# FOREST MANAGEMENT NOTE

*Note 60* *Northwest Region*

## RELEASING WHITE SPRUCE FROM TREMBLING ASPEN—A YIELD ANALYSIS

In the boreal mixedwood forests of western Canada (Rowe 1972), pure aspen stands that originate after fire often have white spruce understory established in areas where seed source is available. Some of this understory persists until the aspen reaches maturity and starts to die out, thereby releasing the white spruce. Treatments to remove aspen along the way have been beneficial in releasing white spruce (Steneker 1963, 1967; Yang 1989), giving up to 82% improvement in volume growth of this white spruce component 35 years after release (Yang 1991).

These mixedwoods are a large and highly productive source of forest product in the prairie provinces. They have historically been a primary source of softwood, especially white spruce, while the hardwood component has been largely ignored (Brace and Bella 1988). The accelerating harvest of aspen in the last decade, and increasing recognition of the value of white spruce understory in recent years, present new management challenges and opportunities, particularly in mixed stands where both aspen and white spruce are grown and harvested on the same land base.

Treatments in the past ignored the aspen because it had little commercial timber value. Current increase in aspen use has made it more valuable, and the white spruce can now be released as a result of harvesting the aspen component. This development presents four questions to forest managers:

1) What are the yields of aspen and white spruce at rotation age with no release treatment?

2) What is the aspen volume that can be removed in a release operation?

3) What are release-related aspen volume loss and white spruce volume gain at rotation? and

4) What is total final yield at rotation (i.e., white spruce at rotation plus removed aspen)?

This forest management note describes and illustrates how releasing white spruce understory from trembling aspen overstory can substantially change yields of aspen and white spruce. As actual stand data are scarce or nonexistent, rough extrapolations from a white spruce tree release study are used for comparisons and analyses of yield that help answer the four questions. The yield values presented, therefore, are somewhat arbitrary, yet should be accurate enough to provide meaningful comparisons.

### METHODS

The white spruce release data came from a study located in a 50-km radius of Smith, in north-central Alberta. In 1951 and 1952, a total of 656 spruce trees were chosen in 25 dense, fully stocked stands between age 5 and 65 years; 333 were released and 323 used as controls (Lees 1966).

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The release operation removed and poisoned the stumps of all competing hardwood trees in a distance twice the radius of the spruce crown at its widest point. In 1987, a total of 370 sample trees (202 treated and 168 controls) were relocated and measured in 22 areas. Breast height diameters (dbh) and heights of study trees were measured. Aspen stumps tallied within the clearing provided estimates of the number of trees removed. For the control spruce, diameters and heights were tallied at the establishment of all trees within a distance of twice the open-grown crown radius of the study tree. (More detailed methods can be found in Yang [1991]).

Individual tree volumes were estimated with Honer's (1967) volume equations. Circular plot volumes equivalent to the above radius were converted on a per-hectare basis. This provided estimates of spruce and aspen tree numbers and volumes at various ages.

The original study was designed to assess white spruce growth response to individual release from aspen competition. Sampled trees were selected in areas where both spruce and aspen densities were somewhat higher than what generally occurs in mixedwood forests in this region. Furthermore, growing conditions created by this release were probably optimal for spruce development and would not be operationally feasible. To eliminate this potential positive bias in the results and approximate average density in release stands, yield estimates were subsequently reduced by 20%. Yield estimates after reduction are somewhat in line with published yields of mixed stands in this region.

In addition to the release study, supplemental data consisting of 229 single-examination plots established in spruce–aspen stands between 16 and 146 years of age (Johnstone 1977) were also analyzed to describe aspen density, dbh, and total volume over age in mixed stands.

## RESULTS AND DISCUSSION

Below are answers to the four questions posed in the Introduction. The values used to respond to these questions are tentative, and need to be interpreted carefully for specific local conditions when operational use is desired.

### Question 1: What are the yields of aspen and spruce at rotation age with no release treatment?

Aspen and white spruce had similar numbers of trees before age 55, but aspen numbers were generally higher thereafter; on average, there were twice as many aspen as spruce trees by age 95 (Table 1). Even with fewer trees, white spruce volumes were about 50% greater than that of aspen. Although some of these trends might be due to sampling variation and insufficient sample size, it is fair to suggest that removing aspen at 60–70 years would ensure greater volumes of merchantable spruce at rotation age.

Aspen total volume culminated at age 65, then declined slightly thereafter. Johnstone's (1977) interim yield table shows hardwood yields culminating at 70 years. At age 65, about 70% of aspen total volume was in stems over 18 cm dbh, and this proportion reached 95% at age 95.

White spruce stem volume in young stands was low and amounted to under 30% of aspen volume at age 45. Spruce volume increased with age, surpassed that of aspen at age 85 years, and reached 300 $m^3$/ha at age 95. This concurs with findings of MacLeod and Blyth (1955), who estimated the spruce component of mixed stands on good sites to be 384 $m^3$/ha at age 100.

The analysis described here used two estimates of aspen density in mixed stands: one was based on stump counts around released spruce trees, and the other on complete-tree tallies on untreated yield plots. The density estimates based on 1987 stump counts were quite similar to average densities in Alberta yield plot data (Fig. 1; Table 2). In contrast, tree numbers on the untreated tree plots were slightly higher than the average-yield plot densities in Saskatchewan, and much higher than Alberta yield-table values, probably because sample trees in the release study were located in the densest part of the stand. In general, these estimates for the tree plots are reasonably close to yield-table values.

### Question 2: What is the aspen volume that can be removed in a release operation?

Total volume of aspen ranged from 97 to 207 $m^3$/ha in untreated stands between ages 45 to 95 years, while usable wood (dbh greater than 18 cm)

**Table 1. Density and total volume of spruce and aspen estimated from 168 control tree plots (per-ha values)**

| Spruce age | Species | No. of stems | Total volume ($m^3$) | | |
|---|---|---|---|---|---|
| | | | Dbh <18 cm[a] | Dbh >18 cm | Total |
| 45 | White spruce | 2152 | 34.9 | 0.0 | 34.9 |
| | Trembling aspen | 2039 | 76.9 | 21.6 | 97.4 |
| 55 | White spruce | 1106 | 78.1 | 0.0 | 78.1 |
| | Trembling aspen | 1119 | 96.4 | 88.4 | 184.8 |
| 65 | White spruce | 780 | 65.8 | 67.0 | 132.8 |
| | Trembling aspen | 995 | 61.1 | 156.2 | 217.3 |
| 75 | White spruce | 766 | 57.2 | 117.2 | 174.4 |
| | Trembling aspen | 916 | 59.1 | 145.3 | 204.4 |
| 85 | White spruce | 197 | 6.1 | 247.4 | 253.1 |
| | Trembling aspen | 347 | 6.7 | 169.3 | 176.0 |
| 95 | White spruce | 190 | 1.3 | 300.9 | 302.2 |
| | Trembling aspen | 390 | 5.3 | 201.8 | 207.1 |

[a] Diameter at breast height.

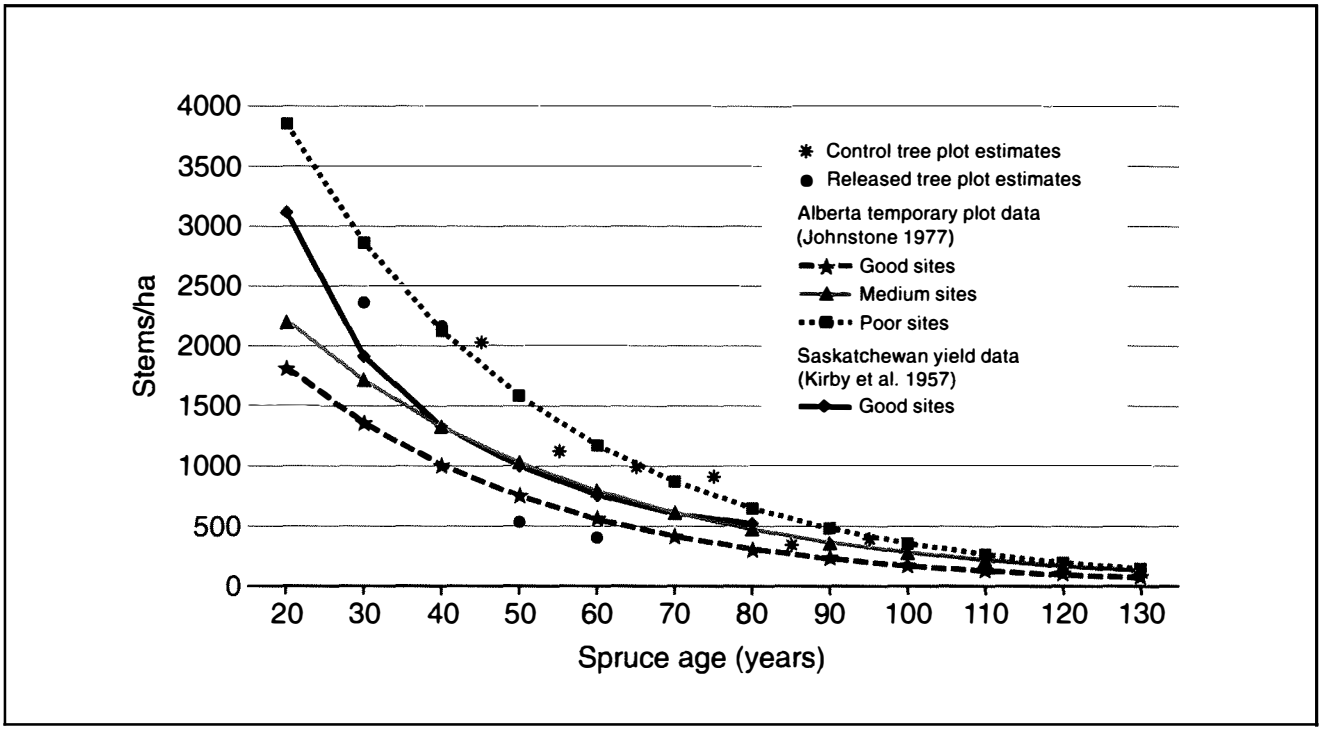


**Figure 1. Number of aspen stems/ha in relation to age in mixedwood stands.**

**Table 2. Estimated current total volume and potential volume gains of white spruce 35 years after release (per-ha values)**

| Spruce age | | No. of | Total volume ($m^3$) | | | Volume gain |
|---|---|---|---|---|---|---|
| Release | Current | hardwood removed[a] | Dbh <18[b] | Dbh >18 | Total | ($m^3$) |
| 10 | 45 | N/A[c] | 68.5 | 0.0 | 68.5 | 33.6 |
| 20 | 55 | 708 | 88.9 | 33.3 | 122.2 | 44.1 |
| 30 | 65 | 2364 | 32.5 | 228.5 | 261.1 | 128.3 |
| 40 | 75 | 2168 | 36.9 | 269.9 | 306.8 | 132.4 |
| 50 | 85 | 533 | 2.4 | 430.0 | 432.4 | 179.3 |
| 60 | 95 | 406 | 0.3 | 499.6 | 499.9 | 197.7 |

[a] Estimated from stump counts in 1987.

[b] Diameter at breast height.

[c] N/A = not available.

ranged from 22 to 202 $m^3$/ha (Table 1). Although these volume estimates are somewhat higher than those from yield plots, they compare well to the aspen yield on good sites in Saskatchewan (Kirby et al. 1957), which represent the upper limit for this species.

The volume of aspen in mixed stands that can be removed in a release treatment increased with stand age up to 95 years. At age 45, only 21% of the aspen production was usable; at 65 years it was 70%, and at age 85 years it was 95%.

Although usable aspen volume increased as the release was delayed, the opposite might be applied to spruce volume. (Losses from decay were not considered, but should be included based on local information.) In old stands, white spruce showed little response to release treatment (Steneker 1974), so the time of release should be selected to minimize aspen volume loss and maximize white spruce gain.

### Question 3: What are release-related aspen volume loss and white spruce volume gain at rotation?

Aspen volume loss from release is estimated as the difference in aspen volumes at rotation age from those at the time of release. This study showed 202 $m^3$/ha merchantable aspen volume at age 95 in untreated stands (Table 1). Release cut before age 45 means complete loss of aspen production, as the trees would not have reached usable size.

Spruce volume gains for the treatment conditions ranged from 34 to 198 $m^3$/ha over a 35-year period, as release age increased from 10 to 60 years (Table 2). These periodic volume increments were extrapolated to a common age of 95 years (Table 3) for comparing spruce volume gains at various release ages.

With increased age of release, both volume gain in spruce and volume loss in aspen declined. Spruce gains ranged from 205 $m^3$/ha, after release at age 55, to 56 $m^3$/ha if released at age 85. Spruce volume gains surpassed aspen losses at all release ages between 45 and 85 years. The best net volume gains occurred after releasing spruce at about 55 years.

### Question 4: What is the total final yield at rotation?

Total volume production of spruce and aspen increased from 512 $m^3$/ha, with release treatment at age 45, to 627 $m^3$/ha when released at 65 years (Table 3). Releasing spruce between 55 and 65 years seemed to maximize stand production. These findings support the two-stage mixedwood management concept proposed by Brace and Bella (1988), which suggests releasing the spruce understory by harvesting the aspen component at age 60.

MacLeod and Blyth (1955) showed that total volume of spruce and aspen in untreated mixed stands in Alberta can reach 500 $m^3$/ha at 100 years of spruce age on good sites. This study suggests a combined spruce and aspen volume of 504 $m^3$/ha at

**Table 3. Aspen and spruce volume statistics ($m^3$ $ha^{-1}$) for various release scenarios**

| Release age | Aspen volumes | | Spruce volumes | | Pooled production potential[e] |
|---|---|---|---|---|---|
| | Usable volume[a] | Loss at 95 years[b] | Gain over control at 95 years[c] | At 95 years[d] | |
| 45 | 21.6 | 180.2 | 189.1 | 490.0 | 511.6 |
| 55 | 88.4 | 113.4 | 204.9 | 505.8 | 594.2 |
| 65 | 156.2 | 45.6 | 169.5 | 470.4 | 626.6 |
| 75 | 145.3 | 56.5 | 113.0 | 415.2 | 560.5 |
| 85 | 169.3 | 32.5 | 56.5 | 358.7 | 528.0 |
| 95 | 201.8 | 0.0 | 0.0 | 302.2 | 504.0 |

[a] Volume of aspen 18-cm dbh or larger.

[b] Difference of aspen volume at age 95 and usable volume at release.

[c] Projected as: 35-year volume increment / 35 × (95 – age at release). For example, 35-year volume gain at release age 40 years is: 132.4 / 35 × (95 – 45) = 189.1.

[d] Calculated as: spruce volume gain to age 95 + spruce volume in control stands at age 95 in Table 1 (300.9 $m^3$ $ha^{-1}$).

[e] Calculated as: aspen usable volume + spruce volume at 95 years of age.

spruce age 95 can be achieved (Table 3). While this value is compatible with MacLeod and Blyth's estimate, it is slightly higher than the average volume provided by yield tables. On good sites, combined yields of conifers and hardwoods range from 443 to 456 $m^3$/ha at age 100 years (Johnstone 1977; Alberta Forest Service 1985).

A study on labor productivity and costs of releasing spruce from hardwoods in Manitoba showed labor and equipment costs for releasing a 55-year-old stand at roughly $350/ha (De Franceschi and Bell 1990). Merchantable volume of poplars in the stand at release was 144 $m^3$/ha. Using this volume might partially offset release costs, with the balance recovered from the expected spruce volume gain of over 200 $m^3$/ha at rotation age (Table 3).

## CONCLUSIONS

Spruce–aspen stands in the boreal mixedwood forests in Alberta can produce 200 $m^3$/ha aspen when spruce is at 95 years of age (Table 1). Releasing the spruce by removing aspen lowers aspen production while substantially increasing spruce production. Ratios of species production will depend on the time of release.

Releasing white spruce on medium and good sites at age 45 likely improves its growth both in diameter and height (Yang 1991). With the increasing market value of aspen, even such early cutting can produce usable wood. Applying release cuts at older ages raises aspen production (Table 2), although this would be countered by an increase in decay. Releasing white spruce at age 65 could mean a direct loss of 45 $m^3$ in aspen production at age 95 (Table 3), not considering decay. The white spruce volume gain due to release, however, would generally exceed the aspen volume loss. This scenario is likely to give the best combined aspen–spruce production.

This maximum mixedwood volume production would apply particularly on good growing sites, where spruce shows excellent response to release between ages 5 and 65 years (Yang 1991). In that study, however, the growing conditions created for spruce by the study treatment were nearly optimal; operational partial cutting would simply remove merchantable aspen at the desired age.

Preliminary results of logging trials in mixedwood forests, conducted cooperatively by the Canadian Forest Service, the Alberta Land and Forest Services, and private companies, appear very promising in terms of white spruce growth response.

*R.C. Yang*
*I.E. Bella*
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*Natural Resources Canada*
*Canadian Forest Service, Northwest Region*
*Northern Forestry Centre*
*5320 – 122 Street*
*Edmonton, Alberta T6H 3S5*
*(403) 435-7210*


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