FOREST MANAGEMENT NOTE

Note 54 Northwest Region

FERTILIZATION: A TOOL FOR MANAGING ASPEN IN WESTERN CANADA

With the increasing utilization of trembling aspen (*Populus tremuloides* Michx.) in recent years (Ondro 1989), the large aspen inventory in the prairie provinces may diminish to the extent that the fertilization of areas near the mills will be an option for improving wood volume and corresponding fibre production.

Information is limited on trembling aspen response to fertilization. A study undertaken in the Alaskan interior indicated that the application of nitrogen (N), phosphorus (P), and potassium (K) improved the height and diameter growth of 15-year-old aspen after two years (Van Cleve 1973), and that N fertilization increased bole and total above-ground tree biomass twofold over the controls after seven years (Van Cleve and Oliver 1982). The species was particularly responsive to a combination of N fertilization and thinning (Perala and Laidly 1989).

The Canada-wide Interprovincial Forest Fertilization Study (Krause et al. 1982, 1987) examined the responses of major commercial tree species to N, P, and K fertilization in pole-size stands. The Saskatchewan component included trembling aspen (labeled Sask. Installation No. 4), which was established in a 35-year-old stand near Hudson Bay. Following fertilization of N in combination with K and P, results showed that 5-year volume growth ranged from 26 to 37 $m^3 \cdot ha^{-1}$ for the treated plots over the control plots (Krause et al. 1982).

This note contains a 15-year update of the data and results from the Saskatchewan component of the interprovincial aspen study.

SITE DESCRIPTION AND TREATMENTS

The study area was located in Saskatchewan, about 30 km south of Hudson Bay (legal description: Tp. 42, Rng. 4, W2). The site consisted of 2 ha of moderately well-drained, level, loamy sand, which supported a 35-year-old aspen stand of about 4000 stems ha^{-1}; a 15% admixture of balsam poplar (*P. basamifera* L.) was included.

Two blocks composed of six square plots were established, each plot consisting of a 10 × 10 m inner plot within a 20 × 20 m outer plot. Treatments were applied randomly to the plots within a block (completely randomized design).

The six treatments consisted of a control and five fertilizer treatments: N1, N2, N2P, N2K, and N2PK, representing combinations of N at two levels (112 and 224 kg ha^{-1}) and a single level (112 kg ha^{-1}) of K and P, which were applied only in combination

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with the higher N level. Urea (44%N), triple superphosphate (45% P_2O_5) and potassium chloride (61% K_2O) were used as nutrient sources.

The fertilizer was broadcast manually by spreader in the latter part of April 1973. At the time of establishment, all living trees of at least 5-cm diameter at breast height (dbh) within the inner plots were numbered and measured for diameter. Remeasurements were taken on these plots 5 and 15 years after treatment, when all surviving trees were tallied by species and diameter. The height measurements of 15 to 20 trees on control plots were used to derive a height-diameter curve.

Periodic diameter increment was determined from diameter remeasurements: diameter increments were highly correlated with initial diameter, and therefore an adjustment was made for initial diameter.

The summing of individual tree basal areas and tree volumes provided plot values. Tree volume was estimated by using the equation of Honer et al. (1983), for which height was estimated from the height-diameter curve. Volume mortality was estimated for each period by plot.

RESULTS

Diameter

The 5-year periodic dbh growth of N2P, N2K, and N2PK treated plots ranged from 1.07 to 1.17 cm, versus 0.71 cm for unfertilized controls—a 51-65% improvement. After 15 years, the improvement was 29-41%, or 3.40-3.71 cm for the treated plots, versus 2.64 cm for the untreated. Diameter increment following the application of N2 alone was not statistically significant (Table 1).

Regression analysis of 15-year diameter increments over initial dbh showed that fertilization improved diameter growth in all diameter classes; greater response was observed among dominant and codominant trees on N2 and N2K plots (Fig. 1.).

Basal Area

Fifteen years after treatment, the basal areas of plots treated with N2K and N2PK increased by 50% and 39%, respectively, while basal areas on control plots showed only a 6% increase. However, these differences were not statistically significant (Table 1). Basal area growth on the control and N1 plots decreased due to mortality for trees from age

Table 1. Stand statistics at initial treatments in a 35-year-old aspen stand, and in 5-year and 15-year cumulative increments after treatment

Treatment[a] ($kg\ ha^{-1}$)	Dbh (cm)			Basal area ($m^2\ ha^{-1}$)			Total volume ($m^3 \cdot ha^{-1}$)			Mortality ($m^3 \cdot ha^{-1}$)	
		Cumulative increments			Cumulative increments			Cumulative increments		Cumulative increments	
	Initial	5-year	15-year	Initial	5-year	15-year	Initial	5-year	15-year	5-year	15-year
Control	8.52	0.71	2.64	24.86	1.78a[b]	1.57a	152.3	24.2c	52.2a	9.1a	43.1a
N1	9.17	0.73	2.60	21.98	2.30a	2.14a	140.8	28.1bc	49.5a	7.4a	43.9a
N2	8.38	0.85	2.91	31.20	3.45a	5.45a	196.2	40.5abc	89.8ab	9.2a	44.8a
N2P	8.30	1.07**[c]	3.40**	22.58	4.41a	6.90a	133.0	44.0ac	93.1ab	5.7a	36.5a
N2K	9.30	1.17**	3.71**	23.38	4.97a	11.67a	152.9	52.5ab	134.9ab	6.4a	25.4a
N2PK	9.03	1.08**	3.42**	31.36	4.67a	12.31a	196.8	55.8a	152.8b	14.8a	32.9a

[a]N1 = 112 kg ha^{-1}; N2 = 224 kg ha^{-1}; P = 112 kg ha^{-1}; K = 112 kg ha^{-1}.

[b]Treatment averages in the same column followed by different letters are significantly different (p = 0.05).

[c]Adjusted treatment averages are significantly greater (** = $P < 0.01$) than controls.

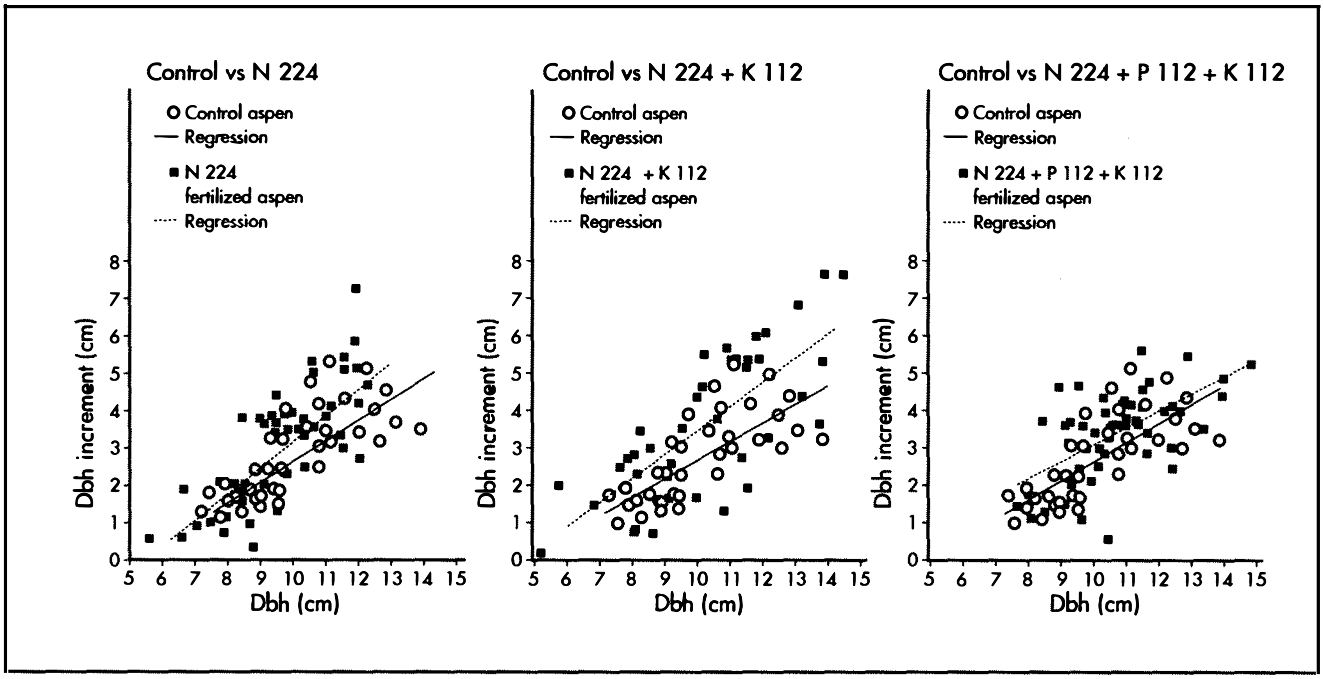

Figure 1. Regressions of 15-year diameter increments over initial diameter for aspen on control and fertilized plots.

40 to 50, but there was a continued response on N2, N2P, N2K, and N2PK plots (Fig. 2; Table 1).

Total Volume

Five years after fertilization, total volume increments on N2P, N2K, and N2PK plots ranged from 44.0 to 55.8 $m^3 \cdot ha^{-1}$, an increase of 80-130% over the 24 $m^3 \cdot ha^{-1}$ of the control plots. After 15 years, the N2PK treated plots had a total volume increment of 152.8 $m^3 \cdot ha^{-1}$—a nearly threefold improvement over the control plots with 52.2 $m^3 \cdot ha^{-1}$ (Fig. 3; Table 1).

The annual volume growth rate was about 3% on control plots in the first period (trees aged from 35 to 40 years) (Table 2). The rates on fertilized plots ranged from 3.7 to 6.1% in the same period. Although rates declined substantially on all plots for the next 10-year period, the N2K and N2PK plots still maintained their growth rate at about twice that of the control plots. In general, the annual volume growth rates of the stand from age 35 to 50 increased with the amounts of N applied; the N2K and N2PK plots (with the higher N level) consistently had the best growth rates.

Mortality

Fertilization had no effect on aspen mortality after either 5 or 15 years (Table 1). On plots where N was applied in combination with P or K, mortality was lower than on either the control plots or plots where only N was applied.

DISCUSSION AND CONCLUSION

Aspen is managed for many uses (DeBlye and Winokur 1985), but, in practical terms, total wood volume is the main criterion of fibre production. This study showed that, 15 years after fertilizing a 35-year-old aspen stand with 224 kg ha^{-1} N in combination with 112 kg ha^{-1} K (N2K) and P (N2PK), there was a threefold improvement in the volume growth rate of fertilized plots over the control plots (Table 2).

Although previous research in other regions had shown that aspen responded well to N fertilization (Van Cleve and Oliver 1982; Perala and Laidly 1989), data in this study indicated that on Luvisolic soils N alone did not improve diameter and stand volume growth. The lack of initial soil and foliar

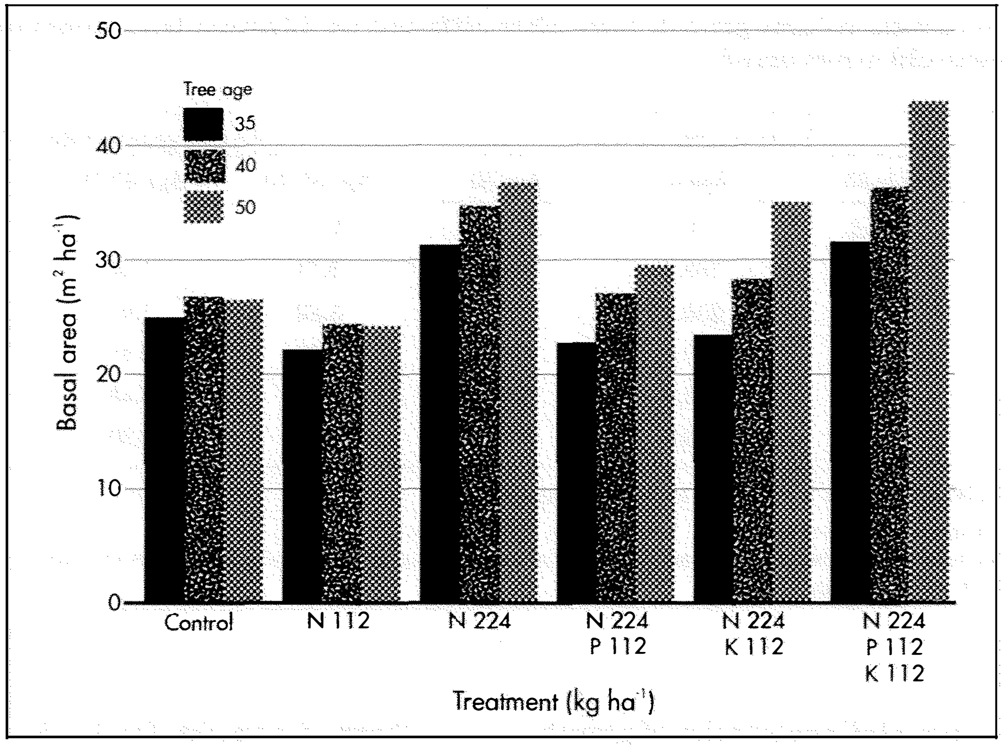

Figure 2. Initial, 5-year, and 15-year basal areas after different fertilizer treatments.

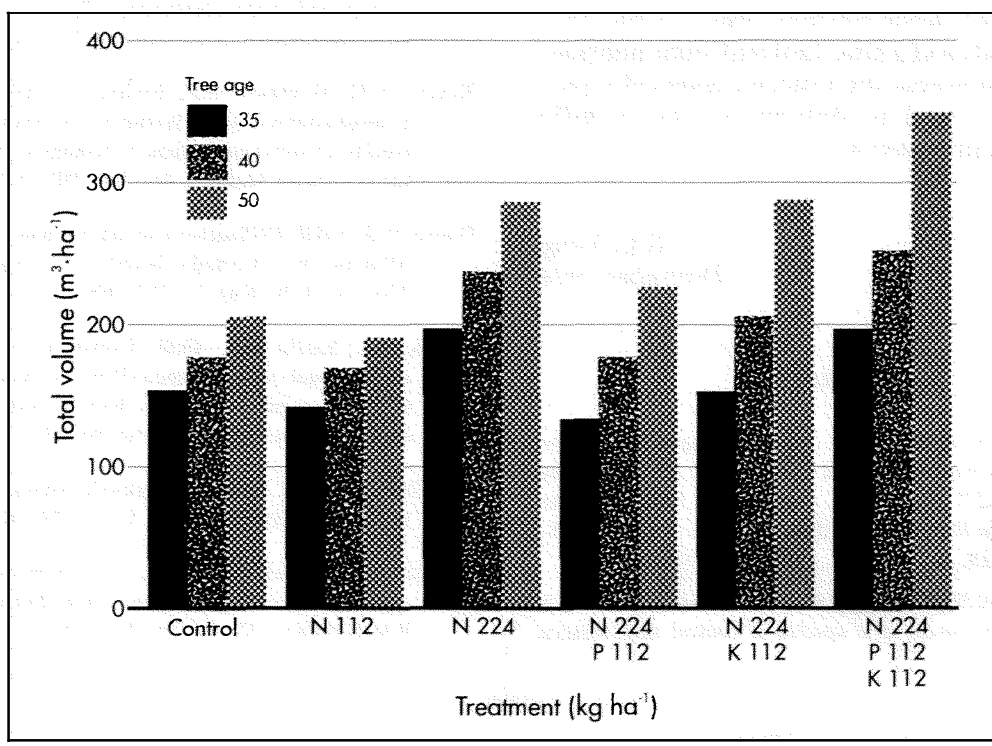

Figure 3. Initial, 5-year, and 15-year total volumes after different fertilizer treatments.

Table 2. Annual total volume growth rates after different fertilization treatments in a 35-year-old aspen stand

Treatment[a] ($kg\ ha^{-1}$)	Total volume ($m^3 \cdot ha^{-1}$)			Annual growth rate (%)[b]		
	Age 35	Age 40	Age 50	Age 35-40	Age 40-50	Age 35-50
Control	152.3	176.5	204.5	2.99	1.48	1.98
N1	140.8	168.9	190.3	3.71	1.20	2.03
N2	196.2	236.7	286.0	3.82	1.91	2.54
N2P	133.0	177.0	226.1	5.88	2.48	3.60
N2K	152.9	205.4	287.8	6.08	3.43	4.31
N2PK	196.8	252.6	349.6	5.11	3.30	3.90

[a]N1 = 112 $kg\ ha^{-1}$; N2 = 224 $kg\ ha^{-1}$; P = 112 $kg\ ha^{-1}$; K = 112 $kg\ ha^{-1}$.

[b]The equation for the annual growth rate (R) is: $V_0 * (1 + R)^n = V_t$ or $R(\%) = e^{[\ln(V_t/V_0)]/n} - 1$
where V_0 is initial total volume (beginning of period); V_t is final total volume (end of period); n is number of years in period; e = 2.71828; and ln is natural logarithm.

analyses prevents a full explanation of growth response to N. It is likely, however, that N alone may have accentuated P and K deficiencies in the soil.

The results of this study indicate that growth response to fertilization depends largely on the overall nutrient status of a site. Soil and foliar analyses are required to assess the nutrient levels of a particular stand, and to determine its specific fertilization requirements.

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