Archives

Frontline

Forestry Research Applications

Canadian Forest Service–Ontario

Technical Note No. 64

DRAINAGE AND FERTILIZATION IMPROVE GROWTH AND VALUE OF PEATLAND BLACK SPRUCE

B. Payandeh, E. Sundström, and R.A. Haig

CATEGORY: Stand management
KEY WORDS: Black spruce, Clay Belt, drainage, fertilization, growth improvement, economic analysis, rate of return

INTRODUCTION

It is estimated that about half of Ontario's black spruce (*Picea mariana* [Mill.] B.S.P.) sites are poorly drained peatlands (Ketcheson and Jeglum 1972) where the growth rate is slow, largely because of excess water and unavailability of nutrients (McEwen 1966).

In Europe, drainage and/or fertilization of similar sites have produced significant increases in growth (Heikurainen 1980) and these treatments are widely applied on an operational scale. Ontario foresters therefore have an interest in determining both the physical potential and economic feasibility of applying the treatment in Canada.

This note presents the highlights of three studies that were designed to determine the growth response resulting from drainage and/or fertilization of typical peatland black spruce sites in northern Ontario and the economics of drainage.

THE STUDIES

Study 1

One of the earliest Canadian forest drainage trials was established in 1929 by the Abitibi Paper Company near Iroquois Falls, Ontario. The project involved digging approximately 2,600 m of ditches by hand (Fig. 1) to drain almost 27 ha of typical submarginal black spruce, about 80 years of age. In terms of present day site classification, these stands would fit the Forest Ecosystem Classification (FEC) Operational Groups (OGs) 8, 9, 10, 11, and 12 (Jones et al. 1983). Forty 23.8 m^2 growth plots were established at various distances from the ditches and three control plots were located in an adjacent undrained area.

Remeasurements were carried out in 1956 and 1965, but the most intensive examination was conducted in 1969. Payandeh (1973a,b) provides complete growth and economic analyses of the project.

Study 2

In 1970, an experimental fertilization was carried out on a portion of the area drained in 1929 and on a 1962 drainage project in nearby Leitch Township. The 5-year growth response to drainage and fertilization was studied (Payandeh 1982).

Figure 1. Photograph taken in 1929 shortly after the completion of the drainage ditches near Iroquois Falls, Ontario.

Natural Resources Canada Ressources naturelles Canada

Canada

Study 3

Recognizing that the design of earlier studies was inadequate, the Canadian Forest Service–Ontario and the Ontario Ministry of Natural Resources established the Wally Creek Area Forest Drainage Project in 1984. This peatland drainage project covered 375 ha near Cochrane, Ontario (Haavisto 1984, Rosen 1986). The drainage system consists of 87 km of open ditches dug by a Finnish Lännen S-10 digging machine.

Twenty-eight growth plots were established in 1985: four drained and two undrained (control) plots in each of four OGs (8, 11, 12, 14), as well as an additional four plots established in an adjacent stand. Each of the plots consisted of eight subplots of about 400 m² each, reaching from one ditch to the next. In a 3-year period (1985–1987), a replicated subplot in each plot was fertilized with a solid 150-100-100 kg/ha NPK fertilizer. The first remeasurement was carried out in 1989, 5 years after drainage and 2 to 4 years after fertilization (Sundström 1992).

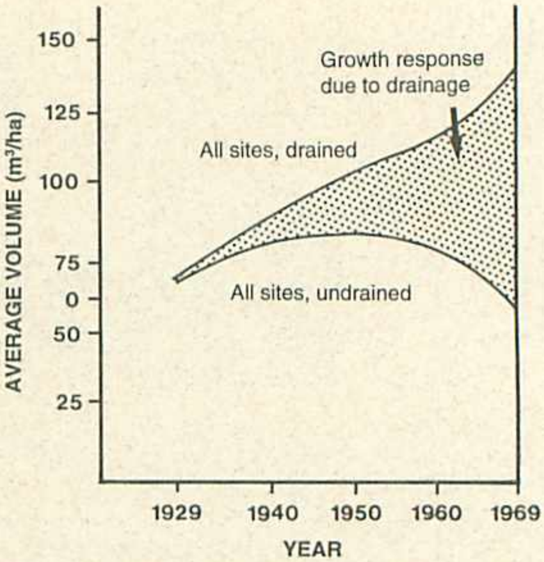

Figure 2. Merchantable volume (m³/ha) from 1929 to 1969 for the Abitibi drainage area, showing increased volume due to drainage (average of good, medium, and poor sites).

RESULTS AND DISCUSSION

Drainage

Forty-year results of Study 1 show that diameter, height, and volume growth of individual trees increased significantly after drainage. Because of disease and suppression, highly irregular mortality occurred among plots, resulting in uneven net growth. Therefore, the data was analyzed on an individual-tree basis to determine the relationship to drainage (Payandeh 1973a). Table 1 shows a single tree's response (Tree Number 28 from this experiment).

Table 2 shows the initial volume in 1929, and the natural yield in 1969, for both the treated and control areas. It also shows the total yield in 1969 for the treated area and, by subtracting the natural yield from the total yield, provides an estimate of the additional growth as a result of drainage.

Table 2 indicates that the merchantable volume in the control area actually declined by 14% between 1929 and 1969, presumably because growth was not sufficient to offset mortality. On the other hand, the volume in the drained area more than doubled as a result of drainage (Fig.2).

For Study 3, results from only 5 years of growth are available. As in Study 1, diameter, height, and volume increments were greater in drained than in undrained areas. Growth response was greatest close to a ditch.

Table 1. Pre- and postdrainage growth of Tree Number 28 on the Abitibi drainage area (merchantable volume).

Period	Age (years)	DBH[a] (cm)	Height (m)	DBH growth per year (cm)	Height growth per year (m)	Volume growth per year (m³)
Before drainage (1929)	41	2.01	2.69	0.167	0.065	-
After drainage	81	21.34	12.50	0.483	0.245	0.005

[a] DBH = diameter at breast height.

Economic Analysis of Drainage

In simple terms, the economics of forest drainage hinge on four main factors: (1) the cost, (2) the period between drainage and harvest, (3) the increase in volume as a result of drainage, and (4) the value of this additional volume. As discussed by Payandeh (1973a,b), the initial drainage layout and plot design had shortcomings. By today's standards, the drainage plan was not adequate. Therefore, the response results are considered conservative when taken on an areal basis.

In this instance (Study 1), the cost of treatment was $41.44/ha (in 1929 dollars). The increase in volume was calculated by assuming that growth in the drained area would have been directly proportional to that on the control area if the former had not been drained. To account for possible differences due to site quality, the plots were stratified (on the basis of their 1929 volumes) into "good", "medium", and "poor" sites. For the sake of simplicity this note deals only with the average of all sites. Stumpage values for the "natural yield" (i.e., that volume of growth that could have occurred without drainage), and for the increased volume as a result of drainage, were based on the actual stumpage rates charged by the Ontario Ministry of Natural Resources in the Cochrane District from 1929 to 1969.

Table 2. Natural yield and additional growth due to drainage, Abitibi drainage area.

Treatment	Number of plots	Merchantable volume (m³/ha) Initial (1929)	1969 yield Drained	Natural	Response[a]
Drained area	38	67.1	141.0	57.6	+83.4
Control area	3	63.1	-	54.1	-

[a] Response to drainage = yield for drained plots minus yield for natural plots.

Table 3 shows the gross value ($/ha) of the initial (1929) merchantable volumes on the drained and control areas, the 1969 value of the natural yield by itself and with drainage, and the value of the increased volume as a result of drainage. Note that these values were calculated using the stumpage rates prevailing at that time (i.e., $0.57/m^3 in 1929 and $1.31/m^3 in 1969).

Table 3 clearly shows that drainage significantly increased the value of the final crop over the 40 years of the study.

Knowing both the cost of drainage and the value of the additional growth, it is possible to calculate the annual rate of return on the investment. For all sites, the average annual rate of return attributable to drainage over the 40-year period was 2.5%. Furthermore, because the ratio of drainage cost to stumpage rate is currently declining, the annual rate of return from drainage can be expected to increase.

The reader should take note that higher rates of return would result if the analysis was based on the price of wood delivered to the mill. Such an analysis would include lower transportation costs, particularly if unproductive stands close to the mill were brought into production. It would also include reduced harvesting costs because these are lower per unit volume for large trees than for small ones.

Fertilization

In addition to studying the combined effects of fertilization and drainage, Study 3 provided results for fertilization as a separate treatment. Fertilization significantly increased diameter growth on the richer OG 11 and OG 12 sites. The response of diameter growth to fertilization was not affected by distance from a ditch, but medium-sized trees (7.5 to 10 m) showed the greatest response, independent of their location in relation to a ditch.

Drainage Plus Fertilization

Study 2 involved the fertilization of previously drained stands. The key finding was that the best growth response observed was from the application of NPK (urea, triplesuperphosphate, potassium chloride) at a rate of 112 kg/ha. This resulted in the production of approximately 1.4 m^3/ha per yr of extra wood as compared to the drained controls during the 5 years following fertilization.

The key results from the first 5 years of Study 3 (drainage alone, fertilization alone, and drainage plus fertilization) are shown in Figure 3. This figure indicates that drainage and fertilization, separately or in combination, had a positive impact on diameter growth, but that in the short assessment period fertilization had a greater impact than did drainage.

Although the beneficial effect of drainage decreased beyond 3 m from a ditch during this period, the effect of fertilization was not a function of the distance from a ditch. In addition, the effects of the two treatments were additive since trees on drained and fertilized areas generally had the best diameter growth.

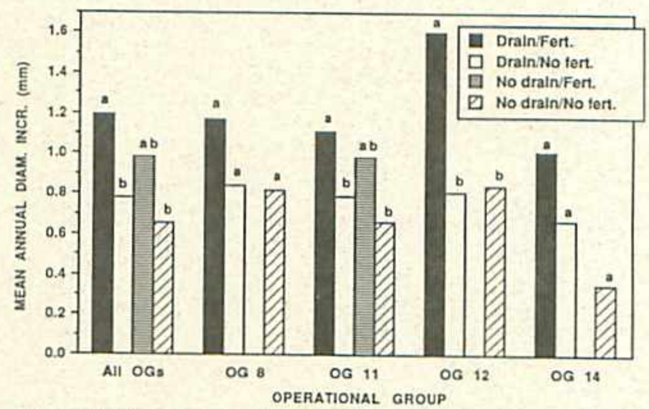

Figure 3. Mean annual diameter increment (mm) from 1985 to 1989 for trees in four distance classes from a ditch for drained (D), fertilized (F), and not fertilized (NF) areas with all OGs combined, Wally Creek Drainage Project. Diameter increments in undrained (ND) areas are shown as controls.

SILVICULTURAL IMPLICATIONS

Based on these three studies of drainage and/or fertilization of typical peatland black spruce sites in northern Ontario, it may be concluded that drainage of rich peatland sites that have young, full-crowned trees is worth contemplating so as to increase diameter, height, and volume growth. Presumably, better response could have been expected if the area had been more effectively drained (i.e., a better designed drainage system). Based on stumpage value, drainage has been shown to be advantageous and could be viewed in a more favorable light if wood prices F.O.B. millyard were used.

Other benefits of drainage include an increased size of individual trees and higher volumes per hectare. This will reduce operating costs when the stands are harvested.

Fertilization has an additive effect when used with drainage. According to these and other studies, however, fertilization produces shorter term (5–10 years) effects and might be considered as an opportune treatment if carried out closer to the anticipated time of harvest. The value of the product (pulpwood versus sawlogs) will dictate the fertilization investment decision.

Finally, consideration must be given to the fact that drainage has long-term growth benefits in that it adds to the productive land base. Such benefits will extend beyond a single rotation.

Table 3. Gross stumpage value ($/ha) of the initial and final total merchantable volumes, and those portions due to natural growth and to drainage, in the Abitibi drainage area.

	Stumpage value ($/ha)			
	Initial	1969 $		
Treatment	(1929)	Drained	Natural	Response[a]
Drained Area	38.18	184.48	75.34	109.12
Control Area	35.88	-	70.84	-

[a] Response to drainage = value for drained plots minus value for natural plots.

REFERENCES AND FURTHER READING

Haavisto, V.F. 1984. Peatland forest drainage in northern Ontario: a Finnish approach. p. 5-6 *in* C.A. Plexman, ed. Dep. Environ., Can. For. Serv., Sault Ste. Marie, ON. Forestry Newsletter, Fall/Winter Issue.

Hannula, O. 1971. The effect of average stand diameter on tree length logging costs. Pulp Pap. Mag. Can. 72:(2)96–100.

Heikurainen, L. 1980. Drainage condition and tree stand on peatlands drained 20 years ago. Acta For. Fenn. 167. 39 p.

Jones, R.K.; Pierpont, G.; Wickware, G.M.; Jeglum, J.K.; Arnup, R.W.; Bowles, J.M. 1983. Field guide to forest ecosystem classification for the Clay Belt, Site Region 3e. Ont. Min. Nat. Resour., Maple, ON. 123 p.

Ketcheson, D.E.; Jeglum, J.K. 1972. Estimates of black spruce and peatland areas in Ontario. Dep. Environ., Can. For. Serv., Sault Ste. Marie, ON. Inf. Rep. 0–X–172. 29 p.

McEwen, J.K. 1966. An effect of *Sphagnum* on the growth of black spruce. For. Chron. 42(2):175–183.

Payandeh, B. 1973a. Analysis of a forest drainage experiment in northern Ontario. I. Growth analysis. Can. J. For. Res. 3:387–398.

Payandeh, B. 1973b. Analysis of a forest drainage experiment in northern Ontario. II: An economic analysis. Can. J. For. Res. 3:399–407.

Payandeh, B. 1982. Five-year growth response of peatland black spruce to drainage and fertilization. Dep. Environ., Can. For. Serv., Sault Ste. Marie, ON. Inf. Rep. O–X–340. 20 p.

Payandeh, B. 1989. Growth of black spruce trees following fertilization on drained peatland. For. Chron. 65:102–106.

Rosen, M.R. 1986. Management plan for the Wally Creek area forest drainage project. Ont. Min. Nat. Resour., Cochrane, ON. File Rep. 88 p.

Sundström, E. 1992. Five-year growth response in drained and fertilized black spruce peatlands. I. Permanent growth plot analysis. For. Can., Ont. Region, Sault Ste. Marie, ON. Inf. Rep. O–X–417. 19 p. + appendices.

Dr. Bijan Payandeh, of the Canadian Forest Service – Ontario, conducts modeling studies on forest regeneration systems and on growth and yield of major forest types in Ontario.

Dr. Erik Sundström, visiting from the Swedish University of Agricultural Sciences in Umeå, Sweden, studied growth response of black spruce to drainage at the Wally Creek Drainage Project.

Bob Haig is a retired former deputy regional director of the Canadian Forest Service – Ontario. He prepared this technical note under contract.

Bijan Payandeh

Eric Sundström

Bob Haig

The preparation of this note was funded under the Northern Ontario Development Agreement's Northern Forestry Program.

Additional copies of this publication are available from:

Natural Resources Canada
Canadian Forest Service – Ontario
Great Lakes Forestry Centre
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7
(705) 949-9461
(705) 759-5700 (FAX)

Catalogue No. Fo 29–29/64E
ISBN 0–662–22604–6
ISSN 1183–2762

This technical note is printed on paper containing recycled material.