6 MANAGING COTTONWOOD-BALSAM POPLAR FOR NON-TIMBER RESOURCE USES

Management of cottonwood, red alder, and other broadleaf species has increased markedly in the last decade and will continue to do so, a trend supported by both economic and ecological factors. This section focuses on the contribution of cottonwood and balsam poplar to biodiversity, wildlife habitat, riparian values, and integrated resource management.

6.1 Managing Cottonwood–Balsam Poplar to Enhance Wildlife Habitat and Forest Biodiversity

- **Current land management guidelines in the Prince Rupert Forest Region stress that cottonwood management can influence preferred habitats of pileated woodpecker, beaver, fisher, moose, and snowshoe hare.**

Cottonwood stands on alluvial floodplains are important foraging areas for grizzly bear, black bear, Roosevelt elk, and black-tailed deer in coastal British Columbia, and for moose and mule deer in the interior.

- **Large-diameter live cottonwood and balsam poplar are good candidates to retain for future snags. Management to promote future snags is often best done in patches such as green-tree retention areas and along riparian corridors. Windfirm trees that have the potential to grow until they are at least 25 cm dbh are the best candidates to leave as future snags. Anecdotal observations indicate that minimum diameter criteria developed for wildlife trees on the coast may not be appropriate for interior regions where smaller-diameter trees show wildlife usage.**

Wildlife values of black cottonwood and balsam poplar are derived from:standing live trees that retain dead branches of substantial diameter (Figure 30); dead standing snags that provide a gradual exposure of decayed wood for cavity-nesting opportunities (Figure 31); and dead down coarse woody debris of high biodiversity value (Figure 32). Recent observations in the Cariboo and Prince George forest regions indicate that wildlife tree use of broadleaf species not only exceeds wildlife use of conifers, but that use of live broadleaf species by cavity nesters is sometimes even greater than use of broadleaf snags.

Cottonwood-associated wildlife species that are of particular concern during silvicultural planning and timber harvesting are as follows:

- Pileated woodpeckers are common residents of mature coniferous and mixed forests. They use coniferous and deciduous trees for nest cavities, and need trees at least 25 cm dbh — but preferably over 50 cm dbh — for nesting.
- Beaver use riparian deciduous forests and willow shrublands, with highest densities in low-gradient streams and sheltered lakes where there are plenty of deciduous trees under 10 cm dbh.
- Fisher are secondary users of cavities in large cottonwoods, mainly in summer when they use riparian areas, pole-sapling forests, and mixed forests.
- During severe winters, moose are dependent on mature deciduous and mixed forests for feeding and shelter. In summer, moose also use wetland and riparian areas that have a dense deciduous cover.
- Snowshoe hare prefer brush fields or deciduous mixed forests that have willow understory.

FIGURE 30. Live black cottonwood with relatively large-diameter dead branches that add value to these stems as wildlife trees.

FIGURE 31. Dead standing snag of black cottonwood with relatively lengthy bark retention which provides a gradual exposure of cavity-nesting sites.

FIGURE 32. Dead down coarse woody cottonwood biomass of high biodiversity value.

In British Columbia's current approach to silviculture prescriptions, "leave trees" retained for wildlife purposes typically have specifications such as: broadleaf species; patches around raptor nests; patches of poor-quality trees with deformities; veteran trees; trees in riparian and wetland areas; patches of trees in areas that are difficult or uneconomical to harvest, such as steep gullies or wet depressions; and patches of merchantable trees in uniform blocks. Cottonwood and balsam poplar frequently qualify for one or more of the first six specifications listed above, perhaps more so than any other of British Columbia's tree species. For naturally occurring cottonwood and balsam poplar, it is only the seventh listed specification — merchantable trees in uniform blocks — for which conifers likely play a bigger role than broadleaf species as leave trees.

Cottonwood and balsam poplar are recognized as significant components of riparian zones, where they provide distinct structure and habitat edge with special value for wildlife. Although cottonwoods and balsam poplar experience decay at much earlier ages than conifers, they provide particular habitats for wildlife as snags, wildlife trees, and down woody material that provide shelter, cover, and cavities for birds and mammals (see Tables 25 and 26, and Figures 30, 31, and 32). Where cottonwood, balsam poplar, willow, and aspen occur, they are heavily used by such species as woodpeckers. In British Columbia and the Pacific Northwest, several bird species are primary cavity nesters in riparian cottonwoods, including owls, hummingbirds, starlings, sapsuckers, flickers, veerys, orioles, grosbeaks, and vireos; and several mammal species are secondary cavity users, including opossum, raccoon, fisher, and spotted skunk.

TABLE 25. British Columbia animal species with habitat requirements that can be influenced by management, harvesting, and regeneration of ecosystems where *Populus* species are prominent (Meidinger and Pojar 1991; McLennan and Mamias 1992; Massie et al. 1994).

Category	Species
Primary cavity nesters	Lewis' Woodpecker, Pileated Woodpecker, Hairy Woodpecker, Northern Flicker, Yellow-bellied Sapsucker, Red-naped Sapsucker, Red-breasted Sapsucker, and Downy Woodpecker
Secondary cavity nesters	Barrow's Goldeneye, Bufflehead, Common Goldeneye, Common Merganser, Hooded Merganser, Wood Duck, Western Screech-owl, Boreal Owl, Northern Saw-whet Owl, and Tree Swallow
Common nesters	Great Horned Owl, Bald Eagle, Great Blue Heron, Osprey, Mourning Dove, Ruffed Grouse, Cooper's Hawk, and Red-eyed Vireo
Small mammals	Northern long-eared myotis, Pacific water shrew, Southern red bat, and Pacific jumping mouse
Large mammals	Grizzly bear, Black bear, Moose, Roosevelt elk, Mule deer, and White-tailed deer
Furbearers	Bobcat, Mink, Ermine, and River otter
Reptiles and amphibians	Clouded salamander, Giant salamander, Long-toed salamander, Painted turtle, Western toad, Canadian toad, Striped chorus frog, Wood frog, and Tailed frog

The following is a collective list of animal species that are known to occur in ecosystems where black cottonwood or balsam poplar occur.

Bald Eagle	Red-eyed Vireo	Roosevelt elk
Great Blue Heron	House Wren	Pacific water shrew
Lewis' Woodpecker	Ovenbird	Southern red bat
Barrow's Goldeneye	Pileated Woodpecker	Grizzly bear
Bufflehead	Hairy Woodpecker	Beaver
Mourning Dove	Common Goldeneye	Bobcat
Wood Duck	Common Merganser	Mule deer
Cooper's Hawk	Hooded Merganser	White-tailed deer
Great Horned Owl	Boreal Owl	Hoary, Silver-haired, other myotis bats
American Kestrel	Northern Saw-whet Owl	Porcupine
Northern Goshawk	Tree Swallow	River otter
Long-eared Owl	Osprey	Ermine
Western Screech Owl	Ruffed Grouse	Mink
Northern Flicker		Black bear
Red-naped Sapsucker		Moose
Yellow-bellied Sapsucker		Pacific jumping mouse
Red-breasted Sapsucker		Northern long-eared myotis
Downy Woodpecker		

TABLE 26. Wildlife species in British Columbia using or dependent on black cottonwood and balsam poplar in mixed or pure stands (based on Enns et al. 1993). Ranking of species is based on B.C. Ministry of Environment, Lands and Parks (1991). Red-listed species are endangered or threatened, blue-listed species are considered vulnerable and "at risk," and yellow-listed species are species actively managed at a population level.

Species	Use of cottonwood or balsam poplar	Management concern
Red-listed birds	None	None
Blue-listed birds		
Bald Eagle	Nest trees usually deciduous (*Populus* spp.) in interior and often deciduous, mostly cottonwood, on the coast.	Cottonwood harvesting in coastal habitat may affect nest and roost tree requirements.
Great Blue Heron	Most common nest trees are cottonwood (interior) and red alder (coast).	Cottonwood harvesting on coast and on alluvial floodplains may affect rookeries; protection and identification of rookeries needed.
Green-backed Heron	Riparian cottonwoods part of habitat.	Harvesting may disturb habitat require-ments; response to disturbance poorly known.
Lewis' Woodpecker	Black cottonwood provides 30% of all nest trees; primary cavity excavator that provides nest holes for secondary users.	Mixedwood and riparian cottonwood utili-zation may conflict with habitat use.
Yellow-listed birds		
Barrow's Goldeneye	Aspen and cottonwood common nest trees; minimum dbh is 50 cm.	Planning for future large-stemmed trees necessary.
Bufflehead	Secondary nest trees after aspen are cottonwood and balsam poplar; minimum dbh is 38 cm; nests in cavities excavated by Northern Flicker.	Adequate buffer strips around lakes in breeding habitat.
Hooded Merganser	Breeding habitat is freshwater wooded shorelines where deciduous and coniferous tree cavities used; minimum dbh is 38 cm.	Adequate buffer strips around lakes in breeding habitat.
Mourning Dove	Breeding habitat and roosts include deciduous woodlands (cottonwood and red alder).	Alluvial cottonwood utilization may affect habitat.
Sharp-tailed Grouse	Preferred year-round habitat is lowlands adjacent to open woodlands which in northeast B.C. is young seral deciduous.	Requires deciduous riparian areas in valley bottoms for winter; may be compatible with mix of crop rotations.
Wood Duck	Breeding habitat is mature deciduous woodlands adjacent to ponds and slow-moving rivers. Secondary cavity nester, uses Pileated Woodpecker nest holes, mainly in *Populus* spp., red alder, and bigleaf maple.	Harvesting in riparian areas may affect habitat; cottonwood leave strips recommended.

TABLE 26. Continued

Species	Use of cottonwood or balsam poplar	Management concern
Red-listed mammals		
Some bat species (Fringed myotis, Keen's long-eared myotis, Townsend's big-eared bat)	Require deciduous riparian habitat and insect sources.	Riparian harvesting may affect habitat and feeding; poorly understood.
Blue-listed mammals		
Pacific water shrew	Cottonwood stands included in primary habitat with red alder. .	Protection of broadleaf species in riparian zones.
Southern red bat	Roosts in and forages above cottonwoods in range in southern B.C.	Inventory and habitat use by bats are in need of study.
Grizzly bear	Forages in seral and maturing cottonwoods and red alder with rich shrub understories.	Openings should be maintained in riparian zones.
Yellow-listed mammals		
Beaver	Aspen is primary dam and lodge construction species but will also use other broadleaf species, including cottonwood. .	Protection of shore areas that serve as beaver habitat.
Mule deer	In northeast B.C., seral aspen and cottonwood used for forage; cottonwood with aspen and alder provide early successional forage species. .	Encouragement of a mosaic of small cuts and leave blocks.
White-tailed deer	Forages in early seral aspen and cottonwood.	May be compatible with mixed rotations.
Moose	Balsam poplar is one of moose's deciduous browse species, especially early successional stages.	Shelter patches should be left within cutovers.
Bobcat	Part of habitat requirements includes riparian cottonwood (areas of high productivity and high small mammal density).	Alluvial and lakeside harvesting could ultimately affect habitat utilization; otherwise, low potential conflicts with broadleaf management.
Ermine	Habitat requirements include deciduous forests	Low potential conflicts with broadleaf management.
Fisher	Some secondary use of nesting cavities in deciduous trees.	May be compatible with mix of rotations over local ranges

Black cottonwood trees are used extensively in British Columbia as eagle roost trees. They can offer the necessary height, diameter, growth form, and nearness to water and available food required by eagles. Eagles nest along waterways, sites where cottonwood or balsam poplar are also found. On the coast, old-growth conifers and cottonwoods provide communal night roost near some concentrated food sources. For example, large concentrations of eagles feed on salmon in the Squamish, Harrison, and Qualicum river areas. Eagles use cottonwoods for daytime perching, especially in winter. Winter roosts, because of their specific vegetative characteristics and their rare and localized status, need to be identified, deferred from harvest, and protected from disturbance. Cottonwood in the Squamish River valley near Brackendale is an example of prime winter roosting habitat for bald eagles. The annual count at that location in early January 1994 recorded 3766 eagles, making this North America's largest known winter concentration area for bald eagles. In such circumstances, cottonwood clearly fills a special wildlife habitat role that needs to be recognized by managers of alluvial and floodplain ecosystems. The Nechako River, which has been under regulated flow for several decades, is an example of a British Columbia alluvial ecosystem where there is now a lack of eagle nest trees because existing cottonwood–balsam poplar stands are breaking up and new stands of these *Populus* subspecies are not regenerating. On Carey Island, in the Fraser Valley downstream from Agassiz, Scott Paper Limited became the first firm to preserve communal eagle night roosts and to adjust logging to reduce disturbance to eagles.

Managers should give special attention to retention of wildlife trees in floodplain ecosystems. Wildlife trees are standing dead or live trees with special characteristics (such as current use by wildlife, large diameter and height for the site, and relative scarcity) and structural complexity (such as well-branched, presence of rot, good height amongst surrounding vegetation, and broadleaves or conifers with hard and soft stems). They provide denning, shelter, nesting, roosting, and foraging for birds, mammals, and other wildlife. The manager has three options: green-tree retention, leave patches of wildlife trees, and wildlife tree creation. Wildlife tree patches can be designated on a temporary basis for wildlife trees judged a safety risk for forest workers. Such patches can range in size from an area with a single wildlife tree, to several hectares with many wildlife trees, both live and dead. Wildlife trees can be created by high-cutting stumps to create "stubs" which then provide structure in subsequent second-growth forests and eventually coarse woody debris (Figure 32). Good candidates for stubs are trees exhibiting some defect or rot such as canker, scar, or conk in the lower bole.

Pathogens have been suggested as important agents of diversity where cottonwood and other broadleaf species intermix with conifers. There are secondary influences on wildlife as a result of these pathogens. For example, in the Interior Cedar–Hemlock zone, patches of mixedwood forest are often large root disease centres, mainly for *Armillaria ostoyae* and *Phellinus weirii*. Since these pathogens spread very slowly, such root disease centres are probably very old, possibly 100 or more years. These two pathogens survive fires and other major stand-destroying events as mycelium in stumps and roots, and invade the regeneration that follows as new roots come in contact with the buried inoculum. From there, the pathogens spread from tree to tree. The result in the infected areas is a mixed forest in which the more disease-resistant broadleaf species such as cottonwood, birch, and aspen assume a dominant position. The combination of cover in the surrounding conifer stands and browse available in the root disease centres may provide near-optimum conditions for moose and deer. Also, these root diseases create a constant supply of snags in all stages of deterioration, providing essential habitat for cavity-nesting birds. The latter, in turn, may play a role in insect population regulation both in the disease centres and in the surrounding forests. Other forest features are also modified in root disease centres.

In summary, the forest manager should recognize that the root diseases create special habitats that may favour plant and animal species not well adapted to living in dense, even-aged coniferous stands.

Deciduous trees in a largely coniferous landscape provide habitat diversity that is exploited by many wildlife species. Many songbirds, such as warblers, vireos, and flycatchers, preferentially use deciduous trees rather than conifers as foraging and nesting areas. Some primary cavity nesters prefer deciduous species to conifers because cavity excavation in stems of broadleaf species is easier than in conifers, and some species of insect are associated only with deciduous species. Cottonwood and aspen are particularly important in this regard because mature trees of this genus frequently have heart rot. The significance of cottonwood and balsam poplar for maintaining wildlife through the conservation of important wildlife habitats and habitat components is particularly evident in estuarine and riparian locations. Deciduous trees in riparian and adjacent areas are a required habitat component for beaver, regarded as a keystone species for its role in creating valuable habitat for many other wildlife species.

Information Sources:

Thomas 1979; Hamilton and Archibald 1986; Cannings et al. 1987; Green and Salter 1987; Kochanski 1987; Schofield 1989; Nyberg et al. 1990; Bryant et al. 1991 and 1992; Kuhnlein and Turner 1991; Meidinger and Pojar 1991; van der Kamp 1991; Backhouse 1993; Banner et al. 1993; Bunnell et al. 1993; Enns et al. 1993; Klenner and Kremsater 1993; Blood and Anweiler 1994; Telfer 1994; Lee 1995; Obee 1995; Peterson and Peterson 1995; D. Lousier, pers. comm., Aug. 1995.

In certain situations, livestock can interact with cottonwood and balsam poplar to the detriment of the two subspecies. In these circumstances, the suggestions made in the *Aspen Managers' Handbook for British Columbia* for integration of livestock use with aspen are relevant:

- Remove obstacles and hazards such as high stumps and slash.
- Seed forage species to increase the quantity and quality of grazing.
- Use fences to direct cattle to desired cutblocks, and to control unwanted foraging.

The emphasis in this handbook is on production of *Populus* wood fibre and the role of *Populus* in provision of protective measures for wildlife, riparian ecosystems, biodiversity, and integrated resource management. Although not discussed in detail here, these broadleaf species also provide culturally important raw materials. For example, balsam poplar's biodiversity values include a wide variety of craft, food, and medicinal uses. Specific examples are: use of catkins as early spring sources of vitamin C; use of cambium as a food; medicinal use of buds to produce Balm of Gilead; extraction of salicin and populin for pain relief, antiseptic, and liniment; and use of poplar wood ashes to aid cleaning and as a substitute for baking soda.

6.2 Managing Cottonwood–Balsam Poplar to Meet the Goals of Integrated Resource Management

- **On alluvial floodplains, the ease and low cost of establishing cottonwoods, plus severe conifer regeneration problems and integrated resource management concerns, indicate that cottonwood may often be the preferred subspecies in alluvial ecosystems and that cottonwood management systems will increase in the future.**

- **There is growing awareness of the potential to manage cottonwoods for fibre production in proximity to important fish and wildlife areas in ways that can protect non-timber resource values.**

Low fluvial benches that are subject to prolonged annual flooding, often of high velocity, are examples of sites where "no management" is the best choice for black cottonwood or balsam poplar.

Development of suitable habitat conditions for all native plant species present in an area is recommended as the best way to conserve biodiversity. In this respect, forest types that are often less common than coniferous types, such as cottonwood, balsam poplar, birch, aspen, alder, and maple stands, should be maintained over the rotation.

Retaining clumps of balsam poplar during aspen harvesting operations provides additional structural diversity that clearcutting all trees does not. These clumps can provide cover for ungulates and offer habitat for cavity nesters. Alberta data indicate that clumps of balsam poplar with more than about 35 stems can reduce aspen suckering within the residual clump, but such effects do not extend outside the clump. The biodiversity benefits of retaining balsam poplar clumps in aspen harvesting areas appear to outweigh any resulting reductions in density and growth of aspen suckers.

Information Sources:

McLennan and Mamias 1992; Navratil et al. 1994.

6.3 Cottonwood–Balsam Poplar in Riparian Zone Management

- **Both cottonwood and balsam poplar are high-value wildlife trees in riparian areas.**

- **Several factors justify the need for appropriate objectives for management of cottonwood and balsam poplar in riparian zones, particularly because of the extreme importance of riparian zones for aquatic and terrestrial wildlife and for water quality, and because of the predominance of these species in British Columbia riparian zones.**

Although increases in conifer stocking are desirable in many riparian zones, cottonwood and balsam poplar play such a dominant role in riparian forest ecology that they must be provided for by continuing management.

In most forest regions of British Columbia, cottonwoods are now considered acceptable subspecies to regenerate alluvial floodplain sites. Extensive management of black cottonwood is well suited to alluvial floodplains because whip plantations establish readily and are adapted to flooding and siltation typical of such sites. Also, short rotations are well suited to alluvial surfaces that may erode before longer-rotation species such as conifers can mature; cottonwoods stabilize eroding banks and act as sediment filters that protect conifer plantations from flooding; and, in stream buffers, cottonwood canopies help to regulate stream temperatures and provide litter for detritus-based food chains in streams.

In unregulated streams, cottonwood reproductive events are highly correlated with stream discharge, water levels, and extent and duration of deposition by flooding. This raises questions about the future of the cottonwood resource along rivers that are increasingly under the influence of regulated discharge rates that do not simulate natural flooding and the subsequent seasonal lowering of water tables in alluvial ecosystems. In general, cottonwood management is a desirable alternative to the problem of conifer regeneration on alluvial floodplains. Cottonwoods can be established rapidly, and at lower ecological and economic cost than is the case with conifers.

A particular use of *Populus* species in riparian situations adjacent to farmland is the Ecolotree Buffer ™ developed by the University of Iowa. This technique may deserve testing in British Columbia where agricultural uses are near cottonwood stands. It involves a wooded buffer strip planted between a stream and row-cropped land with the tree roots intentionally grown deep enough to intersect the near-surface water table and use utilize nitrate from non-point source agricultural pollutants. Such poplar buffers have the capacity for high rates of biomass production. They also have several other benefits: poplar has preformed root primordia below the bark (e.g., cuttings 1.7 m long can be planted 1.5 m into the ground); poplar grows rapidly and can be grown in close spacing; poplar can reproduce vegetatively, allowing specific clones to be selected and propagated for specific applications; poplar tolerates submerged root systems, important in situations with high and fluctuating water tables; poplar can coppice after cutting; and poplar can absorb nitrates from adjacent agricultural areas.

The Operational Planning Regulations (Part 5, Sec. 44 and 45; Part 6, Sec. 54 (2) (A), (b); Part 10, Sec. 72-77), the Timber Harvesting Practices Regulation (Part 2, Sec. 5; Part 3, Sec. 11, 14, and 15), the Silviculture Practices Regulation (Part 2, Sec. 4 and 15), and the Cutblock and Road Review Regulation (Part 3, Sec. 5) under the Forest Practices Code provide details on silvicultural systems for riparian reserve zones, circumstances requiring retention of streamside trees, and other aspects of riparian zone management. Any of black cottonwood, balsam poplar, or red alder could be involved in these regulatory requirements. Penalties that accompany contravention of certain riparian-related sections listed above range from $5000 to $20 000 per incident, as specified in Section 6 and the Schedule of the Administrative Remedies Regulation under the Forest Practices Code. The riparian guidebook under the Forest Practices Code provides more details for managers of black cottonwood and balsam poplar.

Managers of naturally occurring coastal cottonwood should also know that the *British Columbia Coastal Fisheries/Forestry Guidelines* specifically recommend maintaining deciduous tree and brush species where these are important for erosion control, stabilization of streambanks, streamside cover, or water temperature control during silviculture operations in streamside management zones. Cottonwood, together with red alder, has an important role in coastal riparian zone management (Figure 33). The importance of cottonwoods in inland riparian areas has been well documented for southern Alberta.

Information Sources:

Rood and Mahoney 1991; Licht 1992; McLennan and Mamias 1992; British Columbia Coastal Fisheries/ Forestry Guidelines Technical Committee 1993; Enns et al. 1993; R. Stettler, pers. comm., July 1994; British Columbia Ministry of Forests and British Columbia Ministry of Environment, Lands and Parks 1995a, 1995b, 1995d.

FIGURE 33. In many interior valleys, cottonwood stands dominate lowland sites, as along the North Thompson River, British Columbia (upper photo). In coastal British Columbia, cottonwood (together with red alder) is also an important species in riparian zone management, as in this example along the Cowichan River (lower photograph).

6.4 Role of Cottonwood and Balsam Poplar in Restoration Forestry

- **Their common occurrence on sites adjacent to streams gives cottonwood and balsam poplar a special role in restoration forestry related to enhancement of wildlife and fish habitat. The cost of rehabilitating sites with cottonwood is less than with conifers, mainly because cottonwoods are at a free-to-grow stage in 2–5 years.**

- **Cottonwood-related restoration forestry measures can include techniques such as: creating optimal bear-foraging habitat using clumped spacing approaches, especially for coastal grizzly habitats; leaving the cottonwood component in nurse-tree shelterwood systems to die out naturally, thus creating habitat for cavity-nesters and associated species; and using nurse-tree shelterwoods in riparian zones to stabilize streambanks and provide shade and energy inputs to stream ecosystems.**

On a province-wide basis, cottonwood and balsam poplar have a variety of potential new forest roles including: to stabilize riparian areas and provide cover and nutrients for stream ecosystems; to replenish nutrient-depleted soils; to stabilize unstable slopes; to reclaim denuded land and mine spoils; and to reforest root-rot areas.

Although there is little recorded experience to date, this handbook contains examples to indicate that forest managers can achieve impressive results if the wide variety of seed and vegetative regeneration capacities of cottonwood and balsam poplar are used to their fullest potential during ecosystem restoration. Restoration and reclamation approaches are currently being redesigned in British Columbia and broadleaf species have an important role in the restoration of landings, bladed skid trails, and access roads. Recent suggestions from the Prince George Forest Region include the following ideas:

- A 7–10% deciduous component on each cutblock may help to reduce some of the current conflict in planning for biodiversity and wildlife goals.
- Using deciduous species, instead of lodgepole pine, on landings and access roads,would facilitate relocation and reuse of these areas in the second harvest, thereby reducing additional soil degradation.
- A deciduous component would give future generations opportunities for economic diversification by providing a continuous volume of broadleaf species.

An understanding of responses to disturbances is the key for using particular tree species for rapid green-up in ecosystem restoration projects. As explained in other sections of this handbook, these responses are the main tools available to the silviculturalist or ecosystem restoration specialist.

Stewardship principles increasingly stress the responsibilities of planting, harvesting, regenerating, and now restoring sites damaged by past operations. Broadleaf trees such as cottonwood, balsam poplar, aspen, and alder offer an initial means of restoring lands damaged by harvesting. They provide quick green-up, renewed soil stability, rapid initiation of ecological succession, and rapid provision of wildlife habitat. In some cases, coniferous underplanting beneath the broadleaf species can increase the potential for mixed species management. The restorative possibilities of broadleaf trees in specific bioengineering situations are detailed in Schiechtl's (1980) text, originally applied to damaged European landscapes requiring protection and restoration with mainly natural materials. Genera of Salicaceae are generally used in many situations demanding quick and reliable response for establishment and growth. An example is the use of balsam poplar in locales where flooding is a problem. In addition, recent emphasis on restoration forestry acknowledges the role broadleaf trees have to play in providing biodiversity, wildlife habitat, and elements for sustained yield.

Information Sources:

Schiechtl 1980;
Haeussler et al. 1990;
Buse and Bell 1992;
Licht 1992; Canadian Forest Service 1994;
Klinka et al. 1994;
Kranabetter 1994;
Pilarski 1994.

Use of cottonwood has restoration potential on brush-covered low-elevation lands to get the land back into production. Both a remarkable growth rate and an ability to thrive on the banks of streams and lakes where other commercial tree species have trouble establishing give cottonwood a very important advantage.

7 BLACK COTTONWOOD AND BALSAM POPLAR FUTURE PROSPECTS

As described in earlier sections of this handbook, cottonwood and balsam poplar are not only rapid producers of woody biomass, but they also fill other important forest management roles. They stabilize riparian areas and provide cover and nutrients for stream ecosystems. They help replenish nutrient-depleted soils. They stabilize unstable slopes. They reclaim denuded land and mine spoils. And they can be used to reforest areas where root-rot limits coniferous reproduction. Application of research results in the past 2 decades has shown that native black cottonwood is an important resource for rapid, repetitive, and sustainable biomass production, and a remarkable environmental resource because of the special ecosystems where it occurs naturally (referred to as “Special Sites” in the handbook by Green and Klinka 1994).

In habitats where they occur naturally, cottonwood and balsam poplar can be a popular choice because: they are a way to produce woody biomass in areas that have often before been classified as non-commercial brush; they have exceptionally rapid growth rates compared to other tree species; they grow well on river-side sites and annually flooded riparian habitats where other commercial tree species do not even survive; and, once established, they will not be overtopped by other species, which means that they can be encouraged and managed without use of herbicides.

7.1 Role of Cottonwood–Balsam Poplar in Future Fibre Production

- **Cottonwood’s softness, light colour, and ease of bleaching assure its future use for pulp and paper. The main commercial limitation of this subspecies is its short fibre length.**

Accompanying all of the silvicultural and commercial trends predicted in this handbook will be the ever-increasing importance of broadleaf species for biodiversity and riparian zone values.

- **Cottonwood and balsam poplar are expected to figure more prominently in mixedwood forest management once there is increased acceptance of the idea that successive rotations can be alternately dominated by broadleaf species and then by conifers. This flexibility was not possible when commercial use was limited to coniferous biomass.**

In northeastern British Columbia, cottonwood–balsam poplar is included as part of a deciduous resource component for which more intensive utilization is planned. The chemical and physical wood properties of cottonwood and balsam poplar are not considered to be significantly different in terms of specific gravity, strength, stiffness, or fibre length. Fortunately for forest managers, when in some parts of British Columbia it is not possible to know if one is taxonomically dealing with cottonwood or balsam poplar, there is no basis for separating the potential commercial uses of these subspecies. Cottonwood and balsam poplar do not meet the brightness requirement for chemithermomechanical pulp (CTMP). The future of these *Populus* subspecies would be changed if a process could be developed to permit their use in CTMP production.

Even though extensively managed cottonwood plantations are being established by both industry and the Ministry of Forests on alluvial sites throughout the Prince Rupert Forest Region, no utilization is planned at present. Except for Vancouver Island, the Powell River area, the Fraser River valley area downstream from Hope, and segments of the Skeena River valley, other areas of British Columbia have no plans for establishing cottonwood or balsam poplar utilization facilities in the near future.

Much interest exists in the management of black cottonwood in coastal British Columbia, but only Scott Paper Limited now uses this subspecies in any quantity. This may change in the future if a reliable supply can be ensured. For example, MacMillan Bloedel Ltd. has undertaken an internal analysis of potential for growing and using hybrid poplar fibre in pulp mixtures. Cottonwood pulp has high opacity and good bulk and printability. It also blends with softwood kraft pulp containing 1–50% poplar fibre. Cottonwood pulp is well suited to book papers, computer paper, offset printing papers, and a range of other fine papers. Utilization as pulp raw material has the largest potential for increasing cottonwood utilization in coastal British Columbia.

Overall, there is a bright future for cottonwood–balsam poplar in British Columbia for reasons emphasized in this handbook. The overriding importance will be the role of *Populus* as a commercially important genus in which its pioneer nature will make natural regeneration easier, will suppress regeneration delays, and will reduce problems associated with competing vegetation as has been the case where conifer regeneration was the predominant focus.

Information Sources:

Kellogg and Swan 1986; Swan and Kellogg 1986; Kroll et al. 1992; McLennan and Mamias 1992; R. Stettler, pers. comm., July 1994.

7.2 Information Needs for More Intensive Cottonwood–Balsam Poplar Management

- **A recent (1992) ranking of cottonwood–balsam poplar research needs indicated that the greatest number of very high priority needs occurred in the Prince Rupert and Prince George forest regions, followed by the Vancouver Forest Region. Most cottonwood–balsam poplar research needs were given a low or medium ranking in the Cariboo, Kamloops, and Nelson forest regions.**

- **The Kalum, Dawson Creek, and Fort Nelson forest districts are the prime inland areas with a focus on cottonwood–balsam poplar utilization and therefore a high interest in more research information on extensive management; by contrast, in the Vancouver Forest Region, information to assist more intensive management of plantations involving hybrid poplars is a high priority.**

A major priority for cottonwood research is to establish stocking trials that examine both the effects of different spacings on economic factors (such as piece size, mean annual increment, and merchantable volume), and also the impacts of different spacings on integrated resource management objectives. Cottonwood management invariably occurs in alluvial areas with high integrated resource management values and there is some risk that the high stocking levels recommended will severely reduce forage values of cottonwood plantations.

The assessment of cottonwood–balsam poplar research needs by McLennan and Mamias (1992) is the most recent comprehensive review available. That assessment, based on ideas from forest managers in British Columbia, literature reviews, and the cottonwood management experience of D. McLennan and co-workers is reproduced in Table 27. The 1992 review revealed a consensus that physical and chemical wood characteristics of cottonwood–balsam poplar, as they relate to different utilization processes, are already sufficiently documented not to limit commercial use of these species now.

Operational procedures for regenerating cottonwood are well established for coastal British Columbia and are directly applicable to appropriate interior sites. There is, however, a shortage of robust cottonwood growing material that is suitable for interior climates. This is partly due to historically low demand, and may change as initiatives such as the Watershed Restoration Program demand growing stock suited to interior climates. The Kalamalka-based program that is actively collecting cottonwood genetic material throughout the province is providing critical information and should be expanded.

In conjunction with the Watershed Restoration Program, the influence of cottonwood stands on adjacent stream ecosystems should be more systematically evaluated. Topics requiring further research include: the importance of organic inputs for stream energy pathways; in-stream temperature regulation; large woody debris inputs, control of sedimentation; and the role of cottonwood roots in protecting streams from polluted subsurface seepage in areas adjacent to landfills and agricultural fields

Stocking standards for cottonwood are still being debated. This is an important topic because some foresters believe that the present targets of over 1000 stems per hectare for all end products are much too high, especially for veneer products. Further information is also needed about the appropriate spacing and management of mixedwood forest types that involve cottonwood or balsam poplar growing with shade-tolerant conifers.

Because of the high habitat values and biodiversity levels in ecosystems where cottonwood management is economical, stand-level and landscape-level impacts of cottonwood management on non-timber resources also require further evaluation. Specifically, impacts of short-rotation broadleaf management on cavity-nesters, reptiles, amphibians, small mammals, songbirds, and raptors should be studied.

Foresters interested in cottonwood hybrids have expressed concern about the long-term conservation of natural cottonwood genotypes. Although this concern is greater in the U.S. Pacific Northwest than in British Columbia, the future for cottonwood is uncertain in any valleys that are subject to residential, commercial, or other developments, livestock grazing, or lack of periodic floods because of regulated river flow. The main steps to maintain or regain genetically diverse natural cottonwood populations are to:

- allow periodic flooding so that new deposits of sediments are available for seedling establishment;
- restore cottonwood ecosystems that have been damaged by development activities or agricultural use; and
- give special protection to cottonwoods that now occur in riparian buffer strips.

TABLE 27. Ranking of cottonwood, balsam poplar, and hybrid poplar research priorities in British Columbia, as recommended by McLennan and Mamias (1992)

Management system	Research topic	Forest region			
		Vancouver	Prince George	Prince Rupert	Other
Extensive	Operational standards	medium	very high	very high	low
	Whips	medium	high	high	low
	Site selection	low	very high	very high	low
	Stem analysis	medium	very high	very high	low
	Decay factors	high	very high	very high	low
	PSPs	high	high	high	low
	IRM effects	very high	very high	very high	low
Intensive	Genetic collections	very high	high	high	high
	Hybrid poplar breeding	very high	medium	medium	medium
	Ongoing plantations	very high	low	low	medium
	New plantations	very high	low	medium	low
Mixedwood	Nurse tree	very high	very high	very high	medium
Habitat enhancement	Stocking manipulation	very high	medium	medium	medium
	Buffer zone management	very high	very high	very high	high
End products	Utilization complexes	medium	very high	very high	low
	Specialty products	medium	very high	very high	low
	Markets	medium	very high	very high	low

Aside from the biodiversity values and biomass production potential of naturally occurring black cottonwood and balsam poplar (the focus of this handbook), the genus *Populus* has an exciting future related to several well-advanced biotechnology approaches to propagation and use of desirable genetic material. For example, these two subspecies are easily propagated vegetatively through tissue culture and they can be genetically transformed by current methods of gene transfer. Their genome is also relatively small, which makes gene isolation and characterization simpler, and propagation through tissue culture is possible using either organogenesis (plantlet formation) or somatic embryogenesis (embryo formation). Genetic engineering involving introduction of isolated genes into a host genome is a relatively new biotechnology technique for trees, but based on successes to date, *Populus* species have the potential to be at the forefront of this field.

Information Sources:

McLennan and Mamias 1992.

REFERENCES

Annas, R.M. 1977. Boreal ecosystems of the Fort Nelson area of northeastern British Columbia. Ph.D. thesis, Univ. B.C., Vancouver, B.C.

Armson, K.A. and J.H.G Smith. 1978. Management of hybrid poplar: case study 5. *In* Forest management in Canada. Can. For. Serv., Ottawa, Ont. Inf. Rep. FMR-X-103.

Armstrong, J.A. and W.G.H. Ives. 1995. Forest insect pests in Canada. Nat. Resour. Can., Can. For. Serv., Ottawa, Ont.

Backhouse, F. (compiler). 1993. Wildlife tree management in British Columbia. For. Can., B.C. Min. Environ., B.C. Min. For., and Workers' Comp. Bd., Victoria, B.C.

Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. B.C. Min. For., Victoria, B.C. Land Manage. Handb. 26.

Barclay, B.A. 1983. A silvicultural guide for hybrid poplar in Ontario. Ont. Min. Nat. Resour., Toronto, Ont.

Beaudry, P.G., D.L. Hogan, and J.W. Schwab. 1990. Hydrologic and geomorphic considerations for silvicultural investments on the lower Skeena River floodplain. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. 122.

Binkley, D., K. Cromack, Jr., and D.D. Baker. 1994. Nitrogen fixation by red alder: biology, rates, and controls. *In* The biology and management of red alder. D.L. Hibbs, D.S. DeBell, and R.F. Tarrant (editors). Oreg. State Univ. Press., Corvallis, Oreg. pp. 57–72.

Biring, B.S., P.G. Comeau, and J.O. Boateng. 1996. Effectiveness of forest vegetation control methods in British Columbia. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Handb. 11.

Blood, D.A. and G.G. Anweiler. 1994. Status of the bald eagle in British Columbia. B.C. Min. Environ, Lands and Parks, Victoria, B.C. Wildl. Work. Rep. WR-62.

Blouin, G. and P. Peddle. 1994. Private woodlots. Forestry on the Hill. Spec. Issue 7.

Boysen, B. and S. Strobl (editors). 1991. Grower's guide to hybrid poplar. Ont. Min. Nat. Resour., Toronto, Ont.

Brace, L.G. and I.E. Bella. 1988. Understanding the understory: dilemma and opportunity. *In* Management and utilization of northern mixedwoods. Proc. Symp., April 11–14, 1988. Edmonton, Alta. J.K. Samoil (editor). Can. For. Serv., North. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-296. pp. 69–86.

Braumandl, T.F. and M.P. Curran (editors). 1992. A field guide for site identification and interpretation for the Nelson Forest Region. B.C. Min. For., Victoria, B.C. Land Manage. Handb. 20.

Brayshaw, T.C. 1965. The status of black cottonwood (*Populus trichocarpa* Torrey and Gray). Can. Field-Nat. 79(2):91–95.

______. 1978. Catkin bearing plants of British Columbia. B.C. Prov. Museum, Victoria, B.C. Occas. Pap. Series 18.

British Columbia Coastal Fisheries/Forestry Guidelines Technical Committee. 1993. British Columbia coastal fisheries/forestry guidelines. Rev. 3rd ed. B.C. Min. For., B.C. Min. Environ., Dep. Fish. Oceans, and Council of Forest Industries. Victoria, B.C.

British Columbia Ministry of Environment, Lands and Parks. 1991. Managing wildlife to 2001: a discussion paper. B.C. Environment, Victoria, B.C.

British Columbia Ministry of Forests and British Columbia Ministry of Environment, Lands and Parks. 1995a. Forest Practices Code of British Columbia. Establishment to free growing guidebook: Cariboo Forest Region; Kamloops Forest Region; Nelson Forest Region; Prince George Forest Region; Prince Rupert Forest Region; Vancouver Forest Region. Victoria, B.C. [Six guidebooks.]

______. 1995b. Forest Practices Code of British Columbia. Regulations. Victoria, B.C.

______. 1995c. Forest Practices Code of British Columbia. Biodiversity guidebook. Victoria, B.C.

______. 1995d. Forest Practices Code of British Columbia. Riparian management area guidebook. Victoria, B.C.

______. 1995e. Forest Practices Code of British Columbia. Seed and vegetative material guidebook. Victoria, B.C.

Bryant, J.P., F.D. Provenza, J. Pastor, P.B. Reichardt, T.P. Clausen, and J.T. du Toit. 1991. Interactions between woody plants and browsing mammals mediated by secondary metabolites. Annu. Rev. Ecol. Syst. 22:431–446.

Bryant, J.P., P.B. Reichardt, and T.P. Clausen. 1992. Chemically mediated interactions between woody plants and browsing mammals. J. Range Manage. 45:18–24.

Bunce, H.W.F. 1990. Black cottonwood yield and volume tables for natural fully stocked forests in the Skeena Valley, B.C. Reid, Collins, and Associates, Vancouver, B.C.

Bunnell, F.L., B. Booth, and A.C.M Farr. 1993. Bald eagles and forestry. B.C. Environ., Lands and Parks, Victoria, B.C. and World Wildl. Fund. [foldout.]

Buse, L.J. and F.W. Bell. 1992. Critical silvics of selected crop and competitor species in northwestern Ontario. NW Ont. For. Tech. Devel. Unit, Thunder Bay, Ont.

Callan, B.E. [1995.] Aspen and poplar diseases. *In* Ecology and management of B.C. hardwoods. Workshop Proc., Dec. 1–2, 1993, Richmond, B.C. P.G. Comeau, G.J. Harper, M.E. Blache, and J.O. Boateng (editors). B.C. Min. For., Victoria, B.C. FRDA Rep. (In press).

______. (In press). Diseases of *Populus* in British Columbia: a diagnostic manual. Can. For. Serv., Pac. For. Cent., Victoria, B.C.

Callan, B.E. and F.M. Ring. 1994. An annotated host fungus index for *Populus* in British Columbia. Can. For. Serv. and B.C. Min. For., Victoria, B.C. FRDA Rep. 222.

Canadian Forest Service. 1994. Managing cottonwoods. Small Scale Woodlands (Pac. & Yukon Reg.) Winter 1994:8.

______. 1995. Common poplar diseases in British Columbia. Pac. For. Cent., Victoria, B.C. [Poster].

Cannings, R.A., R.J. Cannings, and S.G. Cannings. 1987. Birds of the Okanagan Valley, British Columbia. Royal B.C. Museum, Victoria, B.C.

Carlson, M. 1990. Cottonwoods rediscovered in British Columbia. Poplar Coun. Can. Newsl. 1(June):10.

______. 1991. Hybrid poplars flourish under municipal wastewater irrigation in southern British Columbia. Poplar Coun. Can. Newsl. 2 (Jan.):2–3.

______. 1992. Municipal effluent irrigation of fast-growing hybrid poplar plantations near Vernon, British Columbia. For. Chron. 68:206–208.

Comeau, P.G. and J.O. Boateng. 1992. Forest vegetation management in British Columbia. *In* Biocontrol of forest weeds, Proc. Workshop, Aug. 9, 1991, Vernon, B.C. C. Dorworth and S.G. Glover (editors). For. Can., Pac. For. Cent., Victoria, B.C. pp. 13–20.

Comeau, P.G., G.J. Harper, and B. D'Anjou. 1995. Effects of red alder on stand dynamics and nitrogen availability - EP 1121. FRDA Res. Memo 223.

Conard, S.G. 1984. Forest vegetation management in British Columbia: problem analysis. B.C. Min. For., Victoria, B.C. Res. Rep. RR84001-HQ.

D.A. Westworth & Associates Ltd. 1994. Aspen woodlot feasibility study. Can. For. Serv. and Alta. Land For. Serv., Edmonton, Alta. Can-Alta FRDA.

DeBell, D.S. 1990. *Populus trichocarpa* Torr. & Gray. Black cottonwood. Salicaceae - Willow family. *In* Silvics of North America. Vol. 2, Hardwoods. R.M. Burns and B.H. Honkala (editors). USDA For. Serv., Washington, D.C. Agric. Handb. 654. pp. 570–576.

Demeritt, M.E., Jr. 1990. *Populus* L. Poplar hybrids. Salicaceae - Willow family. *In* Silvics of North America. Vol. 2, Hardwoods. R.M. Burns and B.H. Honkala (editors). USDA For. Serv., Washington, D.C. Agric. Handb. 654. pp. 577–582.

Dickmann, D.I. and K.W. Stuart. 1983. The culture of poplars in eastern North America. Mich. State Univ., East Lansing, Mich.

Eckenwalder, J.E. 1984. Natural intersectional hybridization between North American species of *Populus* (Salicaceae) in sections *Aigeiros* and *Tacamahaca*. II. Taxonomy. Can. J. Bot. 62:325–335.

Enns, K.A., E.B. Peterson, and D.S. McLennan. 1993. Impacts of hardwood management on British Columbia wildlife: problem analysis. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. 208.

Farmer, R.E. 1990. Genetic improvement of poplar in western Canada: alternatives, opportunities, and pitfalls. *In* Aspen management for the 21st century. Proc. Symp., Nov. 20–21, 1990, Edmonton, Alta. S. Navratil and P. B. Chapman (editors). For. Can, NW Reg. and Poplar Coun. Can., Edmonton, Alta. pp. 129–134.

Farrar, J.L. 1995. Trees in Canada. Fitzhenry & Whiteside, Markham, Ont. and Can. For. Serv., Ottawa, Ont.

Galloway, G. and J. Worrall. 1979. Cladoptosis: a reproductive strategy in black cottonwood? Can. J. For. Res. 9:122–125.

Green, J.E. and R.E. Salter. 1987. Reclamation of wildlife habitat in the Canadian prairie provinces. Volume II: Habitat requirements of key species. Can. Wildl. Serv. and Recreation, Parks and Wildl. Foundation, Edmonton, Alta.

Green, R.N. and K. Klinka. 1994. A field guide to site identification and interpretation for the Vancouver Forest Region. B.C. Min. For., Victoria, B.C. Land Manage. Handb. 28.

Haeussler, S., D. Coates, and J. Mather. 1990. Autecology of common plants in British Columbia: a literature review. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. 158.

Hamilton, A.N. and W.R. Archibald. 1986. Grizzly bear habitat in the Kimsquit River Valley, coastal British Columbia: evaluation. *In* Proc. Grizzly Bear Habitat Symposium, Missoula, Mont. G.P. Contreras and K.E. Evans (compilers). USDA For. Serv. Gen. Tech. Rep. INT-207. pp. 50–57.

Hansen, E.A., D.A. Netzer, and D.N. Tolsted. 1993. Guidelines for establishing poplar plantations in the north-central U.S. USDA For. Serv. Res. Note NC-363.

Harrington, C.A. 1987. Responses of red alder and black cottonwood seedlings to flooding. Physiol. Plant. 69:35–48.

Heilman, P.E. and G. Ekuan. 1979. Effect of planting stock length and spacing on growth of black cottonwood. For. Sci. 25:439–443.

Heilman, P.E. and R.F. Stettler. 1985. Mixed, short-rotation culture of red alder and black cottonwood: growth, coppicing, nitrogen fixation, and allelopathy. For. Sci. 31:607–616.

______. 1990. Genetic variation and productivity of *Populus trichocarpa* and its hybrids. IV. Performance of short-rotation coppice. Can. J. For. Res. 20:1257–1264.

Heilman, P.E., R.F. Stettler, D.P. Hanley, and R.W. Carkner. 1995. High yield poplar plantations in the Pacific Northwest. Wash. State Univ., Pullman, Wash. Coop. Exten., PNW356, rev.

Hibbs, D.E. and D.S. DeBell. 1994. Management of young red alder. *In* The biology and management of red alder. D.E. Hibbs, D.S. DeBell, and R.F. Tarrant (editors). Oreg. State Univ. Press, Corvallis, Oreg. pp. 202–215.

Hiratsuka, Y. 1987. Forest tree diseases of the prairie provinces. Can. For. Serv., North. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-286.

Hiratsuka, Y., D.W. Langor, and P.E. Crane. 1995. A field guide to forest insects and diseases of the prairie provinces. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, Alta. Spec. Rep. 3.

Hiratsuka, Y. and A.A. Loman. 1984. Decay of aspen and balsam poplar in Alberta. Environ. Can., Can. For. Serv., North. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-262.

Hiratsuka, Y. and H. Zalasky. 1993. Frost and other climate-related damage of forest trees in the prairie provinces. For. Can., North. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-331.

Hosie, R.C. 1990. Native trees of Canada. 8th ed. Fitzhenry and Whiteside Ltd., Markham, Ont.

Huang, S., S.J. Titus, and T.W. Lakusta. 1994. Ecologically based site index curves and tables for major Alberta tree species. Alta. Environ. Protec., Land For. Serv., Edmonton, Alta. Publ. T/307.

Ives, W.G.H. and H.R. Wong. 1988. Tree and shrub insects of the prairie provinces. Can. For. Serv., North. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-292.

Johnson, J.D., L. Kershaw, A. MacKinnon, and J. Pojar. 1995. Plants of the western boreal forest and aspen parkland. Lone Pine Publ., Edmonton, Alta.

J.S. Thrower & Associates Ltd. 1992. Height-age/site-index curves for black cottonwood in British Columbia. Rep. to B.C. Min. For., Inven. Br., Victoria, B.C.

Kabzems, R.D. and J.D. Lousier. 1992. Regeneration, growth and development of *Picea glauca* under *Populus* spp. canopy in the Boreal White and Black Spruce Zone. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. 176.

Kellogg, R.M. and E.P. Swan. 1986. Physical properties of black cottonwood and balsam poplar. Can. J. For. Res. 16:491–496.

Klenner, W. and L. Kremsater. 1993. Forest management and biodiversity. B.C. Min. For., Victoria, B.C. Workshop notes.

Klinka, K, R.E. Carter, and G.J. Kayahara. 1994. Forest reproduction methods for coastal British Columbia: principles, criteria, and a stand selection guide. For. Chron. 70:569–577.

Klinka, K. and M.C. Feller. 1984. Principles used in selecting tree species for regeneration of forest sites in southwestern British Columbia. For. Chron. 60:77–85.

Klinka, K., M.C. Feller, R.N. Green, D.V. Meidinger, J. Pojar, and J. Worrall. 1990. Ecological principles: applications. *In* Regenerating British Columbia's forests. D.P. Lavender, R. Parish, C.M. Johnson, G. Montgomery, A. Vyse, R.A. Willis, and D. Winston (editors). Univ. B.C. Press, Vancouver, B.C. pp. 55 72.

Klinka, K., V.J. Krajina, A. Ceska, and A.M. Scagel. 1989. Indicator plants of coastal British Columbia. Univ. B.C. Press, Vancouver, B.C.

Kochanski, M.L. 1987. Northern bush craft. Lone Pine Publ., Edmonton, Alta.

Krajina, V.J., K. Klinka, and J. Worrall. 1982. Distribution and ecological characteristics of trees and shrubs of British Columbia. Univ. B.C., Fac. For., Vancouver, B.C.

Kranabetter, M. 1994. Rethinking reclamation. Northern For. Veg. Manage. Newsl. Oct. 1994:15–16.

Krasny, M.E., J.C. Zasada, and K.A. Vogt. 1988a. Adventitious rooting of four Salicaceae species in response to a flooding event. Can. J. Bot. 66:2597–2598.

______. 1988b. Establishment of four Salicaceae species on river bars in interior Alaska. Hol. Ecol. 11:210–219.

Krinard, R.M. and R.L. Johnson. 1984. Cottonwood plantation growth through 20 years. USDA For. Serv., Res. Pap. SO-212.

Kroll, R.E., D.C. Ritter, R.O. Gertjejansen, and K.C. Au. 1992. Anatomical and physical properties of balsam poplar (*Populus balsamifera* L.) in Minnesota. Wood Fiber Sci. 24:13–24.

Kuhnlein, H.V. and N.J. Turner. 1991. Traditional plant foods of Canadian indigenous peoples: nutrition, botany, and use. Gordon and Breach Sci. Publ., Philadelphia, Penn.

Lee, R.M. 1995. Bald eagles find their last great refuge in trees of Brackendale. *Globe and Mail*, Saturday, Feb. 4, 1995: D2.

Licht, L.A. 1992. *Salicaceae* family trees in sustainable agroecosystems. For. Chron. 68:214–217.

Lloyd, D., K. Angove, G. Hope, and C. Thompson. 1990. A guide to site identification and interpretation for the Kamloops Forest Region. Parts 1 and 2. B.C. Min. For., Victoria, B.C. Land Manage. Handb. 23.

McAuliffe, P.A.K. 1989. Managing cottonwoods. TreeTalk, Indian Forest Lands Program 7:1–2.

______. 1993. Management and culture of poplars on the B.C. coast by Scott Paper Limited. Paper presented at Forest Nursery Association of B.C. Annual Meeting, Sept. 23–26, 1991, Prince George, B.C. Revised Sept. 1993.

MacKinnon, A., J. Pojar, and R. Coupé (editors). 1992. Plants of northern British Columbia. Lone Pine Publ., Edmonton, Alta.

McLennan, D.S. 1990. Management of black cottonwood, red alder, bigleaf maple, and paper birch in coastal British Columbia. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Memo 133.

______. 1991. Black cottonwood: ecological site quality and growth in British Columbia. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Memo 183.

______. 1993. Growth and nutrient relations in black cottonwood in south-coastal British Columbia. Ph.D. thesis, Univ. B.C., Vancouver, B.C.

McLennan, D.S. and K. Klinka. 1990. Black cottonwood - a nurse species for regenerating western redcedar on brushy sites. B.C. Min. For., Victoria, B.C. FRDA Rep. 114.

McLennan, D.S. and A.-M. Mamias. 1992. Cottonwoods in British Columbia: problem analysis. B.C. Min. For., Victoria, B.C. FRDA Rep. 195.

MacMillan Bloedel Ltd. 1995. Poplar farms. Poplar Farms Division, Parksville, B.C. [brochure.]

MacPherson, D. 1993. Alberta-Pacific undertakes hybrid poplar trials, grow big or go home. Poplar Coun. Can. Newsl. 4(1):5.

Mahon, J.E. 1966. Empirical yields from stands of black cottonwoods in the Lower Fraser River Valley. B.S.F. thesis, Univ. B.C., Vancouver, B.C.

Maini, J.S. and J.H. Cayford. (editors). 1968. Growth and utilization of poplars in Canada. Can. For. Serv., Ottawa, Ont. Publ. 1205.

Massie, M.R. [1995.] Hardwood utilization and supply in British Columbia. *In* Ecology and management of B.C. hardwoods. Workshop Proc., Dec. 1–2, 1993, Richmond, B.C. P.G. Comeau, G.J. Harper, M.E. Blache, and J.O. Boateng (editors). B.C. Min. For., Victoria, B.C. FRDA Rep. (In press).

Massie, M.R.C., E.B. Peterson, N.M. Peterson, and K.A. Enns. 1994. An assessment of the strategic importance of the hardwood resource in British Columbia. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. 221.

Meidinger, D. 1987. Recommended vernacular names for common plants of British Columbia. B.C. Min. For. and Lands, Victoria, B.C. Res. Rep. RR87002-HQ.

Meidinger, D. and J. Pojar (editors). 1991. Ecosystems of British Columbia. B.C. Min. For., Victoria, B.C. Spec. Rep. Ser. 6.

Mitchell, C.P., J.B. Ford-Robertson, T. Hinckley, and L. Sennerby-Forsse. 1992. Ecophysiology of short rotation forest crops. Elsevier Applied Science, New York, N.Y.

Murray, M.D. and C.A. Harrington. 1983. Growth and yield of a 24-year old black cottonwood plantation in western Washington. Tree Plant. Notes 34(2):3–5.

Nanson, G.C. and H.F. Beach. 1977. Forest succession and sedimentation on a meandering river floodplain, northeast British Columbia, Canada. J. Biogeog. 4:229–251.

Navratil, S. [1995.] Sustained aspen productivity on hardwood and mixedwood sites. *In* Ecology and management of B.C. hardwoods. Workshop Proc., Dec. 1–2, 1993, Richmond, B.C. P.G. Comeau, G.J. Harper, M.E. Blache, and J.O. Boateng (editors). B.C. Min. For., Victoria, B.C. FRDA Rep. (In press).

Navratil, S., L.G. Brace, E.A. Sauder, and S. Lux. 1994. Silvicultural and harvesting options to favour immature white spruce and aspen regeneration in boreal mixedwoods. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-337.

Newton, M. and P.G. Comeau. 1990. Control of competing vegetation. Chapter 19. *In* Regenerating British Columbia's forests. D.P. Lavender, R. Parish, C.M. Johnson, G. Montgomery, A. Vyse, R.A. Willis, and D. Winston (editors). Univ. B.C. Press, Vancouver, B.C. pp. 256–265.

Niemiec, S.S, G.R. Ahrens, S. Willits, and D.E. Hibbs. 1995. Hardwoods of the Pacific Northwest. Oreg. State Univ., Coll. For., Corvallis, Oreg. Res. Contrib. 8.

Nyberg, J.B., L.D. Peterson, L.A. Stordeur, and R.S. McNay. 1990. Deer use of old-growth and immature forests following snowfalls on southern Vancouver Island. B.C. Environ. and B.C. Min., Victoria, B.C. IWIFR-36.

Obee, B. 1995. The gathering of the eagles. Beautiful B.C. 37(4):30–35.

Ostry, M.E., L.F. Wilson, H.S. McNabb, Jr., and L.M. Moore. 1989. A guide to insect, disease, and animal pests of poplars. USDA For. Serv. Agric. Handb. 677.

Palmer, C.L. 1991. Short-rotation culture of *Populus* and *Larix:* a literature review. For. Can., Ont. Region, Sault Ste. Marie, Ont. COFRDA Rep. 3306.

Patrick, L. 1995. Managing cottonwoods. First Nations Woodlands (B.C. FRDA II) Spring 1995:6–7.

Peterson, E.B., R.D. Kabzems, and N.M. Peterson. 1989. Hardwood management problems in northeastern British Columbia: an information review. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. 66.

Peterson, E.B. and N.M. Peterson. 1992. Ecology, management, and use of aspen and balsam poplar in the prairie provinces, Canada. For. Can., NW Reg., North. For. Cent., Edmonton, Alta. Spec. Rep. 1.

______. 1995. Aspen managers' handbook for British Columbia. B.C. Min. For., Victoria, B.C. FRDA Rep. 230.

Pilarski, M. 1994. Restoration forestry: an international guide to sustainable forestry practices. Kivaki Press, Durango, Colo.

Pojar, J. and A. MacKinnon (editors). 1994. Plants of coastal British Columbia including Washington, Oregon, and Alaska. Lone Pine Publ., Edmonton, Alta.

Radwan, M.A., J.M. Kraft, and D.S. DeBell. 1987. Bud characteristics of unrooted stem cuttings affect establishment success of cottonwood. USDA For. Serv. Res. Note PNW-RN-461.

Robinson, B. 1994. Draft, interim stocking standards for British Columbia. Prep. for B.C. Min. For., Res. and Silv. Br., Victoria, B.C.

Robinson, B. and M. Eriksen. 1994. Summary of existing hardwood stocking standards, discussion of issues, and recommendations for research. Prep. for B.C. Min. For., Res. and Silv. Br., Victoria, B.C.

Roe, E.I. 1958. Silvical characteristics of balsam poplar (*Populus balsamifera*). USDA For. Serv., Lake States For. Exp. Sta., St. Paul, Minn.

Ronald, W.G. and J.W. Steele. 1974. Biosystematics of the genus *Populus*. III. Naturally occurring Manitoba hybrids of introduced *P.* x *petrowskyana* with native *P. deltoides* var. *occidentalis* and *P. balsamifera*. Can. J. Bot. 52:1883–1887.

Rood, S.B. and J.M. Mahoney. 1991. The biology and management of southern Alberta's cottonwoods. Univ. Lethbridge, Lethbridge, Alta.

Sanders, P. 1994. The role of private woodlot owners in sustainable development: a view from British Columbia. *In* Timber supply in Canada: challenges and choices. Conf. Proc., Nov. 16–18, 1994. Nat. Resour. Can., Can. For. Serv., Ottawa, Ont. pp. 131–141.

Schiechtl, H. 1980. Bioengineering for land reclamation and conservation. Univ. Alberta Press, Edmonton, Alta. Transl. by N.K. Horstmann.

Schofield, J.J. 1989. Discovering wild plants - Alaska, western Canada, the Northwest. Alaska Northwest Books, Anchorage, Alaska.

Shainsky, L.J., B.J. Yoder, T.B. Harrington, and S.S.N. Chan. 1994. Physiological characteristics of red alder: water relations and photosynthesis. *In* The biology and management of red alder. D.E. Hibbs, D.S. DeBell, and R.F. Tarrant (editors). Oreg. State Univ. Press., Corvallis, Oreg. pp. 73–91.

Silviculture Interpretations Working Group. 1993. Correlated guidelines for tree species selection (first approximation) and stocking standards (second approximation) for the ecosystems of British Columbia. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep.

Simard, S. and A. Vyse. 1992. Ecology and management of paper birch and black cottonwood in southern British Columbia. B.C. Min. For., Victoria, B.C. Land Manage. Rep. 75.

Smith, J.H.G. 1957. Some factors indicative of site quality for black cottonwood (*Populus trichocarpa* Torr. and Gray). J. For. 55(8):578–580.

______. 1980. Growth and yield of poplar in British Columbia. Paper presented at 1980 meeting of Poplar Council of Canada, Vancouver, B.C.

Smith, J.H.G. and G. Blom. 1970. Poplar spacing trials show the way to gains in wood yield. Can. For. Indust. July: 40–41.

Steventon, J.D. 1994. Biodiversity and forest management in the Prince Rupert Forest Region: a discussion paper. B.C. Min. For, Victoria, B.C. Land Manage. Rep. 82.

Stoltmann, R. 1993. Guide to the record trees of British Columbia. West. Can. Wild. Comm., Vancouver, B.C.

Swan, E.P. and R.M. Kellogg. 1986. Chemical properties of black cottonwood and balsam poplar. Can. J. For. Res. 16:497–501.

Telfer, E.S. 1994. Cattle and cervid interactions on a foothills watershed in southwestern Alberta. Can. Field-Nat. 108:186–194.

Thomas, J.W. (technical editor). 1979. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv., Washington, D.C. Agric. Handb. 553.

Thomas, P.G. and D.B. Podmore. 1953. Studies in forest pathology. XI. Decay in black cottonwood in the middle Fraser region, British Columbia. Can. J. Bot. 31:672–692.

Thrower, J.S. and A.F. Nussbaum. 1991. Site index curves and tables for British Columbia: coastal species. B.C. Min. For., Victoria, B.C. Land Manage. Handb. Field Guide Insert 3.

Truck Logger. 1995. Poplar Farms creating short-rotation crop. Truck Logger 18(4):36, 38–39.

van der Kamp, B.J. 1986. Nitrogen fixation in cottonwood wetwood. Can. J. For. Res. 16:1118–1120.

______. 1991. Pathogens as agents of diversity in forested landscapes. For. Chron. 67:353–354.

van Oosten, C. 1991. Poplar trials on Vancouver Island. Poplar Coun. Can. Newsl. 2 (Jan 1991):4.

Van Sickle, G.A. 1995. Forest insect pests in the Pacific and Yukon Region. *In* Forest insect pests in Canada. J.A. Armstrong and W.G.H. Ives (editors). Nat. Resour. Can., Can. For. Serv., Ottawa, Ont. pp. 73–89.

Wall, R.E. 1996. Pathogenicity of the bioherbicide fungus *Chondrostereum purpureum* to some trees and shrubs of southern Vancouver Island. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. 246.

Wang, J. and B.J. van der Kamp. 1992. Resistance, tolerance, and yield of western black cottonwood infected by *Melampsora* rust. Can. J. For. Res. 22:183–192.

Winship, R. 1990. The role of balsam poplar in aspen management. *In* Aspen management for the 21st century, Proc. Symp., Nov. 20–21, 1990, Edmonton, Alta. S. Navratil and P.B. Chapman (editors). For. Can., North. For. Cent. and Poplar Counc. Can., Edmonton, Alta. pp. 29–32.

Wood, C.S. 1992. Forest tent caterpillar. For. Can., Pac. For. Cent., Victoria, B.C. For. Pest Leafl. 17.

Wright, L. 1992. James River first to harvest SRWC in U.S. Poplar Coun. Can. Newsl. 2 (Jan):7.

Zasada, J.C. and H.M. Phipps. 1990. *Populus balsamifera* L. - Balsam poplar. Vol. 2, Hardwoods. *In* Silvics of North America. R.M. Burns and B.H. Honkala (editors). USDA For. Serv., Washington, D.C. Agric. Handb. 654. pp. 518–529.

Zasada, J.C., T.L. Sharik, and M. Nygren. 1992. The reproductive process in boreal forest trees. *In* A systems analysis of the global boreal forest. H.H. Shugart, R. Leemans, and G.D. Bonan (editors). Cambridge Univ. Press, Cambridge, U.K. pp. 85–125.

Zasada, J.C., L.A. Viereck, M.J. Foote, R.H. Parkenson, J.O. Wolff, and L.A. Lankford, Jr. 1981. Natural regeneration of balsam poplar following harvesting in the Susitna Valley, Alaska. For. Chron. 57:57–65

GLOSSARY

abiotic A non-organic material or force.

adventitious bud A bud that has developed at a location other than the usual or expected, such as roots growing from leaves, or buds developing at locations other than at leaf axils.

alluvial; alluvium Sediments, ranging from fine to coarse textures, deposited on land by a stream.

biodiversity The diversity of plants, animals, and other living organisms in all their forms and levels of organization, including the diversity of genes, species, and ecosystems, as well as the evolutionary and functional processes that link them.

bud bank The collective supply of buds on branches, stems, and roots.

canker A relatively localized necrotic lesion, primarily of the bark and cambium.

clone Any group of plants derived from a single individual by vegetative reproduction. All members of a clone have the same genetic makeup and consequently tend to be uniform.

endemic Restricted to a particular region.

fluvial Parent material deposited by the action of moving water.

free-growing An established seedling of an acceptable commercial species, meeting minimum height requirements, that is free from growth-inhibiting brush, weed, and excessive tree competition.

genome The chromosomal makeup of an organism.

genotype The entire genetic constitution, or the sum total of genes, in an organism.

girdling To kill a tree by severing the cambium layer and interrupting the flow of food between the leaves and the rest of the tree.

inoculate; inoculum To introduce a microorganism, virus, or serum into an organism; the substance so introduced.

mesothermal With moderate warmth and moderate moisture.

mycelium	A group or mass of hyphae constituting the vegetative body of a fungus.
propagules; propagation	Sources of new plants, including seed from annual seed production (seed rain), seed stored in the ground (seed banks), or vegetatively produced shoots (bud banks).
provenance	The place of origin of seeds or other propagules.
riparian zone	Land adjacent to the normal high water line in a stream, river, or lake extending to the portion of the land that is influenced by the presence of ponded or channeled water.
root primordia	A primordium is the beginning or rudimentary structure of a plant part, in this case a root tip.
root sucker	Vegetative reproduction originating primarily from adventitious buds within the root cork cambium or from preformed primordia; suckers also develop from dormant buds but these are less vigorous than those from adventitious buds. Root suckers are sometimes referred to as suckers or root sprouts
saprophyte; saprophytic	A plant that obtains food from dead or decaying organic material.
seed bank	The collective supply of seeds on living or dead plants and in the soil.
seral	Stages in a sequence of biotic communities (the sere) that successively occupy and replace each other in a particular environment over time.
stool; stoolbed	The base of a plant from which shoots arise; a special growing bed in which such shoots are rooted.
stump sprout	A sprout that arises from a dormant bud or callus tissue of a tree stump above the root-collar zone.
urediniospores	Spore produced after the aecium stage and before the telium stage in the life cycle of a rust; these spores are capable of infecting the same host on which it originated.
whip	A whip-like sprout or shoot, commonly 0.5–2.0 m long, used for vegetative propagation of *Populus*.
wildling	A seedling or a young plant that grew under natural conditions, not cultivated, which is dug and used as planting stock.

APPENDIX 1 Abbreviations used in this handbook for biogeoclimatic zones and tree species

Biogeoclimatic zones:

BG	Bunchgrass
BWBS	Boreal White and Black Spruce
CWH	Coastal Western Hemlock
ESSF	Engelmann Spruce – Subalpine Fir
ICH	Interior Cedar – Hemlock
IDF	Interior Douglas-Fir
MS	Montane Spruce
PP	Ponderosa Pine
SBPS	Sub-Boreal Pine – Spruce
SBS	Sub-Boreal Spruce
SWB	Spruce – Willow – Birch

Tree species:

Acb	balsam poplar
Act	cottonwood
At	aspen
Ba	amabilis fir
Bl	subalpine fir
Cw	western redcedar
Dr	red alder
Ep	paper birch
Fd	Douglas-fir
Hw	western hemlock
Lw	western larch
Mb	bigleaf maple
Pa	white bark pine
Pl	lodgepole pine
Py	ponderosa pine
Sb	black spruce
Ss	Sitka spruce
Sw	white spruce
Sx	hybrid spruce
Sxw	hybrid white spruce