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AN EXCEPTIONAL BLACK SPRUCE STAND

by

G. L. Baskerville and W. C. Calvert

FOREST RESEARCH LABORATORY

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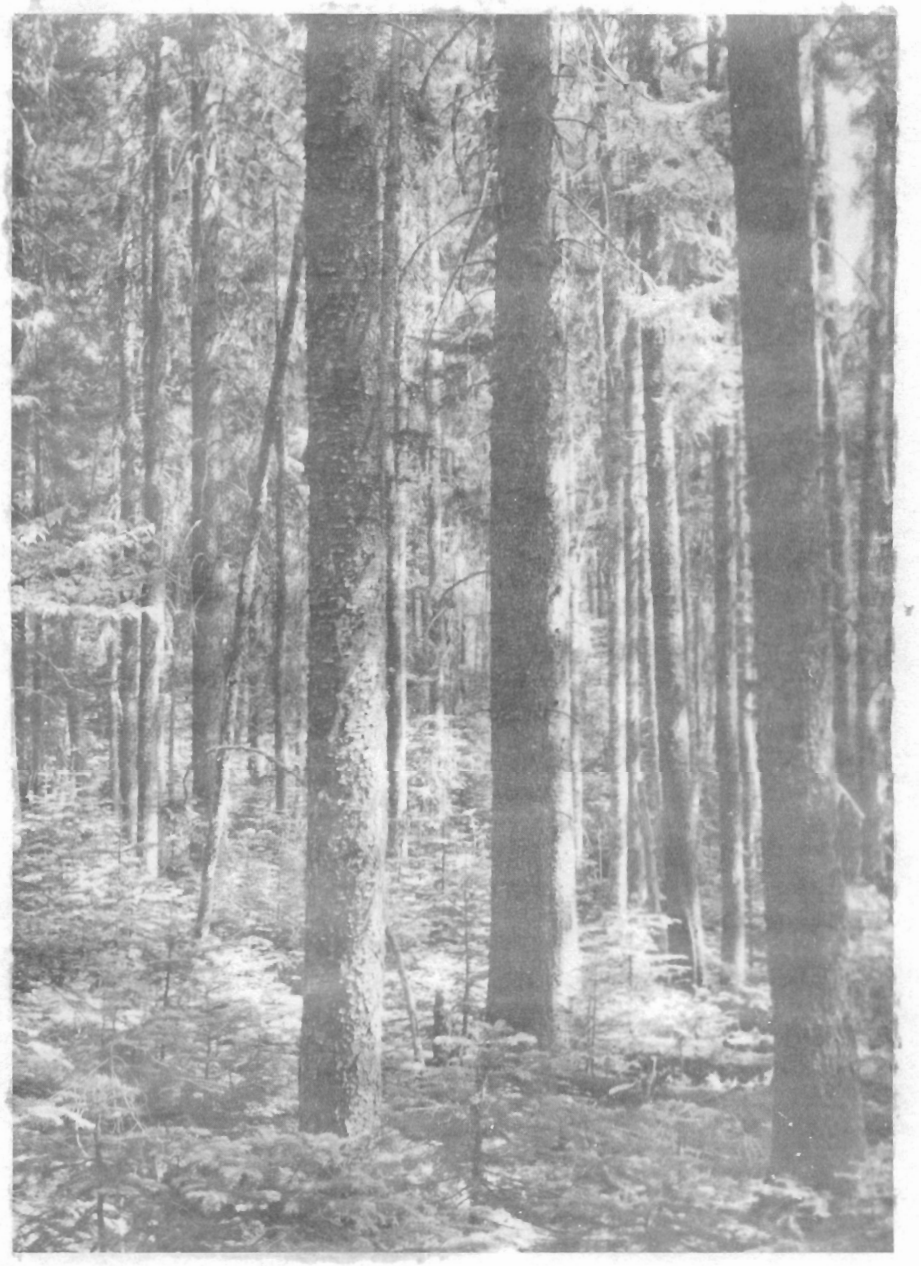

Figure 1. Interior of an exceptional black spruce stand on Kedgwick watershed, N. B.

An Exceptional Black Spruce Stand

by

G. L. Baskerville[1] and W. C. Calvert[2]

INTRODUCTION

Native Trees of Canada (1956) refers to black spruce[3] as a slow-growing tree, 30 to 50 feet in height and 6 to 10 inches in diameter. A black spruce stand comprised of much larger trees exists in northwestern New Brunswick. The stand is even-aged and averaged 103 years at stump height in 1965. It contained 510 stems per acre averaging 68 feet in height and 9 inches in diameter. The basal area was 233 sq. ft. and the total volume was 7,024 cu. ft. per acre. This paper records details of this exceptional stand, which is now deteriorating rapidly because of windfall along its recently exposed edges.

THE AREA

The stand occupies 70 acres on a mid-slope position at 1,400 feet above sea level in the Kedgwick control area (of the Green River Project), a 17 square mile area reserved

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1/ Research Scientist, Maritimes Region, Department of Forestry and Rural Development, Fredericton, New Brunswick.

2/ Graduate assistant Maritimes Region, 1965. Currently with the Ontario Department of Lands and Forests.

3/ Checklist in App. gives common and scientific names.

from cutting and from spraying for spruce budworm (Choristoneura fumiferana Clem.) in the 1951-58 outbreak. The aspect is southerly with a 5% slope towards the South Branch of the Kedgwick River.

The forest is classified by Rowe (1959) as boreal (Sec. B2). Loucks (1962) included the area in the Green River District of his Fir-Pine-Birch Zone. The region has short, cool summers and long, cold winters. Annual precipitation is 42 inches of which 18 to 22 inches falls during the frost-free period. The growth of the stand on the study area suggests that climate and soil are near optimum for black spruce which is otherwise a minor species in what is essentially a balsam fir--white spruce--white birch forest.

Until recently, when a road was constructed through the western portion of the stand, there had been little or no recent human disturbance except for the establishment and re-measurement of a number of sample plots. Black spruce is phenologically protected from severe defoliation by the spruce budworm, and the infestations of the 1880's, 1910's (Swain and Craighead) and 1950's gradually eliminated balsam fir from the overstorey without serious damage to the spruce. Some further release resulted from the loss of the few white birch due to birch dieback beginning in the late 1940's.

SAMPLING

The overstorey stand, advance growth, ground vegetation, and soil were examined separately. As the object was to provide a description rather than an inventory the sampling was detailed and limited rather than extensive. The stand sample consisted of three 0.1-acre transects (198 feet x 22 feet). A map was prepared for each transect showing stem position and crown projection of each stem. Data recorded for individual trees over six feet in height included: d.b.h., total height, crown length, length of dead crown, branch-free bole, and crown width. Age was determined by boring 135 black spruce at a height of one foot.

Eight trees ranging in diameter from 5 to 14 inches were felled and sectioned at 6-foot intervals. Diameters, outside and inside bark, and age were determined at each section. Total stem wood volume was calculated for the eight stems and correlated to diameter and height in the form:

$$V = 1.07 + .00215D^2H \qquad (r^2 = .994)$$

where V is the total volume in cubic feet, D is the diameter at breast height outside bark in inches, and H is the total height in feet. Stand volume was estimated by substituting the diameter and height for each tree on the transects in this equation.

For the advance growth, total counts were made by species and one-foot height classes on 40 randomly-distributed milliacre quadrats on each transect. Advance growth cover was estimated on each quadrat by species. Microtopographical position, grouping, and seedbed of the advance growth were determined at a total of 100 randomly-located points on the three transects.

The ground vegetation was sampled on 100 circular, 1/16-square-meter quadrats laid out in random fashion in each of the three transects. An ocular survey of those parts of the stand lying outside of the sampling area disclosed several additional species, which have been included in the check list for the area.

The primary soil study was made in a trench 198 feet long running the length of one of the transects. All horizons, rocks, major roots, rotten wood, rooting levels and frozen ground were mapped at 3-inch intervals along this trench. Soil temperature was taken at the surface, mid-duff, duff-mineral soil interface, Ae-B interface, mid-B, mid-B-C, and in the C horizon as the trench was opened. Soil reaction was measured with a porcelain soil test kit and color chart.

THE STAND

Overstorey

The overstorey, comprised of 500 black spruce per acre greater than 20 feet in height, was distinct from the advance growth (Table 1, Figs. 1, 2, 3, and 4). Diameter at breast height of trees on the three transects ranged from 4 to 14 inches, averaging 9.1 inches while diameters of 16 inches were recorded elsewhere in the stand. The average diameter for the three transects varied only 0.25 inches. Current diameter growth was somewhat less than the average growth over the previous 20 years but was still fairly vigorous for black spruce.

Heights ranged from the 30- to the 90-foot height class, the tallest black spruce being 86 feet. The mean height of all spruce was 68 feet and the average height varied only 2.5 feet among the three transects. One-third of the trees were 70 feet tall and 9 or 10 inches in diameter. Fifty per cent of the trees fell in the 70-foot height class (Table 2).

The basal area of 233 sq. ft. per acre supported a total volume of 7,024 cu. ft. per acre (Table 1). There were minor variations among the transects reflecting slight differences in the distribution of number of stems and mean diameters.

The average green crown length was 35 feet giving an average live crown ratio of about 51%. Although there was considerable variation in individual green grown length, there was little difference among the transect means.

The height growth history was reconstructed using the 8 trees felled for volume analysis (Fig. 5). There was no indication here or in the discs or cores of early suppression and current height growth was vigorous.

The stem position maps and stand profile diagrams show a definite grouping of the black spruce (Figs. 2, 3 and 4). This resulted in a very open overstorey canopy with the crown closure (main canopy) of the three transects averaging only 53%. The second transect deviated rather markedly from the others by being more open:

Transect	Number trees/acre	Cover/tree (sq. ft.)	Crown cover (%)
1	520	50	59
2	500	37	42
3	510	49	57

The open condition of this transect is reflected in the release of advance growth as shown in the stand profile diagram (Fig. 3).

The average age of the bored trees was 103 years with a range of from 58 to 131 years:

Age class	60	70	80	90	100	110	120	130
Number of trees	3	2	7	11	37	63	10	2
% of total number	2	2	5	8	27	47	7	2

Nearly 50% of the trees were in the 110-year age class. The oldest and largest tree in the stand was a recent windfall which had been 25.8 inches d.b.h. and 74 feet tall. This stem was 179 years old at a height of 15 feet. The largest standing tree was 15.8 inches d.b.h., 76 feet tall, and 104 years old.

The stand ranks well above the best site reported in the yield tables of Plonski (1956) and Kabzems (1953). Data from these tables for 105-year-old stands on site class I (upper limit of site I in parentheses are compared with the Kedgwick stand in the following tabulation:

	Kedgwick	Plonski	Kabzems
Height of dominants and codominants	72	57(67)	52(58)
Average d.b.h.	9.1	6.5	5.8
Number trees/acre	510	758	1100
Basal area/acre (sq. ft.)	233	172(178)	168
Total vol./acre (cu. ft.)	7020	4400(4900)	3000(3500)

Butt rot, as revealed in the age core sampling, was found in 130 black spruce per acre. It commonly terminated 2.5 to 4.0 feet up the bole. Only in 5% of the trees did butt rot extend 5 feet along the bole and form a significant reduction

in the merchantable volume of the tree.

The even-aged structure of the stand suggests it originated following heavy disturbance. Although fire is a common mechanism of regeneration for black spruce a thorough search of surface material failed to reveal any charcoal suggesting that fire was unimportant here. While disturbance by fire or humans is unlikely, several features including the range of ages suggest windfall as the regenerating disturbance. Windfall is common and heavy windstorm could level this isolated shallow-rooted stand, especially since the surrounding mixedwood and softwood types have been opened up by mortality as a result of birch dieback and spruce budworm defoliation. Previous stands have probably been similarly isolated in the past. The soil beneath the many rotting logs contains deep pockets of Ae and many similarly-oriented buried Ae's exist. These correspond with the direction of the now rotten windfalls upon which the present stand is commonly rooted in linear fashion (Fig. 1). The presence of many partially decomposed black spruce cones immediately beneath the rotten logs suggests that the previous stand contained considerable black spruce and a good black spruce seed supply was present when that stand was eliminated. A fresh mineral seedbed created by uprooted trees and abundant seed would increase the black

spruce stocking in the regeneration. At the initiation of the present stand the advance growth was probably predominantly balsam fir, as is the case in the present advance growth. One black spruce, 180 years old, presumably a relic of the previous stand, had a pronounced release 115 years ago coinciding roughly with the age of the present stand.

Understorey

The dense understorey beneath the black spruce received its initial release with the death of the few overstorey fir, during the recent budworm infestation. Balsam fir predominated in the understorey, accounting for 79% of the stems. Black spruce accounted for about 21%, mountain ash (Sorbus americana (Marsh.)), and white birch, each less than one per cent. There was considerable variation in the number and size distribution of balsam fir and black spruce advance growth on the three transects:

	Black Spruce		Balsam fir		Hardwoods	
	No./ac	Average height (feet)	No./ac	Average height (feet)	No./ac	Average height (feet)
Transect 1	2,850	0.8	17,225	1.6	125	2.3
Transect 2	3,375	0.8	8,675	2.9	25	3.0
Transect 3	6,025	1.0	21,100	2.0	75	2.7
Average	4,083	0.9	15,666	2.1	74	2.3

From casual observation one would not think that black spruce comprised one-fifth of the advance growth as only one spruce seedling in eight is greater than 1.5 feet in height and half of the stems are in clusters of up to 20.

Of about 15,600 balsam fir per acre in the understorey, 690 were greater than 0.5 inches d.b.h. ranging to a maximum height of 15 feet (Table 1). These had a basal area of 7.61 sq. ft. per acre. Approximately 70% of the fir in 1- to 3-inch diameter classes showed evidence of damage by the spruce budworm during the infestation of the 1950's. Disregarding height class, 99% of the quadrats were stocked to balsam fir, 68% with black spruce, 4% with mountain ash and 3% with white birch.

The average cover class for balsam fir advance growth was 42% and for black spruce 2%. These values indicate the dominance of balsam fir in the understorey. Black spruce cover never exceeded 25% on any of the milliacre quadrats sampled, while the balsam fir cover value exceeded 25% on 82 of the 120 quadrats:

	Cover class (% of quadrat covered)								
	0	to 1	1-10	10-25	25-50	50-75	75-100	Total	Mean cover%
	(Number of quadrats)								
Balsam fir	1	1	12	24	38	31	13	120	41.5
Black spruce	39	61	14	6	-	-	-	120	1.5

The advance growth micro-habitat survey revealed that black spruce tended to establish itself on the tops of hummocks, while balsam fir survived better on the sides of the hummocks (Table 4). There was a definite tendency for black spruce to grow in clusters. Both species were most commonly rooted in mois with black spruce having a tendency toward rotten wood and balsam fir toward mineral soil. Layering was noted in both species.

Many of the black spruce, as small as two feet tall, developed sterile female flower buds particularly on the leader.

Ground Vegetation

A most impressive feature of the stand is the continuous carpet of feather mosses interspersed with low herbaceous plants (Table 5). Schrebers moss, plume moss, hair-cap moss, and Hylocomium splendens (Hedw.) BSG., were the common feather mosses. Canada maianthemum, bunchberry, creeping snowberry, and wood sorrel were common herbaceous plants. A comparison of the species frequency list for the three transects indicated that the composition of the ground vegetation was uniform. Notably absent or present in small numbers are the ericaceous plants that commonly dominate the forest floor under black spruce stands. A checklist of all species identified in the stand is given in Appendix I.

With the blowdown of large black spruce and the loss of balsam fir as a result of budworm defoliation more light is reaching the forest floor, and species such as wild red raspberry and brachen fern are appearing. As a result a larger number of species composes the ground vegetation in open areas. The shade-tolerant species such as the feather mosses which presently predominate will gradually be replaced by light-demanding species as the stand continues to break up and fewer species will again compose the ground vegetation.

Soil

The soil underlying the study area was a strongly podzolized, slightly stony, silt loam (Langmaid, 1967, McGee series, see Appendix II for description). The parent material was a deep till derived from steeply dipping, highly fractured soft shale bedrock.

The soil profile reflected the historic churning up resulting from the upheaval of root systems by windfall. As soil is washed from the upturned root systems, it gathers in piles sloping away from the overturned trees. A layer of Ae in these sloping piles is later recognized as a buried Ae. A prolonged effect of the windfalls, through their release of humic acids in the decay process, is the formation of deep pockets of Ae. All horizons were extremely variable in

thickness and a C horizon was the only mineral horizon continuous along the entire length of the trench (Fig. 6). The Ae and B-C horizons were continuous for most of the length of the trench, while the B horizons were short and intermittent. There was little variation in the amount of shale found in the profile along the trench.

Weathering was shallow, and usually ranged from 12 to 18 inches in depth being somewhat shallower under the large black spruce. This could be a result from the restriction of downward water movement by the trees and the thick organic layer surrounding the trees.

Soil reaction was acid throughout the profile and was rather uniform within a horizon at various points along the trench:

	Soil Horizon						
	L	F	H	Ac	Bh to Bfh	B-C	C
pH	4.6	3.8	3.8	3.9	3.9	4.4	5.1

The B-C and C horizons, which are the furthest removed from the effects of the humic acids, were least acid. The moss and litter horizon was extremely variable in pH.

The humic horizons (moss and litter, fermentation, and humus) were continuous but variable in thickness. Although they did attain a considerable depth near bases of trees,

surface roots, and rotting logs, decomposition is such that their combined thickness was generally about one inch. Golden and white mycelium were prominent in the fermentation and humus layers. Mottling was absent from the profile of this open, permeable, highly aerated soil. Adequate moisture is provided by the heavy precipitation of the area. Although the pockets of Bfh were dark in color there was no evidence of induration.

Rooting depth was variable but shallow, centering around the mineral-organic interface with "sinkers" penetrating well into the mineral horizons. The rooting zone most commonly extended from the fermentation layer to the upper parts of the B horizon. The larger roots have developed the typical I-beam shape.

Soil temperatures generally decreased with depth. Several pockets of frozen ground of varying length and thickness were found at the beginning of July 1965. These often centered about the B-C and C interface, directly under trees, rotten wood or areas of thick organic accumulation.

CONCLUSION

The stand is truly exceptional as an example of black spruce at its ecologic and aesthetic best. Total height and productivity are among the best reported for black spruce and

clearly the species is well adapted to this particular soil and climate. Although the evidence suggests that this stand is at least second generation black spruce there is little or no evidence of the so-called site deterioration often ascribed to black spruce. The absence of an ericaceous undergrowth and the well drained nature of the soil are probably significant in this respect.

While current growth is relatively vigorous there is a tendency towards levelling off of height and diameter increment in individual stems. However, because of its exposed location the stand will never reach classical overmaturity. Depletion by windfall along the borders exposed by spruce budworm-caused balsam fir mortality is increasing annually and over the next decade or two the stand will collapse completely. Destruction by windfall will provide advantageous conditions for additional black spruce regeneration but the next stand will be essentially balsam fir with an admixture of black spruce. Unless future budworm outbreaks successively eliminate the balsam fir as in the past, a situation which is unlikely, we will witness, over the next few years, the disintegration of one of the finest black spruce stands on record.

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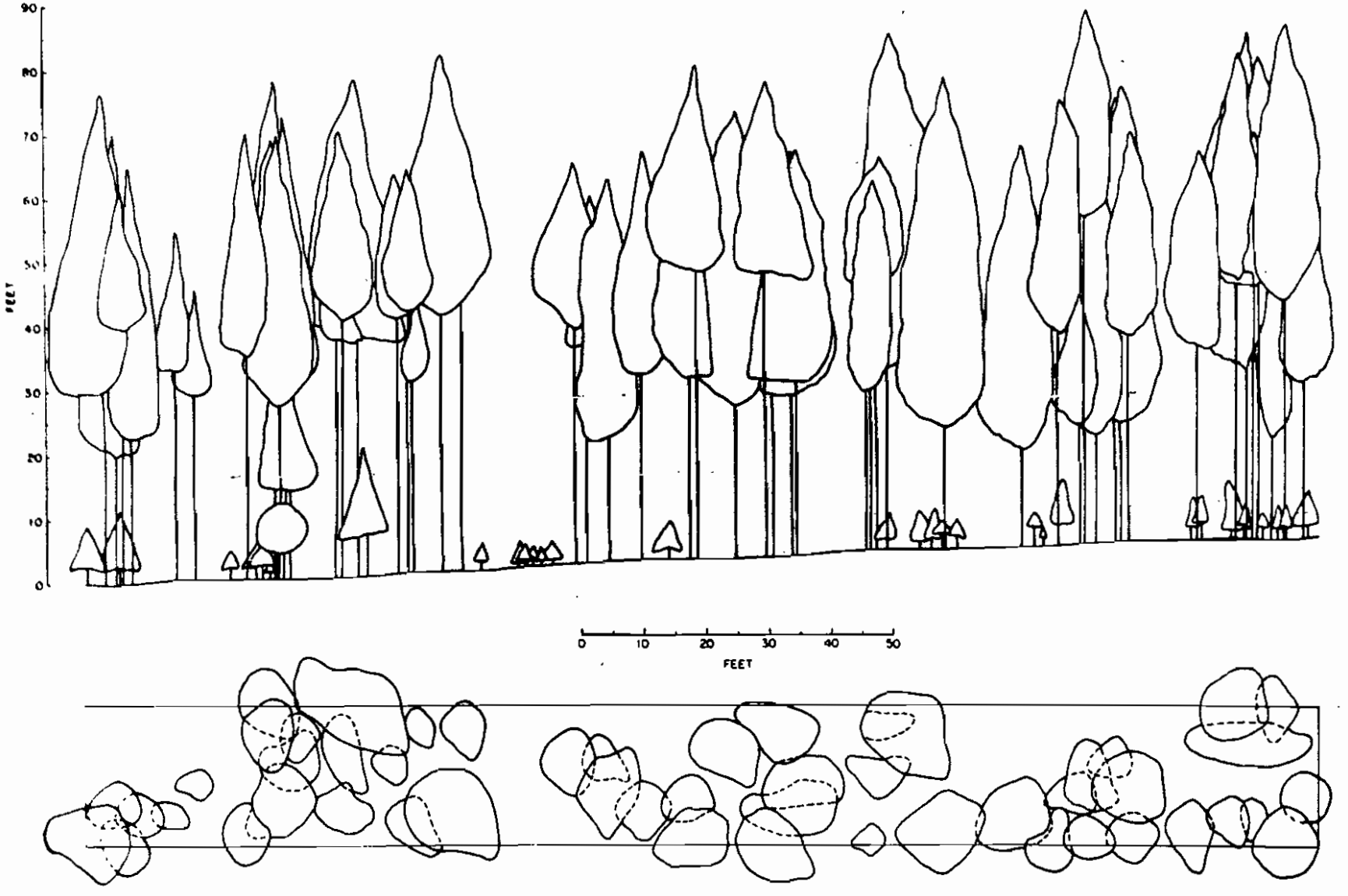

Figure 2. Profile, stem position and crown projection maps for transect 1

Figure 3. Profile, stem position and crown projection maps for transect 2

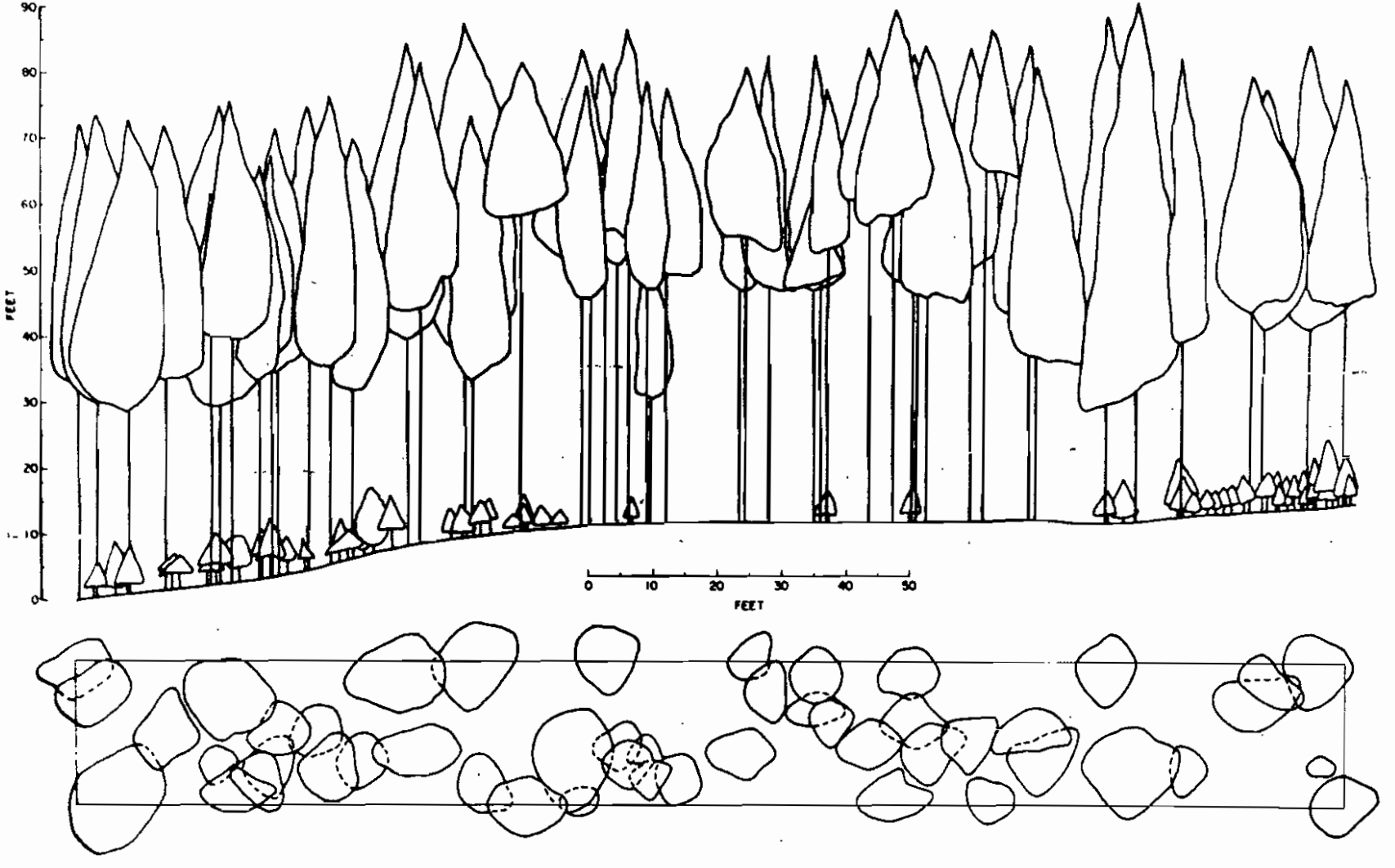

Figure 4. Profile, stem position and crown projection maps for transect 3.

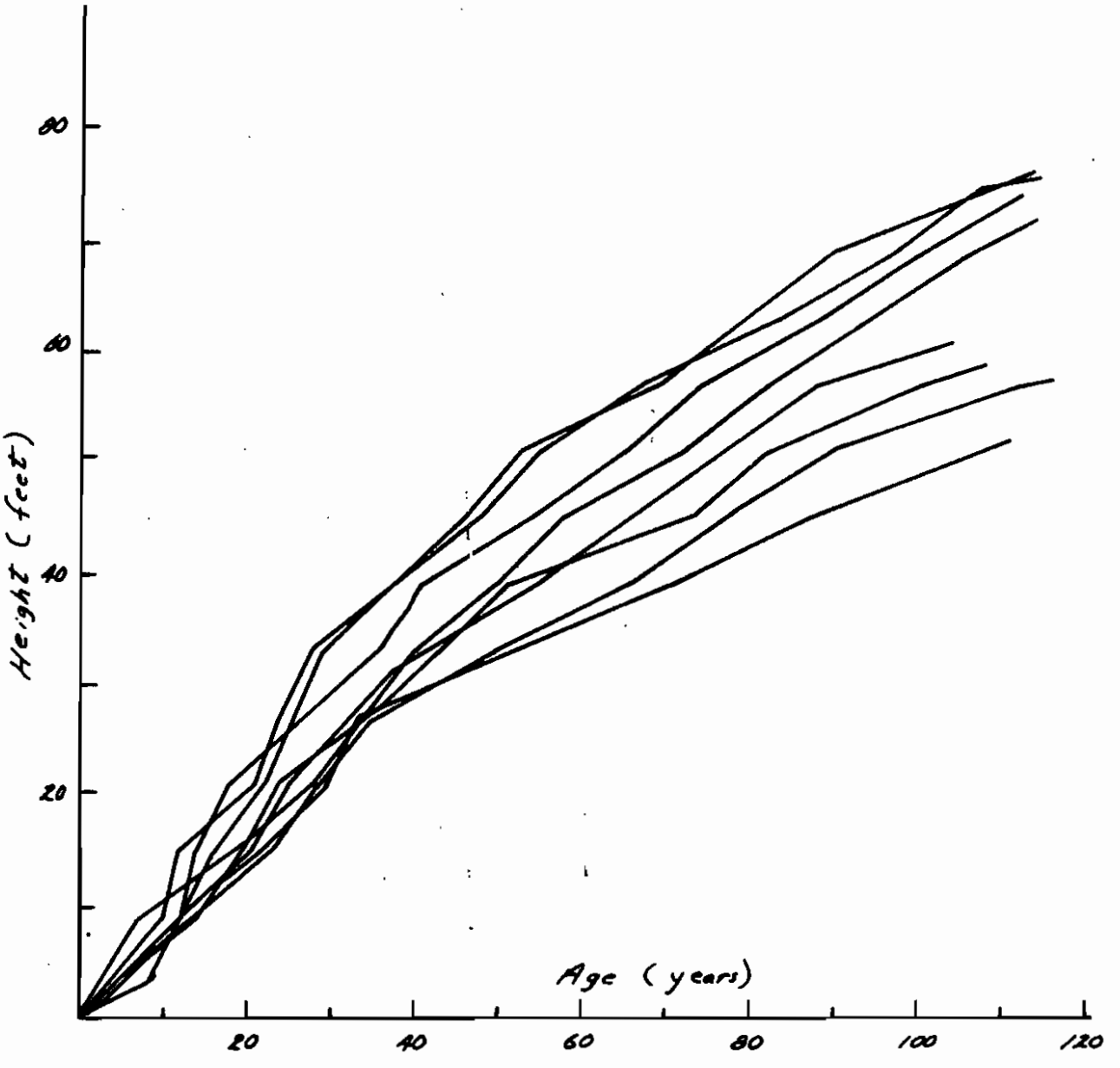

Figure 5. Height over age curves reconstructed from stem analysis of eight black spruce trees.

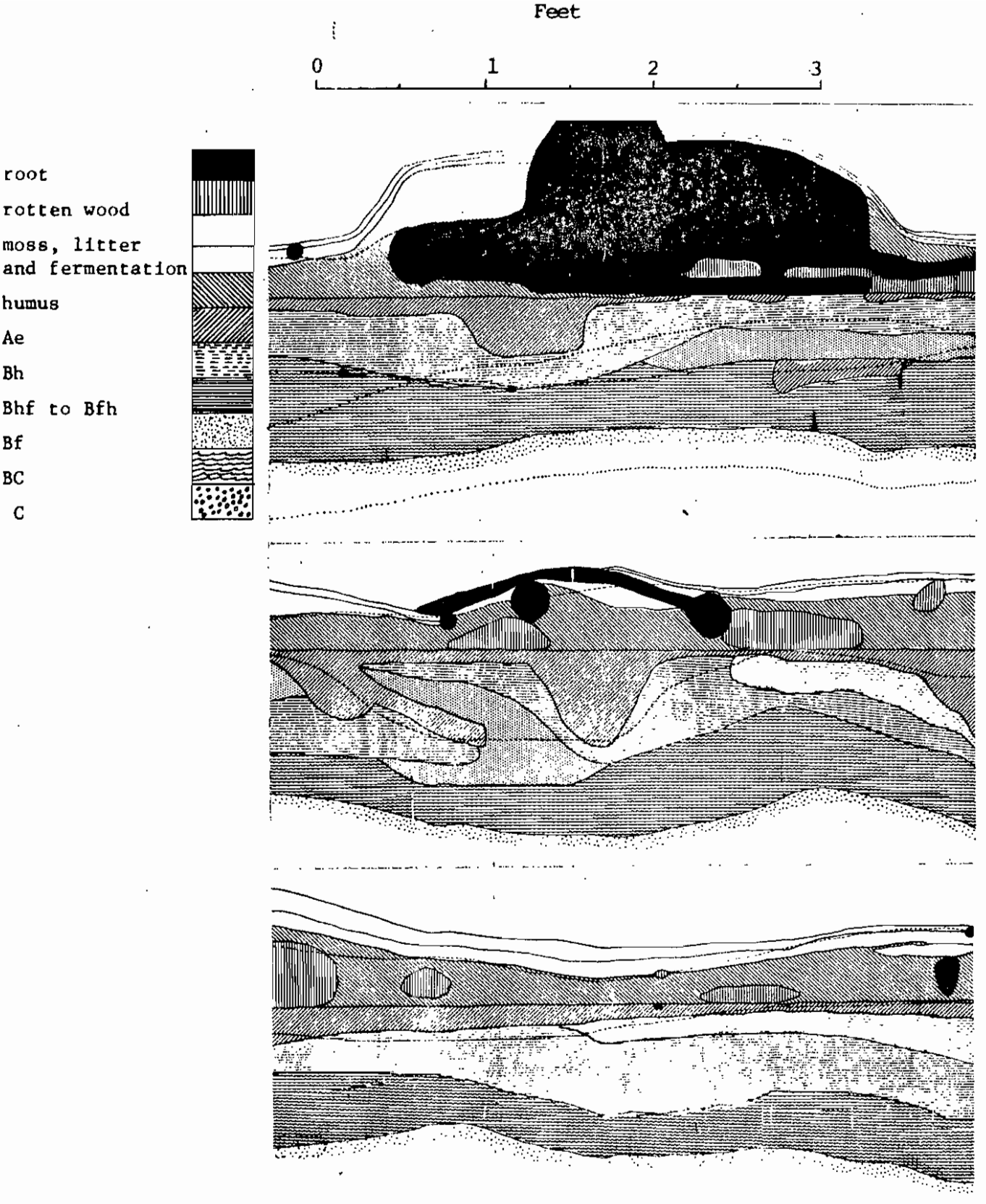

Figure 6. Three sections of soil profile from the trench.

Table 1. Number of trees, basal area, and total volume per acre by one-inch diameter classes based on the three 0.1-acre transects.

Diameter class	Black Spruce			Balsam Fir			White Birch		
	Number	Basal area (sq.ft.)	Total volume (cu.ft.)	Number	Basal area (sq.ft.)	Total volume (cu.ft.)	Number	Basal area (sq.ft.)	Total volume (cu.ft.)
1	6	.02	.1	477	2.38	14.3	3	.02	
2	3	.05	.7	193	4.25	32.8	7	.15	
3	-	-	-	20	.98	10.0	-	-	-
4	7	.66	16.1						
5	10	1.42	36.6						
6	37	8.08	221.0						
7	60	15.68	441.3				3	.80	
8	70	25.15	733.3						
9	130	58.17	1744.8						
10	80	42.85	1295.8						
11	60	39.97	1242.8						
12	27	20.82	667.0						
13	10	8.80	274.7						
14	10	11.00	350.0						
Total	510	232.67	7024.2	690	7.61	57.1	17	.97	

Table 2. The distribution of the overstorey black spruce stems by one-inch diameter and 10-foot height classes based on measured heights and diameters of 150 trees.

Diameter class	Height class (ft)							
	30	40	50	60	70	80	90	Total
	(number of stems per acre)							
4	3		4					7
5	3		3	4				10
6			24	10	3			37
7			13	34	13			60
8				37	27	6		70
9				27	93	10		130
10				7	53	20		80
11					37	20	3	60
12					10	17		27
13					3	7		10
14						10		10
Total	6	-	44	119	239	90	3	501

Table 3. Number of stems of advance growth per acre by species and one-foot height class based on 120 milliacre quadrats.

Height class (ft.)	Black Spruce	Balsam Fir	White Birch	Mountain Ash
		(number stems/acre)		
0-0.5	1325	2100		
1	2350	6092		33
2	258	3017		8
3	108	2025		
4	17	975		
5	25	500	17	
6		258		
7		167		
8		133	8	
9		133		
10		83		
11		75		
12		17		
13		33		
14		33		
15		25		
Total	4083	15,666	25	41

Table 4. The nature of the establishment of black spruce and balsam fir advance growth based on 100 point samples.

	SPECIES	
	Black Spruce (% of all points examined)	Balsam Fir
Microtopography		
hummock	38	12
hollow	18	21
midslope	25	41
flat	19	26
	100	100
clustered	50	12
not clustered	50	88
	100	100
Seed bed		
rotten wood	35	6
moss	53	63
mineral soil	12	31
	100	100

Table 5. Percentage frequency of the most common mosses and herbaceous plants based on 300-1/16-square metre quadrats.

Species	Per cent frequency
Pleurozium schreberi	99.3
Hypnum crista-castrensis	68.7
Cornus canadensis	50.0
Maianthemum canadense	47.7
Gaultheria hispidula	36.0
Dicranum fuscesens	29.7
Oxalis montana	24.4
Hylocomium splendens	24.0
Clintonia borealis	20.3
Polytrichum commune	18.0
Linnaea borealis	9.7
Bazzannia trilobata	4.3
Vaccinium myrtilloides	3.3
Cladonia rangiferina	3.3
Pyrola secunda	2.7
Coptis groenlandica	2.3
Trientalis borealis	2.3
Pteridium aquilinium	0.7
Aralia nudicaulis	0.3
Dicranum rugosum	0.3
Sphagnum capillaceum	0.3

APPENDIX I. A checklist of species identified in the stand.

Trees

Botanical Name	Common Name
Abies balsamea (L.) Mill.	Balsam fir
Betula papyrifera Marsh.	White birch
Picea glauca (Moench) Voss.	White spruce
Picea mariana (Mill.) BSP.	Black spruce
Sorbus americana (Marsh.)	American mountain ash

Shrubs

Amelanchier sp.	Serviceberry
Rubus strigosus Michx.	Wild red raspberry
Vaccinium myrtilloides Michx.	Sour-top blueberry

Ferns

Pteridium aquilinum (L.) Kuhn	Braken fern

Herbs

Aralia nudicaulis L.	Sarsaparilla
Clintonia borealis (Ait.) Raf.	Yellow clintonia
Coptis groenlandica (Oeder) Fern.	Gold thread
Cornus canadensis L.	Bunchberry
Gaultheria hispidula (L.) Bigel.	Creeping snowberry
Linnaea borealis (L.)	Twinflower
Maianthemum candense Desf.	Canada maianthemum
Oxalis montana Raf.	Wood-sorrel

Herbs (contd)

Botanical Name	Common Name
Pyrola secunda L.	One-sided pyrola
Trientalis borealis Raf.	Starflower

Mosses

Dicranum fuscescens Turn.	
Dicranum rugosum Brid.	Wavy dicranum
Hylocomium splendens (Hedw.) BSG.	
Hypnum crista - castrensis Hedw.	Plume moss
Pleurozium schreberi (BSG.) Milt.	Schreber's moss
Polytrichum commune Hedw.	Hair-cap moss
Sphagnum capillaceum	Acuteleaf sphagnum

Liverworts

Bazzania trilobata (L.) S.F. Gray

Lichens

Cladonia rangiferina (L.) Web.

APPENDIX II - Soil description for a typical profile.

Soil series - McGee (with more soft shale than normal)

Horizon Descriptions:

M+L: 0.025' - 0.125' thick; pH 3.8-4.3; colour 2.5 GY 7/6 (yellowish green-yellow); feather moss, needles, bark, cones, and twigs (balsam fir and black spruce).

F: 0.025' - 0.175' thick; pH 3.8; colour 10.0 R 4/2 (red yellow-red); partially decomposed organic material (as described above); felted structure; golden and white mycelium.

H: 0.050' - 0.250' thick (up to 1.00' ± thick near trees); pH 3.8; colour 10.0 R 3/2 (red yellow-red); well decomposed organic material (as described above); felted structure; greasy consistence.

Ae: 0.050' - 0.500' thick (pockets 1.00' + thick); pH 3.8; colour 5 YR 6/2 (pinkish grey); silty clay loam; strong medium, platy structure; consistence, moist - slightly firm, dry-moderately hard, wet-slightly sticky and slightly plastic; horizon boundary abrupt; horizon variation wavy.

Bh: 0.025' - 0.300' thick (intermittent); pH 3.8; colour 2.5 YR 3/2 (dusky red); gravelly loam; weak, fine, granular structure; consistence, moist-slightly firm, dry-slightly hard, wet-moderately plastic and slightly sticky; horizon boundary abrupt; horizon variation broken.

Bhf: to BfH 0.025' - 0.500' thick; pH 3.8; colour 5 YR 4/8 (yellowish red); gravelly loam; strong, fine, granular structure; consistence, moist-loose, dry-soft, wet-slightly plastic and slightly sticky; horizon boundary abrupt; horizon variation irregular.

Bf: 0.025' - 0.500' thick; pH 3.8; colour 5 YR 4/8 (yellowish red); gravelly loam to silt loam; moderate, fine, granular structure; consistence, moist-loose, dry-loose, wet-slightly plastic and slightly sticky; horizon boundary clear; horizon variation wavy.

B-C: 0.025' - 0.750' thick; pH 4.3 - 4.8; colour 10 YR 5/6 (yellowish brown); silty gravel; single grain structure/ silt particles adhere to gravel; consistence, moist-loose, dry-loose, wet-non-plastic and slightly sticky; horizon boundary gradual; horizon variation wavy; gravel fragments angular-flat, soft shale with some slate (some gravel found throughout mineral horizon but in greatest amount in B-C).

C: thick; pH 4.8 - 5.4; colour 2.5 Y 5/4 (light olive brown) gravelly silt loam; moderate, medium, granular structure, consistence, moist-friable, dry-soft, wet-non-plastic and slightly sticky; horizon boundary gradual; horizon variation wavy; gravel fragments as in Bf with more fines.

Mottles: absent from profile (MR2) skins or flows - none

Cementation or Compaction: None (open soil)

Permeability: moderate to rapid

Lithology: soft, flat, shale, orientated parallel to each other and the surface.

Drainage: Internal - good Type of water movement - downward

External - good

Effective - well drained

Geology: mode of accumulation - till

Stoniness: 1

Vegetation: overstory black spruce

understory predominantly balsam fir with black spruce

ground vegetation feather moss with scattered herbaceous plants.