# Effect of Rotation Length on Productivity of Aspen Sucker Stands

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### Abstract

Repeated harvesting of young aspen sucker stands at the Petawawa Forest Experiment Station indicated that biomass production cannot be sustained on rotations of up to ca. 10 years. Results for longer periods are not yet available but growth trends point to at least 15 years as the minimum rotation age.

### Résumé

Des récoltes répétées sur des peuplements à drageons de jeunes trembles à la forêt expérimentale de Petawawa indiquent que la production de biomasse ne peut être soutenue pour des révolutions allant jusqu'à 10 années environ. Les résultats pour des périodes plus longues ne sont pas encore disponibles mais le taux de croissance laisse croire que l'âge d'exploitabilité minimum serait d'au moins 15 ans.

## Introduction

Any move towards substantially greater utilization of forest biomass, as for the development of energy, will require the exploitation of currently untapped resources. Pre-eminent amongst native tree species, in this respect, are the poplars, which are abundant and widely distributed, yet greatly under-utilized in terms of their calculated allowable cut (Fitzpatrick and Stewart 1968).

Poplars have the ability to reproduce by root suckers, a faculty best developed in trembling and largetooth aspen (*Populus tremuloides* Michx. and *P. grandidentata* Michx. respectively) and enabling these species to produce high yields at early ages (Person, Hallgren and Hubbard 1971, Einspahr 1972). These aspects of rapid growth and relatively easy regeneration would seem to lend the aspens naturally to short-rotation management for fibre production (Einspahr and Benson 1968). Development of rational programs along these lines, however, will require, among other things, elucidation of certain aspects of growth, particularly the relation of age to dry weight yield, and whether that relation changes in subsequent rotations.

This paper provides 9-year results of an experiment designed to determine, for young aspen, (a) the age when maximum fibre mean annual increment occurs and (b) how continuing production is affected by rotation length.

## Methods

The experiment is being carried out at the Petawawa Forest Experiment Station, on a 7-ha area which previously supported mature mixed intolerant hardwoods, about 50% aspen by volume. The soil is a moderately deep glacial till, highly productive for aspen. Following clear cutting of the stand in 1968, 28 sample plots with adequate surrounds were laid out to represent seven rotation-ages (1, 2, 3, 5, 8, 13 and 20 years), each replicated four times.

Beginning in 1969, when the stand was one year old, all living suckers on every plot were counted annually, and harvested in the year of their prescribed rotation. Material was oven dried and weighed, and the yield per hectare calculated. Weight-dimensional relations were derived to allow estimates of yields for plots in years between harvesting, as follows:

$$Y = 99.2196 + 42.77X - 0.02712X^2 \quad (R^2 = 0.978)$$

where Y is oven dry weight in grams
X is (diameter in cm)$^2$ (height in m)

Sucker crops were harvested after leaf-fall, and "biomass" here refers to the above-ground portion less foliage. Only live suckers were counted and harvested, so the potential commercial cut is underestimated.

The plots were laid out and treatments (rotation lengths) randomly assigned prior to the advent of the first crop of suckers. There was very large variation in density of this first crop over the area, but no evident correlation of density with treatment. These initial differences are considered acceptable, since the emphasis is on comparative development rather than actual yields.

Detailed descriptions of the plots (each 25.3m$^2$), surround requirements (based on anticipated root length at time of harvest) and of field and office methods were given by Berry (1973).

## Results

The year after cutting the parent stand, the sucker crop for the different treatments ranged from 46,000 to 90,000 stems/ha, and averaged 62,000. Corresponding dry weights varied between 960 and 1,650 kg/ha, with an average of 1,240. To facilitate comparison of response to treatment, values one year after the initial cut were taken as 100%, and subsequent numbers and weights related to them. The pattern of behaviour is shown in Tables 1 and 2, where each entry is the mean of four plot values.

### Numbers of Stems

Stands with the three longest rotations experienced heavy mortality, declining yearly in numbers to ca. 20% eight years after the initial cut (Table 1). Follow-

ing its first harvest, the 8-year rotation produced a crop of suckers 157% that of the initial number.

The 2-, 3-, and 5-year rotations all yielded fewer stems with each successive harvest, and in no case produced as many in the year following a harvest as were present in the initial sucker stand.

At the 1-year rotation, numbers increased at harvest II and III, and then diminished sharply every year to ca. 8% by harvest IX.

### Biomass

Dry weight per hectare at the three longest rotations was still increasing by the eighth year, when it was 950 to 1470% of the initial sucker biomass (Table 2). Values were still higher at rotations of 13 and 20 years in the ninth year and their mean annual increments (ca. 1850 kg/ha/yr) had not maximized. The crop produced in the year after harvest I at the 8-year rotation was only 80% of the initial.

At the shorter rotations, the early dry weight harvests exceeded the initial crop, but in every case were successively reduced thereafter. Yields were least with the 1-year rotation, falling to only 1.3% of the initial by harvest IX. Total production by the ninth year was similar at the 5- to 20-year rotations, much lower for the shorter rotations.

In the ninth year actual dry weight averaged 14 kg/ha at the 1-year rotation, while about 16,600 kg/ha was estimated for the two longest rotations. Average dry weights per tree were then 3.5 g and 1810 g respectively.

## Discussion

Increasing biomass accompanied by decreasing stem numbers represents normal development of untreated stands, evinced at the three longer rotations at least to the eighth year. Stands harvested at younger ages apparently cannot sustain any level of

**Table 1. Numbers of aspen stems as per cent of those present one year after initial cut.**

| Years from initial cut | Rotation age, years | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 5 | | 8 | | 13 | 20 |
| 1 | I | 100.0 | | 100.0 | | 100.0 | | 100.0 | | 100.0 | 100.0 | 100.0 |
| 2 | II | 138.2 | I | 92.8 | | 80.0 | | 85.8 | | 84.8 | 82.9 | 85.5 |
| 3 | III | 116.2 | | 111.9 | I | 50.3 | | 48.7 | | 45.8 | 55.4 | 51.3 |
| 4 | IV | 59.1 | II | 92.8 | | 42.4 | | 40.2 | | 37.8 | 38.3 | 43.7 |
| 5 | V | 32.5 | | 61.2 | | 30.1 | I | 37.9 | | 33.5 | 33.0 | 37.9 |
| 6 | VI | 23.9 | III | 44.1 | III | 24.7 | | 91.9 | | 25.3 | 23.9 | 30.3 |
| 7 | VII | 15.5 | | 28.8 | | 17.3 | | 61.1 | | 22.6 | 20.5 | 25.5 |
| 8 | VIII | 10.8 | IV | 24.8 | | 13.1 | | 35.7 | I | 20.7 | 16.8 | 21.9 |
| 9 | IX | 8.2 | | 32.1 | III | 11.9 | | 31.4 | | 156.9 | 15.4 | 18.8 |

(Underlining indicates a sucker-harvest year, and Roman numeral the number of the harvest for that rotation).

**Table 2. Aspen biomass as per cent of that produced in the first year following the initial cut.**

| Years from initial cut | Rotation age, years | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 5 | | 8 | | 13 | 20 |
| 1 | I | 100.0[1] | | 100.0 | | 100.0 | | 100.0 | | 100.0 | 100.0 | 100.0 |
| 2 | II | 107.9 | I | 284.6 | | 231.9 | | 248.9 | | 259.8 | 221.1 | 333.5 |
| 3 | III | 57.2 | | 59.1 | I | 379.8 | | 471.3 | | 399.9 | 349.6 | 452.7 |
| 4 | IV | 16.1 | II | 128.7 | | 16.6 | | 692.2 | | 584.0 | 449.9 | 693.9 |
| 5 | V | 13.3 | | 33.8 | | 42.2 | I | 919.4 | | 752.6 | 558.8 | 947.8 |
| 6 | VI | 7.2 | III | 52.5 | II | 67.6 | | 37.5 | | 962.7 | 678.9 | 1135.3 |
| 7 | VII | 2.9 | | 16.9 | | 11.5 | | 107.5 | | 1239 4 | 803.6 | 1284.7 |
| 8 | VIII | 2.4 | IV | 17.5 | | 16.6 | | 122.7 | I | 1452.3 | 947.0 | 1470.2 |
| 9 | IX | 1.3 | | 12.2 | III | 32.6 | | 146.2 | | 80.0 | 1178.4 | 1724.0 |
| Production[2] | | 308.3 | | 495.5 | | 480.0 | | 1065.6 | | 1532.3 | 1178.4 | 1724.0 |
| [3] | | 3166 | | 5614 | | 7916 | | 15269 | | 16146 | 16787 | 16502 |

[1]Underlining indicates a sucker harvest year, and Roman numeral the number of the harvest for that rotation.

[2]Biomass (cut plus standing) as a per cent of biomass at end of first year.

[3]Biomass (cut plus standing) in kg/ha.

production, let alone match the yields of uncut stands of the same age. It is doubtful if even an 8-year rotation will be able to recoup its first yield at the time of the second harvest.

Declining dry weight production at these rotations is not thought to result from reduced fertility of the soil, an acknowledged consequence of repeated cropping at short intervals in some circumstances (Norton and Young 1976). In this experiment the site is a productive one, the nutrient-rich foliage and of course the roots were not removed from it, and the diminution in biomass yield was almost immediate. Rather it is considered that the root systems were unable to sustain the level of sucker production, being starved of adequate feedback from the photosynthesizing tops.

Management of young sucker stands on rotations of less than about 10 years appears out of the question. Whether the 13- or 20-year rotations will be long enough remains to be seen, but the trend of their biomass m.a.i. suggests culmination at about age 15 years.

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