EFFECT OF NITROGEN FERTILIZATION AND LOW THINNING ON GROWTH OF SEMIMATURE JACK PINE FOREST, CHAPLEAU, ONTARIO: FIFTH-YEAR RESULTS

I. K. MORRISON, D. A. WINSTON

and

N. W. FOSTER

GREAT LAKES FOREST RESEARCH CENTRE

SAULT STE. MARIE, ONTARIO

REPORT O-X-267

CANADIAN FORESTRY SERVICE

DEPARTMENT OF FISHERIES AND THE ENVIRONMENT

JULY 1977

Copies of this report may be obtained from

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

ABSTRACT

The effect of simultaneous urea fertilization and low thinning on jack pine (*Pinus banksiana* Lamb.) was tested in a factorial experiment in the Chapleau area of north central Ontario. The experiment, initiated in 1970, was in a 45-year-old, relatively thrifty, close stand of fire origin on a Site Class I sandy site. Typical of wild stands of the area, the experimental stand had no previous history of intermediate cutting. Three levels of N (0, 168 and 336 kg N/ha) supplied as urea were tested, as was thinning-from-below (conventionally by felling, and by silvicide injection) for a 20% BA reduction. After five years the following response variables were determined: mean DBH increment, BA increment, % BA growth, and total and merchantable volume increments. Analyses of variance revealed highly significant (1%) treatment effects for N in relation to all response variables and for thinning in relation to mean DBH increment only. No interactions were significant. Better treatments produced gains in PAI over controls in the order of 1.2 to 2.0 m^3/ha/yr. While both treatments produced significant responses over control at least in relation to some parameters, lack of interaction between them suggests that there is no particular advantage in carrying them out simultaneously.

RÉSUMÉ

Lors d'une expérience factorielle effectuée dans la région de Chapleau, au centre-nord de l'Ontario, les auteurs ont étudié l'effet de la fertilisation à l'urée et de l'éclaircie par le bas simultanées sur le Pin gris (*Pinus banksiana* Lamb.). Amorcée en 1970, l'expérience a eu lieu dans un peuplement serré de 45 ans, venu par suite d'un incendie sur une station sableuse de classe I. Typique des peuplements naturels de la région, le peuplement expérimental n'avait pas subi de coupe intermédiaire par le passé. Trois concentrations de N (0, 168 et 336 kg N/ha) sous forme d'urée ont été essayées avec l'éclaircie par le bas (abattage conventionnel, puis injection de sylvicide) en vue de reduire la ST de 20%. Après cinq ans, les variables de réponse suivantes ont été déterminées: accroissement moyen du dhp, accroissement de la ST, % d'augmentation de la ST, enfin accroissement des volumes total et marchand. Les analyses de variances ont révélé des effets très significatifs (1%) de N pour toutes les variables de réponse et l'éclaircie quant à l'accroissement du dhp moyen seulement. Il n'y avait aucune interaction significative. Les meilleurs traitements produisirent des gains dans l'APA (accroissement périodique annuel) de l'ordre de 1.2 à 2.0 m^3/ha/an par rapport aux témoins. Les deux traitements ayant eu des réponses significatives, du moins pour quelques paramètres, l'absence d'interaction de l'un à l'autre porte à croire que le fait de les administrer simultanément ne comporte aucun avantage particulier.

ACKNOWLEDGMENTS

The following employees, past and present, of the Canadian Forestry Service, Great Lakes Forest Research Centre, contributed to the research reported here: Messrs. W. Hall, F. Hegyi, D. Kurylo, D. Ropke and B. Smith. Data analysis was by D. Ropke.

TABLE OF CONTENTS

INTRODUCTION

Increased interest in more intensive forest management and actual intensification of silvicultural practice in the boreal forest of northern Ontario, phenomena largely of the past two decades, mark the shift from what Stone (1975) has termed the phase of the *exploited forest* to the phase of the *regulated forest*. This interest came about partly in response to forest industry's increasing roundwood requirement, as a result of which the annual cuts of the principal pulpwood-producing species of the province, jack pine (*Pinus banksiana* Lamb.) and black spruce (*Picea mariana* [Mill.] B.S.P.), have almost doubled. These species regularly account for approximately 90% of the annual softwood harvest (Anon. 1975). Although on a province-wide basis allowable cuts of these species have not yet been reached, wood shortages are being felt in some local situations. Further, in some areas the land base available for timber growing is being reduced as land is withdrawn for alternative uses. The increasing interest in more intensive silviculture is related to the need to keep the per unit cost of wood delivered at the mill as low as possible, since a large part of northern Ontario's forest industry depends upon the competitive export markets. Slow growth of trees in the boreal forest and low volumes per unit area force a wide deployment of effort with concomitant high costs of tending, harvesting and transporting. Increasing harvestable volume per unit area to lessen harvesting cost, increasing tree size to lessen handling cost, and concentrating fiber production in areas close to mills are attractive forestry measures. Concurrently, labor's reluctance to work in distant locations, coupled with Steenberg's (1976) suggestion that employment in silviculture can be an important method of stabilizing rural employment, favors more intensive silviculture close to utilization centers. Obviously stands to be harvested in this century are already established, and are now past mid-rotation. Aside from protective measures against fire, insects and disease, the most economically feasible silvicultural options, at least for upland sites, would appear to be fertilization and thinning.

Interest in mineral fertilizing as a silviculture measure for increasing tree size and volume per unit area in pulpwood stands in northern Ontario developed approximately a decade ago, and various series of field trials were established by government and industry. In 1969 nine trials were established in 55-year-old natural jack pine forest in the Dryden area of northwestern Ontario. In 1970 five more trials, including the experiment reported here, were established near Chapleau in north central Ontario. In general, response has been chiefly to nitrogen (N), although there is some suggestion that when the N requirement is met, other elements such as phosphorus (P) could become limiting (Hegyi 1974, Morrison et al. 1976a, 1977a). Response to better treatments in these natural stands is generally lower, though not markedly so, than response to similar treatments in managed stands of Scots pine (*Pinus sylvestris* L.) in Scandinavia.

Interest in thinning of natural jack pine stands arose in eastern Canada somewhat earlier than did interest in fertilization. Much of the earlier work, particularly in Manitoba and Ontario, was reviewed by Cayford et al. (1967) who reported that thinning generally increased diameter increment even up to late rotation, and that usually the heavier the thinning the greater the effect on growth. More recently, Bella and DeFranceschi (1974) reported that jack pine stands on good sites in Manitoba showed improved tree and stand growth 15 years after low thinning and crown thinning at age 40.

Fertilization in concert with thinning in semimature natural jack pine stands has not been well researched, nor has fertilization in concert with thinning in natural stands of any species. This contrasts with late rotation fertilization of plantations, which normally have a history of thinning. The possible benefits of simultaneous fertilizing and thinning in semimature jack pine forest were investigated in one experiment of the aforementioned northwestern Ontario series where it was observed that both N fertilization and thinning increased growth. The best treatment in terms of growth over controls was a combination of urea supplied at a rate of 303 kg N/ha and a thinning to reduce basal area (BA) by 20% (Hegyi 1974, Morrison et al. 1976a). Thinning in the northwestern Ontario experiment, as in this one, was carried out as conventional low thinning (or thinning-from-below). As low thinning by the conventional method (tree-felling or T_{FELL}) could be economically disadvantageous, a thinning-by-silvicide-injection treatment (T_{SILV}) was also incorporated into the present experiment. The silvicide used, commonly known as Silvisar 510, has as an active ingredient dimethylarsenic acid (cacodylic acid), and was injected at recommended rates.

The objective of the present study was to investigate, for this stand of jack pine, responses to combinations of urea fertilization and low thinning by conventional means and by silvicide.

STUDY AREA

The study area (lat. 47°38'N, long. 83°15'W) of this and other experiments of the same series (Morrison et al. 1976b, 1977a, b) is located in Nimitz Township, on the border of Dupuis Township (formerly Township 12E), Sudbury District, Ontario, 25 km SSE of the town of Chapleau. It is within the Missinaibi—Cabonga Section (B.7) of the Boreal Forest Region (Rowe 1972) and the Height-of-Land Climatic Region (Chapman and Thomas 1968). The average length of the growing season, based on a 5.5°C index, is 161 days, roughly May through September inclusive (ibid.). Mean total precipitation measured at the nearest weather station (Chapleau) is 810 mm annually (Anon. 1973). Approximately 53% of this falls during the growing season (ibid.). Mean annual potential evapotranspiration has been estimated at 480 mm (Chapman and

Thomas 1968). The study area is located on the boundary of the Foleyet Site District of Site Region 3E and the Mississagi Site District of Site Region 4E (Hills 1955). It lies almost astride the height-of-land between the Arctic and Great Lakes watersheds. The soil in profile is a Mini Humo-Ferric Podzol (Anon. 1974), developed in approximately 30 cm of silt loam over loamy sand. Bedrock throughout the area is mapped as Early Precambrian felsic igneous, comprised chiefly of granites and diorites.

At the beginning of the experiment the stand was 45-year-old (stump age), relatively thrifty, uniform jack pine forest of fire origin. In the immediate vicinity of the plots mean dominant height was approximately 17.7 m; mean diameter at breast height (DBH) 10.4 cm (range 2.8-26.9 cm); BA 28.2 m^2/ha; total standing volume 169.3 m^3/ha; merchantable standing volume 123.8 m^3/ha; and stocking 3300 tree/ha. The Site Class was I (Plonski 1974), corresponding to a site index of 18.8 m at 50 years. A continuous moss layer, with *Pleurozium schreberi* (BSG.) Mitt. as the predominant species and *Dicranum polysetum* SW. and *Hypnum crista-castrensis* Hedw. in lesser abundance, occupied the forest floor. The herb and shrub layer was light. Frequently occurring species were *Maianthemum canadense* Def., *Anemone quinquefolia* L., *Cornus canadensis* L., *Vaccinium angustifolium* Ait., *Diervilla lonicera* Mill. and *Polygala paucifolia* Willd. (see Appendix).

METHODS

The experiment was set out as a 3 x 3 completely randomized factorial, with three levels of N (0, 168 and 336 kg N/ha) supplied as commercial-grade prilled urea and three thinning treatments (unthinned, 20% BA reduction by felling smallest trees, 20% BA reduction by silvicide injections into smallest trees). Each treatment was replicated three additional times for a total of four plots per treatment and a grand total of 36 treatment plots. Treatment plots were square, 0.08 ha in area, each with an interior 0.04 ha measurement plot, and were arranged in a grid pattern with plots contiguous to one another. Trees were numbered individually with metal tags. Urea fertilizer, in predetermined amounts appropriate to the statistical design, was applied in late May, 1970. Fertilizing was carried out at the same time as low thinning, i.e., the smallest trees were removed to achieve for each thinned plot a 20% reduction in pre-thinning BA by (1) felling with axe and saw and (2) hypo-hatchet injection of Silvisar-510 into boles at a rate of 1.5 mL per 2.5 cm of DBH. The DBH of all trees, and the height of one randomly selected tree in each 2.5 cm diameter class per plot, were measured when the experiment was initiated. Diameters were remeasured 5 years later, in late May, 1975. All measurements were in English units and were subsequently converted to S.I. units.

In accordance with standard practice, trees which died during the period 1970-1975 (i.e., natural mortality) were removed from the calculation.

The following fifth-year response variables were calculated: mean DBH increment, BA increment, percent BA growth, total volume increment, and merchantable volume increment. Mean DBH and BA increment and percent BA growth were calculated in the usual manner. Total and merchantable volume increments were calculated as follows: a height-on-diameter regression, based on pooled measurements on sample trees, was used to estimate the height of each tree. Total and merchantable volumes, for both 1970 and 1975, were computed for each plot on a tree-by-tree basis, using estimated heights, measured DBH and Honer's (1967) volume equations. Increments of total and merchantable volume were calculated for each plot by subtracting initial from remeasurement values. Data were subjected to analyses of variance, and Duncan's New Multiple Range Test was used to detect significant differences among means.

RESULTS

Table 1 summarizes results (F-ratios) of analyses of variance. Highly significant differences occurred for N fertilization in relation to all variables and for thinning in relation to mean DBH increment only. No interaction was detectable between N fertilization and thinning. Fifth-year incremental responses, and in the case of BA, percentage growth response as well, are listed in Table 2. All treatments except T_{FELL} increased mean DBH significantly over controls. At no level of N, however, could differing effects of DBH increment be ascribed to thinning method. In relation to BA increment (absolute), significant responses over control occurred for the N168, N336 and N336 T_{SILV} treatments only. No significant effect could be ascribed to thinning over and above fertilization and, as with DBH increment, no significant effect could be attributed to thinning method. Three treatments (N168, N336 and N336 T_{SILV}) increased total volume increment significantly over controls and four treatments (N168, N168 T_{FELL}, N336 and N336 T_{SILV}) increased merchantable volume increment significantly over controls. Neither thinning method was superior to the other at either level of N in terms of total or merchantable increment.

The increase in total volume increment of treated plots compared with controls is presented in Table 3. The generally lower absolute responses of the thinning treatments reflect the 20% BA reduction, although in one instance, a thinning treatment (N336 T_{SILV}) produced somewhat more volume (not statistically significant) than its unthinned counterpart. When the effect of the BA reduction is lessened by expressing BA growth as a percentage of the residual BA, six treatments result

Table 1. Summary of F-ratios from analyses of variance illustrating significant treatment effects of urea fertilization (N) and thinning (T) and combinations on growth of 45-year-old jack pine

	Mean DBH increment	Basal area increment	Basal area growth (%)	Total vol. increment	Merch. vol. increment
N	26.44**	14.43**	23.15**	15.29**	14.92**
T	12.42**	2.16	.92	1.50	.97
NT	2.14	1.54	2.15	1.65	1.59

** Statistically significant, P = 1%

Table 2. Fifth-year growth response of 45-year-old jack pine to urea fertilization and low thinning by felling (T_{FELL}) and silvicide (T_{SILV})

Treatment	Mean DBH increment (cm)	Basal area increment (m^2/ha)	Basal area growth (%)	Total vol. increment (m^3/ha)	Merch. vol. increment (m^3/ha)
CONTROL	0.72^{a}	3.76^{ab}	14.03^{a}	28.57^{ab}	28.41^{ab}
N168	1.00^{cd}	5.02^{d}	19.38^{cd}	38.36^{e}	38.19^{e}
N336	$.90^{bc}$	4.57^{cd}	18.68^{bc}	34.78^{cde}	34.68^{cde}
T_{FELL}	$.83^{ab}$	3.30^{a}	13.80^{a}	25.57^{a}	25.76^{a}
N168 T_{FELL}	1.18^{ef}	4.44^{bcd}	20.38^{cd}	34.48^{bcde}	34.80^{cde}
N336 T_{FELL}	1.15^{def}	4.37^{bcd}	19.95^{cd}	33.83^{bcde}	34.26^{bcde}
T_{SILV}	$.90^{bc}$	3.74^{ab}	15.58^{ab}	28.87^{abc}	29.20^{abc}
N168 T_{SILV}	1.07^{de}	4.09^{bc}	17.68^{bc}	31.63^{bcd}	31.95^{bcd}
N336 T_{SILV}	1.25^{f}	4.71^{cd}	21.53^{d}	36.49^{de}	36.87^{de}

NOTE: Corresponding superscript letters in vertical columns indicate no significant (5%) differences between means, by Duncan's New Multiple Range Test.

in significant increases over control (Tables 2, 4). Still, response was chiefly to N, and only in one instance, N336 T_{SILV}, did a thinning treatment produce an effect over and above that which could be ascribed to fertilizer alone.

Table 3. Fifth-year total volume growth-over-control of 45-year-old jack pine subjected to various nitrogen and thinning treatments

Treatments	Total volume growth-over-control (m^3/ha)		
	N 0	N 168	N 336
UNTHINNED	0	9.79*	6.21*
FELLING	-3.00	5.91	5.26
SILVICIDE	.30	3.06	7.92*

* Statistically significant over control, P = 5%.

Table 4. Percent basal area growth-over-control of 45-year-old jack pine subjected to various nitrogen and thinning treatments

Treatment	Percent BA growth-over-control		
	N 0	N 168	N 336
UNTHINNED	0	5.35*	4.05*
FELLING	-.23	6.35*	5.92*
SILVICIDE	1.55	3.65*	7.50*

* Statistically significant over control, P = 5%.

DISCUSSION

Whereas in intensively managed coniferous forest, thinnings are the rule rather than the exception, natural stands of jack pine, at least in northern Ontario, are rarely subjected to intermediate cutting. In the present discussion, comparison is limited to those situations where fertilization and thinning are carried out more or less simultaneously to promote growth, and excludes those more usual situations where fertilizers are applied to intensively managed stands.

In terms of magnitude, responses to both fertilization and thinning were of the same order as those reported for jack pine in other studies. Responses in terms of periodic annual increment (PAI) over controls (total and merchantable volume basis) ranged up to approximately 2 m^3/ha/yr. The main findings of the present study, as they pertain to the effects of urea fertilization and thinning, are revealed in the analyses of variance. Response to N was highly significant (1%) for all parameters; response to thinning was highly significant for mean DBH increment only. On the other hand it might be noted that the silvicide-thinned stand did produce as much wood as the control, despite the 20% reduction in BA. There was no significant interaction between fertilization and thinning and the data suggest that the results were essentially additive. These results tend to substantiate the findings of an earlier fertilization-thinning study with 55-year-old natural jack pine forest on a sandy outwash site in the Dryden area of northwestern Ontario (Hegyi 1974, Morrison et al. 1976a). There significant responses were observed as a result of urea fertilization and thinning, but without any significant interaction between the two. Those data also suggested largely additive effects. Similarly, with 65-year-old black spruce in Quebec, Weetman (1968, 1971, 1975) reporting upon combined urea fertilization with modified French thinning, noted significant responses to each separately, but no interaction. The results were essentially additive. Lee (1974) with 25-year-old Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) in British Columbia detected significant responses to urea fertilization and to thinning but no significant interaction between the two.

One advantage often ascribed to low thinning or thinning-from-below is that potential mortality is salvaged. However, if we consider the overall profitability picture as it pertains to jack pine pulpwood growing in northern Ontario, it seems highly unlikely that such thinning (i.e., low thinning in its classic form) would be economically sound. In this regard, however, silvicide injections to kill at least those trees unlikely to reach merchantable size might prove a lower-cost option, there having been in the present study no statistically significant difference in terms of overall effect on growth between the two thinning procedures. Injury to adjacent trees from silvicide injection ("backflash") in the present study appeared not to be a problem. Quite possibly this was because only smaller trees were injected, with accordingly adjusted small dosages, which were not sufficient to affect larger neighbors.

A second advantage often ascribed to low thinning, which may be extended to include thinning plus fertilization, is that future growth is concentrated on fewer, larger stems. Tucker (1974), citing others, illustrates that as logging costs are inversely proportional to tree size, some cost reduction accrues directly to increased mean stand DBH. While in the present study there were appreciable increases in mean DBH increment relative to both thinning and fertilization, there is some evidence (Morrison, unpublished data) to suggest that at least fertilizer-derived growth was already being accrued mainly on larger stems. This tends to negate any advantage of low thinning as it interacts with simultaneous fertilization. A possible beneficial effect of combining thinning with urea fertilization that could not be evaluated in the present experiment is a prolonging, by thinning, of the duration of fertilizer response, as was observed by Mallonee and Strand (1976) with young Douglas-fir in British Columbia.

Notwithstanding this possible prolonging effect we conclude that as there is no (positive) interaction in terms of incremental growth, and as fertilizer growth is likely being accrued already, chiefly on larger stems, there would be no particular advantage to carrying out both treatments simultaneously, unless they happened to coincide in the normal course of operations.

LITERATURE CITED

Anon. 1973. Canadian normals. 2. Precipitation 1941-1971. Can. Dep. Environ., Atmosph. Environ. Serv. 330 p.

Anon. 1974. The system of soil classification for Canada. Can. Dep. Agric., Publ. 1455. 255 p.

Anon. 1975. Statistics 1975. A statistical supplement to the Annual Report of the Ministry of Natural Resources for the year ending March 31, 1975. Ont. Min. Nat. Resour. 116 p.

Bella, I. E. and J. P. DeFranceschi. 1974. Commercial thinning improves growth of jack pine. Can. For. Serv., Edmonton, Alta. Inf. Rep. NOR-X-112. 23 p.

Cayford, J. H., Z. Chrosciewicz and H. P. Sims. 1967. A review of silvicultural research in jack pine. Can. Dep. For. Rur. Dev., Publ. 1173. 255 p.

Chapman, L. J. and M. K. Thomas. 1968. The climate of northern Ontario. Can. Dep. Transp., Meteorol. Br., Climatol. Stud. 6. 58 p.

Hegyi, F. 1974. What we found: growth-response evaluation of fertilizer trials in jack pine Dryden field trials. p. 33-38 *in* Proceedings of a workshop on forest fertilization in Canada. Can. For. Serv., Sault Ste. Marie, Ont. For. Tech. Rep. 5.

Hills, G. A. 1955. Field methods for investigating site. Ont. Dep. Lands For., Site Res. Man. 4. 120 p.

Honer, T. G. 1967. Standard volume tables and merchantable conversion factors for the commercial tree species of central and eastern Canada. Can. Dep. For. Rur. Dev., Ottawa, Ont. Inf. Rep. FMR-X-5.

Lee, Y. J. 1974. Four-year basal area growth response of a 25-year-old Douglas-fir stand to thinning and urea fertilization. Can. J. For. Res. 4:568-571.

Mallonee, E. H. and R. F. Strand. 1976. Seven-year growth response of young Douglas-fir plantations following thinning and urea fertilization. Crown Zellerbach, Camas, Wash. For. Res. Note 6. 8 p.

Morrison, I. K., F. Hegyi, N. W. Foster, D. A. Winston and T. L. Tucker. 1976a. Fertilizing semimature jack pine in northwestern Ontario: fourth-year results. Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-240. 42 p.

Morrison, I. K., D. A. Winston and N. W. Foster. 1976b. Urea dosage trial in semimature jack pine forest, Chapleau, Ontario: fifth-year results. Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-251. 8 p.

Morrison, I. K., D. A. Winston and N. W. Foster. 1977a. Effect of nitrogen, phosphorus and potassium fertilizers on growth of semimature jack pine forest, Chapleau, Ontario: fifth-year results. Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-258. 12 p.

Morrison, I. K., D. A. Winston and N. W. Foster. 1977b. Effect of calcium and magnesium, with and without NPK, on growth of semimature jack pine forest, Chapleau, Ontario: fifth-year results. Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-259. 11 p.

Plonski, W. L. 1974. Normal yield tables (metric) for major forest species of Ontario. Ont. Min. Nat. Resour., Div. For. 40 p.

Rowe, J. S. 1972. Forest regions of Canada. Can. For. Serv., Ottawa, Ont. Publ. 1300. 172 p.

Steenberg, B. K. 1976. The northern coniferous forest, a primary source of world resources: can Canada meet the growing challenge of expanding world demands? For. Chron. 52:255-262.

Stone, E. L. 1975. Soil and man's use of forest land. p. 1-9 *in* B. Bernier and C. H. Winget, *Ed.* Forest soils and forest land management. Univ. Laval Press, Que.

Tucker. T. L. 1974. What is it worth? An economic evaluation of fertilizer trials in jack pine at Dryden, Ontario. p. 39-45 *in* Proceedings of a workshop on forest fertilization in Canada. Can. For. Serv., Sault Ste. Marie, Ont. For. Tech. Rep. 5.

Weetman, G. F. 1968. The nitrogen fertilization of three black spruce stands. Pulp Pap. Res. Inst. Can. W.P. No. 6. 45 p.

Weetman, G. F. 1971. Effects of thinning and fertilization on the nutrient uptake, growth and wood quality of upland black spruce. Pulp. Pap. Res. Inst. Can. W.P. No. 28. 18 p.

Weetman, G. F. 1975. Ten-year growth response of black spruce to thinning and fertilization treatments. Can. J. For. Res. 5: 302-309.

APPENDIX

APPENDIX

Occurrence of lesser plant species prior to treatment expressed as a percentage of subplots on which species occurred based on sample of 24 subplots, each 1 m^2.

Species	Occurrence (%)
LICHENS	
Cladonia spp.	8
MOSSES	
Dicranum polysetum SW.	50
Hypnum crista-castrensis Hedw.	17
Pleurozium schreberi (BSG.) Mitt.	100
SEED PLANTS	
Picea mariana (Mill.) B.S.P.	17
Oryzopsis asperifolia Michx.	67
Carex spp.	75
Clintonia borealis (Ait.) Raf.	25
Maianthemum canadense Desf.	100
Salix spp.	67
Alnus crispa (Ait.) Pursh	17
Anemone quinquefolia L.	92
Coptis groenlandica (Oeder) Fern.	33
Amelanchier spp.	33
Fragaria virginiana Duchesne	42
Rubus pubescens Raf.	17
Rosa acicularis Lindl.	67
Polygala paucifolia Willd.	83
Cornus canadensis L.	100
Viola spp.	25
Aralia nudicaulis L.	8
Pyrola secunda L.	8
Ledum groenlandicum Oeder	8
Epigaea repens L.	25
Vaccinium myrtilloides Michx.	58
Vaccinium angustifolium Ait.	100
Trientalis borealis Raf.	42
Diervilla lonicera Mill.	83
Linnaea borealis L.	75
Solidago bicolor L.	58
Aster macrophyllus L.	8