March 1990 FRDA Memo No. 133

Synopsis

Topic Summary for the Operational Forester

Management of Black Cottonwood, Red Alder, Bigleaf Maple and Paper Birch in Coastal British Columbia

INTRODUCTION

The area occupied by hardwood stands in coastal British Columbia has increased rapidly in this century. Most coastal hardwood species produce seed in abundance, grow very quickly in the first ten years, and thus dominate many of the successional forest stands that develop after clearcut logging of coniferous forests. It has been estimated that there are about 30 million m³ of useable deciduous volume in coastal British Columbia. Red alder (56%) and black cottonwood (32.8%) are the most abundant, with bigleaf maple (7.5%), paper birch (2.3%) and trembling aspen (1.4%) making up less than 10% of the total. Although small in comparison to the total volume of softwood, this is a significant timber resource which, until recently, has received very little attention from forest managers. The most common perception of coastal hardwoods is that they are weeds that interfere with the establishment of conifers on the better sites. Much money and effort has been spent fighting hardwoods in order to establish coniferous plantations.

In coastal British Columbia black cottonwood and hybrid poplars are the only hardwoods that have been purposefully managed for forest products. Starting in 1956 West Tree Farms established widely spaced veneer plantations on private land in the Fraser Valley. Historically, the market for black cottonwood has been limited and supply has usually exceeded demand. The demand for other hardwood species, such as red alder and bigleaf maple, has been sporadic, and few companies utilizing these species exclusively have survived over the long run. Nevertheless, there is an increasing interest today in the coastal hardwood resource for a number of reasons:

1. Difficulty in establishing conifers on some sites has led land managers to conclude that hardwoods are an acceptable management alternative in these areas. The recent awarding of a black cottonwood tree farm licence is evidence of this trend.
2. Offshore markets for hardwood logs have made hardwood silviculture more practical in areas where distance to hardwood pulp mills makes pulp production uneconomical.
3. Pulp manufacturers, who have relied entirely on softwood chips, are now considering schemes to include a percentage of hardwood chips in their pulping mixtures.
4. Prices for red alder chips have increased recently, making harvesting of red alder stands more economically attractive.
5. Forest managers are becoming aware of the potential of hardwood stands in replenishing nutrient-depleted soils, reforesting sites where conifers have been infected with laminated root rot, and as nurse trees to establish conifers.
6. Hardwood species can be managed on 7- to 40-year rotations and could be useful in providing needed fiber to offset predicted shortages in timber supply.

Although interest in hardwood management has increased, our knowledge base for managing these species is poor. This report summarizes the ecology and silvics of the four most common coastal hardwood species - red alder, black cottonwood, bigleaf maple and paper birch. Management information is presented only for red alder and black cottonwood as little research has been carried out in this region on the other two species.

BLACK COTTONWOOD *(Populus trichocarpa)*

Ecology and Silvics

Black cottonwood is the fastest-growing tree in British Columbia. It is considered by some botanists to be a subspecies of the balsam poplar (*P. balsamifera*) of northeastern British Columbia and the Canadian boreal forest. The approximate boundary between the two species is shown in Fig. 1. Hybridization is common in the transition area. Black cottonwood occurs throughout southern and western British Columbia, except in the most maritime subzones of the CWH zone, where it is replaced by red alder (Figs. 1, 2). In most of coastal British Columbia black cottonwood occurs in and often dominates communities on alluvial floodplains – often forming pure and extensive stands. The species occurs as scattered individuals in stands on suitably moist upland sites but seldom predominates as it does on alluvial floodplains. Black cottonwood thrives on nutrient-rich to very rich soils with fresh to very moist soil moisture regimes and is poorly adapted to soil drought.

Black cottonwood flowers develop from late March to late May with seeds ripening quickly and being released as early as late May and throughout June. Large crops of light, downy seeds are produced and can be wind- or water-dispersed over long distances. Seed viability is high but of short duration, and seedling development requires moist, mineral seed beds for at least a month. The timing of seed release coincides with annual flooding in many watersheds. Seedling densities are often extremely high on the moist, mineral surfaces exposed as floodwaters recede. After felling, black cottonwood sprouts vigorously from suppressed buds located under the stump bark. It also sprouts from woody fragments that have been transported and deposited by floodwaters or worked into the mineral soil by harvesting equipment.

Black cottonwood tolerates rooting zone flooding and soil waterlogging during the dormant season, but prolonged flooding during the growing season reduces productivity. Black cottonwood is considered to be less flood-tolerant than red alder since it is less well adapted to rooting zone waterlogging (wet soils) during the growing season. Black cottonwood is the most shade-intolerant tree in British Columbia and will rapidly expire at all life stages if shaded.

Special Considerations: Black cottonwood has been used to create fast-growing poplar clones by hybridizing the species with *Populus* species from other geographic areas. Many of these hybrids outperform the native species and major programs to utilize them in high-yield, short rotation plantations have been established in other areas of North America and Europe. Such programs are in their

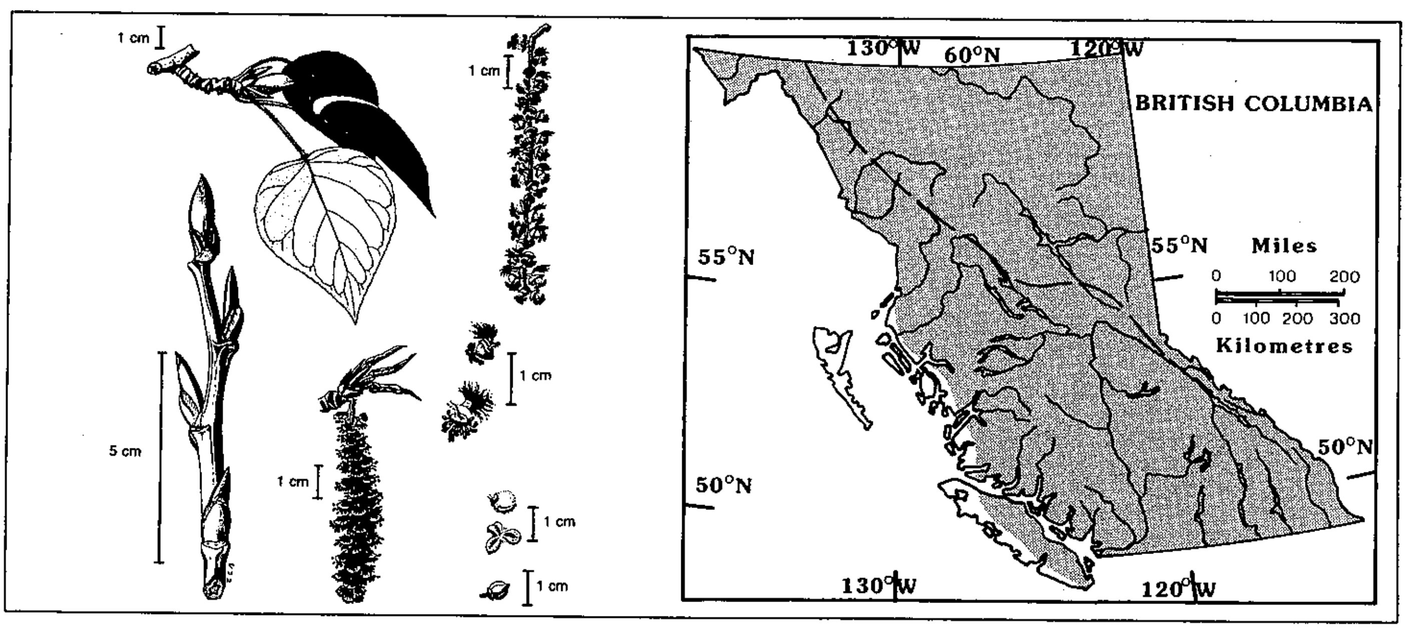


FIGURE 1. (a) Leaf, twig, flowering and seed characteristics of black cottonwood. (b) The range of black cottonwood in British Columbia. The dashed line represents the transition to balsam poplar (north and east of the line). (Source: Coates and Haeussler 1986)

infancy on the British Columbia coast, but it can be expected that many future plantations will be from those hybrid poplar clones best suited to coastal ecosystems.

Management

A. Stand establishment

Whip Plantations: Black cottonwood plantations can be established by dibble-planting long stem cuttings called 'whips'. Whips should be 1.5 to 2 m in length with a caliper of 1.2 to 2 cm. Whips can be collected from young wildling stands of black cottonwood or from small nurseries which can be set up to produce whips annually from 'stool beds'. Wildling whips should be collected from first- and second-year wood of terminal branches and first-year wood of laterals. Although wildling whips are reliable for establishing whip plantations, nursery whipstock grown in closely spaced stoolbeds is generally superior due to lower numbers of lateral branches and larger caliper. More rapid development of the whips can be enhanced if dormant whips are cut between January and early March and then stored in black plastic bags at 2 to 5°C before outplanting. This treatment delays flushing of leaf buds, moistens the whip for maximum storage of moisture and initiates the formation of root primordia. Using this method, better root-shoot ratios can be achieved, increasing whip survival and early growth. Whips can be planted from January to mid-April depending on plantation location and year-to-year climatic variability. In most years whip survival is high (80-90%) so planting about 900 whips/ha will establish 800 whips for a 25-year pulpwood rotation with final stocking of about 400 trees/ha. Whip mortality can be considerably higher if spring weather is dry, vegetation competition is severe, or planted whips are dessicated or partially flushed.

Whips can be divided into shorter sections usually referred to as 'cuttings', which reduces planting costs since up to four cuttings can be produced from a single whip. Cuttings are most suitable for the establishment of intensively managed hybrid poplar plantations since brush is controlled completely. Although rapid early growth of whips and cuttings does occur under optimal conditions, unrooted stock will usually not grow rapidly in the first year until a root system develops. It is during this period that whips and cuttings are most susceptible to soil drought and vegetation competition.

Black cottonwood growth performance is severely retarded by even moderate amounts of shading. High-yielding plantations are simply not possible without proper and extensive vegetation management during the establishment and early growth phases. Whips have the advantage of being taller than most competing vegetation, and light competition should not be a problem if planting occurs as soon as possible after logging or land clearing. Cuttings may suffer from reduced light conditions if competing shrub and herb vegetation is not controlled. Brush control costs may negate any advantage gained from using cuttings. Cuttings are reported to be more susceptible to browse damage than whips, and this should be considered where ungulate populations present a potential problem.

Natural Regeneration: If the stand being harvested has at least 110 well-spaced black cottonwood trees per hectare then it is possible to take advantage of the species' vigorous sprouting characteristics to regenerate a well-stocked stand. Logging should be carried out in winter and early spring when soils are moist. Site disturbance by skidders and other heavy equipment should be evenly dispersed to break up branches and tops left on the site and work them into the substrate where they will sprout and grow rapidly under proper soil moisture conditions. Post-logging scarification treatments with a drum scarifier will accomplish the same objective and can result in more even stocking.

If stands have greater than 300 well-spaced black cottonwood trees per hectare then regeneration will usually occur without treatment, although stocking may be patchy. Where regeneration densities are uneven, fill-planting with black cottonwood whipstock can be used to achieve the stocking objective of 500 well-spaced trees per hectare.

If there are less than 100 stems of black cottonwood per hectare, if spacing is clumpy in the parent stand, or if the cost of whip plantations cannot be justified, then regeneration of black cottonwood may be assisted by creating conditions that maximize the potential of natural seeding-in. Requirements for a moist seedbed in open sunlight with plenty of heat are the same as for red alder. The major differences between the two species are that black cottonwood produces more seed that is dispersed over a wider area, and seed is released in May and June rather than over the winter months. Thus, although viability of cottonwood seed is high and seeds abundant, the window for capturing seed release is shorter and the seedlings themselves very susceptible to even short periods of drought in the upper soil horizons. Exposure of mineral soil during harvesting operations should provide sufficient substrate for seedling establishment.

In most cases, natural regeneration of black cottonwood stands will result from both sprouts and seeds. Both of these processes can be enhanced by careful use of harvesting equipment. Blade scarification has been used to prepare cottonwood sites for whip plantations and to promote natural regeneration. **The use of intense site preparation methods that enhance the natural regeneration of black cottonwood has considerable potential to degrade soils and should be attempted only where soil textures are sufficiently coarse and where the risks of environmental impacts, such as erosion and siltation of fish habitat, are minimal.** Blade scarification has also been shown to result in complete occupation of the site by grasses within two years of treatment. Dense grass mats can seriously interfere with black cottonwood seedling development and can provide cover for rodent pests.

Under ideal conditions black cottonwood will regenerate naturally at between 5,000 and 30,000 stems/ha. A sanitation spacing done 1 or 2 years after establishment may be necessary. Cottonwood stands are strongly self-thinning and spacing of dense juvenile stands is not recommended. Density will decline steadily over the rotation without appreciable stagnation of crop trees.

B. Damaging agents

Thriving stands of black cottonwood in coastal British Columbia are generally free of significant damage by disease and insects. Several cankers (*Venturia, Septoria*) affect foliage and sometimes stemwood, especially outside the natural range of the species. Defoliators such as tent caterpillar, satin moth and sawfly attack trees but are seldom long-term problems. Most major damage in black cottonwood stands in coastal British Columbia is caused by strong winds, ice storms and unseasonable frosts. Plantations and natural stands are also susceptible to ungulate browsing, girdling by voles (especially in plantations with grassy cover) and harvesting by beavers.

C. Site selection

Preliminary results on the growth of black cottonwood indicate that black cottonwood site index ranges from 7 to 28 m at 15 years. The results are based on stem analysis of black cottonwood within a small number of stands but are very consistent within each site unit. Highest productivity of black cottonwood occurs on moist and very moist, very rich soils located on uplands (seepage slopes and deep, fine-textured soils) and on the high bench of alluvial floodplains. Black cottonwood site index declines from 24 to 10 m at 15 years as bench height decreases on alluvial floodplains, probably as a result of rooting-zone flooding during the growing season. Site index declines from 25 to 13 m at 15 years as soil moisture regime changes from very moist to moderately dry on upland sites. In areas of winter wet-summer dry soils black cottonwood has only medium productivity (13 m at 15 yrs) but still drastically outperforms red alder on the same sites. The results illustrate that unmanaged black cottonwood can grow at impressive rates, but only on those sites where its high demands for moisture and nutrients can be met.

D. Growth and yield

Growth and yield estimates and target statistics for four black cottonwood and hybrid poplar management systems presently employed by Scott Paper Ltd. are presented in Table 1. Natural stands are common on alluvial floodplains along coastal rivers and mean annual increments range from 5 to 8 m^3/ha/year. Veneer plantation yields are only marginally higher (10 m^3/ha/year) than natural stands due primarily to the wide spacing employed and because the *P. robusta* hybrids previously used seldomly outperformed native black cottonwood. In the extensively managed pulpwood regimes, hybrid whips are planted as soon as possible after harvesting and site preparation is minimal. Compared to unmanaged stands, yields increase almost two-fold (10-20 m^3/ha/year) in extensively managed pulpwood stands, mostly because of better stocking in whip plantations and the use of faster-growing hybrid stock.

In intensively managed plantations, all stumps and slash are removed from the site so that tractors can be used to control competing vegetation (mostly grasses) for the first four years of the plantation. Hybrid poplar growth performance in intensively managed plantations can also be enhanced by foliar nutrient deficiency analysis and stand-specific fertilization. Yields in intensively managed hybrid poplar plantations are at least triple those of natural stands with a mean annual increment range of 15-30+ m^3/ha/year. Yields as high as 80 m^3/ha/year have been reported from agricultural-style plantations in Washington. Hybrid poplars can also be managed intensively in very short rotations so that, at a spacing of about 1.75 m x 3 m, pulp trees 20 m tall with a dbh of 30 cm can be harvested after 7 years. Compared to extensively managed pulpwood stands, the cost of site preparation and weed control make stand establishment three to four times more expensive in the intensive regime. Successive rotations, however, would not incur these high establishment costs. A careful economic analysis of costs and expected yields, and careful consideration of the environmental impacts of intensive site preparation, should be carried out before initiating an intensive management regime for hybrid poplar.

TABLE 1. Yield estimates for black cottonwood under four management regimes used by Scott Paper Ltd.

	Type of Management System			
	Natural stands	Old Fraser Valley Veneer Plantations[a]	Extensively managed pulpwood stands[b]	Intensively managed pulpwood stands[b]
Rotation age (y)	30-50	25-35	25-30	15-20
Target tree size (ht/dbh)	32m/40cm	34m/38cm	35m/40cm	32m/35cm
Target tree volume (m^3/tree)	1.5	1.5	1.5	1.5
Net stand volume (m^3/ha)	250	280	300-500	300-500
Stocking at harvest (trees/ha)	200	236	250-350	400-450
MAI (m^3/ha/y)				
Fraser Block	7.9[c]	10.0	10-20	15-30+
Upcoast Block	5.4[c]	N/A	10-15	15-20

[a] Based on yield assessments of recently logged stands and stands approaching rotation age.
[b] Projections based on current growth rates and yield data from other areas.
[c] Based on old B.C. Forest Service inventory data. Currently being updated with 10 new growth and yield plots.

RED ALDER *(Alnus rubra)*

Ecology and Silvics

Red alder is another fast-growing broad-leafed tree that aggressively colonizes many upland and alluvial sites following disturbance. Although no subspecies or variants have been described, considerable variation in growth performance has been observed in provenance trials. Red alder is found on suitable sites throughout the CWH and CDF zones and in the lower elevations of the Mountain Hemlock zone of coastal British Columbia (Fig. 2). Red alder, like black cottonwood, grows best on nutrient-medium to very rich soils with fresh to very moist soil moisture regimes.

Flowering in red alder begins in late February to early March and lasts until early May. Large quantities of pollen are released during the flowering period. Seeds begin to ripen by September and are dispersed over the fall and winter months. Seeds are produced annually with bumper crops produced approximately every four years. Red alder seeds are much larger than black cottonwood, but winged structures assist in dispersion over considerable distances. For optimum germination, alder seed requires a moist, mineral soil seedbed, direct sunlight and warm temperatures. Seeds are viable for a year at most, and there is some evidence to suggest that high levels of red light stimulate seed germination. This would allow red alder seed to germinate in canopy openings created by natural and human disturbance throughout the year. Like black cottonwood, red alder sprouts vigorously from a cut stump; the number and vigor of sprouts declines considerably with age, however, so that stump sprouting is generally negligible beyond age fifteen.

As a result of its ability to tolerate summer-wet soils, red alder is considered to be the most flood tolerant of the four species considered here. Although it is highly shade intolerant it is considered more shade tolerant than black cottonwood since germinants show the ability to remain in a shaded understory for several years.

Special Considerations: Red alder roots are characterized by nitrogen-fixing nodules – the result of a symbiotic relationship between the tree and micro-organisms of the genus *Frankia*. Red alder can add between 20 and 100 kg/ha/yr of nitrogen to forest soils. The addition of nutrient-rich litter from red alder also enhances many soil properties (soil organic matter, cation exchange capacity, soil moisture retention, mineralization rates), thus increasing the availability of other necessary nutrients. These ameliorative effects have resulted in increased growth rates by associated conifers on some nutrient-medium and poor sites. On better sites, however, red alder commonly overtops and suppresses associated conifers, and a planned management regime is required to take advantage of its ameliorative influence.

Management

A. Stand establishment

Red Alder Plantations: Red alder has been successfully established using bare-root nursery stock and by transplanting wild seedlings. Plantations have the advantages of lower site preparation requirements, more easily achieving stocking and spacing goals, and managing genetically superior growing stock. Planted trees may suffer from competition from natural red alder seedlings, other fast-growing hardwoods (especially black cottonwood) and shrub and herb vegetation. Vegetation control measures may be required to meet management objectives. Herbicides cannot be used after planting since red alder is as susceptible as competing vegetation. This factor, combined with planting costs and present-day low prices for the final product, may mean that red alder plantations cannot be justified economically at this time. However, red alder plantations are being established in Washington and Oregon where the red alder industry is presently flourishing. This may foreshadow developments in British Columbia.

Natural Regeneration: As a result of its high seed productivity, effective seed dispersal and aggressive early growth characteristics, red alder commonly forms dense young stands following clearcut logging in coastal British Columbia. For optimum development, seedlings require a moist, mineral soil seedbed, direct sunlight and warm temperatures. These conditions can best be met by clearcut logging methods that expose mineral soil. Mechanical site preparation carried out in the fall would capture red alder seedfall and provide the dual role of exposing mineral soil and delaying the early development of competing vegetation. **Such intensive site preparation has the potential to degrade site productivity seriously and affect non-timber resources and should only be used when all of these factors have been carefully considered and potential impacts evaluated.** It should not be taken for granted that using natural seeding as a method of red alder regeneration will invariably result in the establishment of thriving red alder stands. Natural seeding is subject to the uncertainties of natural variation in climatic conditions and seed production. Even when seedlings can be established in sufficient numbers stocking can be irregular, and thus full site potential will not be captured. However, the general reliability and relatively low costs associated with natural regeneration of red alder make it an attractive method of stand regeneration.

Young red alder stands (1-2 years) often have densities in excess of 100,000 stems/ha with self-thinning reducing this to 10,000 to 15,000 stems/ha by age 8; thus density control measures may be necessary. Experience has shown that thinning before age 15 can increase crop tree growth, but rot pockets and dense lateral branching have been observed in thinning trials in older red alder stands. Red alder is highly sensitive to changes in light regime,

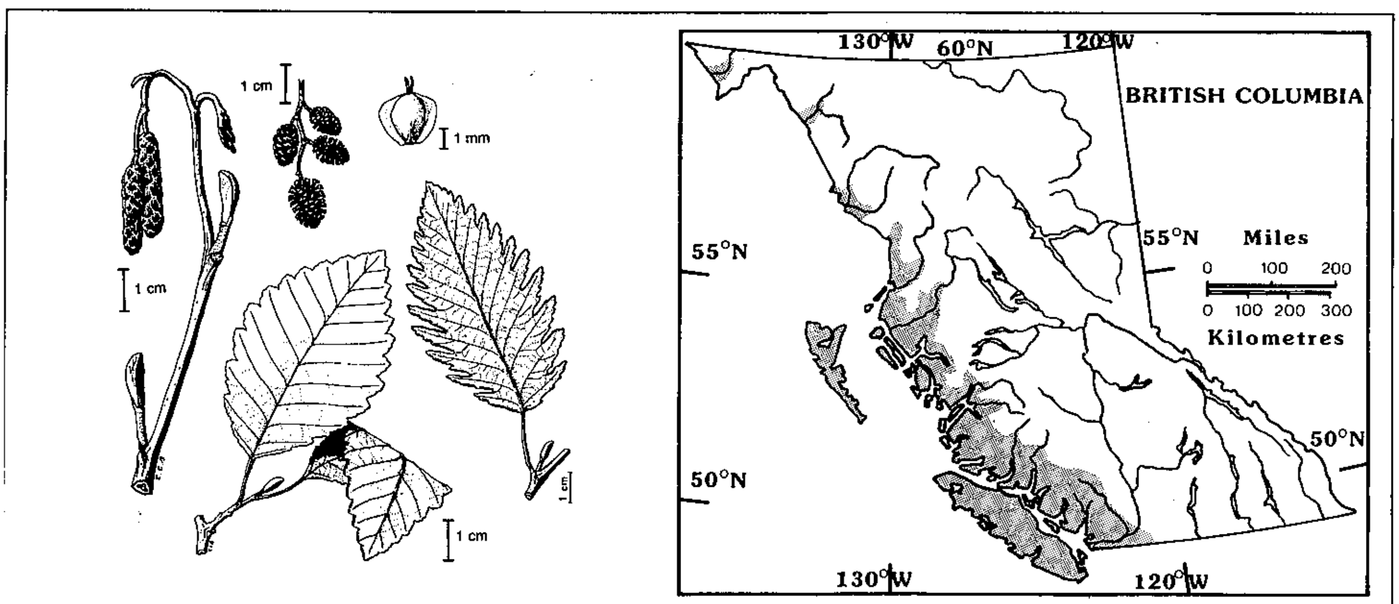


FIGURE 2. (a) Leaf, flowering and seed characteristics of red alder. (b) The range of red alder in coastal British Columbia. (Source: Coates and Haeussler 1986)

and stem form can be severely affected by trees growing towards uneven sources of light. Red alder sawlog prices are as much as triple that of red alder chips. This provides an important economic incentive to manage red alder densities and spacing in juvenile stands. Work in Washington has demonstrated the importance of careful thinning to create even spacing of red alder stands in order to grow a quality sawlog.

B. Damaging agents

Like black cottonwood, red alder has few serious pest problems for the first 40 years of stand development. White heart rot is the most serious problem but is confined primarily to injured trees or trees on wet soils. Local outbreaks by defoliators such as tent caterpillar, sawfly and flea beetle do occur, but damage is temporary and affected trees usually recover. Red alder is also damaged by unseasonal or severe frosts and by ice storms and strong winds.

C. Site selection

Growth performance of red alder is presently being studied; information on its site index on a range of sites in coastal British Columbia is not available at this time. Work in Washington and Oregon has shown that topographic position, soil moisture and aeration during the growing season, and soil nutrient status are the most important factors determining site index of red alder. Alluvial floodplains had the highest site index with lower slopes and terraces also having high productivity. These most productive sites have deep soils with high base status and are moist and well aerated throughout the year. Black cottonwood will invariably outperform red alder on the best sites. Because of its ability to fix atmospheric nitrogen, red alder can be more productive than black cottonwood on soils with lower levels of available nitrogen. Red alder is also better adapted to seasonal drought than black cottonwood and will outperform it on dry soils. It will colonize wet soils but growth is reduced considerably, as it is on soils with pronounced summer drought.

D. Growth and yield

Unmanaged, well-stocked stands of red alder on medium to good sites can produce 8-10 m^3/ha/yr (based on complete tree utilization) over 20-40 year rotations. It has been predicted that growth and yield of managed stands of red alder would be considerably higher and Tables 2 and 3 present target statistics for red alder under two proposed management regimes - pulpwood log and pulpwood log-sawlog. The scenarios have been developed in Briggs *et al.* (1978) from normal yield tables and research trials conducted in red alder stands in Washington and Oregon. Yield estimates in both management regimes are based on whole-tree utilization, which is presently not carried out in coastal British Columbia. Estimates of yield volumes are approximately halved when 4-inch-top standards are utilized.

The pulpwood log option (Table 3) uses a relatively short rotation (10-14 yrs) with 1300 trees/ha at rotation to produce 88 m^3/ha of useable pulpwood. Feller-buncher-forwarding systems could be used for harvesting the young stands if site topography and ecological and economic factors permit.

The pulpwood log and sawlog option presented in Table 3 attempts to take advantage of the considerable economic benefits received by producing sawlog-quality timber. Wide spacing to produce sawlogs and peelers is projected to produce a log 36 cm dbh with a height of 25 to 29 m (depending on site quality) in about 35 years. This reduces rotation age by about 14 years compared to unmanaged stands. Predictions of red alder growth and

TABLE 2. Yield estimates for red alder in pulpwood log production (in Briggs et al. 1978)

Stems/hectare	1300
Rotation age	10-14 yrs[a]
Spacing	2.75 m x 2.75 m
DBH	15 cm
Height	14 m
Average tree volume (CVTS[b])	0.16 m^3
Total yield (CVTS[b])	88 m^3

[a] Rotation age decreases with increasing site quality.
[b] CVTS = cubic volume of total stem, including stump and tip, inside bark.

TABLE 3. Yield estimates for red alder in pulpwood log and sawlog production (in Briggs et al. 1978)

	Thinning	Final harvest
Stems/hectare	1300	420
Rotation age	9-12	27-35
Spacing	2.75 x 2.75 m	4.9 x 4.9 m
DBH	15 cm	30 cm
Height	14	24-27 m
Average tree volume (CVTS[a])	0.16 m^3	0.73 m^3
Total yield / ha (CVTS[a]) (thinning + final harvest)	145-170 m^3	

[a] CVTS = cubic volume of total stem, including stump and tip, inside bark.

yield after thinning are based on experience with Douglas-fir, so that the estimates should be used cautiously. Serious problems exist with management regimes that employ wide spacing of red alder which the pulpwood log and sawlog option attempts to overcome. Open-grown red alder will develop large branches which will have to be pruned to maintain log quality – the problems with thinning older stands of red alder have already been discussed and the economic return is questionable. Furthermore, wide spacing will create opportunities for natural regeneration to compete with crop trees, so vegetation management regimes may have to be developed to achieve management objectives. The pulpwood log and sawlog option shown could employ a rectangular spacing of 2.5 m x 5 m. The stand could then be row-harvested to produce useable pulpwood logs at about 10 years of age and a 5 m x 5 m spacing of residual trees could be harvested as sawlogs after about 30 years. The approach overcomes some of the problems associated with wide spacing of red alder plantations since the tighter spacing would promote natural pruning and some site productivity could be captured with the pulpwood harvest.

The relatively low present economic value of red alder means that costs of stand establishment and tending should be kept to a minimum. Stands can usually be regenerated by natural seeding at low cost and stand tending operations will depend on management objectives. For the pulpwood log rotation described above, a density control entry may not be necessary if self-thinning has reduced stand density sufficiently. Maintaining even spacing is a prerequisite to producing a quality red alder sawlog. Sawlogs can be produced on an approximate 30-year rotation and would require one thinning before age 15. Rather than employing a rigid time-frame for stand rotation, harvesting schedules of stands older than 25 years should be flexible enough to take advantage of fluctuations in product prices.

BIGLEAF MAPLE *(Acer macrophyllum)*

Ecology and Silvics

Bigleaf maple, although less abundant than red alder, is an important component of the second-growth forest in southern, coastal British Columbia. Bigleaf maple is restricted to the CDF and CWH biogeoclimatic zones (Fig. 3). Soil moisture and nutrient requirements are the same as for black cottonwood, although, unlike black cottonwood, bigleaf maple is more abundant in stands on upland sites.

The low frost tolerance of bigleaf maple restricts geographic range (Fig. 3). While the species has the highest shade tolerance of all coastal hardwoods it is still considered to be only moderately shade tolerant relative to other species.

Bigleaf maple flowers in April to early May when the insect-pollinated flowers appear for about three weeks. The relatively heavy, winged seeds ripen by September and are dispersed by wind over only moderate distances from October through January. Given adequate soil moisture, seedlings grow equally well on mineral or organic surfaces. The species has been described as a

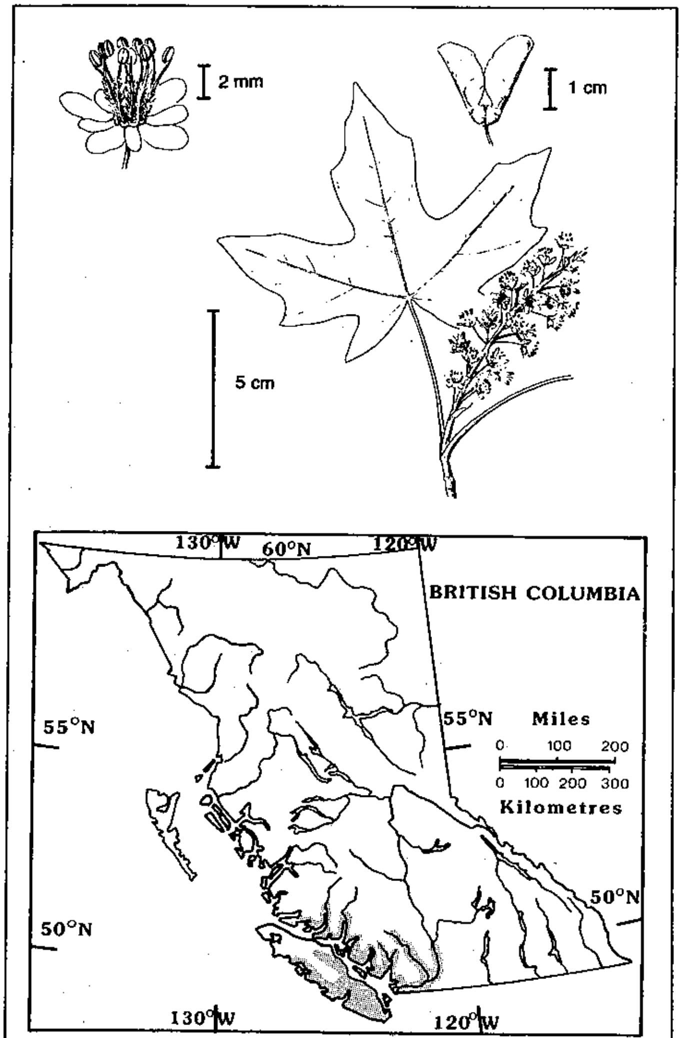


FIGURE 3. (a) Leaf, flowering and seed characteristics of bigleaf maple. (b) The range of bigleaf maple in coastal British Columbia. (Source: Coastes and Haeussler 1986)

'seedling banker', since seedlings and young saplings can maintain themselves for up to 15 years in suppressed canopy positions and can then be released with canopy opening. The low numbers of bigleaf maple seedlings found in clearcut settings has been attributed to rodent predation, dense competing vegetation and poor dispersal. Bigleaf maple sprouts are second only to black cottonwood in height growth, and multi-stemmed clumps can cover large areas of coniferous plantations.

PAPER BIRCH *(Betula papyrifera)*

Ecology and Silvics

Where it occurs, paper birch forms a locally important component of hardwood stands in coastal British Columbia. Paper birch occurs in the driest and coolest subzones of the CWH zone and is common in eastern British Columbia and in the Canadian boreal forest (Fig. 4). The species has a large number of varieties across its broad geographic range. The form that is restricted to southwestern British Columbia is considered as *Betula papyrifera* var. *commutata*. Although paper birch occurs on floodplains and upland sites in other regions of British Columbia, it is restricted to upland sites on the coast. Of the four hardwood species considered in this summary, paper birch is the least demanding in terms of soil nutrients and is the best adapted to soil drought. As with the other species, best growth performance occurs on fresh to very moist, nutrient-medium to very rich soils.

Paper birch flowers throughout April and seeds are ripe by the end of August to early September. Large crops of relatively light, winged seeds are produced every two years and are dispersed over the fall and winter months. Although some seeds may be dispersed over considerable distances by wind and water, most fall within 100 m of the parent tree. Seeds are viable for at least two years although germination success can be very low. Seedling success is best on soils where organic and mineral components are mixed. In continental varieties of paper birch, seed germination is enhanced by freezing temperatures, although it is not known whether this is true for the coastal variety of paper birch. As in the other hardwood species considered, sprouting from the stump is common, especially after fire. Growth of sprouts is the slowest of the four species, and, as in red alder, has been shown to decrease as tree age increases. Branch and stem cuttings have been used for propagation in a controlled environment, but they seldom sprout in nature.

Although the species as a whole is extremely frost tolerant it is not known whether the coastal variety of paper birch has the same tolerance. It is also assumed that it will be more frost tolerant than the other hardwood species considered - all of which have predominantly coastal distributions. Paper birch is assumed to be flood tolerant because of its occurrence on alluvial floodplains in interior British Columbia, but it seldom occurs on floodplains on the coast. Paper birch is considered to be very tolerant of fire because of vigorous, post-fire sprouting and often predominates in areas with repeated fire history.

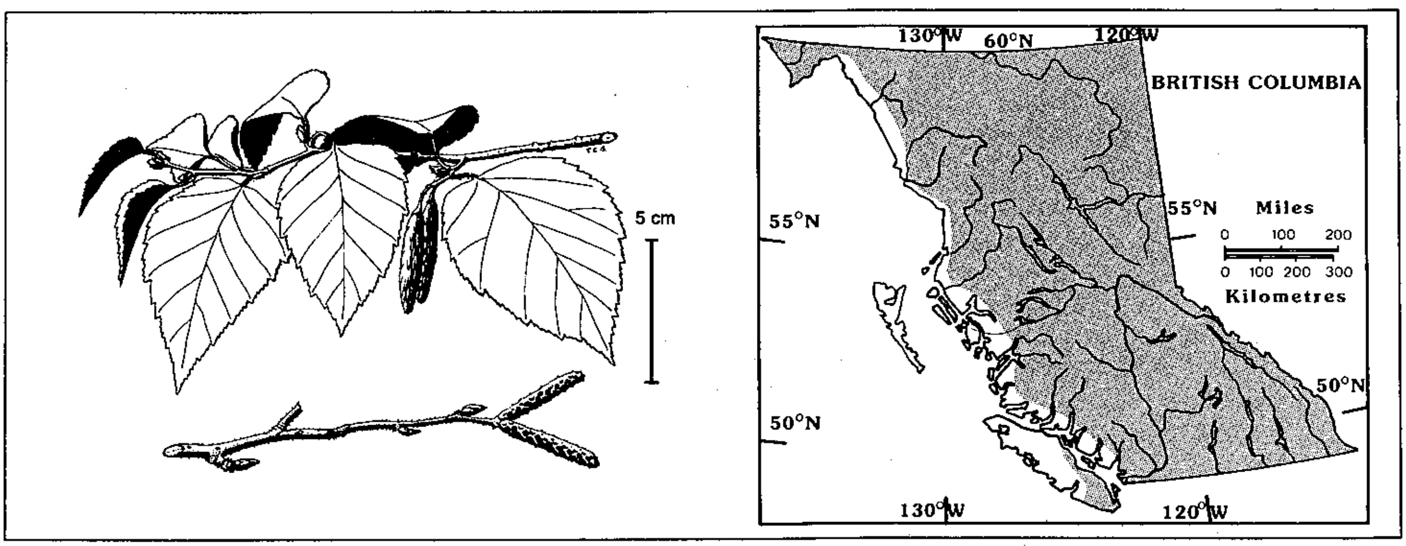


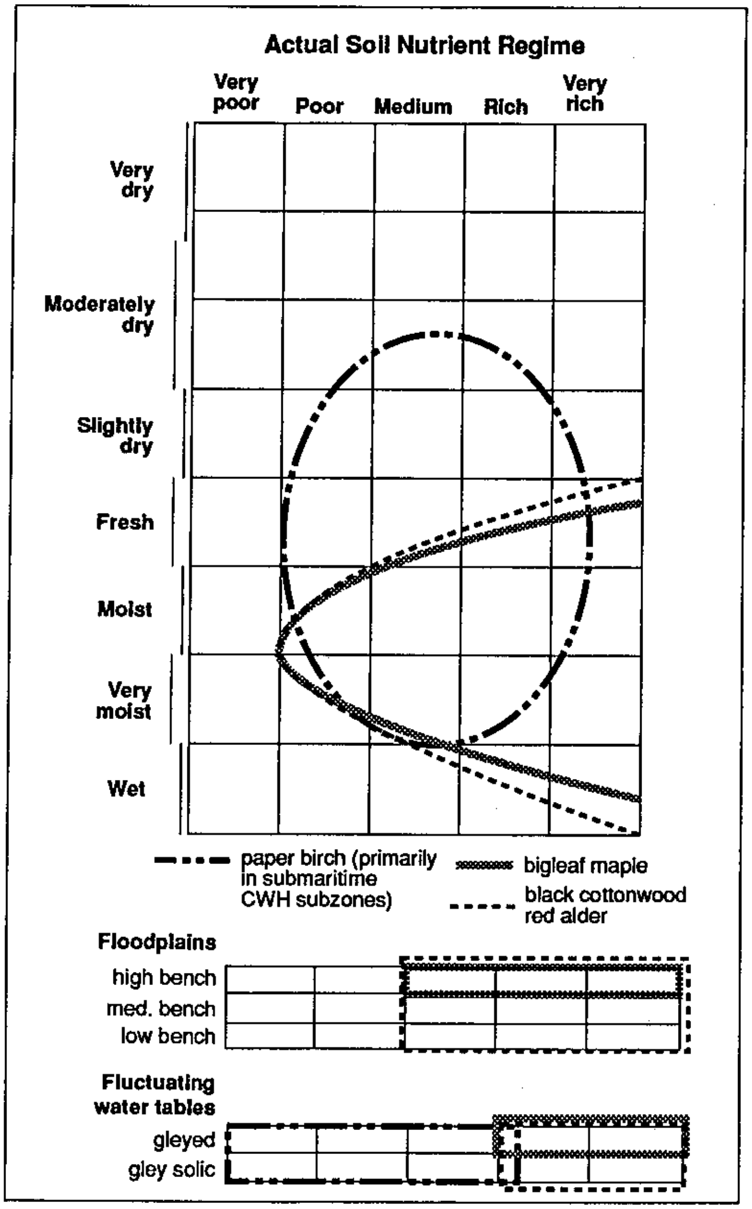
FIGURE 4. (a) Leaf and flowering characteristics of paper birch. (b) The range of paper birch in British Columbia. (Source: Coates and Haeussler 1986)

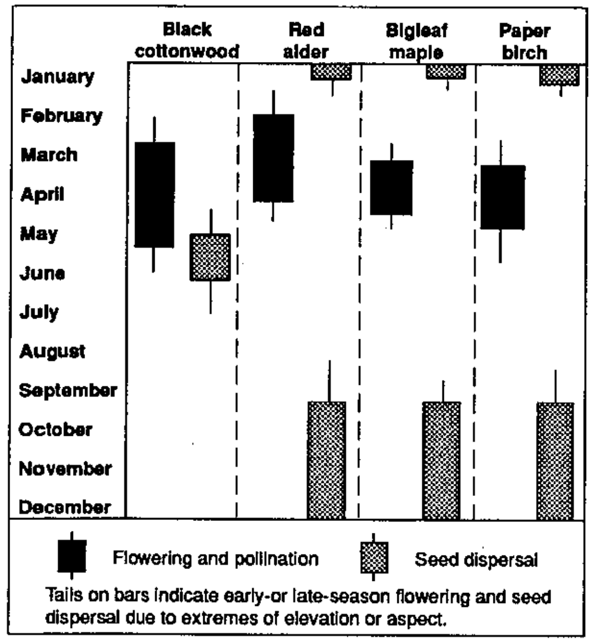
COMPARISON OF FOUR COASTAL HARDWOODS

Ecological tolerances important for the management of 4 hardwood species in coastal British Columbia

Ecological factor	Black cottonwood	Red alder	Bigleaf maple	Paper birch
flooding	tolerant	tolerant	tolerant	tolerant
frost	tolerant	mod. tolerant	intolerant	tolerant
snow	tolerant	tolerant	intolerant	intolerant
shade	intolerant	intolerant	mod. tolerant	intolerant
fire	intolerant	tolerant[a]	mod. tolerant	tolerant[a]

[a] regeneration from sprouts





Flowering and seed dispersal phenology of four hardwood species in coastal British Columbia.

Most productive sites for four hardwood species in coastal British Columbia.

HARDWOOD FOREST MANAGEMENT IN COASTAL BRITISH COLUMBIA – OPPORTUNITIES AND KNOWLEDGE GAPS

Hardwood silviculture has several advantages that help compensate for the relatively low present value of hardwood fiber. Compared to coniferous species, black cottonwood and red alder stands can be reliably established at relatively low cost on high brush hazard sites. On these sites growth performance is impressive and stands can be managed for 25-35 year rotations – approximately half that of coniferous plantations. This means that establishment costs are lower, fiber will be available sooner, and returns on investment realized earlier. These factors make the management of hardwoods an attractive option for both small woodlot owners (low establishment costs and short rotations) and large licencees, who may be trying to deal with projected fiber shortages (short rotations).

Hardwood stands have several characteristics which make them very useful for integrated resource management. Stands can be established without herbicides or slashburning, thus reducing many conflicts with fisheries and wildlife resources. In the first 10 to 15 years hardwood stands have well-developed shrub layers which provide important forage for for wildlife – especially ungulates and bears. As the canopy closes, shrub productivity decreases and the major value of hardwood stands is as cover, although often stands remain brushy throughout the rotation. It may be possible to manipulate the densities of hardwood stands to promote the development of different understory species with particular wildlife value (e.g., berry-producing shrubs) and still meet silvicultural objectives. Hardwoods established along streambanks are also very useful for the protection and enhancement of fisheries resources. Streambanks are occupied rapidly, hardwood canopies provide shade to regulate water temperatures, and litterfall provides important organic material for aquatic food chains. Thus, hardwood stands of different ages interspersed throughout coniferous stands and along watercourses can enhance overall forest complexity and provide a range of habitat requirements for both wildlife and fisheries resources.

The establishment and development of mixed stands of hardwoods and conifers, with the hardwood acting as nurse trees to help establish the conifers, is a promising but poorly understood aspect of hardwood silviculture. Operational plantations, where black cottonwood acted as a nurse tree to establish western redcedar on a high brush hazard site, demonstrate the potential. Weevil damage to Sitka spruce has been shown to be reduced if crop trees develop under a hardwood canopy. Where the Sitka spruce weevil is expected to be a problem, it may be feasible to use black cottonwood or red alder to protect the Sitka spruce. The silvicultural feasibility and productivity of these combinations, as well as many others from the coast and interior, should be evaluated.

The silviculture of most hardwood species is in its infancy in coastal British Columbia and there is much to learn. The lack of any sort of local management information on bigleaf maple and paper birch is an obvious research requirement. Some information for bigleaf maple is emerging from Washington and Oregon where there is now considerable interest in management of the hardwood resource. Research has been carried out on paper birch in other forest regions of Canada and Scandinavia and the applicability of this information to coastal British Columbia should be evaluated.

Most growth and yield scenarios for black cottonwood and red alder in this report are based on projected values. More reliable information can come only from observations on complete rotations. Hybrid poplars are very promising, but clones need to be matched to sites and susceptibility to pests and pathogens examined. The timing and intensity of thinning required for hardwood stands is another important information gap. Coastal British Columbia has one of the most impressive softwood resources in the world and, with proper management, will continue to produce large volumes of softwood timber indefinitely. Hardwood forestry will continue to occupy a small proportion of the volume harvested but can provide necessary diversity for a maturing forest economy. Given its increasing value as a timber resource, as well as its soil ameliorative functions and integrated resource management roles, forest managers must learn to include the hardwood resource to manage the forests of coastal British Columbia effectively.

REFERENCES FOR FURTHER READING

Information for this summary was compiled from the following sources. Also, I would particularly like to thank Peter MacAuliffe of Scott Paper for providing information on management of black cottonwood and hybrid poplar.

Briggs, D.G., D.S. DeBell, and W.A. Atkinson (compilers). 1978. Utilization and management of alder. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. PNW-70.

Chester, R.A. 1988. Management and use of red alder in the Vancouver Forest Region. M. Sc. Thesis. Simon Fraser University, Burnaby, B.C.

DeBell, D.S. and T.C. Turpin. 1983. Red alder. *In* R.M. Burns (compiler), Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., For. Serv. Handb. No. 445, pp. 26-28.

Evans, J. 1984. Silviculture of broadleaved woodland. For. Comm. Bull. 62, London.

Fowells, H.A. (compiler). 1965. Silvics of Forest Trees of the United States. U.S. Dep. Agric., For. Ser. Handb. No. 271.

Fried, J.S., J.C. Tappeiner II, and D.E. Hibbs. 1988. Bigleaf maple seedling establishment and early growth in Douglas-fir forests. Can. J. For. Res. 18:1226-1233.

Haeussler, S. and D. Coates. 1986. Autecological characteristics of selected species that compete with conifers in British Columbia: A literature review. B.C. Min. For. Land Manag. Rep. No. 33.

Kenady, R.M. 1978. Regeneration of red alder. *In* Utilization and management of alder. D.G. Briggs, D.S. DeBell, and W.A. Atkinson (compilers). U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. PNW-70, pp. 183-192.

Krajina, V.J., K. Klinka, and J. Worrall. 1982. Distribution and ecological characteristics of trees and shrubs of British Columbia. Faculty of Forestry, University of British Columbia, Vancouver, B.C.

Lousier, J.D. 1990. Guidelines for alder seed tree control. FRDA Memo 132. B.C. Min. For. and For. Can., Victoria, B.C.

MacPherson, A.C. 1980. Status of the hardwood resource on the B.C. coast. *In* Proceedings of a Symposium on Utilization of Western Canadian Hardwoods. Forintek Canada Corporation, Spec. Publ. No. SP-2, pp. 9-16.

Marquis, D.A. 1964. Effect of seedbed condition and light exposure on paper birch regeneration. J. For. 62: 876-881.

Minore, D. 1979. Comparative autecological characteristics of northwest tree species - a literature review. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. PNW-87.

Information compiled by:
Donald S. McLennan
OIKOS Ecological Consultants
209 - 1977 Stephens Street
Vancouver, B.C. V6K 4M7