# FERTILIZATION AND STRIP THINNING IN 45-YEAR-OLD JACK PINE IN ONTARIO

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## ABSTRACT

Fertilization with nitrogen and phosphorus was carried out on a 45-year-old jack pine (*Pinus banksiana* Lamb.) stand in which a commercial strip-thinning operation had been conducted the previous year. The same fertilizer treatments were carried out on portions of an adjacent unthinned control stand.

Despite a 40% reduction in growing stock, trees in the thinned portion produced as much total volume increment as did the unthinned control over a 4-year period. A fertilizer treatment of N 168 kg/ha plus P 112 kg/ha on the thinned stand produced 5 $m^3$/ha and 7.5 $m^3$/ha more wood (total volume) than did the thinned and unthinned controls, respectively.

In the unthinned portion of the stand, total volume increment increased with increasing fertilizer N to the N 336 P 112 kg/ha level, which produced 17 $m^3$/ha over the control.

It is suggested that strip thinning and fertilization deserve greater consideration in jack pine silviculture.

## RÉSUMÉ

On a fertilisé à l'azote et au phosphore un peuplement de Pin gris (*Pinus banksiana* Lamb.) âgé de 45 ans, qui avait subi une coupe commerciale d'éclaircies par bandes un an auparavant. On a appliqué le même traitement de fertilisation à des portions témoins d'un peuplement voisin non éclairci.

Malgré une diminution de 40% du matériel sur pied, les arbres de la portion éclaircie ont produit un accroissment de volume total aussi important que la portion témoin non éclaircie, au cours d'une période de 4 ans. Une fertilisation à raison de N 168 kg/ha plus P 112 kg/ha du peuplement éclairci a produit plus de bois (5 $m^3$/ha et 7.5 $m^3$/ha) (volume total) que les portions témoins éclaircies et non éclaircies, respectivement.

Dans la portion non éclaircie du peuplement, l'accroissement de volume total augmenta en proportion de l'augmentation de N, jusqu'au niveau N 336, P 112 kg/ha, qui produisit 17 $m^3$/ha de plus que le témoin.

L'auteur propose de donner plus d'importance aux coupes d'éclaircies par bandes subséquemment fertilisées dans les traitements sylvicoles du Pin gris.

## TABLE OF CONTENTS



Cover photo: Courtesy of Ontario Ministry of Natural Resources, Chapleau, Ontario.

# INTRODUCTION

It is generally accepted in silvicultural theory that tree spacing influences growth and that average diameter and volume increment of heavily stocked stands can be improved by thinning. Tree spacing has been found to affect productivity of loblolly pine (*Pinus taeda* L.) (Balmer et al. 1975) and commercial thinning is recommended for improving productivity of slash pine (*P. elliottii* Engelm. var. *elliottii*) in the southern United States. Several studies have evaluated the effect of thinning on boreal forest species (Steneker 1969, van Nostrand 1973, Bella and De Franchesi 1974). Steneker (ibid.) and Bella and De Franchesi (ibid.) found that 40-year-old jack pine (*P. banksiana* Lamb.) showed a modest response while 60-year-old black spruce (*Picea mariana* [Mill.] B.S.P.) showed little response to thinning. To date, only a few reports have examined thinning in combination with fertilizer application to boreal forests. One study in 55-year-old jack pine in northwestern Ontario tested growth response to three levels of thinning by basal area (BA) reduction and six nitrogen (N) and phosphorus (P) fertilizer treatments (Hegyi 1974, Winston 1974, Morrison et al. 1976). Maximum volume increments were obtained with a combined treatment of 20% basal area removal and N supplied as urea at a rate of 672 kg N/ha (Hegyi 1974). Weetman (1968) reported that 65-year-old black spruce responded to both fertilizer N at 448 kg/ha and BA thinning with an additive combination effect.

As part of a program to assess the effects of fertilizers and other silvicultural treatments on jack pine growth in northern Ontario, a fertilizer-plus-strip-thinning experiment was established in 1971 near Chapleau, Ontario. The stand, a 45-year-old even-aged jack pine forest of fire origin, was commercially strip-thinned in late 1970 by a conventional short-wood method, and yielded a profit to the contractor (Mattice and Riley 1975). The present report describes 4-year growth responses to several fertilizer levels applied to the thinned stand and to an adjacent unthinned portion of the same stand.

# METHOD

## *General Stand Information*

The experiment is located in Nimitz Township, Ontario (latitude 47°38'N, longitude 83°15'W) approximately 25 km south-southeast of the town of Chapleau. This places it within the Missinaibi—Cabonga Section (B7) of the Boreal Forest Region (Rowe 1972) and astride the boundary of Sites 3E and 4E of the Ontario Site Classification (Hills 1960). The overall climate is modified continental, and it is in the Height of Land Climatic Region (Chapman and Thomas 1968). The average length of growing season based on a 5.5°C index is approximately 161 days, extending roughly from May through September inclusive (Chapman and Thomas 1968).

Mean total precipitation, measured at the nearest weather station (Chapleau), is approximately 81 cm annually with approximately 53% of this falling during the growing season (Anon. 1973). Potential evapotranspiration within the area was estimated at 48 cm annually (Chapman and Thomas 1968).

*Stand Description*

The stand, at the beginning of the experiment, was a 45-year-old, relatively pure, close jack pine forest of fire origin. Mean dominant height was approximately 13.7 m, mean diameter at breast height (DBH) was 13.9 cm and the BA was 28.7 $m^2$/ha. This corresponds to Plonski's (1974) Site Class II.

## PRELIMINARY INVESTIGATIONS

*Soil and Foliage Analysis*

Within the stand three soil pits were dug and samples were collected for analysis. The soil is a Mini Humo-Ferric Podzol (Anon. 1974). Tree roots predominate in the H and to some extent the B horizons, with little rooting development in the Ae and virtually none in the C horizons. The site is dry and well-drained. Litter and organic matter buildup is moderate in depth (3-7 cm); charcoal from the 1922 fire is common throughout the F and H horizons. The B horizon is a sandy loam, while the C is a loamy sand with stones.

Foliar samples were collected from the upper crowns of randomly selected trees in the fall of 1970, and analyzed by standard techniques. When the results of these analyses were compared to suggested standards (Swan 1970), the following indications of nutrient status were obtained: N between deficiency and sufficiency; P acutely deficient; Potassium (K) adequate; Calcium (Ca) barely sufficient; and Magnesium (Mg) between deficiency and sufficiency.

*Description of Experiment*

The experiment was a three-factor factorial experiment testing the response of semimature jack pine to N and P fertilizers singly and in combination with strip thinning.

All six combinations of three levels of N (supplied as urea) and two levels of P (supplied as triple superphosphate) were applied to both a thinned and non-thinned stand condition, at the following rates: N 0, 168, 336 kg/ha, and P 0, 112 kg/ha.

Thinning was done during August-December 1970, by hand, removing strips 4.6 m wide and leaving intermediate uncut strips 5.5 m wide (Mattice and Riley 1975). The six fertilizer treatments were replicated four times for a total of 24 plots. Treatment plots were square, with an area of 0.061 ha, each containing inner measurement plots with an area of .04 ha. Each measurement plot contained two uncut (leave) strips and two cut strips. Fertilizer was broadcast by hand in June, 1971 on the entire treatment plot. The treatment plots were separated by a buffer zone consisting of an uncut strip.

All trees within a measurement plot were identified by numbered metal tags and DBH was measured in June 1971, then remeasured in June 1975. Randomly selected trees were measured for height at the same time.

In the unthinned portion of the stand, fertilizer treatments were replicated twice for a total of 12 plots. Treatment plots were 0.081 ha in area and contained inner measurement plots of 0.020 ha. Buffer zones were provided by the portion of the treatment plot external to the measurement plot.

Mean DBH and BA increment were calculated in the usual manner using diameter measurements. Total and merchantable volumes, for both 1971 and 1975, were computed on a tree-by-tree basis for each plot using Honer's (1967) volume equations. Data were then subjected to analysis of variance as a completely randomized factorial experiment and Duncan's Multiple Range Test was used to compare differences between treatment means.

## RESULTS

At the time of initial measurement (immediately after thinning) in 1971, the unthinned plots contained approximately 62% more BA and volume than the thinned plots (Table 1). Despite this, the strip-thinned portion of the stand produced as much wood volume increment as the unthinned portion over the 4-year response period (Table 2). The thinned and unthinned controls produced merchantable volume increments of 18.3 and 17.4 $m^3$/ha, respectively. Furthermore, mean DBH increment was greater in the thinned stand than in the unthinned for any given fertilizer treatment. The greatest mean DBH increment (1.20 cm) was obtained in the thinned N 168 P 0 treatment while maximum mean BA increment and maximum total and merchantable volume increment were obtained with the thinned N 168 P 112 treatment. Response tended to decline after reaching a peak at the latter treatment level.

In the unthinned stand, maximum growth responses were obtained at the N 336 P 112 treatment level. Growth was significantly greater than in the control but not significantly greater than with most other

Table 1. 1971 and 1975 treatment means for semimature jack pine, Chapleau, Ontario (excluding trees lost by mortality 1971-1975)

| Treatments (kg/ha) | DBH (cm) | | Basal area ($m^2$/ha) | | Total volume ($m^3$/ha) | | Merchantable volume ($m^3$/ha) | | No. trees/ha | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1971 | 1975 | 1971 | 1975 | 1971 | 1975 | 1971 | 1975 | 1975 | mortality |
| Control | 15.2 | 15.9 | 30.4 | 32.8 | 205.9 | 223.5 | 174.4 | 191.8 | 1700 | 275 |
| P 112 | 11.4 | 12.1 | 24.3 | 27.5 | 155.0 | 179.0 | 118.1 | 142.1 | 2225 | 375 |
| N 168 | 13.2 | 14.0 | 26.6 | 30.0 | 177.8 | 203.1 | 148.2 | 172.6 | 1750 | 125 |
| N 168 P 112 | 11.6 | 12.2 | 30.2 | 33.7 | 194.0 | 220.1 | 148.0 | 173.5 | 2750 | 350 |
| N 336 | 13.0 | 13.9 | 27.0 | 30.7 | 178.2 | 205.4 | 144.8 | 172.2 | 1925 | 175 |
| N 336 P 112 | 12.2 | 13.2 | 28.4 | 33.0 | 185.0 | 219.4 | 145.5 | 179.7 | 2275 | 275 |
| Mean | 12.8 | | 27.9 | | 182.7 | | 146.5 | | | |
| Thinned | 12.4 | 13.5 | 18.9 | 21.6 | 124.9 | 145.0 | 102.3 | 120.7 | 1056 | 88 |
| Thinned P 112 | 11.4 | 12.3 | 13.9 | 15.9 | 89.2 | 104.0 | 68.6 | 82.6 | 943 | 276 |
| Thinned N 168 | 14.3 | 15.5 | 17.4 | 20.4 | 117.8 | 139.6 | 99.6 | 120.8 | 806 | 119 |
| Thinned N 168 P 112 | 11.9 | 13.0 | 17.7 | 21.1 | 115.7 | 140.7 | 91.2 | 116.0 | 1093 | 219 |
| Thinned N 336 | 11.3 | 12.4 | 14.9 | 18.0 | 95.6 | 118.7 | 72.6 | 95.1 | 1068 | 213 |
| Thinned N 336 P 112 | 12.8 | 13.9 | 15.2 | 17.9 | 100.8 | 120.6 | 88.2 | 101.3 | 860 | 218 |
| Mean | 12.4 | | 16.3 | | 107.4 | | 86.1 | | | |

Table 2. Effect of treatment on growth parameter increments (1975-1971) in 45-year-old jack pine in Chapleau, Ontario

| Treatments (kg/ha) | DBH increment (cm) | Basal area increment ($m^2$/ha) | Total volume increment ($m^3$/ha) | Merchantable volume increment | |
|---|---|---|---|---|---|
| | | | | ($m^3$/tree) | ($m^3$/ha) |
| Control | $.70^{bc}$ | $2.4^{bc}$ | $17.5^{bc}$ | .010 | $17.4^{bc}$ |
| P 112 | $.70^{bc}$ | $3.2^{bc}$ | $24.0^{bc}$ | .011 | $24.0^{bc}$ |
| N 168 | $.85^{abc}$ | $3.4^{abc}$ | $25.2^{abc}$ | .014 | $24.3^{abc}$ |
| N 168 P 112 | $.65^{c}$ | $3.5^{ab}$ | $26.1^{ab}$ | .009 | $25.5^{ab}$ |
| N 336 | $.90^{abc}$ | $3.6^{ab}$ | $27.2^{ab}$ | .014 | $27.4^{ab}$ |
| N 336 P 112 | $.95^{abc}$ | $4.6^{a}$ | $34.4^{a}$ | .015 | $34.2^{a}$ |
| Thinned | $.95^{abc}$ | $2.7^{bc}$ | $20.0^{bc}$ | .017 | $18.3^{bc}$ |
| Thinned P 112 | $.90^{abc}$ | $2.0^{c}$ | $14.8^{c}$ | .015 | $14.0^{c}$ |
| Thinned N 168 | $1.20^{a}$ | $2.9^{bc}$ | $21.7^{bc}$ | .026 | $21.1^{bc}$ |
| Thinned N 168 P 112 | $1.10^{ab}$ | $3.3^{abc}$ | $25.0^{abc}$ | .023 | $24.8^{abc}$ |
| Thinned N 336 | $1.10^{ab}$ | $3.1^{bc}$ | $23.1^{bc}$ | .021 | $22.4^{bc}$ |
| Thinned N 336 P 112 | $1.10^{ab}$ | $2.7^{bc}$ | $19.8^{bc}$ | .023 | $19.0^{bc}$ |

NOTE: Corresponding superscript letters in vertical columns denote no significant difference (P = .05).

treatments. Response tended to increase with increasing fertilizer level. A comparison of the merchantable volume growth increments indicates that the maximum was obtained in the unthinned N 336 P 112 treatment, and that there was a general response trend of fertilization > thinning + fertilization > thinning > control. Taken on a mean merchantable volume increment (MVI) per tree basis (Table 2) greatest growth response was obtained at the thinned N 168 treatment level. Thinning had the effect of almost doubling merchantable volume increment per tree over that of the control. Fertilization, without thinning, increased MVI but not as much as either thinning or thinning + fertilization.

## DISCUSSION

Two results have particular significance for forest managers. First, commercial strip thinning in a 45-year-old jack pine stand resulted in the growth of larger trees and the production of as much volume increment as the unthinned control despite a 40% reduction in growing stock. This suggests a possible shortening of the rotation and an increase in the yield of sawlog-size timber. The commercial thinning was performed at a profit and resulted in a greater net volume yield when thinned and final cut volumes are combined.

Net merchantable volume derived from the thinned stand can be calculated from mean data as:

$$V = I + M + T + G$$

$$= 86.1 + 6.3 + 60.5 + 18$$

$$= 170.9 \text{ m}^3/\text{ha}$$

Whereas for the unthinned stand:

$$V = I + G$$

$$= 146.5 + 18$$

$$= 164.5 \text{ m}^3/\text{ha}$$

Where V = net merchantable volume, I = initial volume in 1971 (not including mortality over the 1971-1975 period), M = merchantable volume captured in 1971 that would have been lost to mortality, T = merchantable volume harvested in the thinning operation, and G = merchantable volume increment over the 1971-1975 period.

The effects of thinning are even more striking when individual tree parameters are evaluated, namely DBH increment and merchantable volume increment per tree. Not only was DBH growth greater in the thinned stand, but also the MVI/tree was almost doubled by thinning.

Second, fertilization at the N 336 P 112 treatment in the unthinned stand produced a MVI of 34.2 $m^3$/ha. This represents a 100% increase over control, and an increase in site productivity from a Site II to an excellent Site I (Plonski 1974) with periodic annual increment being 8.6 $m^3$/ha/yr.

According to Hannula (1971), silvicultural treatments to increase diameter size will reduce logging costs. Furthermore, Tucker (1974) indicated that value added to incremental volume through reduced costs of harvesting, transporting and processing may make even small increments of wood by silvicultural treatment appear profitable. The profitability of fertilizers would depend on demand and supply conditions for specific situations. At current urea costs of $170.00 per metric ton, dosages of 336 kg N (730 kg urea) would cost $124.10/ha for material. The volume over control response of 16.8 $m^3$/ha at the N 336 P 112 unthinned treatment and of 8 $m^3$/ha at the thinned N 168 P 112 treatment level may be feasible where wood is in short supply, transport distances are excessive, etc.

A low cost, wide swath ground fertilizer applicator would reduce the cost of operational application, and increase efficiency of distribution in strip thinnings, where only the residual areas need fertilizing. This would reduce fertilizer quantities required by half.

In the thinned stand, fertilization (N 168 P 112) plus thinning produced a mean of 7.5 $m^3$/ha total volume over unthinned control. This increment is similar to that obtained by Morrison et al. (1976) in 55-year-old jack pine with a 20% BA removal and fertilizer addition of N 303 P 45. By comparison, a removal of 40% BA by Morrison et al. (ibid.) at N 151 P 45 yielded only 3.3 $m^3$/ha total volume increment over control.

Such a comparison suggests that the older stand was less able to respond to increased fertilizer levels, or that the method of strip thinning is somewhat superior to the basal area removal method used by Morrison et al. (ibid.).

Trends in the data indicate a beneficial effect from phosphorus in combination with nitrogen rather than nitrogen alone. This is consistent with foliage analyses reported earlier, suggesting not only a marginal supply of nitrogen but also acutely deficient phosphorus levels. However, the data do not indicate that the effect of phosphorus is significant at this time.

Strip thinning did not result in increased mortality (contrary to popular belief) and, on a percentage basis, losses were similar in thinned and unthinned plots. Thinning had the effect of capturing some of the merchantable volume that would have been lost to natural mortality.

## CONCLUSIONS

Commercial strip thinning in semimature jack pine deserves greater consideration as a silvicultural technique since it was found to yield larger residual trees and slightly greater net merchantable volume increment after the four-year response period. Fertilizer applications to unthinned or strip-thinned stands increased productivity and may be economically feasible under specific conditions of timber supply and operating cost.

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