was following fall seeding in two of three trials (Table 2) suggests that spring seeding is superior to fall seeding. Although this tends to support the author's opinion based on observations, it is hardly conclusive evidence, particularly when one considers the generally deplorable germination.

The mean number of germinants on those seedspots where germination occurred (Tables 3, 4) suggests that 5-8 seeds delivered by the hand seeders used in these trials is adequate. Even at this rate, stocked seedspots were frequently overstocked. Currently, overstocking on an area basis is the least of the problems in black spruce regeneration silviculture, but potential problems related to overstocking in seedspotting operations should not be dismissed out of hand.



There is some indication (Table 2) that more treated than untreated seeds germinated following fall seeding whereas as many untreated as coated seeds, or perhaps more, germinated following spring seeding. Each coating outranked the other (germination) in one fall trial and there was no difference between them in the third. On the other hand, untreated seed outranked (germination) both coatings in one trial and outranked at least one of them in the other two. It is difficult *not* to infer from this that rodents *were* a hazard to direct seeding of these cutovers in the fall when one would expect populations to be high, and less so in the spring when one would expect them to be lower. However, studies (by the Canadian Wildlife Service) of rodent populations on these cutovers and related food-preference studies in the field and under controlled conditions indicated that although there were considerable numbers of different species of rodents on these cutovers they did not constitute a hazard to seedspotting of black spruce.<sup>7</sup>

Although these trials are unconditional failures two years after seeding (Table 6) insofar as stocking is concerned, the stocking pattern, not unexpectedly, is similar to the germination pattern in most respects. Spring seeding resulted in better stocking than fall seeding in two of the three trials. Also, the stocking pattern tends to underline the advantage of coated seeds for fall seeding rather than spring seeding (Table 7). Furthermore, it tends to substantiate inferences that might be drawn from corresponding germination data about the role of rodents in direct seeding of black spruce on these cutovers and the reputed efficacy of the rodent-repellent coatings. However, the evidence is far from conclusive and scarcely relevant in view of the *below-failure* stocking (40%) at the second assessment.

Not unexpectedly, the stocking/seedbed pattern (Table 9) is similar to the germination/seedbed pattern, i.e., with one exception (fall seeding 1974), stocking was always better on mineral soil and/or mineral soil/humus than on humus. As follows almost automatically from the germination data, stocking on spring-seeded areas--with two exceptions--was better than on fall-seeded areas in two of three trials (the first and third): the two exceptions were on humus seedbeds in the 1973/1974 seeding and on mineral soil seedbeds in the 1976/1977 seeding when there was no difference in stocking on spring-seeded and fall-seeded areas. The reverse was true in the second trial, i.e., stocking on the fall-seeded area was vastly superior to stocking on the spring-seeded area. This and the two above-mentioned anomalies caution one not to accept the apparent superiority of spring seeding unreservedly, particularly in view of the unacceptably poor stocking.

When one considers the 54 combinations of seedbed and seed treatment in the three pairs of spring and fall seedings (Table 10), none of the 18 seed treatment/humus combinations was even *marginally* stocked

---

<sup>7</sup>Personal discussions with Dr. A. Martell, Canadian Wildlife Service (current address: Canadian Wildlife Service, 204 Range Road, Whitehorse, Yukon Territory).



(40%-60%) two years after seeding. Of the 36 remaining combinations of seed treatment and mineral soil, or mineral soil/humus, only one was *desirably* stocked (60%), only 10 were *marginally* stocked (40%-60%), and 25 were below the failure level (40%).

Although ranking or rating of treatments according to whether or not they met certain criteria may be a questionable exercise *when all of them are unconditional failures*, the results of these direct seeding trials *indicate* the relative superiority of mineral soil and/or mineral soil/humus for germination, and survival (based on stocking) of black spruce two years after seeding, regardless of seed treatment. Otherwise they do nothing more than underline the failure of operational seed-spotting of black spruce to achieve even *marginal* stocking (40%-60%) on these upland cutovers.

There was considerable variation in the amount and density of slash on these cutovers, all the way from open, light slash to dense, heavy slash. The slash-cover data (Table 13) seem to refute this, i.e., 96%-100% with less than 50% slash cover (shading), until one appreciates that these data are for *seedspots* in furrows from which the post-harvesting slash and debris had been removed during scarification. As well, the slash-cover breakdowns by spring and fall seeding (Table 14) and by seed treatment or sub-plot (Table 15) do little if anything to elucidate the impact of slash on germination and/or stocking. One reason for this may be that the slash-cover categories are assigned subjectively and are applicable to the areas within the 45-cm diameter circle (which is itself difficult to ascertain) and hence may be only remotely related to the place within that area where the seeds actually germinated and developed into established seedlings. With the data at hand, there is no conclusive evidence that increased shading contributed to better stocking.

If we bear in mind that vegetation-cover data apply only to seedspots, the indications in Table 16 are generally applicable across these cutovers, i.e., one year after harvesting more than 65% and 95% of the Mooseskull 1 and 2 cutovers, respectively, and all of the Chickenfarm cutover still had less than 50% vegetation cover. Although no attempt was made to differentiate between regrowth and ingrowth, one or the other or both were responsible for increased shading from vegetation during the second post-seeding season, as is indicated by the increased percentage of seedspots that were more than 50% shaded by vegetation.

The trend of decreased stocking between the first and second assessments, for all shading intensities (Table 17), suggests that shading from vegetation had no more definitive impact on stocking (survival) than did shading from slash. This does not mean that shading may not be beneficial to germination and survival and thereby to stocking of black spruce but only that the minimal amount or degree of shading on these particular cutovers two years after harvesting does not appear to have been beneficial.



There is little point in detailing the composition of the vegetation on these cutovers when they were first assessed one year after seeding or the changes thereon before the second assessment one year later. This is apparent from the percentages of seedspots on which given strata were dominant at each assessment (Table 18). What is more relevant is that the vegetational changes appear to have had no discernable impact on the obvious trend of deteriorating stocking.

Since these trials were unconditional failures in that *none* of the treatments or combinations of treatments resulted in even *marginal* let alone *desirable* stocking, conclusions, as such, based only on relative superiority of treatments or combinations of treatments, are unwarranted. However, from the results of these trials one may conjecture, with some reservations, as follows:

- Germinative capacity was not a contributing factor to the unconditional failures of these trials.
- Spring seeding appears to promote better germination and survival (stocking) of black spruce than does fall seeding.
- Five to eight seeds per seedspot is an adequate rate of seeding to obtain a mean of two surviving germinants per stocked spot.
- There was no conclusive advantage to using repellent-coated rather than untreated seeds in these trials and implied advantages of one coating over the other (Arasan, R-55) were inconsistent.
- Of the seedbeds tested, those consisting of mineral soil or a mixture of mineral soil and humus (as defined for this report) provided the best conditions for germination and survival (judged in this instance by stocking) of direct-seeded black spruce.
- Shading from slash and/or from vegetation regrowth and ingrowth, which logically should be advantageous for germination and survival, was too inconsequential on these cutovers even two years after seeding to have any conclusive impact on either.

The unconditional failure of these trials is attributed primarily to inadequate and improper site preparation. These were *operational* trials and the premise (faulty, in retrospect) was that scarification equipment that created acceptable conditions for planting and/or seeding jack pine on deep, boulder-free sandy soils on jack pine sites would do likewise for black spruce on shallow-soil, bouldery upland black spruce sites.

In the event, the site preparation was extremely erratic. It was frequently too severe, either down to bedrock where soils were shallow (e.g., Chickenfarm), deep into the "B" horizon when there was enough soil (e.g., Mooseskull 2), or varying from one extreme to the other with much of the area untouched owing to rugged terrain and slash conditions (e.g., Mooseskull 1). Hence, creation of conditions that favored germination and survival of black spruce, i.e., mineral soil and/or mineral soil/humus, was by happenstance more than by design.

Seedspotting also may have contributed to the failure of these trials. Traditionally, direct seeding (broadcast seeding or seed-spotting) has been a one-shot operation. Each technique has its advantages and disadvantages. Seedspotting was chosen for these trials primarily to facilitate assessment but also to conserve seed. Theoretically, seedspotting should also ensure better placement of seeds, i.e., preferred microsites where they are most likely to germinate and become established seedlings. This conflicts with a second advantage, i.e., regular spacing between seedspots, as prescribed spacing and good-microsite selection may not always be compatible on upland black spruce cutovers. In these operational trials the tradeoff was usually in favor of spacing, probably because no serious attempt was made to train seeders to recognize preferred microsites. Hence, seeds were usually spotted at 2-m intervals, the prescribed spacing, regardless of microsite, and this undoubtedly had an adverse influence on germination and, by association, on stocking two years after seeding.

From the results of these operational direct-seeding trials, related experimental direct-seeding trials, and Winston's (1975) seedbed studies on boreal forest upland cutovers, and with considerable observational and experiential input from federal, provincial and industrial foresters, a proposal was submitted to the Canada-Ontario Joint Forestry Research Committee (COJFRC). Basically, its purpose was to determine by comparative field trials if any existing scarification equipment and techniques could be used effectively or adapted for effective use to create receptive seedbeds (i.e., suitable conditions) for black spruce germination, survival and growth. These trials, approved by COJFRC and implemented in the Thunder Bay forest district, have since been modified and expanded to include rates of aerial seeding, repeated aerial seeding, and controlled seedspot/seedbed studies. Now in their third year, they are conducted by Mr. Robert Fleming, a forestry officer at the Great Lakes Forest Research Centre, and will be reported by him when they are completed.



## LITERATURE CITED

- FRASER, J. W. 1975. Direct seeding black spruce--is it feasible? p. 140-154 *in* Black Spruce Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Symp. Proc. O-P-4.
- FRASER, J. W., HAAVISTO, V. F., JEGLUM, J. K., DAI, T. S., and SMITH, D. W. 1976. Black spruce regeneration on strip cuts and clearcuts in the Nipigon and Cochrane areas of Ontario. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-246. 33 p.
- FRASER, J. W. 1980. The effects of Arasan and R-55 on germination of black spruce and jack pine seeds. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-320. 14 p.
- ROBINSON, F. C. 1974. A silvicultural guide to the black spruce working group. Ont. Min. Nat. Resour., Div. For., For. Manage. Br. 44 p.
- ROWE, J. S. 1972. Forest regions of Canada. Dep. Environ., Can. For. Serv., Ottawa, Ont. Publ. 1300. 172 p.
- WINSTON, D. A. 1975. Black spruce seeding experiments in the Central Plateau Forest Section, B.8, Manitouwadge, Ontario. p. 125-139 *in* Black Spruce Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Symp. Proc. O-P-4.