AN EFFECT OF SPHAGNUM ON THE GROWTH OF BLACK SPRUCE

By J. K. McEWEN¹

ABSTRACT

Black spruce (P. mariana (Mill.) BSP.) grows slowly and reproduces with difficulty on most of the lowland sites where it normally occurs. An examination of the rooting systems of small and large trees indicates that growth was initiated at points substantially below the present ground surface. From the evidence available it is adduced that the growth of sphagnum is responsible for the poor growth and regeneration of the black spruce.

INTRODUCTION

Early in 1964, a series of observations made upon an organic site in Colquhoun Township of the Cochrane District indicated that there had been an irregular, stimulated growth of sphagnum on the area due to a disturbance in the water balance and the species distribution on the site. During 1964-65, more studies were carried out on both immature and mature spruce to determine in more detail the relationship of the sphagnum to tree growth.

METHODS

The Effect of Sphagnum On Dwarf Immature Spruce

This study took place in two areas; on the same site in Colquhoun Township (East Half, Lot 19, Con. 1) that was under study in the preliminary inquiry and on Lots 22, 23, Con. III, Kennedy Township. This latter site is a level peat bed several feet in depth and with very similar vegetation to the Colquhoun area.

In both cases the surface is hummocky, bearing scattered black spruce (*Picea mariana* (Mill.) BSP) less than 35 years in age. Labrador tea (*Ledum groenlandicum* (Oeder)), leatherleaf (*Chamaedaphne calyculata* (L.) Moench var. *angustifolia* (Ait.) Rehd. and var. *latifolia* (Ait.) Fern.), bog rosemary (*Andromeda glaucophylla* Link), sheep laurel (*Kalmia angustifolia* L.), bog laurel (*Kalmia polifolia* Wang.), blueberry (*Vaccinium angustifolium* Ait.), cranberry (*V. Oxycoccus* L.), cloudberry (*Rubus Chamaemorus* L.), pitcher plant (*Sarracenia purpurea* L.), and cotton grass (*Eriophorum* sp.) constitute the principal vascular vegetation and *Sphagnum*, *Mnium*, *Pleurozium schreberi*, *Cladonia* sp., the bryophytic forms. Figure 1 illustrates the irregular nature of the surface of the moss.

¹ Research Forester, Ont. Dept. of Lands and Forests, Port Arthur, Ont.

From the Colquhoun and Kennedy areas, a number of stunted spruce were dug and classified as hummock, slope or hollow forms according to their position on the sphagnum hummocks. Approximately 30 specimens in each category were collected in each township.

The vertical root lengths of these stunted trees were measured, using the present moss surface as the dividing line. They were then cut at the surface level and at each 1 inch lower level. The surfaces were sanded and the rings counted, using a binocular microscope (20x) for the purpose. The material was small, some annual rings were apparently fused at certain depths and, even under magnification, precise aging was not possible. Nevertheless, it was felt that the counts quite adequately illustrated the conditions encountered. Table 1 summarizes the measurements which were made.

TABLE 1
SUMMARY OF MEASUREMENTS ON STUNTED BLACK SPRUCE

Township	No.	Vert. root length (in.)		Depth to Max. Age (in.)	
		Aver.	Range	Aver.	Range
Hollows					
Kennedy	31	6.5	2.5 - 9.0	0.7	0 - 5
Colquhoun	30	7.4	3.5 - 13.0	0.9	0 - 3
Slopes					
Kennedy	31	8.1	3.0 - 15.0	2.5	0 - 7
Colquhoun	30	12.8	6.5 - 21.0	3.3	0.5 - 10.5
Hummocks					
Kennedy	31	10.9	7.5 - 14.5	4.4	2.0 - 10.5
Colquhoun	29	16.7	12.0 - 25.0	5.2	2.0 - 9.0

THE EFFECT OF SPHAGNUM ON MATURE SPRUCE

Horizontal Root Study

For this study, apparently sound trees representative of the stands in which they grew, were chosen for root examination. In Evelyn Township, one tree was selected from a meso-oligotrophic² site and one from a eutrophic² site. Over 50 miles from Evelyn Township, 17 trees from oligotrophic² or mesotrophic² sites and four trees from eutrophic sites were selected on four lots in Leitch Township.

On the mesotrophic and oligotrophic sites, the species of vegetation cited above appeared. There were also noted, in varying amounts, creeping snowberry (*Gaultheria hispidula* (L.) Bigel.), goldthread (*Coptis groenlandica*

² Eutrophic — of high nutrient content
Mesotrophic — of medium nutrient content
Oligotrophic — of low nutrient content

(Oeder) Fern.), dwarf birch (*Betula* sp.), twinflower (*Linnaea borealis* L.), bunchberry (*Cornus canadensis* L.), comandra (*Geocaulon lividum* (Richards.) Fern.), false Solomon's Seal (*Smilacina trifolia* (L.) Desf.) and the feather mosses (*Ptilium crista-castrensis* and *Hylocomium splendens*).

The better quality sites were flushed by runoff from adjacent mineral soil or had mineral soil less than two feet below the ground surface. On these sites such species as red osier (*Cornus stolonifera* Michx.), mountain ash (*Pyrus decora* Sarg. var. *groenlandica* (Schnied.) Fern.), wood horsetail (*Equisetum sylvaticum* L.), fireweed (*Epilobium angustifolium* L.), sweet-scented bedstraw (*Galium triflorum* Michx.), rose (*Rosa* sp.), raspberry (*Rubus* sp.) were found in addition to sphagnums and feather mosses.

The horizontal roots of selected trees were severed with a chain saw in a circle about 5 feet in diameter about each stump. The stumps were then removed from the ground and stripped of peaty material. The horizontal roots were severed at the point of contact with the vertical root system, numbered and recorded as living or dead. The cut surfaces were sanded and a count was made of the annual rings for each root and for the tree stump at a point about 8 inches above the moss surface. The records obtained from one stump from a meso-oligotrophic site and from a stump from a eutrophic site are given in Table 2 and are representative of all examined.

All stumps showed mortality in the rooting systems. Stumps from eutrophic sites showed much shallower rooting systems and less mortality of roots than did stumps from mesotrophic or oligotrophic sites. Figures 2 and 3 illustrate the difference in appearance of these roots. Heart rot at stump height

Figure 1. Section through sphagnum hummocks

Stump from mesotrophic site.

Stump from eutrophic site.

(approximately 8 inches above the moss surface) seems to be associated with advanced and extensive rot in the lower portions of the rooting system.

The maximum ring count for horizontal roots on oligotrophic or mesotrophic sites were notably lower than the ring counts at stump height. On eutrophic sites the variation was much less. This can be seen from Table 3 in which the comparative ring counts are recorded for the 23 trees studied.

TABLE 2
POSITION, AGE AND CONDITION OF HORIZONTAL ROOTS FROM TWO STUMPS
(measured from lowest point on root)

Meso-Oligotrophic Site Stump age - 140 years			Eutrophic Site Stump age - 145 years		
Height on root (in.)	Age	Condition	Height on root (in.)	Age	Condition
31¾	17		13¼	48	
28¾	37		11¾	59	
27¾	33		11	100	
27½	18		9½	82	
27½	27		8¼	40	
26½	25		7	47	
24¾	39		6½	123	
24½	16		6½	60	
24¼	38		6½	133	
23½	28		5¾	118	
22½	59		5¾	113	
22	56		5¼	59	
21¾	34		4½	72	
20½	27		4½	74	Dead
20¼	65		4½	82	
19¼	70				
18¾	— ¹	Dead			
15½	55	Dead			
15¼	52	Dead			
13½	42	Dead			
12¼	33	Dead			
11	— ¹	Dead			
11	— ¹	Dead			
10½	28	Dead			
10	34	Dead			
8¾	14	Dead			
4½	29	Dead			
3¼	27	Dead			

¹ Too rotten to count.

TABLE 3
COMPARISON OF ROOT AND STUMP AGES

Stump Age	Oldest Horizontal Root	Stump Age	Oldest Horizontal Root
Mesotrophic or Oligotrophic Sites			
131	80	199	102
131	86	140	70
132	103	216	94
92	54	171	73
121	67	160 (approx.)	73
160	76	180 (approx.)	90
143	78	195 (approx.)	61
182+	83	171	60
156	102	241	79
Eutrophic Sites			
145	133	162	146
134	111	158 (approx.)	133
161	153		

VERTICAL ROOT STUDY

In order to examine the annual ring development on the vertical portion of the rooting system, the vertical root portion of two mature trees from mesotrophic sites were chosen. These were not too decayed for counting and were cut horizontally into sections. One of the stumps was small enough to be cut on a band saw and the cuts were made at intervals of 2 inches. The other, due to its larger size, had to be cut with a chain saw and the sections, due to the wide saw kerf, had to be somewhat irregular. The records of these counts are shown in Table 4.

TABLE 4
RING COUNTS AT MEASURED DEPTHS BELOW MOSS SURFACE

Tree A		Tree B	
Depth (in.)	Ring Count	Depth (in.)	Ring Count
2	131	2½	133
4	132	3¾	134
6	133	5½	135
8	136	7½	135
10	134	9¼	135
12	134	11¾	127
14	104	13¾	98
16	72	16¾	65
18	45	18¾	54
20	40	20¼	41

From the record above, it seemed that the oldest portions of these trees lay at depths of about 8 or 9 inches below the moss surface.

A vertical cross section of a tree extending from its apex to the lowest portion of its root could be described as a series of concentric tubes (annual rings) with the innermost tube representing the oldest portion of the tree. Figure 4A represents a stylized version of such a structure.

Figure 4. Stylized representation of annual rings in tree

When vertical cuts were made through the sections counted in Table 4 above it was found that it was the marginal rings at the lower portions of the root that were missing. Figure 4B represents in stylized form what was seen. This may be due to the death of the cambium as the lower roots die. At any rate, it was possible to calculate the age-depth relationship for the two trees with greater accuracy (Table 5).

TABLE 5
ADJUSTED AGE MEASUREMENTS AT MEASURED DEPTHS

Tree A		Tree B	
Depth (in.)	Age	Depth (in.)	Age
2	131	2½	133
4	132	3¾	134
6	133	5¾	135
8	136	7½	135
10	135	9¼	141
12	135	11¾	141
14	134	13¾	141
16	129	16½	139
18	128	18¼	139
20	128	20¼	138

DISCUSSION

During the preliminary studies in 1964, on the basis of a few root systems examined, the conclusion was reached that sphagnum was growing as a result of stand disturbance and that its growth was overwhelming the spruce regeneration upon the area.

In this report, the root study of stunted immature spruce has been extended to 182 trees selected at random on similar areas in two townships 30 miles apart. Once again it has been found that the oldest portion of the tree frequently lies several inches below the surface of the moss.

There is the possibility that seeds have penetrated the sphagnum for some distance before germinating. Also the opinion is frequently voiced that trees tend to sink into the sphagnum.

Unquestionably, some of the fine seeds do penetrate between the sphagnum stems and the moisture content of the sphagnum could lead to germination. The spruce seedling is, however, a comparatively frail object and it is felt that survival would not be possible if the seed began to germinate more than an inch below the surface. On wet, acid sites there is, as well, an osmotic, killing effect on the seed, as has been shown by Rubtsov (1959) in experiments with Scots pine (*Pinus sylvestris* L.).

The stunted spruce which were examined ranged in length (stem plus vertical root portion) from 17 to 43 inches. With such light material it could be anticipated that there would be little or no sinking or that, if sinking occurred, the amount of it might vary directly with the size of the material. This was not the case.

If we hypothesize that the central point for that portion of the stem-root of maximum age was initially the starting point for the seedling, we find that this point now occurs at any distance between the moss surface and a depth of 10.5 inches. The two spruces possessing the longest aerial portions (33 inches and 30 inches) had roots only 2½ inches and 6 inches long respectively.

Depth of rooting varied greatly. The depth could be anticipated with a moderate degree of accuracy by simply noting the depth of sphagnum mounds and the position relative to them in which the dwarfed tree grew.

If sinking actually occurred, one would also anticipate that there would be a greater settling in the vicinity of the stem and that the horizontal root extremities, being flexible and fine, would be at higher levels. Such a structure, which would be somewhat like an inverted, open umbrella, was not found.

All observations support the contention that it is the upward growth of sphagnum rather than the sinkage of seeds or trees that leads to the deeper rooting. The very accumulation of organic remains on these lands is evidence of this growth. Such authorities as Dansereau and Segadas-Vianna (1952) on this continent, Fraser (1933) in the United Kingdom; Sjors (1948) in Sweden, Heikurainen (1960) in Finland and Valk (1959) in Russia have described it.

Since sphagnum attains its optimum growth under conditions of high moisture and half-light, the sphagnum mounds develop according to the location of trees, shrubs and ericaceous plants on the area.

The effect of the inundation of the spruce by wet sphagnum is a retardation

or cessation in growth of the trees. Either new roots form or the lower branches of the tree become converted to roots. LeBarron (1945) reported on sphagnum effects on the rooting of small black spruce.

On the roots of the mature spruce that were examined, the later stages of this paludification were seen. On the eutrophic sites, the horizontal roots show ring counts which are not too different from the tree age as shown by stump count. In these cases, the horizontal roots are confined to a relatively shallow and flat horizon. Even here there is death of some of the roots at the lowest portion of the trees. On mesotrophic or oligotrophic sites, the horizontal roots extend through a much deeper rooting zone. The individual roots are much smaller and with fewer rings. With the increased depth of growing sphagnum, conditions become wetter and there is a much greater vertical extension of the zone of dead roots at the base of the rooting system.

The principles of paludification have been clearly demonstrated and accepted by numerous authorities across the northern hemisphere. The present material is intended to show that the same forces are at work in Northern Ontario and for this purpose the data are considered adequate.

There are certain techniques which, used in conjunction with logging, might prevent the deterioration of the site and of the forest (McEwen, 1964). If these are delayed, more rigorous treatments might restore the sites to their original, or higher, productivity.

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