LOCOMOTIVE SMOKE DAMAGE TO JACK PINE ¹

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ABSTRACT

Soot-laden smoke emanating from a railroad roundhouse suppressed the growth of jack pine trees (Pinus banksiana Lamb.) located in the immediate vicinity. A close correlation was found to exist between the annual wood increment of these trees and the numbers of steam engines serviced in the roundhouse each year.

INTRODUCTION

At Chalk River, Ontario, the Canadian Pacific Railway Company has operated a roundhouse since 1912 for the purpose of servicing coal-burning engines. This roundhouse, containing 15 stalls, was used extensively as a divisional point for train crews from Ottawa and North Bay. With the advent of diesel locomotives in 1953, the use of the roundhouse diminished gradually, until, by the winter of 1959-60, only one steam locomotive was serviced daily.

Soot-laden smoke discharged from the engines being serviced passed through small chimneys projecting above each stall (Fig. 1), and was air-borne for distances of a few hundred yards from the roundhouse. Jack pine trees growing nearby appeared to be adversely affected by these emanations, and a study was undertaken to determine the extent of growth suppression of these trees.

The effects of smoke on tree growth were reported as far back as 1871 (Stockhardt), and 1913 (Clevenger). Both these investigators found that applications of soot alone to young firs did not produce any apparent injury to them, although slight injury was caused to the older needles of young jack pines. All coal contains some sulphur, and during combustion this escapes as sulphur dioxide gas. Felt and Rankin (1932) reported that soot and ashes falling on foliage carry with them a certain amount of sulphuric acid, with the soot itself causing injury by accumulating as a tarry coating on the leaves, clogging the stomates and interfering with the normal exchange of gases.

OBSERVATIONS

A pure, even-aged jack pine stand, about 45 years old, exists near the Chalk River railroad station. This tract of timber grows on a fairly uniform sandy site, with similar ground vegetation throughout. Adjacent to the roundhouse, and at a distance of approximately one mile, a 3-tree sample representing average conditions in each area was felled and dissected. Each felled tree was examined for age, total height, diameter at breast height, lengths of current and one-year-old foliage and terminal leaders, bud development, and annual wood increment.

In every detail the similarly-aged jack pine trees located at a distance, exhibited far superior growth to those trees occurring in the immediate vicinity

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TABLE 1
THE HEIGHT AND DIAMETER GROWTH OF JACK PINE TREES IN LOCATIONS
ADJACENT TO AND AT A DISTANCE FROM CHALK RIVER ROUNDHOUSE

Location of trees	Age at stump height (yrs.)	Total height (ft.)	Diameter at breast height (in.)
Adjacent to roundhouse	44	26.4	4.8
	47	23.3	5.5
	43	28.0	4.9
Approximately one mile from roundhouse	44	54.2	8.2
	44	53.8	8.4
	40	55.0	7.8

of the roundhouse (Figs. 2-5). Table 1 shows the measured heights and diameters for these trees in both locations.

In examining the annual wood increment of these trees, a peculiar growth pattern was observed in all the smoke-affected jack pine trees. Between an initial and a final period of suppressed growth was a period of fast growth. This type of growth sequence in jack pine is very rare. In a cull study of that species conducted throughout northern Ontario, 3,412 trees were classified as to growth pattern, and only 27 belonged in this category.³ In all the non-affected trees, there was a normal, gradually decreasing rate of annual wood increment from pith to periphery (Fig. 5), corresponding to progressive mutual suppression in the stand.

Scrutiny of weather records for the Chalk River area revealed no anomalies to account for the peculiar growth of the trees adjacent to the roundhouse. Further, no logging operations were conducted in this area, which might explain a release of the trees with resultant increased wood growth.

Additional examination of the actual years of slow and fast growth in the smoke-affected trees indicated a connection with the economic conditions occurring in Canada during those years. The Canadian Pacific Railway Company provided a record of the roundhouse operations at Chalk River for the years 1927-1953. Data in Table 2 show the relationship between rainfall, radial growth of non-affected and smoke-affected jack pine trees and servicing of steam engines at Chalk River during 3 decades.

In order to compare the radial growth of smoke-affected trees with the numbers of engines serviced at Chalk River each year, the regression line: $Y = -.025 X + 18.614$ was fitted to the average values for ring width (Y) and for the average numbers of engines (X) dispatched monthly during each year in question. This fit was found to have a correlation coefficient = -0.8091 , a figure which is significant at the 0.1 per cent level. In Fisher and Yates (1953) the values for the correlation coefficient with $24 - 4 = 20$ degrees of freedom are: $r_{.05} = 0.4227$, $r_{.01} = 0.5368$ and $r_{.001} = 0.6524$.

It is clear that the servicing of steam engines at Chalk River declined appreciably between 1930 and 1940. Apparently, the reduction in the amount of smoke emitted during these years allowed the trees to grow at an increased rate during that period.

³ Basham, J. T.—unpublished data.

TABLE 2

RELATIONSHIP BETWEEN RAINFALL, RADIAL GROWTH OF JACK PINE TREES,
AND ENGINE DISPATCH FROM ROUNDHOUSE AT CHALK RIVER, ONTARIO

Year or Period	Average monthly rainfall ¹ (May to August) in inches	Radial growth in 100ths of an inch		Average monthly dispatch of engines ²
		Non-affected trees	Smoke-affected trees	
1921	—	13	2	—
22	—	12	4	—
23	—	18	3	—
24	—	21	3	—
25	—	19	5	—
26	—	24	6	—
27	—	23	3	447
28	—	20	2	464
29	—	13	3	436
1930	—	17	3	402
1921-1930 (average)	—	18.0	3.4	437
1931	2.01	18	7	327
32	3.12	18	11	301
33	3.35	15	15	290
34	2.44	13	15	217
35	3.41	13	15	207
36	3.73	13	14	231
37	2.28	11	16	255
38	2.73	12	15	241
39	3.75	10	12	219
1940	4.20	6	11	298
1931-1940 (average)	3.13	12.9	13.1	258
1941	1.67	6	11	461
42	2.70	7	9	534
43	3.27	7	6	657
44	2.57	7	3	638
45	2.32	9	3	703
46	2.93	8	3	694
47	3.66	6	2	716
48	3.04	6	1	620
49	2.97	5	2	530
1950	3.42	5	3	476
1941-1950 (average)	2.83	6.6	4.3	603

¹ Weather records available from 1931 only.

² Engine dispatch records available from 1927 only. The lowest number of engines serviced was 179 in June, 1939, and the highest number was 848 in March, 1946.

- FIGURE 1. Portion of roundhouse at Chalk River, with chimneys projecting above each stall.
FIGURE 2. Smoke-affected jack pine trees with roundhouse chimneys in background.
FIGURE 3. Normal jack pine trees located at a distance of approximately one mile from roundhouse.
FIGURE 4. Smoke-affected jack pine trees growing in the area adjacent to the roundhouse.
FIGURE 5. Discs removed at butt level from jack pine trees in September, 1959, showing annual wood increment. The disc at left is from a normal tree and the disc at right is from a smoke-affected tree.

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