SHORT-ROTATION PRODUCTION OF RED ALDER:
SOME OPTIONS FOR FUTURE FOREST MANAGEMENT

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ABSTRACT

Many options are available to foresters who may want to consider management of red alder (Alnus rubra Bong.). Four options are discussed in this paper—a coppice system and three high forest systems: pulpwood log, saw-log and peeler, and pulpwood log and saw-log production. Coppice can be grown on 4- to 6-year rotations and pulpwood logs can be produced in 10 to 15 years on most sites. Estimated yields (per acre per year) of these options are about double those obtained in natural stands. Saw logs and peelers can probably be grown in 28 to 37 years, and yields are estimated to be about 40 percent higher than those listed in normal yield tables for well-stocked stands.

Introduction

The intent of our paper is to examine some options available to foresters who want to consider management of red alder (Alnus rubra Bong.). Short rotations are essential for capturing the benefits of alder's rapid initial growth and the financial advantages associated with it; therefore, our paper will concentrate on short-rotation production systems. We will describe four of several possible management options. Each option will be
discussed in terms of products, rotation length, spacings, and suitable locations or sites. We will also provide estimates of yield and discuss some of the special problems and limitations associated with each option. We have not attempted to analyze the costs and benefits of the options, nor have we made comparisons with conifer culture.

**General Overview of Short-Rotation Options**

The four systems selected to illustrate options for production of wood and fiber include a coppice or sprout system and three conventional, high forest systems: (1) pulpwood log, (2) saw log and peeler, and (3) a combination of the pulpwood log and saw log option which involves thinning. Table 1 summarizes the major aspects of each system—primary products, average size of tree at harvest, plantation spacing, and rotation length. Each system will be considered in detail in separate sections.

Table 1--Summary of 4 options for short-rotation production of red alder

<table>
<thead>
<tr>
<th>System</th>
<th>Primary product</th>
<th>Average tree size at harvest</th>
<th>Spacing</th>
<th>Rotation length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D.b.h.</td>
<td>Height</td>
<td></td>
</tr>
<tr>
<td>Coppice</td>
<td>Barky chips</td>
<td>2</td>
<td>20 to 30</td>
<td>4 by 4</td>
</tr>
<tr>
<td>High forest</td>
<td>Pulpwood logs</td>
<td>6</td>
<td>45 to 47</td>
<td>9 by 9</td>
</tr>
<tr>
<td>High forest</td>
<td>Saw logs and peeler</td>
<td>14</td>
<td>81 to 95</td>
<td>17 by 17</td>
</tr>
<tr>
<td>High forest</td>
<td>Pulpwood logs and saw logs</td>
<td>6</td>
<td>40 to 43</td>
<td>8 to 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>77 to 90</td>
<td>16 by 16</td>
</tr>
</tbody>
</table>

**The Coppice System**

The objective of the coppice system is growth of fiber for paper, other reconstituted fiber products, or energy. It consists of dense spacings of plants cut on short cycles, with regeneration by stump sprouting. The system was proposed for sycamore in 1966 by southern foresters (McAlpine et al. 1966). Soon thereafter, Smith (1968) suggested that such methods might be applicable for red alder in the Pacific Northwest. Subsequent evaluations by Schmidt and DeBell (1973) indicated that alder yields were favorable and satisfactory pulp could be produced.

**YIELD ESTIMATES**

We think the following specifications are reasonable for managing alder by the coppice system. Spacings of 4 by 4 to 6 by 6 feet would probably
be appropriate for cutting cycles of 4 to 6 years—at least data for cottonwood in the Northwest and sycamore in the Southeast point in this direction. Stands would be established initially with seedlings, but regeneration after harvest would be by stump sprouts for several cutting cycles. At harvest, the dominant sprouts would be 20 to 30 feet tall and 3 inches or less in diameter. Yield expressed in terms of mean annual increment might vary from 2 to 6 oven-dry tons per acre or approximately 200 to 600 cubic feet per acre. Actually, one could probably expect about 4 oven-dry tons under a good system of management.

This yield estimate is based on two studies conducted at Crown Zellerbach: (1) an evaluation of productivity in dense, young alder thickets, and (2) 2-year coppice yields from alder-cottonwood plantings spaced at 2 by 4 feet. Details on these studies and the yields obtained follow.

**Natural thicket**s. — Information on stocking, dominant tree height, and mean annual production in alder thickets of various ages is given in table 2 (adapted from DeBell 1972). These data were collected from 28 small plots (6 by 6 feet) and averaged by age class. The plots were selected in thickets of extreme density and located in the lower Columbia River valley. Because the data represent a highly selective population, interpretations must be made with some caution. It appears that mean annual production can be very high in such thickets, especially at ages beyond 5 years. Production was highest for 7- to 12-year-old plots. This finding agrees with a report by Zavitkovski and Stevens (1972) that mean annual increment peaks between ages 10 and 15. Our data also suggest that mortality is high in dense, young alder thickets. Stocking in 1- to 2-year-old thickets averaged 122,000 stems per acre whereas 13- and 14-year-old stands had only 13,000 stems. Such loss of wood through mortality could be minimized under intensive, short-rotation management. Growth could be concentrated on fewer, larger stems, and maximum yields might be obtained at younger ages.

<table>
<thead>
<tr>
<th>Age class</th>
<th>Stems per acre</th>
<th>Height of dominants</th>
<th>Estimated mean annual</th>
<th>Number of plots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Feet</td>
<td>Dry matter production</td>
<td>Wood production</td>
</tr>
<tr>
<td>Years</td>
<td></td>
<td></td>
<td>Tons per acre</td>
<td>Cubic feet per acre</td>
</tr>
<tr>
<td>1-2</td>
<td>122,000</td>
<td>6.0</td>
<td>1.89</td>
<td>100</td>
</tr>
<tr>
<td>3-4</td>
<td>64,000</td>
<td>12.2</td>
<td>2.35</td>
<td>130</td>
</tr>
<tr>
<td>5-6</td>
<td>35,000</td>
<td>16.2</td>
<td>3.54</td>
<td>190</td>
</tr>
<tr>
<td>7-12</td>
<td>17,000</td>
<td>27.3</td>
<td>6.85</td>
<td>380</td>
</tr>
<tr>
<td>13-14</td>
<td>13,000</td>
<td>32.6</td>
<td>5.91</td>
<td>320</td>
</tr>
</tbody>
</table>

1/ These data are based on averages of individual plots on sites of varying stocking and productivity within each age class; they may not indicate actual trends with time in 1 stand.

2/ Assumptions: Wood (minus bark and foliage) = 66 percent of total production. 1 cubic foot of oven-dry wood = 24 lb.
Alder-cottonwood planting.--Pure and mixed plantings of red alder and black cottonwood (*Populus trichocarpa* Torr. & Gray) were established in March 1973 on an alluvial site near Crown Zellerbach's pulp and paper mill in Camas, Washington. These plantings had a dual purpose: (1) to compare coppice production of alder and cottonwood at 2- by 4-foot spacing and (2) to test effects of pulpmill sludge and of irrigation on growth of the two species. The plantings have been harvested twice, after the 1974 and 1976 growing seasons. Although the 1974 harvest yields were relatively low (average about 1.5 ovendry tons per acre per year), stumps sprouted vigorously in spring 1975 and the growing space was rapidly occupied by several shoots per stump. The resulting coppice growth harvested in fall 1976 (table 3) averaged 60 percent higher than the earlier harvest, and some cottonwood treatments compared favorably with short-rotation yields of species in other regions (see, for example, Steinbeck 1973 or Ribe 1974). Irrigation led to improved yields from both species; sludge benefited growth of cottonwood but had the opposite effect on red alder, perhaps because of the high supplements of nitrogen fertilizer added with the sludge. Alder got off to a slower start than cottonwood, and yields averaged about 40 percent lower than those of cottonwood. This finding parallels observations that cottonwood almost invariably outgrows alder under natural conditions. When no sludge was applied, alder yields were equal to those of cottonwood. Presumably, if spacing was widened and rotation length extended to 4 or 5 years, 4 to 5 ovendry tons of alder per acre per year could be produced. Perhaps the most interesting sidelights of the 1976 harvest were the higher yields obtained in mixed plantings (4.2 ovendry tons per acre per year) compared with yields in pure plantings of the two species (2.5 ovendry tons per acre per year) (table 3). This may be indicative of gains that might be obtained with mixtures of alder and other species in other production systems.

Table 3--Effect of irrigation and pulpmill sludge on annual wood production from 2-year coppice

<table>
<thead>
<tr>
<th>Species</th>
<th>Irrigation</th>
<th>Sludge (tons per acre)</th>
<th>Ovendry tons per acre per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Red alder</td>
<td>Yes</td>
<td>2.8</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>2.5</td>
<td>2.4</td>
</tr>
<tr>
<td>Black cottonwood</td>
<td>Yes</td>
<td>2.8</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>2.5</td>
<td>3.7</td>
</tr>
<tr>
<td>Mixed alder-cottonwood</td>
<td>No</td>
<td>4.2</td>
<td>--</td>
</tr>
</tbody>
</table>

1The sludge application included sufficient nitrogen fertilizer to bring the C:N ratio to 100:1.
SPECIAL CONSIDERATIONS

Concerns hindering immediate implementation of coppice management include efficient planting techniques, unknowns regarding sprouting capacity, harvest technology, and chip storage. Establishing large numbers of plants at dense spacings by conventional methods is costly, but perhaps costs would be acceptable if spacings were at least 4 by 4 feet with rotations of 4 to 6 years. Young alder stumps sprout vigorously, but sprouting of stumps of older saw-log size alder is not an effective means of reproduction (Worthington et al. 1962). Thus, there are unknowns regarding the number of times and the age to which alder stumps will sprout in a short-rotation coppice system. Harvesting still remains a source of concern, especially on wet, flood plain soils during the dormant season. Engineers believe the components for adequate systems are now available, but assemblage of a prototype harvester has yet to be accomplished. Degradation of chips during storage is also a potential problem; it may be resolved by immediate processing or by treatment if chips must be stored for several months.

The major obstacle to widespread use of the coppice system in the Pacific Northwest is the limited amount of suitable acreage. Production of total mill requirements by this system is probably precluded by limitations on land. A substantial increase (more than 10 percent) in fiber supply however, could be provided to some mills in the region. More important than fiber per se may be the use of densely spaced plantations for treatment of mill waste waters. Current environmental guidelines require zero discharge from mills by 1983. Whereas some companies are attempting to accomplish this by engineering advances within the mill, others are investigating the possibility of using intensively cultured plantations as a filter. With such a dual purpose, lease or purchase of highly productive agricultural land can probably be justified economically for coppice management—provided it is close to millsites.

High Forest Systems—General Considerations

High forest systems are management systems in which the crops originate from seedlings and the rotation is generally longer than that of coppice systems. High forest systems will probably play the greatest role in future production of alder in short rotations. Though planting and harvesting methods can be improved and tailored for alder production, existing techniques are usable and much more land is suitable for such management systems.

Given that rainfall is adequate for growth of alder, high forest systems may be applied to three types of land: (1) typical alder sites (stream bottoms, swales, and depressions in the uplands), (2) wet and/or deep soils now considered conifer sites, and (3) land where crop rotation is needed for correction of soil nutrient deficiencies or possible disease problems. Except in the last case where other considerations are involved, we believe that intensive, short-rotation management of alder should be considered only on lands having alder site indices of 90 feet or above at
50 years. According to an inventory by the State of Washington Department of Natural Resources, this includes about 70 percent of the land now growing alder in Washington. The two high forest systems which produce pulpwood logs (pulpwood log only and pulpwood log-saw log combinations) appear most applicable to lands having long, gentle slopes of 30 percent or less because small piece size will probably rule out cable yarning systems. There should be fewer topographic restrictions, however, for saw log-peeler production since tree size at harvest would lend itself to saw felling and cable yarding.

Our yield estimates for the high forest systems are based on several pieces of information.

1. Normal yield tables for red alder prepared by Worthington et al. (1960) provided data on relationships of average stand diameter, basal area, and spacing or number of trees.

2. Rotation length was also based on data in the normal yield tables, but with an adjustment for gain in years (reduced rotation length) because of early spacing. This adjustment was based on the assumption that the time required for a spaced stand to grow to a given diameter is equivalent to the time required for one-third of that number of largest stems in a normal stand to attain that size.2

3. Height was estimated from site index curves for alder (Worthington et al. 1960) for ages predicted as indicated above.

4. Tree volumes (cubic feet to a 4-inch top) were obtained from the double-entry volume tables for red alder compiled by Johnson (1955). Total stem volumes were computed from conversion ratios published by Brackett (1973). Estimates of total tree volumes were calculated from data on percent composition given in Smith and DeBell (1973).

Yield estimates obtained by the above steps were compared with data from the following sources:

a. 8-year performance of an alder plantation (DeBell and Wilson 1978),

b. response to thinning as reported by Warrack (1964) and Berntsen (1961a, 1962), and

c. Smith's (1972) summary of tree size and yields in juvenile alder stands.

Our derived estimates appeared compatible with the information available from these other sources. Though they are by necessity conjectural, we do believe our yield figures are a reasonable (and probably conservative) approximation of yields that might occur in managed alder stands.

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2This hypothesis was developed from experience in Douglas-fir plantations and spacing trials compared with natural stand development. Data are on file at Forestry Sciences Laboratory, Olympia, Washington.
Let us now examine these yield estimates and some special considerations for each of the three high forest systems.

**Pulpwood Log Production**

**YIELD ESTIMATES**

To illustrate one of many possible options for producing pulpwood logs, we have selected a target stand having the following characteristics:

- **Stems per acre**: 540
- **Spacing**: 9 by 9 feet
- **D.b.h.**: 6 inches
- **Height**: 45 to 47 feet
- **Average tree volume (CVTS)**: 5.6 to 5.9 ft³
- **Total yield (CVTS)**: 3,000 to 3,200 ft³

Although stands would appear nearly identical at harvest, rotation age and mean annual productivity would differ according to productivity of the site (table 4).

<table>
<thead>
<tr>
<th>Site index</th>
<th>Rotation age</th>
<th>Mean annual increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet</td>
<td>Years</td>
<td>4-inch top</td>
</tr>
<tr>
<td>90</td>
<td>14</td>
<td>150</td>
</tr>
<tr>
<td>100</td>
<td>13</td>
<td>170</td>
</tr>
<tr>
<td>110</td>
<td>12</td>
<td>190</td>
</tr>
<tr>
<td>120</td>
<td>10</td>
<td>220</td>
</tr>
</tbody>
</table>

Stand age at harvest could range from 10 years on site 120 to 14 years on site 90. Corresponding mean annual increments (total stem inside bark) are 320 and 220 cubic feet per acre. Averaged over all sites, estimated yields are more than double the normal yields listed for red alder at the suggested rotation ages (Worthington et al. 1960). If suitable processing systems were available, whole-tree chipping could increase yields to about 400 cubic feet per acre per year on the best sites.

**SPECIAL CONSIDERATIONS**

Red alder plantations have been established successfully by planting container or bare-root stock after slash burning in at least two locations. These plantings have done remarkably well without followup control of vegetation, but initial growth was sometimes slower than anticipated. Limiting

3CVTS = cubic volume of total stem including stump and tip, inside bark.
mechanical site disturbance in order to minimize postlogging development of natural vegetation (including volunteer alder) may be desirable. Residual vegetation could be controlled by chemical means before planting, and on some sites control of vegetation after planting may be necessary. Suitable techniques for postplanting control by chemicals, however, remain to be developed.

Although estimated yields may not be as high as those potentially possible with the coppice system, there are fewer unknowns in this more conventional approach to fiber production. Existing methods for harvest (e.g., small feller-buncher-forwarding systems) could be used provided pulpwood log production is limited to gentle, unbroken topography. Modifications that minimize ground pressure, however, are needed to reduce costs and limit site damage on the wet soils suited to alder production. The problem of storage is of less concern with this system because logs can be stored for longer periods than chips, and water storage can be used if necessary. Moreover, current log and chip processing facilities can be used.

### Saw-Log and Peeler Production

**YIELD ESTIMATES**

To illustrate possibilities for short-rotation culture of solid wood products, we have selected the following target stand:

- **Stems per acre**: 155
- **Spacing**: 17 by 17 feet
- **D.b.h.**: 14 inches
- **Height**: 81 to 95 feet
- **Average tree volume (CVTS)**: 35.5 to 41.5 ft³
- **Total yield (CVTS)**: 5,500 to 6,400 ft³

Trees would be initially planted at the wide spacing; no thinning would be involved in this option. Heights and volumes per tree at rotation age would vary with site productivity; the taller trees would occur on the most productive sites. Rotation age and mean annual productivity also would differ by site as shown in table 5.

<table>
<thead>
<tr>
<th>Site index</th>
<th>Rotation age</th>
<th>Mean annual increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet</td>
<td>Years</td>
<td>4-inch top</td>
</tr>
<tr>
<td>90</td>
<td>38</td>
<td>140</td>
</tr>
<tr>
<td>100</td>
<td>34</td>
<td>160</td>
</tr>
<tr>
<td>110</td>
<td>32</td>
<td>180</td>
</tr>
<tr>
<td>120</td>
<td>30</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 5-- Rotation age and mean annual increment for the saw-log and peeler option, by site index
Stand age at harvest could vary from 30 years on site 120 to 38 years on site 90, with corresponding mean annual increments (CVTS) of 210 and 140 cubic feet per acre. By normal yield table predictions, it would take 41 to 54 years (or 11 to 16 additional years) to grow trees of similar size in unmanaged stands. Or, viewed from another angle, estimated yields would be about 35 percent higher than normal yields at the suggested rotation ages for the target stand.

If tops and branches were chipped for reconstituted fiber products, total yield per acre per year would range from 200 to 300 cubic feet.

SPECIAL CONSIDERATIONS

Although it appears that saw log-veneer products could be produced in less than three-fourths the time it takes in unmanaged stands, there are some serious potential problems with this approach. Large tree size has been achieved by maintaining wide spacing throughout the rotation. Open-grown alder often develop numerous large branches. Pruning may therefore be required to obtain the quality of desired products; however, one pruning trial in red alder (Berntsen 1961b) resulted in rot pockets and epicormic branches.

The underutilized growing space at young stand ages may also lead to problems with competition from unwanted volunteer vegetation. This would require development of selective control methods. Existing harvest methods (including cable yarding systems) are suitable. There should be fewer topographic restrictions for this option than for any other short-rotation option for alder. Site preparation and control of competition, however, could place additional restrictions on land suitable for this option.

Pulpwood Log and Sawlog Production

YIELD ESTIMATES

Because of the potential problems associated with wide spacing, we decided to examine a system that would yield both pulpwood logs and saw logs. The system involves rectangular spacing (8 by 16 feet) of the initial stand with a row thinning for pulpwood at age 9 to 12. This would provide a square spacing (16 by 16 feet) of leave trees for subsequent growth to saw-log specifications. Characteristics of the target stand at thinning and final harvest dates are shown below:

<table>
<thead>
<tr>
<th>Thinning (age 9 to 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stems per acre- - - - - - - - - - - - - - - 340</td>
</tr>
<tr>
<td>Spacing - - - - - - - - - - - - - - - - - - 8 by 16 feet</td>
</tr>
<tr>
<td>D.b.h.- - - - - - - - - - - - - - - - - - - - - 6 inches</td>
</tr>
<tr>
<td>Height- - - - - - - - - - - - - - - - - - - - 40 to 43 feet</td>
</tr>
<tr>
<td>Average tree volume (CVTS) - - - - - - - - - - - - - - 5.0 to 5.4 ft(^3)</td>
</tr>
<tr>
<td>Volume removed (CVTS) - - - - - - - - - - - - - - 840 to 910 ft(^3)</td>
</tr>
<tr>
<td>Residual volume (CVTS)- - - - - - - - - - - - - - 840 to 910 ft(^3)</td>
</tr>
</tbody>
</table>
Final Harvest (age 27 to 35)

- Stems per acre: 170
- Spacing: 16 by 16 feet
- D.b.h.: 12 inches
- Height: 77 to 90 feet
- Average tree volume (CVTS): 25.7 to 29.9 ft³
- Volume removed (CVTS): 4,400 to 5,100 ft³
- Total yield (CVTS) thinning + harvest: 5,200 to 6,000 ft³

Height at rotation age differs by site class. Length of rotation and mean annual production are listed for each site class in table 6.

<table>
<thead>
<tr>
<th>Site index</th>
<th>Rotation age</th>
<th>Thinning</th>
<th>Mean annual increment ¹/²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet</td>
<td>Years</td>
<td></td>
<td>Cubic feet per acre per year</td>
</tr>
<tr>
<td>90</td>
<td>35</td>
<td>12</td>
<td>140 150 210</td>
</tr>
<tr>
<td>100</td>
<td>32</td>
<td>11</td>
<td>160 170 240</td>
</tr>
<tr>
<td>110</td>
<td>29</td>
<td>10</td>
<td>180 200 280</td>
</tr>
<tr>
<td>120</td>
<td>27</td>
<td>9</td>
<td>200 220 310</td>
</tr>
</tbody>
</table>

¹/² Thinning plus final harvest.

Total production by this system would be about 6 percent less than that of the saw-log and peeler option, and rotation age is estimated to be 3 years less. Gains of 40 percent over normal yields would occur. Again, utilization of tops and branches would increase total yield to 210 to 310 cubic feet per acre per year.

SPECIAL CONSIDERATIONS

The objectives of the 8- by 16-foot initial spacing with thinning are several. The denser spacing should result in fairly decent stem form and possibly in more rapid natural pruning. Thus, some of the problems anticipated with wider spacings may be lessened or avoided. In addition, early pulpwood production and thinning permits capture of site productivity normally lost with wide spacing and an earlier return on investment. Because of increased competition at young ages, expected rotations are 3 to 5 years longer than needed to produce trees of 12-inch d.b.h. with an initial stocking of 170 trees per acre.

Warrack (1964) indicated that epicormic branching occurred in a 37-year-old alder stand in British Columbia after thinning, but he does not mention the problem in his discussion of thinning a 21-year-old stand. Neither does Berntsen (1958, 1961a, 1962) mention epicormic branching of alder stands.
thinned at 8 and 21 years of age. Perhaps epicormic branching is not a serious problem when young, vigorous stands are thinned as suggested in this option.

Site requirements are identical to those for the pulpwood log option. Plantations should be oriented to avoid cross-slope yarding which would likely scar and degrade some leave trees. The lean or sweep that is characteristic of alder in unmanaged, irregularly spaced stands may result from phototropic sensitivity of the species (Warrack 1956). If this is true, the geometric spacing of plantations may minimize this problem.

Site preparation needs would be similar to those mentioned for the pulpwood log option. Control of natural vegetation after planting, however, is more likely to be necessary because of the wider spacing.

A Wrap-Up

At present there is little interest in intentional management of red alder by most major forest product companies and public landowners. This lack of interest stems from the fact that merchantable volumes are lower and logging costs are higher in alder stands than in conifer stands. Moreover, past market values for alder logs have been lower and much more unstable than for conifer logs. Some of these factors can be affected by management and developments in harvesting technology. Market values will be affected by future changes in supply and demand for raw materials in fiber and solid wood products industries. If future changes increase the attractiveness of alder management, foresters have a wide range of options available. Of the four options presented in this paper, we suspect that the pulpwood log and the pulpwood log and saw-log options will receive more attention than the coppice and the saw-log and peeler options because potential problems are fewer and the need for new technology is less. In addition, these two high forest options afford greater flexibilities to foresters and mill managers in growing, harvesting, and utilizing the wood produced than does the coppice system. The period between initial cost outlay and first returns on investment is considerably shorter for the two pulpwood log options than for the saw-log and peeler option.

Experimental yields for the coppice system are high and in combination with waste disposal benefits, may lead to establishment of such plantations near mills. Estimated yields for the high forest options are substantially higher than those listed in the normal yield table for unmanaged stands at the suggested rotation ages (see table 7). The higher yields as well as the shorter time to harvest will enhance the profitability and therefore the attractiveness of alder management. Predicted yields of stands managed for solid wood products are about 40 percent greater than those of natural stands of the same age, whereas relative gains for stands managed only for pulpwood are greater yet. We suspect that these increased yields are somewhat conservative. They are based only on anticipated gains from proper spacing. Given other intensive cultural treatments such as site preparation, fertilization, and genetic improvement, even greater yields would likely occur.
Table 7--Comparisons of short-rotation options and normal-yield table predictions in terms of yield at a given age and rotation age needed to attain a specified diameter

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Yield (CVTS) at rotation age</th>
<th>Rotation age for specified diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulpwood log option</td>
<td>3,100</td>
<td>13</td>
</tr>
<tr>
<td>Normal yield table</td>
<td>1,100</td>
<td>22</td>
</tr>
<tr>
<td>Saw-log and peeler option</td>
<td>5,500</td>
<td>34</td>
</tr>
<tr>
<td>Normal yield table</td>
<td>4,100</td>
<td>47</td>
</tr>
<tr>
<td>Pulpwood log and saw-log option</td>
<td>5,500</td>
<td>32</td>
</tr>
<tr>
<td>Normal yield table</td>
<td>4,000</td>
<td>42</td>
</tr>
</tbody>
</table>

1/ All data apply to site 100.
2/ CVTS = cubic volume of total stem including stump and tip, inside bark. Normal yield table estimates were adjusted to total stem (inside bark) values based on conversion ratios presented in Brackett (1973).

In conclusion, it appears that intentional management of alder will result in much higher yields than occur naturally with this fast-growing species. If we consider alder's nitrogen-fixing ability, such yields increase the attractiveness of alternating a short rotation (e.g., 10 to 14 years) of alder with longer rotations of conifers, especially on the more nitrogen-deficient sites. As fiber and solid wood supplies become more costly to produce, alder seems destined to occupy a more prominent niche in the resource management picture of the Pacific Northwest.

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