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THE EFFECTS OF MANURE ON A WHITE AND NORWAY SPRUCE PLANTATION AT GRAND'MÈRE, QUEBEC

by
J. D. MacArthur

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CONTENTS

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(Project Q–11)

by

J. D. MacArthur[1]

INTRODUCTION

Reforestation has long been advocated for making profitable use of abandoned farm lands, and during the past half century thousands of acres in Eastern Canada have been planted, with varying degrees of success. Exhausted soil, incorrect choice of species or strains, and omission of essential cultural measures have all contributed to the failures which have occurred. On the other hand many plantations have been successful, and a description of the means by which good results have been obtained may help reduce failures in the future.

The oldest and most extensive project from which lessons can be learned about spruce plantations is the 15-square-mile plantation at Grand'Mère, Quebec, now belonging to the Consolidated Paper Corporation, where planting on a large scale began in 1920. This plantation was examined in 1946 and reported upon by Cunningham (1).

Several experiments were set out at the beginning of the planting project to study some of the factors influencing growth and survival. These have been followed by permanent sample plot studies and some are now providing interesting results. This report describes one such experiment in which the yields of white and Norway spruce were greatly increased by fertilization with farmyard manure. Norway spruce in this experiment surpasses white spruce in growth and compares favourably with the better stands of Norway spruce in Great Britain.

DESCRIPTION

A plantation of white and Norway spruce covering about 3 acres was established in June, 1920, by the Laurentide Company to test the effects of farmyard manure on growth. The experiment is situated on lots 25–2 and 25–3 in Radnor Township just west of the Grand'Mère–La Tuque highway. According to the plantation records the site was formerly pine land that had been cleared and farmed for some time before planting, but the records do not indicate for how long. The soil is deep, sandy, and fairly dry, and the ground is flat. The manure was spread at rates of 15 and 30 tons per acre and ploughed in before the trees were planted.

The seed source is not definitely known, but it is thought that the Norway spruce (*Picea abies* (L.) Karst.) was collected in the Swedish Province of Norrland. According to the records, the white spruce seed was collected in the Black Hills of South Dakota, and is therefore presumed to be the western variety (*Picea glauca* (Moench) Voss var. *albertiana* (S. Brown) Sarg.).

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[1] Research forester, Quebec District Office, Valcartier, P.Q.

The planting stock was selected 2–2 transplants grown in the Company nursery, near Grand'Mère. The trees were spade planted at 5 feet by 5 feet spacing, and five permanent sample plots were established to follow the experiment. Plot numbers, areas, and treatments were as follows:

PSP Number	Species	Area (acres)	Treatment
36	White spruce	0.47	30 tons manure per acre
37	White spruce	0.47	15 tons manure per acre
38	White spruce	1.00	control
40	Norway spruce	0.46	30 tons manure per acre
41	Norway spruce	0.46	15 tons manure per acre
	Total Area	2.86	

N.B.—No unmanured control plot for Norway spruce.

The sample plots include all the Norway spruce and nearly all the white spruce planted. The plots were laid out side by side with no isolation strips to separate the treatments. PSP's 36 and 40 are bounded by a road only three feet distant from the plots.

In 1939, the four manured plots were pruned and a few suppressed trees were removed. In 1950 higher pruning was done and in 1953 additional suppressed trees were removed. A further removal of suppressed trees from the Norway spruce plots took place in 1957. The white spruce control plot, PSP 38, was not treated.

In June, 1920, immediately after planting, the heights of all seedlings were measured and their location mapped. In September, 1922, and May, 1925, the plots were remeasured to compare mortality and height growth. In 1946 and 1956, diameter and height measurements were taken and height–diameter curves and local volume tables prepared for each species. During the later remeasurement a tally of stumps resulting from the 1953 thinning was made and also a tally of the trees marked for removal in 1957.

RESULTS

Figures for mortality, height, diameter, standing volume, yield, increment and stem distribution are given in Tables 1 to 4. Various comparisons are made between manured and unmanured plots, between white and Norway spruce, and with Norway spruce, Quality II, in Great Britain. As a control plot of Norway spruce was not established, unmanured stands of this species in the vicinity are used for comparison.

Mortality: Table 1 shows the per cent mortality up to 1946 on all five plots, based on the number of trees planted. It is assumed that the few suppressed trees removed in 1939 would have died during the next seven years and they have therefore been included in the mortality figures for 1946. Figures are not shown for 1956 because the heavier thinning of 1953 undoubtedly removed many trees which would otherwise have lived until 1956.

TABLE 1.—PER CENT MORTALITY 1922–1946

Date	White Spruce		Control	Norway Spruce	
	30 Tons	15 Tons		30 Tons	15 Tons
September 1922	2.0	2.0	1.6	2.0	1.4
May 1925	2.0	2.0	8.0	2.0	2.0
August 1946	30	34	36	29	33

FIGURE 1.—White spruce control plot, untreated. Marked tree is 4 inches d.b.h. Photo taken in the best part of the plot bordering the Norway spruce, June 1957. Total volume in 1956, 956 cubic feet; average height, 32 feet. Planted 1920, 37 years old.

FIGURE 2.—White spruce manured plot, 30 tons per acre. Marked tree is 6 inches d.b.h. Trees have been pruned and light thinnings of suppressed trees have been made. Total volume in 1956, 2,420 cubic feet; average height, 40 feet.

The low mortality for the first two years on all five plots indicated good planting. At the end of five years mortality was 2 per cent on the manured plots but had risen to 8 per cent on the white spruce control. By 1946 it was approximately the same on all plots and ranged from 29 per cent to 36 per cent. On the manured plots most of the mortality was the normal result of the intense competition for growing space; but on the white spruce control plot, the mortality was mainly caused by adverse site factors.

Height Growth: Table 2 shows average heights up to 1956 for all plots. The averages for 1920, 1922, and 1925 are averages of measured heights. For 1946 and 1956 they are the heights of trees of average basal area taken from the height-diameter curves. From the start the height growth of the manured Norway spruce exceeded that of the manured white spruce which in turn surpassed that of the white spruce control. The height of the Norway spruce would have been even greater had it not been damaged by the white pine weevil. By 1956 Norway spruce had attained an average height of 52 feet, manured white spruce 40 feet, and the white spruce on the control plot only 32 feet.

TABLE 2.—AVERAGE HEIGHT IN FEET 1920–1956

Date	White Spruce		Control	Norway Spruce	
	30 Tons	15 Tons		30 Tons	15 Tons
June 1920	0.9	0.9	0.9	1.0	0.9
September 1922	1.9	1.8	1.6	2.2	2.1
May 1925	3.3	3.4	2.4	3.8	3.9
August 1946	30	31	20	38	38
October 1956	40	41	32	52	52

It will be noted that the average height of the white spruce control increased more between 1946 and 1956 than did that of the manured white spruce. On all plots part of the increase in average height was an artificial increase caused by the elimination of the smallest trees by mortality and cutting. This was more marked on the white spruce control plot, where mortality reduced the number of trees by 48 per cent during the period, than on the manured plots where only 32 per cent of the trees died or were cut. A better indication of the current height growth is obtained by comparing the average heights in 1947 and 1956 of the 100 largest trees on each plot (Table 3). This increased 16 feet on the Norway spruce plots, six feet on the manured white spruce plots, and only four feet on the white spruce control plot.

Volume Growth: Growth data for the 1946 and 1956 measurements are given in Table 3. The volumes of thinnings were calculated from the 1946 diameters of trees removed in 1953 and are therefore somewhat lower than the true volumes. However, since only suppressed trees were cut the difference is believed to be slight. Average diameters were calculated from the tree of average basal area and the corresponding average heights were obtained from the appropriate height-diameter curve. Volumes are for all trees one inch in diameter and larger, and include stumps and tops.

FIGURE 3.—Norway spruce manured plot, 30 tons per acre. Marked tree is 9 inches d.b.h. Total volume in 1956, 4,920 cubic feet; average height, 52 feet.

FIGURE 4.—Norway spruce manured plot, 15 tons per acre. Marked tree, the largest on the plots, is 12 inches d.b.h., 69 feet high. Total volume, 4,380 cubic feet; average height, 52 feet.

TABLE 3.—COMPARATIVE TABLE OF GROWTH AND YIELD 1920–56

Per Acre	White Spruce		Control	Norway Spruce	
	30 Tons	15 Tons		30 Tons	15 Tons
Number of Trees—					
1946	1,149	1,131	1,150	1,198	1,139
1956	784	765	596	855	731
Basal Area—					
(Sq. Ft.) 1946	138	139	66	192	178
1956	130	140	60	204	180
Average Diameter—					
(Inches) 1946	4.6	4.7	3.3	5.4	5.4
1956	5.5	5.8	4.3	6.6	6.7
Average Height—					
(Feet) 1946	30	31	20	38	38
1956	40	41	32	52	52
Average Height of 100 Largest Trees—					
(Feet) 1946	39	39	35	42	42
1956	45	45	39	58	58
Standing Volume—					
(Cu. Ft.) 1946	2,060	2,110	840	3,470	3,220
1956	2,420	2,640	956	4,920	4,380
Thinned Volume—					
(Cu. Ft.) 1953	280	320	.....	540	720
Yield—					
(Cu. Ft.) 1956	2,700	2,960	956	5,460	5,100
M.A.I.—					
(Cu. Ft.) 1920–46	76	78	31	128	119
1920–56	73	80	26	148	138

Stand Tables: Table 4 shows the diameter distribution of Norway and white spruce and the heights for each diameter class, taken from individual height-diameter curves for each plot. The two Norway spruce plots and the two manured white spruce plots were combined. Nearly 70 per cent of the Norway spruce trees are between 6 and 8 inches in diameter and the height-diameter curve flattens off at 60 feet. The bulk of the manured white spruce stand is 4 to 6 inches d.b.h., the control 3 to 5 inches, and the maximum curved height is only 50 feet on the manured plot.

TABLE 4.—STAND TABLE AND AVERAGE HEIGHTS 1956

Diameter (inches)	White Spruce Manured (2 plots)		White Spruce Control (1 plot)		Norway Spruce Manured (2 plots)	
	Number	Height	Number	Height	Number	Height
1	.....	.....	8	10	.....	.....
2	.....	.....	60	17	.....	.....
3	17	28	154	24	4	33
4	132	34	159	31	55	39
5	229	38	116	36	126	44
6	257	42	75	38	245	49
7	101	44	20	41	157	53
8	33	46	4	42	146	57
9	3	48	1	43	40	58
10	2	50	.....	.....	14	59
11	.....	.....	.....	.....	2	60
12	.....	.....	.....	.....	2	60
Per Acre	774		597		791	

Effects of Manure: The manured white spruce plots are greatly superior to the control plot with respect to diameter and volume, and to a lesser degree with height. The mean annual increment to 1956 on the manured plots was about 76 cubic feet, three times that of the control. Comparison with other stands in the vicinity, also measured in 1946 (1), shows that at that time the manured white spruce was the best in the whole plantation.

Substitutes for a control plot in Norway spruce can be found in nearby untreated plantations of approximately the same age. Cunningham (1) found in 1946 that the average growth of the manured Norway spruce (3,340 cubic feet at 27 years, M.A.I. 124 cubic feet) was three times that of untreated stands of the same age; the average height and diameter of untreated stands were 22 feet and 3.3 inches compared to 38 feet and 5.4 inches on the manured plots. Again, in 1956, growth of untreated Norway spruce on a sample plot in another plantation (3,220 cubic feet at 43 years, M.A.I. 75 cubic feet) was much less than on the younger manured plots (5,280 cubic feet at 37 years, M.A.I. 143 cubic feet), and the height and diameter were only 40 feet and 5.0 inches compared to 52 feet and 6.7 inches.

It is interesting to note that doubling the amount of manure did not increase the growth in either white or Norway spruce. A lower rate of application might have given equally good results.

Comparison of White and Norway Spruce: On the manured plots Norway spruce has greatly exceeded white spruce in height and diameter growth and it has produced almost twice as much wood in the 37 years since planting. Also, the appearance of the Norway spruce on the manured plots is healthy and vigorous in contrast to the white spruce which, with its moss-covered trunks and branches, short crowns and leaders and short yellowish needles, is obviously in poor condition despite its fairly good volume growth.

While it must not be overlooked that the western variety of white spruce used in this experiment is practically an exotic at Grand'Mère, it seems unlikely that even a local strain of white spruce would have approached the growth rate of the Norway spruce. Some evidence of this may be found in Cunningham's figures (1).In an untreated plantation of mixed Norway and white spruce, he found that at 26 years the average height and diameter of white spruce were only 15 feet and 2.2 inches as compared to 20 feet and 3.0 inches for Norway spruce.

Comparison with British Yield Table: The value of Norway spruce as a plantation tree is clearly shown by this study. Although the manured plots have been only lightly thinned, the growth has been remarkable even by comparison with more intensively managed stands in Great Britain. The average height of the 100 largest trees per acre is 58 feet which falls between the figures for Norway spruce Quality Class I (64 feet), and Quality Class II (55 feet) given in the British Forestry Commission yield tables (2). In number of trees per acre, average height, basal area and standing volume, the manured Norway spruce slightly exceeds the yield table figures for Quality Class II, but falls below in average diameter, yield and mean annual increment. With almost 800 trees per acre the stand is too dense and it is likely that the yield could have been appreciably increased by more frequent and intensive thinning.

CONCLUSIONS

Results of this experiment in manuring forest plantations, the first of its kind in Canada, show that farmyard manure applied to depleted soils at the time of planting greatly increased yield during the first 37 years. Addition of 15 tons per acre gave as good results as 30 tons, and less may have been sufficient. Because farmyard manure is not available in quantity sufficient for large-scale reforestation of run-down soils, such as certain abandoned farmlands, research is being conducted by the Forestry Branch, the Department of Agriculture and the Consolidated Paper Corporation to determine what kind and quantity of chemical fertilizer might restore similar areas to a level of fertility where increased yield of spruce is ensured.

In this experiment Norway spruce has shown a much higher rate of growth than white spruce, though this conclusion is tempered by the fact that the white spruce is believed to be a western variety.

The remarkable growth of Norway spruce on the manured plots demonstrates the possibilities of this species in Quebec. Comparison with British yield tables indicates that the Grand'Mère stand is better than Quality Class II, which is above average in Europe. The value of the strain on fertilized soils has been clearly established by 40 years of observation and it can therefore be recommended with confidence as a source for propagation material in future.

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