Provincial Status Report for Coastal British Columbia Broadleaves

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Executive Summary

The broadleaf tree species of coastal British Columbia are a significant, but under-appreciated component of the coastal forests. Adding them to the forest estate requires a review of the methods used to determine appropriate crop trees.

The purpose of this report is to review the current status of broadleaf tree species (red alder, bigleaf maple, black cottonwood/hybrid poplar, and paper birch) with current commercial value and possible future commercial potential in coastal BC. Specifically, we examined (1) ranges (2) current inventory (3) non-timber and timber enhancement values (4) silvicultural practices and trends in (5) log value and (6) harvesting. Also, we discuss possible future harvest levels and changes in log values. Finally, we comment on policy and institutional impediments to, and recommend a methodology for, increasing the presence of broadleaf trees in the coastal forest.

Inventory data were assessed primarily from the Canadian Forest Inventory (Canfi 2001) and supplemented by data from provincial timber supply reviews of crown land tenures. Provincial log-value and harvesting data were provided by the BC of Ministry of Forests and Range. For the purposes of the report, the study area was considered to consist of the BC Ministry of Forests and Range's Coast Forest Region and Kalum Forest District. The ranges and inventories for red alder and bigleaf maple were reviewed in the Skeena Stikine and Cascades Forest Districts.

The total volumes of broadleaves in coastal BC are: ca. 44 million m^3 for red alder, 9 million m^3 for bigleaf maple, 8 million m^3 for black cottonwood and over 2 million m^3 for paper birch. CanFI 2001 estimates of total broadleaf wood volumes and volumes per hectare on private land, estimated from satellite data, appear unreasonably high. Therefore, volumes per hectare on private land were derived from calculations using per hectare volumes on adjacent public land. The total volume estimates differ substantially from previously reported estimates. Additionally, CanFI 2001 estimates of broadleaf volumes on publicly-owned forest lands average three times greater than estimates from timber supply reviews for the same areas.

Non-timber or timber enhancement values for some broadleaf tree species within coastal forests include increased biodiversity, site fertility and improved productivity of associated conifers. Broadleaf trees may be appropriate alternatives for reforesting sites infected with laminated root rot and red alder may reduce the attack of white pine weevil on Sitka spruce. Recent modeling efforts suggest that climate change may increase the ranges of the four broadleaved species. This possibility, combined with shorter rotations, suggests that increased presence of broadleaves may be useful for coping with possible climate change.

The four species examined differ in their main end-products and in harvesting and processing costs. Hence, log prices vary with species. Red alder logs, generally used for a variety of sawn-wood products, generally fetch the highest prices, while black cottonwood, generally grown for pulp, brings the lowest. Bigleaf maple log prices are the most variable and both bigleaf maple and paper birch are intermediate between red alder and black cottonwood in terms of average sawlog prices. Red alder log prices vary significantly with log diameter and the amount of clear wood; this variation is not reflected in log price survey data maintained by the BC Ministry of Forests and Range. Prices for alder sawlogs have increased significantly over the past 10 years in BC, similar to trends in the Pacific Northwest states. Alder sawlog prices in BC exceeded those for second growth western hemlock sawlogs, and alder sawlog prices in Washington and Oregon exceeded those of some grades of second growth Douglas-fir sawlogs. Harvest levels vary yearly, but do not appear to have increased consistently since 1994, the earliest date with harvest volumes used in the study. On average, the volume of broadleaves harvested over that period was ca. 2% of the total harvest for the coast. 69% was red alder, 10% was bigleaf maple, 19% was black cottonwood/hybrid poplar and 2% was paper birch.

Silvicultural practices with coastal broadleaves largely emphasize their control and removal in order to promote the growth of conifer crop trees. Currently, red alder and hybrid poplar are the only coastal

broadleaves which are artificially regenerated. There is a lack of knowledge regarding the management of the broadleaves for timber.

Some research needs include the interaction of the broadleaves in mixes, performance of naturally versus artificially regenerated stands, tolerance to climate change, production of regeneration products – seedlings and/or vegetative material – and cause of red heart in red alder.

Increasing the contribution of broadleaves to the timber supply is impeded by a number of policy and institutional constraints. These include a bias toward conifer-based timber objectives throughout the forest industry; a lack of broadleaf objectives in tree farm licences; current methods of timber allocation and valuation on public land; and rules relating to achieving free growing stands.

Changes are recommended and a methodology is suggested for determining the best means of selecting crop tree species. This methodology would focus on the full-range of values contributed by a species, ensure that intensive uses are limited to sites with good proximity to developed centres, result in a proportion and distribution of the species that is similar to the species proportion and distribution in the natural landscape and give preference to the species' ecological tolerances and amplitudes – its natural strengths and weaknesses.

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Introduction

The values accrued from our forests in British Columbia, and our perception of which values we are accruing, tend to change over time and are difficult to predict. The history of forest management in BC contains various examples of changes in values: the development of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) from a non-merchantable species to the number one source of timber on the coast during the latter half of the 20th century; the gradual increase in utilization standards for conifers from a one-foot top diameter in the 1960s to a four-inch top today; and the development of red alder (*Alnus rubra* Bong.) from a non-merchantable impediment to conifer establishment to a timber source equivalent in value to Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco) in some areas (Mason 2006).

Our perception of the values that we are accruing has also changed. We now understand, for example, that species such as red alder perform various ecological functions, such as nitrogen-fixation and biodiversity enhancement, which increase their total value.

These changes suggest that the forester should be wary when prescribing management regimes or selecting crop species, and should not base those decisions solely on today's market values. Rather, the forester should recognize that those values may change and new values may develop or come to light. To assist decision-making, the forester needs a methodology for determining the optimal course of action – a way of choosing the best mix of crop tree species across the landscape semi-independent of the vagaries of short-term economic considerations. This may include one of the range of broadleaf tree species if they provide the best mix of values.

Purpose

The purpose of this report is to provide information on the four commercially valuable, deciduous, broadleaf tree species in coastal BC. This information will assist the Broadleaf Species Committee of the Forest Genetics Council of BC in setting priorities for the expansion of genetic testing and seed and vegetative production. It will also recommend a methodology for guiding future management and incorporation of broadleaves into the coastal forest estate. The four species are:

- Red alder
- Bigleaf maple (*Acer macrophyllum* Pursh)
- Black cottonwood (*Populus trichocarpa* Torr. & Gray)[1]
- Paper birch (*Betula papyrifera* Marsh.)

The report will provide the following information for the four species:

1. Geographic distributions and commercial ranges;
2. Current inventories;
3. Non-timber and timber enhancement values;
4. Current commercial values and trends in value;
5. Recent harvest levels
6. Current silviculture practices;
7. Potential for increased harvesting
8. Possible changes in commercial value;
9. Policy and institutional impediments to enhanced management; and
10. A methodology for guiding future management and recommendations for change.

[1] Black cottonwood is also known as *Populus. balsamifera* L. spp. *trichocarpa.*

Scope

The study area for the report includes all the forest land in the Coast Forest Region (Figure 1) and the Kalum Forest District (Figure 2), and a discussion of the native range and volumes of red alder in the Skeena Stikine and Cascades Forest Districts and bigleaf maple in the Cascades Forest District (Table 1).

TABLE 1. Forest Districts included in the study area

Campbell River (DCR)
Chilliwack (DCK)
Kalum (Northern Interior Forest Region) (DKM)
North Coast (DNC)
North Island – Central Coast (DNI)
Queen Charlotte Islands (DQC)
South Island (DSI)
Squamish (DSQ)
Sunshine Coast (DSC)

The area covered by the report is approximately equivalent to the entire extent of the Pacific maritime ecozone in BC (Natural Resources Canada website 2007). The Kalum Forest District, which is located in the Northern Interior Forest Region, is included in the report because it is located primarily in the Pacific maritime ecozone and most of the low elevation forest in the Kalum Forest District is located in the coastal western hemlock (CWH) biogeoclimatic ecosystem (BGC) zone, a coastal BGC zone.

FIGURE 1. Coast Forest Region (BC Ministry of Forests and Range website 2003).

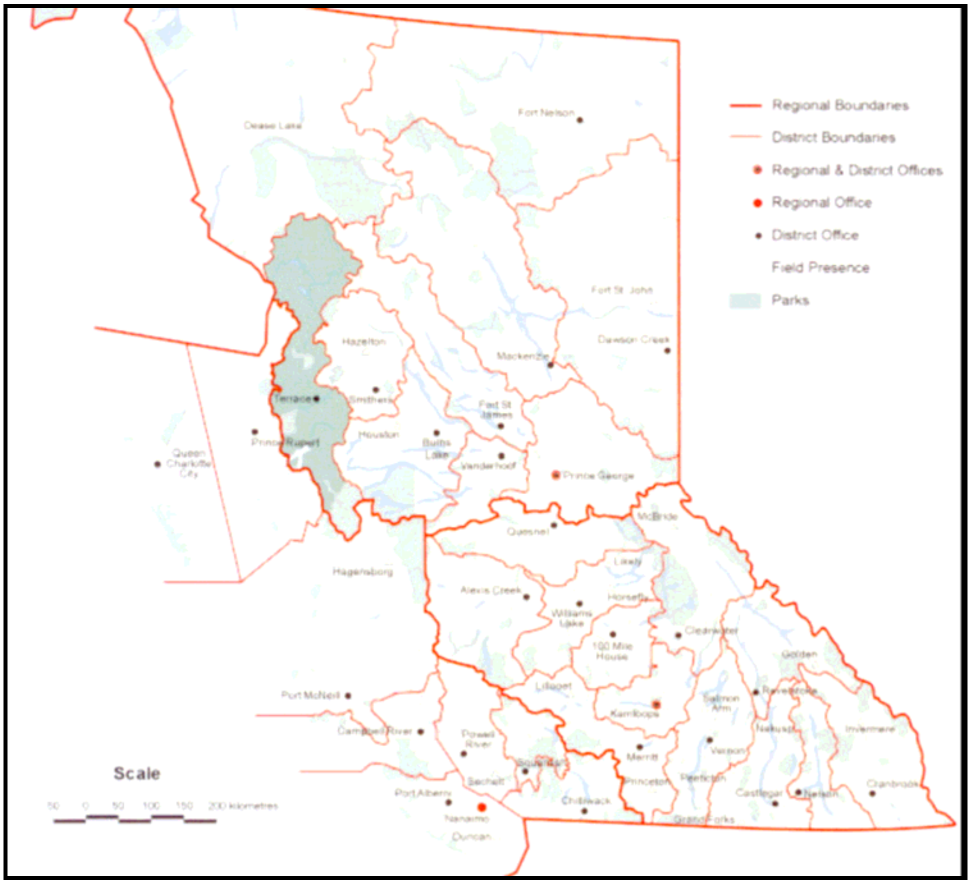

FIGURE 2. Kalum Forest District (BC Ministry of Forests and Range website 2003).

Geographic Descriptions & Commercial Ranges

The geographic description of each of the species includes information on the native range, climate and ecological tolerances, occurrence in the biogeoclimatic zones and the specific soils, topography or silvics information that impact the occurrence or productivity of the species.

The commercial range of each species is the area of land in which the species can, in most years, be managed as a commercial crop; that is, be grown and harvested for a profit. It is usually either equal to, or a subset of, the native range, which is where the species occurs naturally.

The key determinants of the commercial range of each species are:

- The species' value as a source of forest products;
- The technology available for growing and harvesting the species;
- The growth capacity of different ecosystems and subsequent variation in growth of the species across its native range;
- The principle that the species should be encouraged to grow in the biogeoclimatic subzones where it is doing well without silvicultural intervention;
- The principle that a species should not be grown beyond its native range unless the risk is proven to be low; and
- The size of the species' inventory and the way in which that can affect economies of scale.

Red Alder (Dr)

Red alder is the most common broadleaf tree species on the coast of British Columbia. Its native range extends from southeast Alaska to northern California with the majority of the volume is in Washington, Oregon and British Columbia (Ahrens 2006). It is primarily located in the Pacific maritime ecozone (Natural Resources Canada website 2007) with the exception of some stands located in Idaho (Burns and Honkala 1990).

Red alder is primarily suited to mesothermal (mild and rainy) climates (Krajina et al. 1982) and is intolerant of early growing season frost. As a result, it is limited to a maximum elevation of 750 metres in coastal BC – lower in the north and higher in the south (Burns and Honkala 1990). The majority of the stands in coastal BC occur below 350 metres. Red alder occurs throughout the CWH and CDF biogeoclimatic zones but not in the mountain hemlock zone (MH). It occurs on all the fresh to wet site series and is most productive on fresh, nutrient-rich sites.

Red alder is shade intolerant, early seral and short-lived. Its shade intolerance is second only to black cottonwood for coastal BC tree species (Krajina et al. 1982). It produces abundant, light seed and regenerates rapidly after disturbance such as harvesting, fire, windthrow or floods. It occurs in pure stands or in mixtures with all the other coastal tree species. It can tolerate poorly drained soils but does best on fresh, fine textured soils with good aeration and drainage. It requires growing season moisture for optimal growth and so does poorly on xeric sites or south-facing aspects in the southern part of its range or the sub-maritime ecosystems. It grows quickly and reaches 50% of its mature height at age 12 (Nigh and Courtin 1998)[2]. It is mature at about age 60 to 70 years (height growth slows dramatically after age 50) and it is usually dead by 100 years (Harrington 2006).

[2] Site index calculations were performed using equations in Site Tools, version 3.3 available from the BC Ministry of Forests and Range.

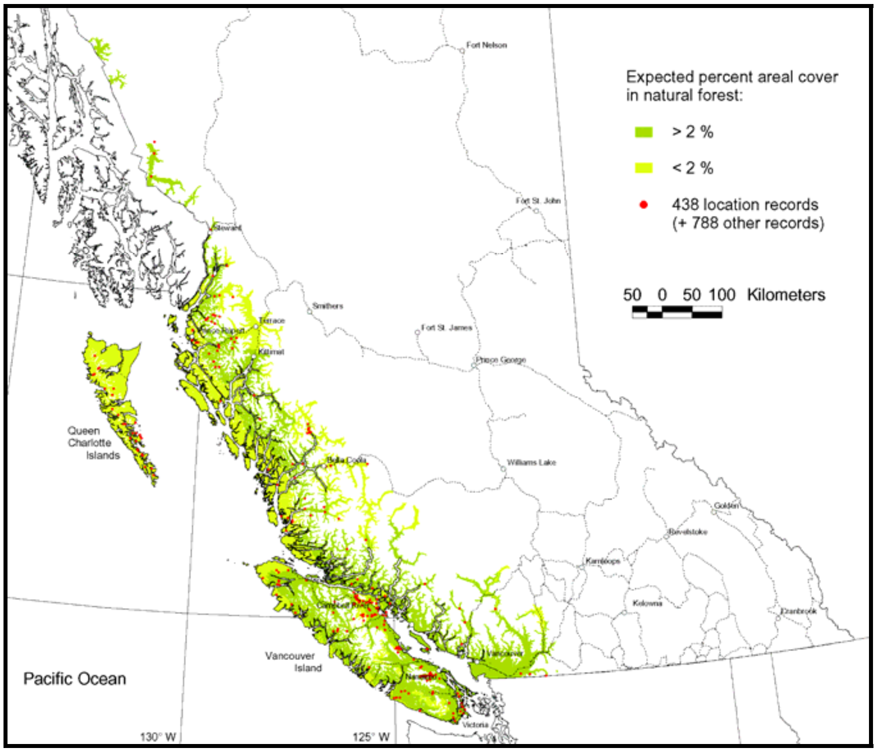

FIGURE 3. Range map for red alder in coastal British Columbia (Hamman et al. 2005).[3]

Red Alder's Commercial Range

The current commercial range of red alder is similar to its native range – anywhere that sawlog-sized[4] red alder occurs it can usually be harvested profitably. This situation has developed in recent years due to the steady increase in the value of red alder sawlogs (see section on Current Commercial Values). Red alder sawlogs in BC now sell for approximately $75 per cubic metre and the cost to harvest them is usually less than that, in the range of $45 to $65 per cubic metre. Hence, they may be harvested for a profit.

Given a continuation of the current prices, red alder could be managed on a wide range of sites provided those sites are able to produce sawlog sized trees; some poorer sites, for example, may not be able to produce a sawlog prior to senescence. The best sites to produce sawlog-sized red alder on the coast are the ecosystems in the CWHxm (very dry maritime), CWHdm (dry maritime), CWHmm1 (moist maritime, submontane variant) CWHvm1 (very wet maritime, submontane variant), CWHwh1 (wet hypermaritime, submontane variant), CWHds1 (dry submaritime, southern variant) and CWHds2 (dry submaritime, central variant)(Courtin et. al. 2002). Productivity for sawlogs diminishes at higher elevations, in some hypermaritime ecosystems and on very wet or very dry sites. At the site level, red alder does best on nutrient medium to rich sites with fresh to moist hygrotopes; gleyed soils are too wet for good red alder growth (Courtin 1991). Soils should be deep and well drained with finer textures although some very fine textures can be limiting (Courtin, pers. comm. 2007); they should be alluvial, glacio-marine or fluvial-marine in origin (Burns and Honkala 1990).

[3] The red dots on the map indicate "species presence" in botanical sample plots and have no applicability to this report (Hamann pers. comm. 2007).
[4] A red alder sawlog is typically a 13 metre log with a 17 to 20 cm top; shorter lengths are also merchantable.

Bigleaf Maple (Mb)

Bigleaf maple is the second most common broadleaf tree species on the south coast of BC after red alder. Its native range extends from northern Vancouver Island and at Sullivan Bay on the BC mainland, and south into California, occurring at higher elevations in the Sierra Nevada. It is located on the windward side of the coastal mountains in the Pacific maritime ecozone (Natural Resources Canada Website 2007). The majority of the volume is located in Washington and Oregon.

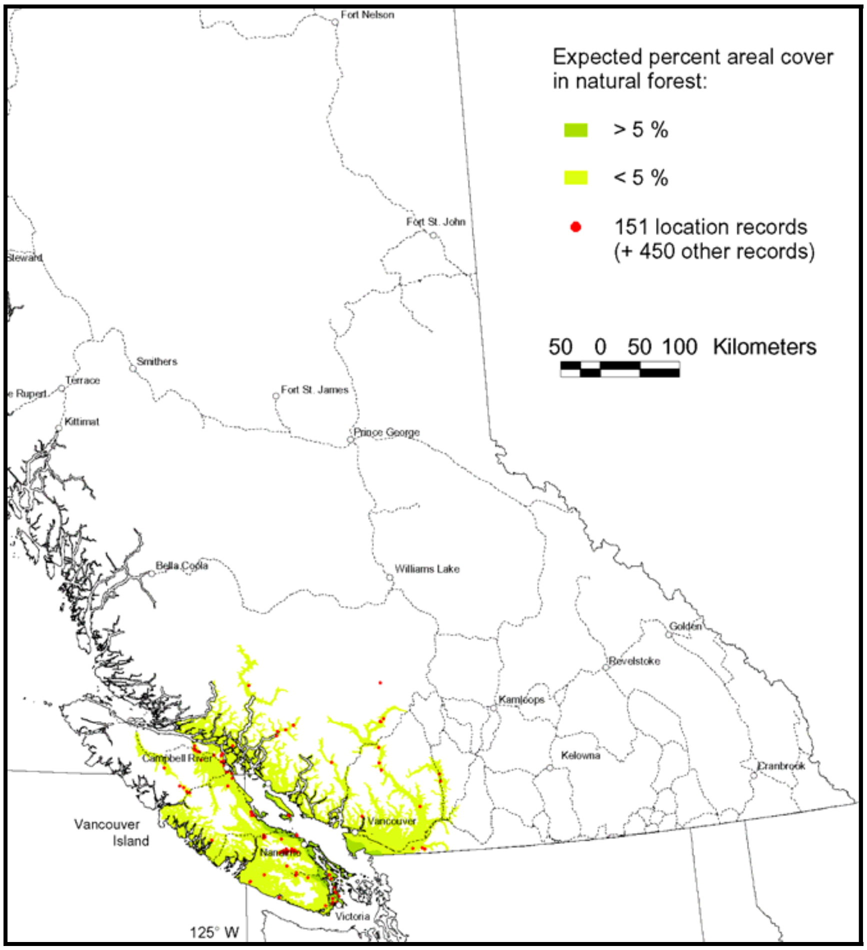

FIGURE 4. Range map for bigleaf maple in coastal British Columbia (Hamman et al. 2005).

Bigleaf maple is primarily suited to mesothermal climates and is intolerant of frozen ground prior to snowfall (Krajina et al 1982). In BC, it occurs up to elevations of 350 metres (Burns and Honkala 1990) and occasionally up to 750 metres in the Lower Fraser Valley (Hughes, pers. comm. 2007). It occurs in the CDF and in the southern CWH. It is most productive on fresh, nutrient rich sites but can tolerate very dry, colluvial sites.

Bigleaf maple is mildly shade tolerant, early to mid-seral and is longest-lived of the four broadleaf tree species; it can live up to 250 years (Peterson et al 1999). It can occur as an intermediate tree in mixed species stands; in fact, approximately 55% of the total stand volume in public forest land in BC occurs in mixed stands (Canfi 2001). Bigleaf maple occurs infrequently in pure stands; when it does, it is most often the leading species[5] on colluvial sites and on rich sites. Productivity is greatest on nutrient rich soils with high cation exchange capacity (Thomas 1999). It grows quickly when young but reaches a mature height of approximately 35 metres on good sites in 60 years (Peterson et al 1999).

Bigleaf Maple's Commercial Range

The current commercial range of bigleaf maple is similar to its native range. Like red alder, the value of bigleaf maple has also increased in recent years though it is worth less due to higher manufacturing costs (Burns and Honkala 1990) (Morgan, pers. comm. 2007). It often occurs in mixes with other species and so is profitable because the harvesting costs are amortized with other species.

Given the use of management techniques to improve the stem form of bigleaf maple and continuation of similar prices for sawlogs, bigleaf maple could be managed profitably throughout its native range in coastal BC. The management techniques that could be used are the growing of bigleaf maple in higher density stands to ensure minimal branching (Thomas 1999) and, with multi-stemmed coppices, cutting of all the stems except for the one to five of the largest. This focuses the growth potential onto fewer stems and permits a shorter time. A significant challenge for managing bigleaf maple plantations is the browsing by deer and elk. Basic silviculture may require the use of browse reduction tactics such as browse guards or repellants. The best sites for growing bigleaf maple are the ecosystems in the CWHxm, CWHdm, CWHds (Fraser Canyon), southern CWHvm1 and CDF. At the site level, bigleaf maple does best on nutrient rich sites and is a good choice on difficult to reforest colluvial sites.

Black Cottonwood (Act)

Black cottonwood occurs from southeast Alaska to California and east to the Rocky Mountains. Its range overlaps with balsam poplar in central BC where the two species hybridize extensively (Klinka pers. comm. 2007). It occurs in both the Pacific maritime and montane cordillera ecozones (Natural Resources Canada website 2007). It also occurs in BC in managed stands as a hybrid with non-native poplar species: *Populus deltoides* and less commonly with *Populus maximowiczii* (Thomas et al. 2000).

Black cottonwood occurs in both mesothermal and temperate climates and rarely in the subalpine (Krajina et al. 1982). In coastal BC it is primarily limited to low elevation sites though may occur at elevations up to 1200 metres. It has a high flood resistance but is intolerant of brackish water and salt spray resulting in a limited occurrence in hypermaritime ecosystems (Krajina et al. 1982). It is primarily a floodplain species but occasionally occurs on upland sites (McLennan 1991). It occurs on the coast of BC in the CWH and CDF and rarely in the MH zone.

Black cottonwood is the most shade intolerant and fastest growing tree species in BC (McLennan 1991). It is early seral, longer-lived than red alder but less than bigleaf maple; it can live for more 150 years. It occurs most often in pure, even-aged stands. For optimal growth it requires a nutrient rich, moist, well aerated and neutral soil (Burns and Honkala 1990). Growth may benefit from flooding (McLennan 1991). On the best sites it reaches heights of greater than 22 metres in 15 years equivalent to a site index (base 50 years) of 44 metres (McLennan 1991) (Thrower 1992).[6] Hybrid poplar has greater growth rates.

[5] The "leading species" is the tree species with the greatest number of stems in the inventory.
[6] From an equation in Site Tools version 3.3.

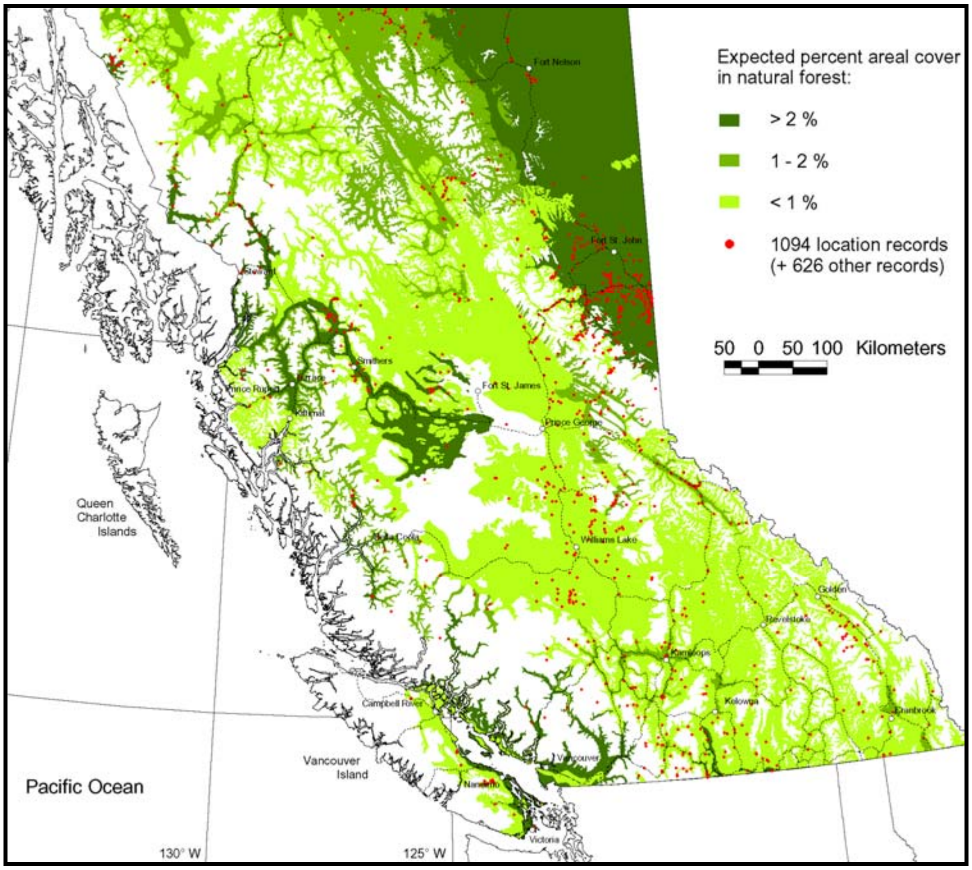

FIGURE 5. Range map for black cottonwood and balsam poplar in British Columbia (Hamman et al. 2005).

Black Cottonwood's Commercial Range

The current commercial range of black cottonwood and hybrid poplar are the floodplains adjacent to major rivers in coastal BC, although it can grow well on upland sites. Its natural occurrence and abundance on floodplain sites, combined with its low commercial value compared with the other broadleaves, makes it more profitable to focus the commercial activity in the floodplain areas. On these sites it can be grown profitably because it can be managed in pure stands with high growth rates, large volumes and low harvesting costs, factors that would be less easy to maintain or control on upland sites.

The best sites for black cottonwood and hybrid poplar production are the medium and high-bench floodplain sites adjacent to medium to large rivers in coastal BC (McLennan 1991).

Paper Birch (Ep)

Paper birch occurs across Canada but with a limited occurrence on the coast of BC. Its range extends into the northern US; its southern range is limited by warm summer temperatures (Burns and Honkala 1990). It occurs in all the major tree-covered, terrestrial ecotones across Canada and its range extends up to the tree limit in the subarctic (Burns and Honkala 1990). In coastal BC it occurs in mixed and occasionally pure stands in the eastern lower Fraser Valley and the mainland inlets. It is rare on the southeast lowlands of Vancouver Island and does not occur on the Queen Charlotte Islands or any of the maritime portions of the mainland south of Prince Rupert.

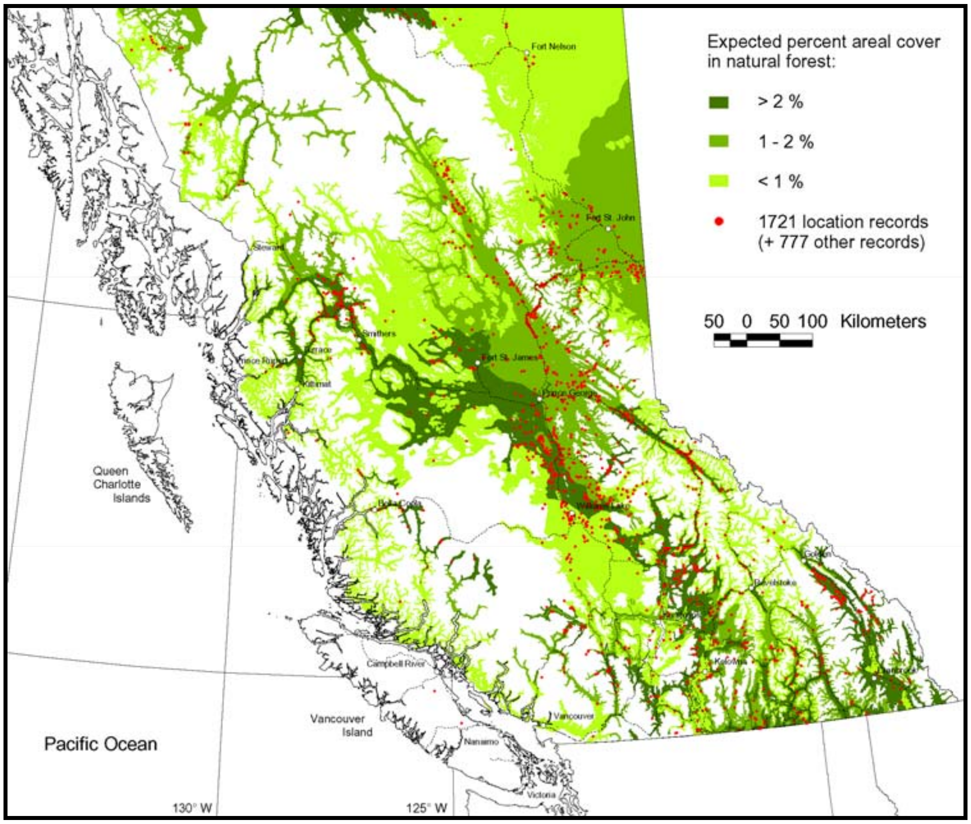

FIGURE 6. Range map for paper birch in British Columbia (Hamman et al. 2005).

Paper birch occurs in both boreal and temperate climates and rarely in mesothermal climates (Krajina et al. 1982). It is primarily a continental species. On the coast of BC it limited to low elevation submaritime ecosystems. It occurs in the CWH and wetter CDF.

Paper birch is shade intolerant, early seral, longer-lived than red alder but less than black cottonwood. It is mature at age 70 but can live over 140 years. It has rapid growth rates relative to its conifer associates but less than the other coastal broadleaves. As a result it rarely occurs on the coast of BC. It has a high tolerance for frost and flooding. Best growth occurs on nutrient medium to rich sites with fresh to medium hygrotopes. Best soils are well-drained sandy loams, silts, or soils derived from limestone. The best sites produce mature trees at year 50 with heights of up to 30 metres (Courtin, pers. comm. 2007).

Paper Birch's Commercial Range

The current commercial range of paper birch on the coast of BC is its native range - the submaritime ecosystems of the coastal valleys and inlets and the eastern portions of the maritime ecosystems in these same valleys. Paper birch on the coast usually occurs in mixed stands with red alder and is often harvested along with that species. Pure stands of large paper birch occur in the eastern Fraser Valley (Hughes, pers. comm. 2007).

The Establishment to Free Growing Guidebook, Vancouver Forest Region, recommends paper birch for broadleaf management in the submaritime ecosystems (CWHds and CWHws) and in the eastern portions of the southcoast low elevation subzones: the CWHxm and CWHdm. Paper birch's commercial range could be extended, initially through artificial regeneration, into the maritime ecosystems of coastal BC – the CWHxm and the CWHdm (Klinka pers. comm. 2007). It may even be acceptable on medium sites in the CDF zone.

Current Inventories

The following summary of the current coastal broadleaves inventory is a review of the inventory on TSA and TFL lands, which represents the majority of the coastal public land forests in coastal BC. Estimates are provided for the private forest land on Vancouver Island. The summary includes a review of the data sources, accuracy and age of the data, and, by forest district, the area, volumes, age distributions and the range of occurrence on different site types. It also includes a discussion of past summaries of the broadleaf inventories.

Data Sources and Accuracy of Data

The primary source for the inventory information for the coastal broadleaves was the Canadian Forest Inventory 2001 (Canfi 2001). Secondary sources included the timber supply reviews for the coastal Timber Supply Areas (TSAs) and Tree Farm Licences (TFLs), Land and Resource Management Plans (LRMPs) and the Mapview 4.0[7] mapping tool, all located on the BC Ministry of Forests and Range website.

The Canadian Forest Inventory includes data from the provincial government for public forest land and estimates of the forest inventory for private land, non-industrial land (urban and agricultural) and some parks. For these latter areas, the estimates were obtained from satellite images. The timber volume for the areas covered by satellite imagery was calculated by determining the species composition (first, second, third etc. up to 28 species) for each polygon then applying an estimate of volume for each species based on volumes per hectare for similar sites on adjacent lands.

To analyze the data at a forest district level ('forest district' is not an attribute of the Canfi database) the data was overlain by staff at the Pacific Forestry Centre with the forest district maps provided by the Forest Analysis and Inventory Branch of the BC Ministry of Forests and Range.

On a close examination of the data it was apparent that the data collected from the satellite imagery was incorrect. For instance, the data indicated a total volume of broadleaves in the South Island Forest District of 43 million cubic metres – ten times greater than the total volume of broadleaves in the TSA and TFL lands in the South Island Forest District. The TSA and TFL lands are approximately half of the total area in the South Island Forest District and therefore should contain a large proportion of the total broadleaf volume (not half because they are located on the west coast, an area with fewer broadleaves). This value – 43 million cubic metres – was equivalent to approximately 80% of the total volume of broadleaves on all TSA and TFL lands in the entire study area (53 million cubic metres).

The error in the data could also be shown by the large discrepancy between average volumes per hectare between satellite-derived data and TSA or TFL areas with known high broadleaf volumes. The highest volumes per hectare for TSA lands in the study area were 26 cubic metres per hectare in the Sunshine Coast Forest District and 24 cubic metres per hectare in the Chilliwack Forest District; consistent with general knowledge of the forests in these areas. The volume per hectare for the TSA lands in the South Island and Campbell River Forest Districts, the two districts with the bulk of the private land and hence the satellite-derive data, were 12 and 10 cubic metres, respectively. In contrast, the data derived from satellite data indicated a volume per hectare of 37 and 116, for the two satellite measurement methods, for the Campbell River Forest District and 69 and 101 for the South Island Forest District.

[7] Mapview 4.0 is a BC Government web-based service that contains forestry-oriented geographic information and has tools for determining areas among other features.

The secondary sources of data, the analysis reports with the timber supply reviews for the coastal TSAs and TFLs, were obtained from the BC Ministry of Forests and Range website. Also, the maps and area measurement tool on the Mapview 4.0 website were used to confirm and establish approximate areas for various features such as parks and most forest districts. The forest district areas had to be confirmed because the maps for the forest districts provided by the Forest Analysis and Inventory Branch contained large areas of salt water for the forest districts with coastline (all except Squamish and Kalum).

The area for parks included an estimate of the new protection areas and parks in the mid- and north coasts. The percentage estimates for these new preserves were contained in the LRMP summaries for the mid-coast and north coast TSAs on the BC Ministry of Forests and Range website.

As a result of the errors in the Canfi 2001 satellite data, and hence areas with non-public ownerships, the analysis was limited to the TSA and TFL data in the Canfi 2001 dataset.

Age of the Data

The Canfi 2001 data had collection dates as early as 1953 and as recent as 1997. 85% of the data was updated in 1996 including approximately 100% of the data for TSAs and TFLs.

The timber supply reviews were from as early as 1999 or as recent as 2006.

Area Summary

The total area of the study area – terrestrial and freshwater – is approximately 19.9 million hectares or about one fifth of the Province's total area of 94.5 million hectares. This consists of approximately 15.9 million hectares in the Coast Forest Region[8] and 4.0 million hectares in the Kalum Forest District. Approximately 3.5 million hectares in the study area are in parks and protection areas (Table 2).

The Canfi 2001 data encompasses a total of 8.9 million hectares in the study area with 5.0 million hectares in TSAs and 1.9 million hectares in TFLs. Of the TSA and TFL area, 663 000 hectares, or 9.6%, contain stands where one of the four broadleaf species is a component; that is, it is one of the top five species in the inventory. The forest area with a broadleaf component is concentrated in the southern forest districts – Sunshine Coast Forest District and Chilliwack Forest District and presumably the private lands on the southeast side of Vancouver Island, although this was not available in the data (Figure 7). Approximately 227 000 hectares, or 3.3% of the total area in the TSAs and TFLs, consists of stands where one of the four species is the leading species.

The TSA and TFL timber supply reviews show a total area of 14.6 million hectares in the landbase and 7.2 million hectares in productive forest. They also record a value of 3.0 million hectares in the timber harvesting landbase (THLB) (Table 3). The total productive forest area in the TSAs is 4.7 million hectares, slightly less than the total reported by Canfi 2001. There are 17 TFLs in the study area. They have a combined total area of 4.6 million hectares, a productive forest area of 2.6 million hectares and a THLB of 1.5 million hectares (Table 4).

[8] The BC Ministry of Forests website for the Coast Forest Region states an area of 16.5 million hectares; however, the measured area determined using the measuring tool in Mapview 4.0 indicated an area of 15.87 million hectares.

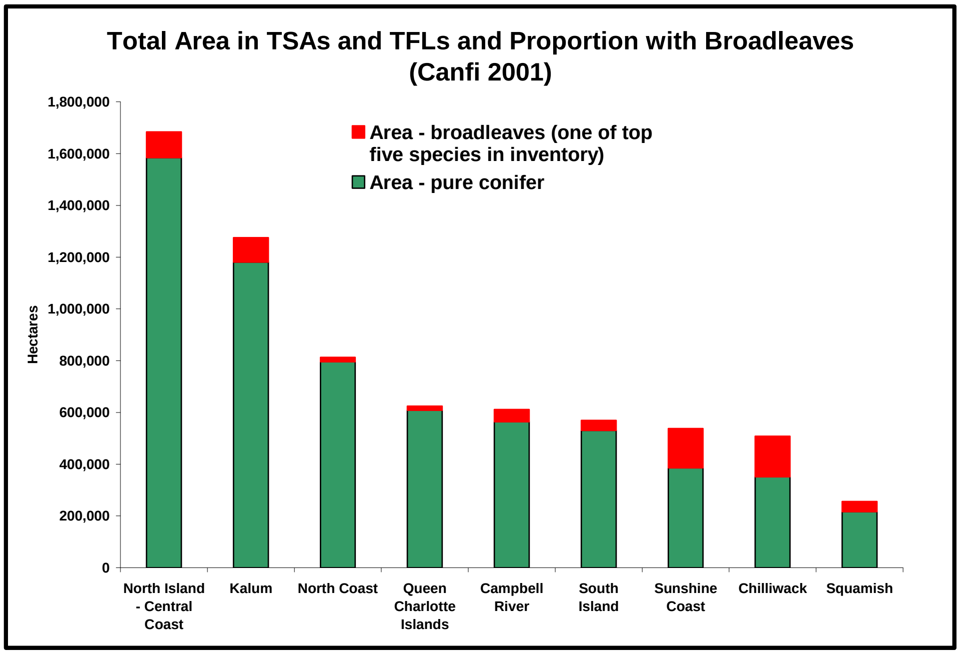

FIGURE 7. Total area in TSAs and TFLs and proportion with broadleaves by forest district (hectares) (source: Canfi 2001).

The TSA and TFL lands have 103 000 hectares, or 1.4%, of broadleaf-leading stands in the productive landbase and 53 000 hectares, or 1.8%, in the THLB. Unlike the Canfi 2001 data, the analysis reports of the timber supply reviews do not describe the total area leading and non-leading broadleaf stands in the TSAs and TFLs.

TABLE 2. Area summary for the forest districts in the study area (hectares) (source: BC Government, Mapview 4.0 and Canfi 2001).

Forest District	Mapview 4.0		Canfi 2001		Dr/Mb/Act/Ep	
	Land	Park	Total	TSA & TFL	Total	Leading
North Island - Central Coast	5,194,000	1,450,000	2,322,546	1,683,800	99,679	37,044
Kalum	4,012,320	150,000	1,357,571	1,275,378	94,883	27,895
North Coast	2,287,000	778,000	813,450	813,052	17,339	5,901
Sunshine Coast	1,650,000	50,000	566,397	537,744	151,599	55,401
Campbell River	1,540,000	250,000	958,839	611,730	47,966	16,379
Chilliwack	1,540,000	267,000	688,061	508,350	157,349	50,506
South Island	1,540,000	152,000	1,071,073	569,108	38,626	14,379
Squamish	1,098,514	220,000	400,011	255,824	39,615	11,919
Queen Charlotte Islands	1,018,000	229,000	703,026	624,314	16,045	7,125
Total Study Area	**19,879,833**	**3,546,000**	**8,880,975**	**6,879,300**	**663,100**	**226,548**

TABLE 3. Area summary for the TSAs and TFLs in the study area (hectares) (source: timber supply reviews, BC Ministry of Forests and Range website).

Timber Supply Area	Landbase	Productive	THLB	BL Prod.	BL THLB
Mid-coast (DNI)	2,211,930	819,436	196,645	1,000	500
North Coast (DNC)	1,830,883	875,902	137,970	1,000	500
Fraser (DCK)	1,420,432	636,675	259,529	15,000	8,000
Kingcome (DNI)	1,139,367	586,345	164,114	2,000	1,200
Sunshine Coast (DSC)	989,477	427,594	219,890	15,000	10,000
Soo (DSQ)	826,160	298,912	120,565	1,500	800
Kalum (DKM)	539,319	197,406	94,180	10,000	4,500
Queen Charlotte (DQC)	460,091	354,353	77,531	500	300
Strathcona (DCR)	395,864	346,926	159,678	6,000	3,000
Arrowsmith (DSI)	169,000	112,050	58,716	4,400	2,300
TSA Totals	**9,982,523**	**4,655,599**	**1,488,818**	**56,400**	**31,100**
Study Area TFL	**4,571,674**	**2,577,697**	**1,504,152**	**46,463**	**21,650**
Total Study Area	**14,554,197**	**7,233,296**	**2,992,970**	**102,863**	**52,750**

The total areas of productive forest in TSAs reported by Canfi 2001 were similar to those reported in timber supply reviews (Table 5). The Canfi 2001 estimates of broadleaf-leading stands, however, were greater. Broadleaf-leading stands comprise approximately 3.6% of the total productive forest area in TSAs in the Canfi estimates, compared with only 1.2% in the timber supply review estimates (Table 5) (Figure 8).

The lower estimate of broadleaf-leading stands in the timber supply reviews likely resulted because broadleaves have historically not been considered merchantable and so may have been under-represented during inventory creation, or relegated to non-productive forest types or forest-level set-asides. Also, including broadleaves in the timber supply can potentially reduce the allowable annual cut available for conifers by reducing the total timber supply, and for older broadleaf stands, by reducing the mean annual increment of the total forest. Hence, there is a disincentive to include broadleaves in the timber inventory if a licensee is not actively harvesting and marketing them.

TABLE 4. Area summary for the TFLs in study area (hectares) (source: timber supply reviews, BC Ministry of Forests and Range website).

TFL	Licensee	Landbase	Productive	THLB	Deciduous Productive
1	Coast Tsimshian Resources Limited Partnership	610,691	272,597	130,645	6,901
6	Western Forest Products Inc.	198,113	185,491	149,747	2,368
10	International Forest Products Limited	229,677	53,723	23,582	3,434
19	Western Forest Products Inc.	191,992	147,834	88,278	450
25	Western Forest Products Inc.	458,447	143,206	112,989	1,761
26	The Corporation of the District of Mission	10,564	9,878	7,236	740
37	Western Forest Products Inc.	196,725	148,720	91,325	557
38	Northwest Squamish Forestry Ltd. Partnership	218,616	60,723	36,609	1,656
39	Western Forest Products Inc.	801,393	548,241	369,970	5,400
41	West Fraser Mills Ltd.	703,744	332,924	69,686	4,088
43	Scott Paper Limited	10,106	6,153	3,326	5,000
44	Western Forest Products Inc.	310,795	258,201	168,013	1,986
45	International Forest Products Limited	231,866	64,918	25,878	1,043
46	Teal Cedar Products Ltd.	83,545	80,545	63,777	2,400
47	TFL Forest Ltd.	167,021	149,068	112,866	8,000
54	International Forest Products Limited	60,986	41,049	23,340	174
57	Iisaak Forest Resources Ltd.	87,393	74,426	26,885	505
	Total Study Area	**4,571,674**	**2,577,697**	**1,504,152**	**46,463**

TABLE 5. Area of productive forest and broadleaf leading stands in TSAs as shown in the Canfi 2001 data and the timber supply reviews (hectares) (source: Canfi 2001 and BC Ministry of Forests and Range website).

Timber Supply Areas	**Canfi 2001**			**Timber Supply Reviews**		
	Productive	**Broadleaf Leading**	**%**	**Productive**	**Broadleaf Leading**	**%**
Mid-coast & Kingcome (DNI)	1,448,031	34,294	2.4%	1,405,781	3,000	0.2%
North Coast (DNC)	711,929	4,622	0.6%	875,902	1,000	0.1%
Fraser (DCK)	508,350	50,506	9.9%	636,675	15,000	2.4%
Sunshine Coast (DSC)	430,687	43,126	10.0%	427,594	15,000	3.5%
Soo (DSQ)	254,857	11,907	4.7%	298,912	1,500	0.5%
Kalum (DKM)	787,349	18,738	2.4%	197,406	10,000	5.1%
Queen Charlotte (DQC)	408,314	2,390	0.6%	354,353	500	0.1%
Strathcona (DCR)	365,525	11,919	3.3%	346,926	6,000	1.7%
Arrowsmith (DSI)	133,331	5,701	4.3%	112,050	4,400	3.9%
	5,048,372	**183,204**	**3.6%**	**4,655,599**	**56,400**	**1.2%**

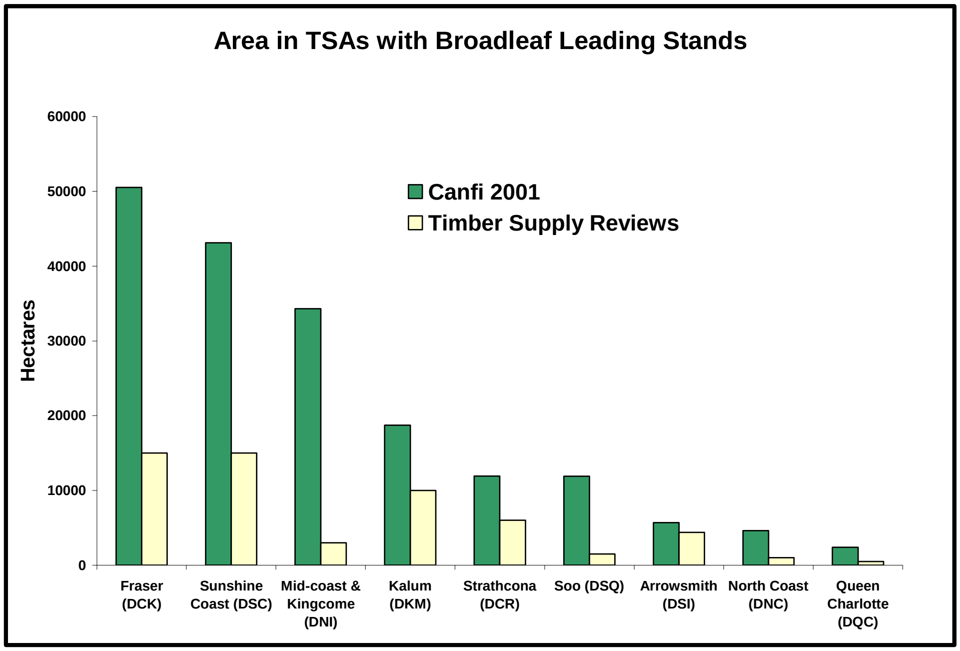

FIGURE 8. Area in TSAs with broadleaf leading stands (hectares) (source: Canfi 2001).

TABLE 6. Total broadleaf volumes by ownership type (source: Canfi 2001).

Forest Ownership	Total	Dr	Mb	Act	Ep
Public - TSA & TFL	52,254,160	35,999,746	6,544,427	7,336,289	2,373,698
Private	9,980,326	7,570,872	1,984,101	425,353	0
Total Study Area	62,234,486	43,570,618	8,528,528	7,761,642	2,373,698
Minimum	57,100,907	40,444,800	6,916,060	7,366,349	2,373,698
Maximum	71,606,093	49,162,859	11,682,422	8,387,113	2,373,698

Volume Summary

There are approximately 62 million cubic metres of broadleaves in the study area on productive forest land (Table 6)[9]. This is approximately 2% of the total volume of timber in the study area. This includes 52 million cubic metres on public lands – TSAs and TFLs - and 10 million cubic metres on private lands. The private land volumes are a rough estimate and could vary by as much as 5 million cubic metres or more. The red alder total for the private land was reviewed by TimberWest Forest Corp. who owns approximately 375 000 hectares; this amount was considered a realistic estimate (McPhalen pers. comm. 2007).

[9] Total volumes are assumed to include all trees recorded in an inventory cruise; the minimum dbh is assumed to vary between10 to 20 cm depending on the cruise standards.

There are 44 million cubic metres of red alder, 9 million cubic metres of bigleaf maple, 8 million cubic metres of black cottonwood[10] and over 2 million cubic metres of paper birch. See below and also table 5 and 7 for a description of the method used to calculate the volumes on private land and the potential range of variation in the volume estimates due to the inclusion of the private land estimates.

Only red alder occurs in all the forest districts in the study area. The largest accumulation of red alder, over 10 million cubic metres, is in the Sunshine Coast Forest District followed by Chilliwack and North Island – Central Coast Forest Districts with over six million cubic metres each. The South Island and Campbell River Forest Districts each have close to four million cubic metres on public land. The South Island could have 9 million cubic metres or more, and Campbell River could have 5 million cubic metres or more, if the private land is included.

Bigleaf maple does not occur in the Kalum, North Coast or Queen Charlotte Islands Forest Districts. Half of the bigleaf maple volume in the study area occurs in the Chilliwack Forest District.

Black cottonwood and paper birch occur in all forest districts except the Queen Charlotte Islands Forest District. Approximately 40% of each species occurs in the Kalum Forest District (Table 7) (Figure 9).

The Canfi 2001 data shows an additional 700 cubic metres of red alder in the Skeena Stikine Forest District, and 5000 metres of red alder and 1500 metres of bigleaf maple in the Cascades Forest District.

TABLE 7. Broadleaves volumes by forest district (Canfi 2001).

Forest Districts	**Red alder**	**Bigleaf maple**	**Black cottonwood**	**Paper birch**	**Total**
Sunshine Coast	10,405,525	1,574,063	539,583	26,441	12,545,612
Chilliwack	6,219,939	3,869,481	791,387	939,019	11,819,826
North Island - Central Coast	6,718,701	13,717	1,393,101	136,855	8,262,374
Kalum	1,282,076	0	3,562,709	1,096,075	5,940,860
Campbell River	3,996,324	336,799	46,993	5,441	4,385,557
South Island	3,708,088	364,449	25,344	0	4,097,881
Squamish	1,214,732	385,918	688,551	169,740	2,458,941
Queen Charlotte Islands	1,441,194	0	0	0	1,441,194
North Coast	1,013,167	0	288,621	127	1,301,915
Total Study Area	**35,999,746**	**6,544,427**	**7,336,289**	**2,373,698**	**52,254,160**

[10] A portion of the black cottonwood volume may contain hybrid poplar but this was not itemized in the Canfi 2001 inventory.

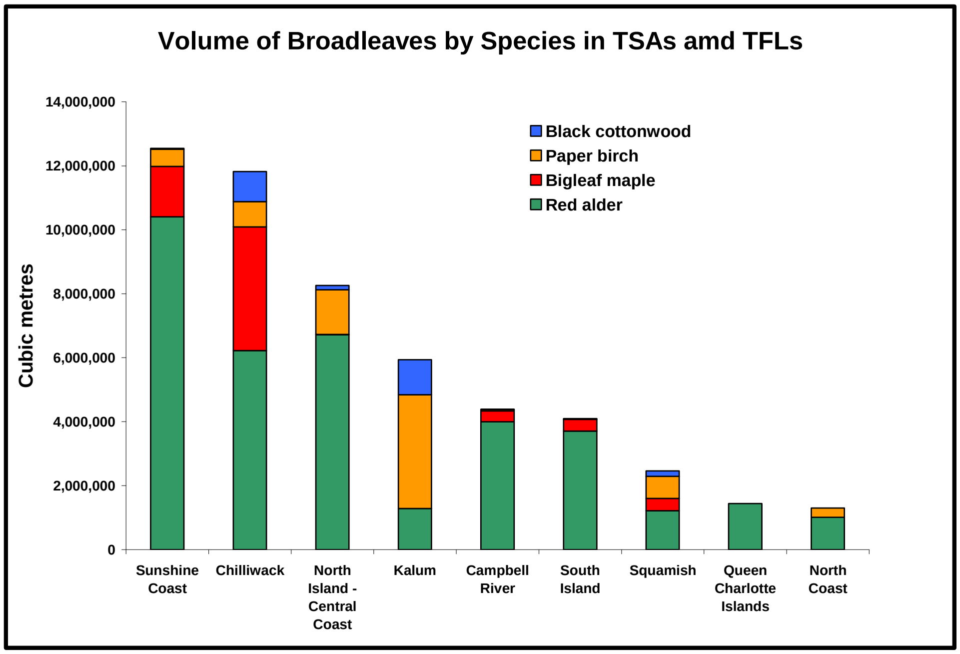

FIGURE 9. Volume of broadleaves by species in TSAs and TFLs (source: Canfi 2001).

Red Alder Volume Estimates

The error in the Canfi 2001 satellite-derived data explains the large discrepancy in red alder volume reported by Ahrens (2006). He reported a total volume from Canfi 2001 for BC of 91.9 million cubic metres and a total volume from Massie et al. (1996) of 33 million cubic metres. He argued that Massie's number was justified because it only included volume in red alder-leading stands. This was unlikely because red alder volume tends to be primarily in alder-leading stands (Figure 10). Furthermore, Massie's data only included forest in the TSAs and only some of the volume in the TFLs, further reducing the estimated total.

Based on an analysis of the Canfi 2001 data for TSA and TFL lands[11], across all forest districts in the study area, 68% of the total volume of red alder is in alder-leading stands. This ranges from a low of 59% in the North Coast Forest District to a high of 80% in the Queen Charlotte Forest District. Therefore, given Massie's estimate of 33 million cubic metres in red alder leading stands, and the Canfi 2001 data, a realistic estimate of the total volume of red alder in BC should have been between 41 and 56 million cubic metres not including the volume from private lands.

62% of the black cottonwood, 43% of the bigleaf maple and 27% of the paper birch volume on the TSA and TFL lands in the study area is in stands where the species is the leading species.

[11] In contrast to the data derived from satellite imagery most TSA and TFL inventory data is based on on-the-ground measurements.

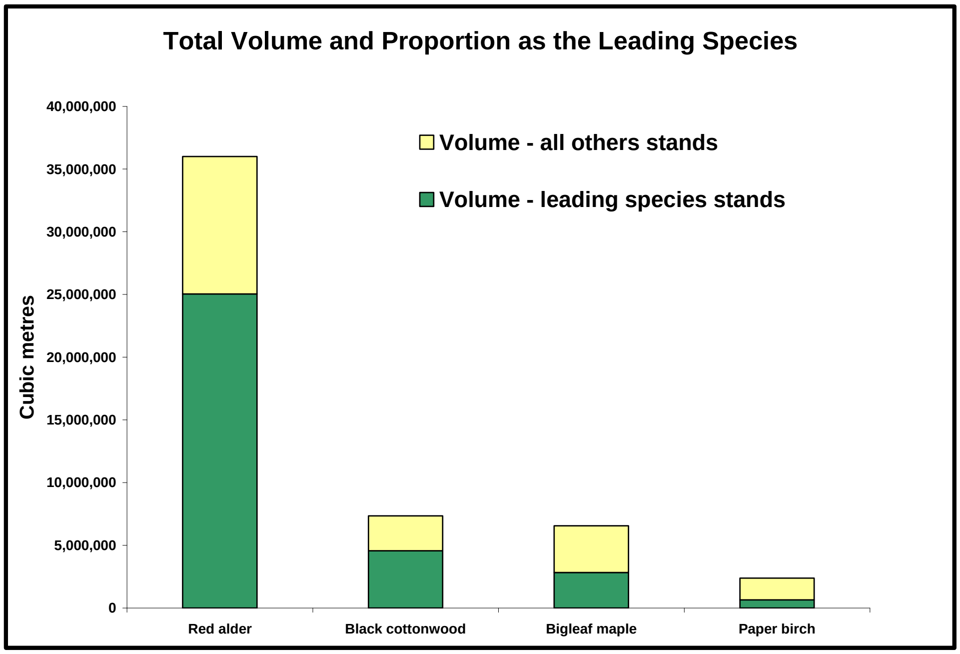

FIGURE 10. Total volume of broadleaves in TSA and TFL lands and proportion in broadleaf-leading stands (source: Canfi 2001).

Volume on Private Land

The total volume of broadleaves on private land on Vancouver Island was estimated from the known area of private forest land (approximately 675 000 thousand hectares – McPhalen pers. comm. 2007) and the existing volumes per hectare of the broadleaves in adjacent Forest Districts (areas with similar forest types) – Campbell River, Chilliwack, South Island and the Sunshine Coast Forest Districts. The average volumes per hectare of the three species that occur in merchantable amounts on Vancouver Island, red alder, bigleaf maple and black cottonwood, are approximately 11.2, 2.9 and 0.6 cubic metres per hectare of total productive forest in the TSAs and TFLs, respectively. There was a large range in variation in these values (Table 8).

TABLE 8. Broadleaf average volumes and private land broadleaf volume estimate (Canfi 2001).

Spp/Fdistrict	**Cubic metres per hectare**		
Dr	**Mean**	**Min.**	**Max.**
Campbell River	6.6		
Chilliwack	12.2		
South Island	7.5		
Sunshine Coast	19.5		
	11.2	**6.6**	**19.5**
Mb			
Campbell River	0.6		
Chilliwack	7.6		
South Island	0.6		
Sunshine Coast	2.9		
	2.9	**0.6**	**7.6**
Act			

Campbell River	0.1		
Chilliwack	1.6		
South Island	0.04		
Sunshine Coast	1.0		
	0.6	**0.0**	**1.6**

Private Land Volume Estimates

Area (ha)	675,000		
		Cubic metres	
	Mean	**Min.**	**Max.**
Dr	7,570,872	4,445,054	13,163,113
Mb	1,984,101	371,633	5,137,995
Act	425,353	30,060	1,050,824
Total Private	**9,980,326**	**4,846,747**	**19,351,933**

Previous Inventory Estimates

Estimates of the area or volume of broadleaf tree species in the study area were provided by the BC Ministry of Forests, Inventory Branch (1972) for red alder and Massie et al. (1994 and 1996) for all four species.

The Ministry of Forests 1972 data indicated a total of 13.3 million cubic metres of red alder in both pure and mixed stands and with a minimum dbh of 17.5 cm (Table 9). This included data from both public and private lands.

Massie's data was from the BC Ministry of Forests, Inventory Branch, 1992 with some TFL data from the period 1988 to 1992.

Massie's summary included only those stands in which the species in question was the leading species. It also did not include some of the TFL data, any of the private land data, or any stands classed as low site productivity. In comparison with the Canfi 2001 data, Massie's data indicated greater areas for red alder and paper birch and less for bigleaf maple and black cottonwood. He showed much greater volumes for red alder and bigleaf maple, a bit more for paper birch and less for black cottonwood.

TABLE 9. Summary of 1972 Volumes of Red Alder on the BC Coast (source: BC Ministry of Forests 1972).

Location	**Crown Lands**		**Other & Private**	**All Lands**
	in PSYU	**in TFL**		
North and Mid Coast and Q.C. Islands	2296000	391000	329000	**3016000**
South Coast of Vancouver Region	756000	5485000	4035000	**10276000**
Total	**3052000**	**5876000**	**4364000**	**13292000**

It is possible that the greater volume attributed to red alder by Massie was the result of the volume from TFLs. This could also explain the greater volume for paper birch but would increase the discrepancy in regard to bigleaf maple and black cottonwood. Without knowing the exact TFLs that were not included in the data it is not possible to make a comparison. The Canfi 2001 data indicates that approximately 20% of the broadleaf volume is located in TFLs. Hence, the limit to the variation between the Canfi 2001 TSA data and the Massie data is capped at 20%.

Two other variables to explain the discrepancies are the possible reduction in red alder volume as the trees die and the fact that Massie indicated that the volume was only from stands that are harvestable. In other words, Massie may have only looked at data in the THLB, a distinction not feasible with the Canfi 2001 data.

TABLE 10. Comparison of data summarized by Massie et al. (1994 and 1996) and Canfi 2001 data for coastal TSAs. (source: Massie et al. 1994 and 1996 and Canfi 2001).

Species	**Massie TSA 1994**		**Canfi 2001 - TSA**	
	Area (ha)	**Volume (m^3)**	**Area (ha)**	**Volume (m^3)**
Red alder	139,465	32,353,000	126,678	19,656,439
Bigleaf maple	15,164	4,948,000	21,640	2,578,743
Black cottonwood	20,035	2,822,000	26,721	3,705,840
Paper birch	11,171	879,000	8,165	638,142

Age-class Distributions

The following figures (11 to 15) show the age-class distributions of leading-species stands by volume for the coastal broadleaves on TSA and TFL lands.

The 2006 distribution for each species was determined by migrating the age-classes; that is, by adding half the volume in one age-class to the next oldest age-class. Additionally, the harvest volume for the past ten years was subtracted uniformly from all trees over 60 years old.

The volume was also migrated to 2026 for red alder with a steady harvest of approximately 260 000 cubic metres per year (the mean harvest over the past ten years).

This resulted in an approximate 24% decline over today’s volume of red alder in 20 years time without accounting for mortality at ages over 80 years.

In general, the Canfi 2001 inventory contained volume values for species well beyond their normal ages indicating an error in the data collection – black cottonwood in particular (Figure 13). There is no explanation for this anomaly. The only correction made by the authors was to cap the volume for red alder ages over 100 years to the volume in the previous time period and to only graph the younger age-classes in most cases.

The total volume of red alder over 80 years old went from 18% of the total volume in 1996 to 29% in 2006. This included a subtraction for harvesting.

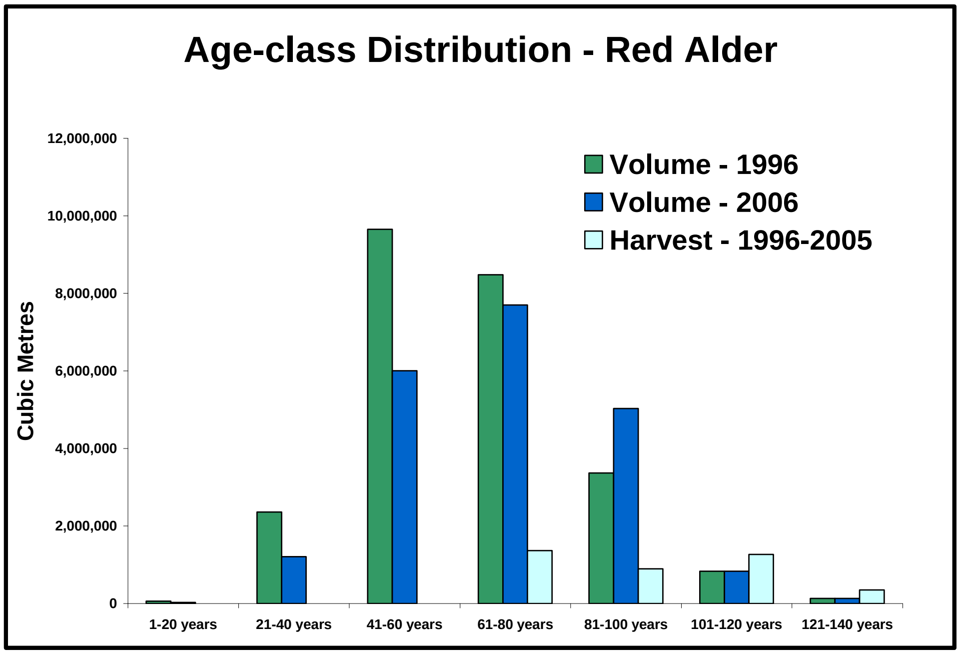

FIGURE 11. Age-class distribution of red alder volume on TSA and TFL lands in 1996 and 2006 (source: Canfi 2001).

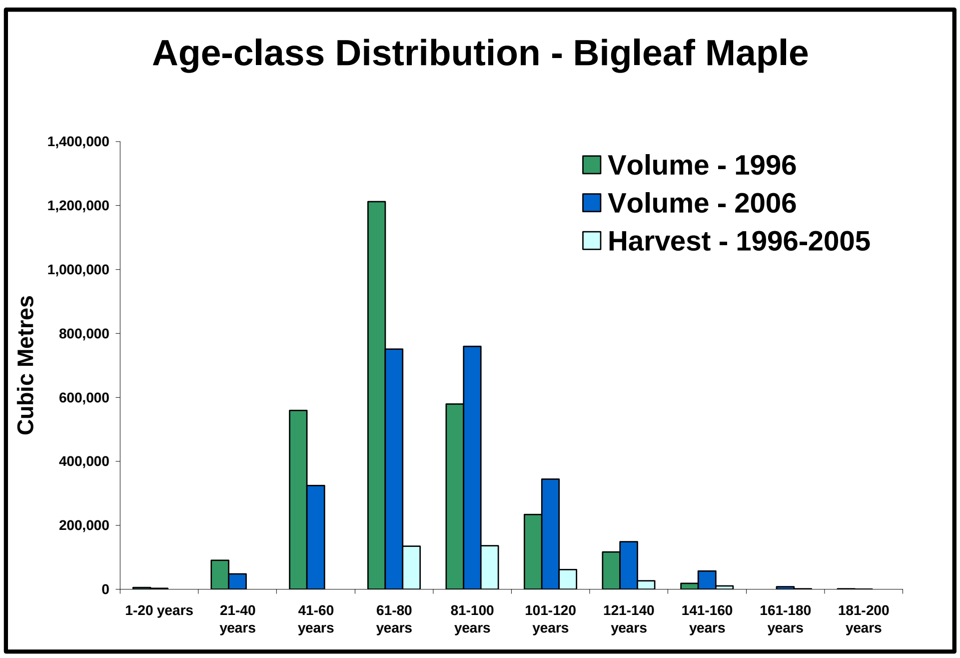

FIGURE 12. Age-class distribution of bigleaf maple volume on TSA and TFL lands in 1996 and 2006 (source: Canfi 2001).

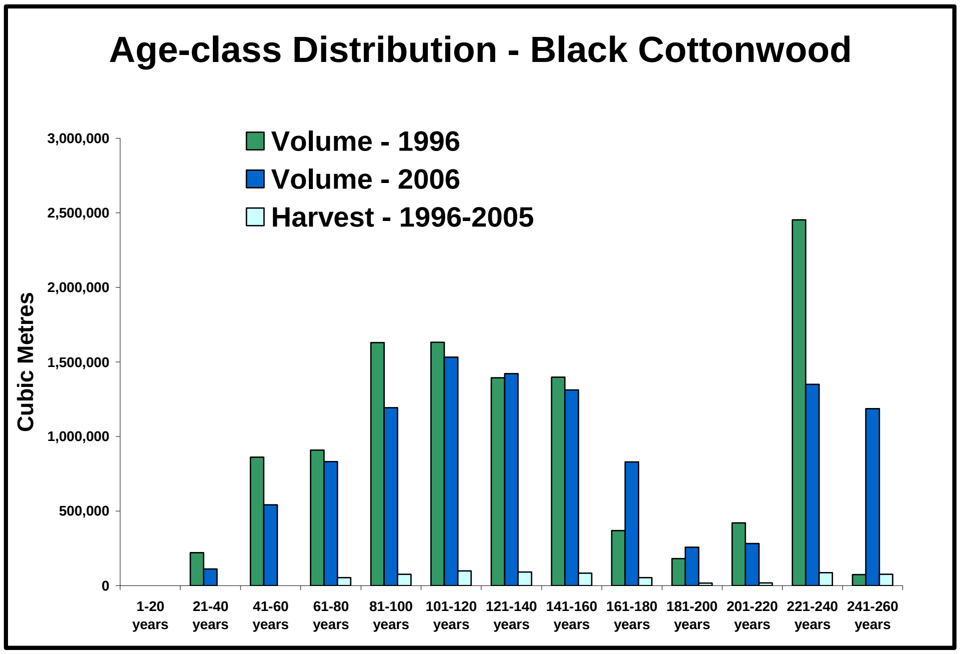

FIGURE 13. Age-class distribution of black cottonwood volume on TSA and TFL lands in 1996 and 2006 (source: Canfi 2001).

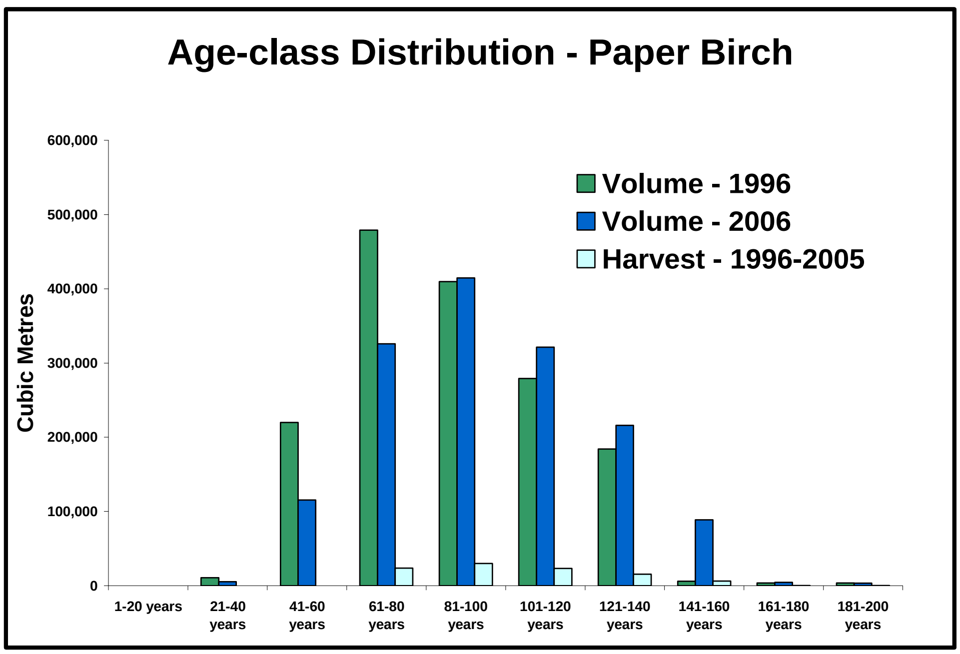

FIGURE 14. Age-class distribution of paper birch volume on TSA and TFL lands in 1996 and 2006 (source: Canfi 2001).

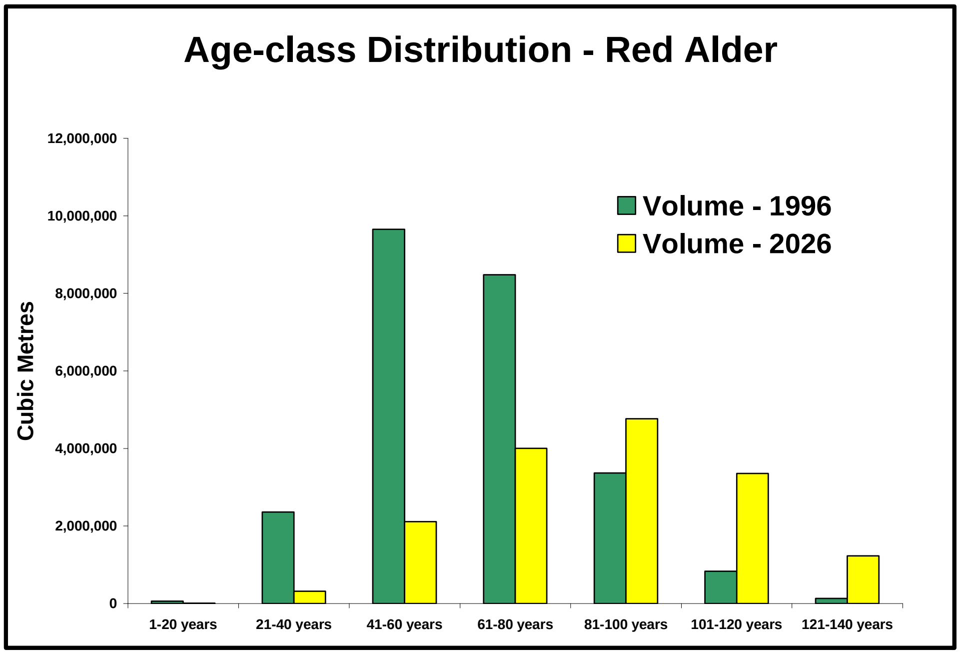

FIGURE 15. Age-class distribution for red alder volume on TSA and TFL lands in 1996 and 2026 (source: Canfi 2001).

Site Class Distributions

The following figures (16 to 19) show the site-class distributions of leading-species stands by volume and area for the coastal broadleaves on TSA and TFL lands.

The site class values are the mid-points for five metre site index (50) value ranges. "7.5" represents the midpoint of the 5.0 to 9.9 metre site index range and so on.

The site class distributions for red alder and bigleaf maple demonstrate those species preference for, and preponderance on, productive sites.

The addition of sawlog volume data to the site class distribution for red alder, for now (2007) and when the data was updated (1996) would likely indicate a shifting of the graph to the left. That is, the majority of sawlog material occurs on better sites. Hence, harvesting over the past ten years would have resulted in a larger removal of volume from the higher site index stands.

The site class distribution for black cottonwood, with large volumes in the poorer site types, possibly demonstrates the range of site classes that occur on flood plains, from moderate to rich sites on the mid and upper benches, respectively, and lower site productivity on the low bench areas (McLennan 1991), all frequented by naturally occurring black cottonwood.

The site class distribution for paper birch, with a lower mean value than red alder or bigleaf maple, is a possible demonstration of the tendency for paper birch to be out-competed by red alder on coastal sites and therefore occur more frequently on poorer sites on the coast.

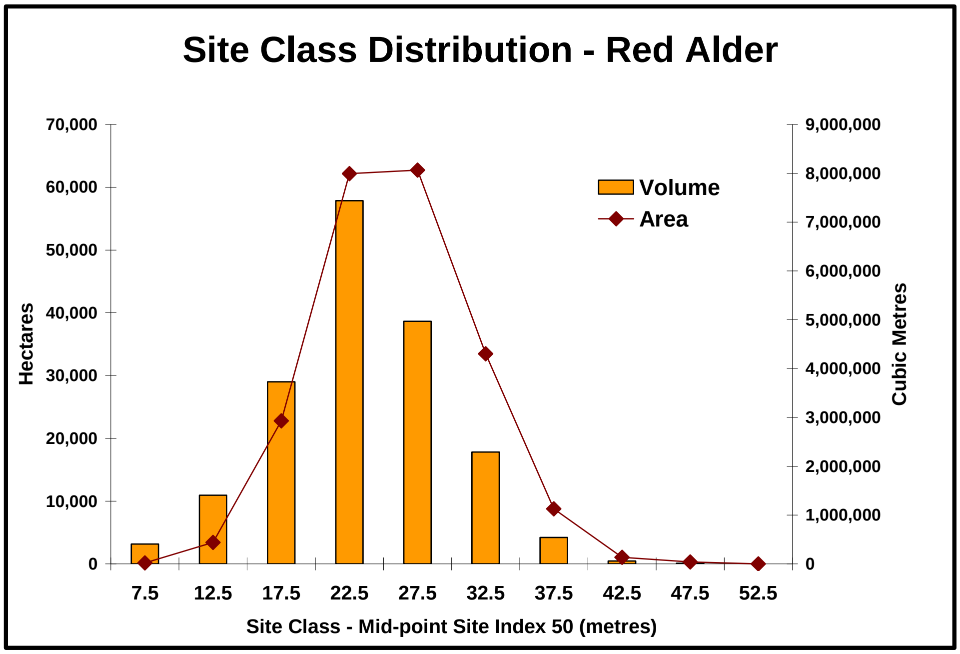

FIGURE 16. Site class distribution of red alder volume and area on TSA and TFL lands in 1996 (source: Canfi 2001).

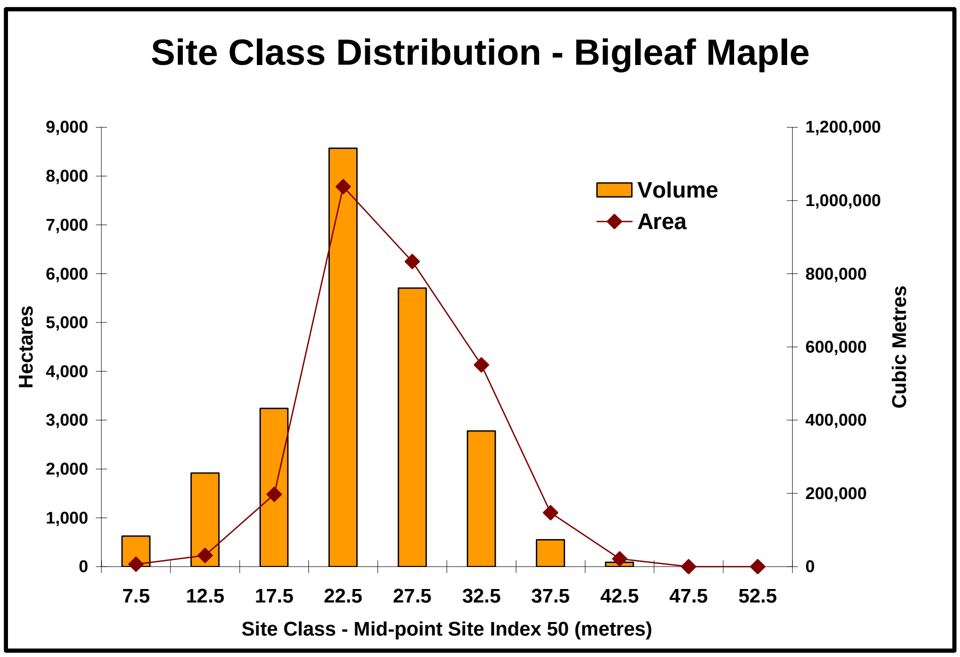

FIGURE 17. Site class distribution of bigleaf maple volume and area on TSA and TFL lands in 1996 (source: Canfi 2001).

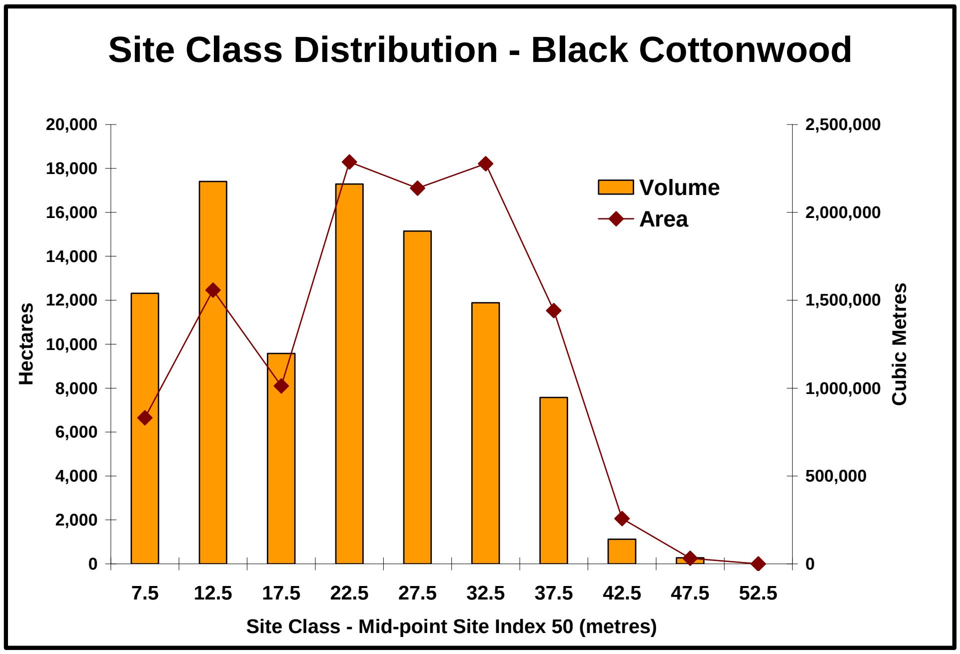

FIGURE 18. Site class distribution of black cottonwood volume and area on TSA and TFL lands in 1996 (source: Canfi 2001).

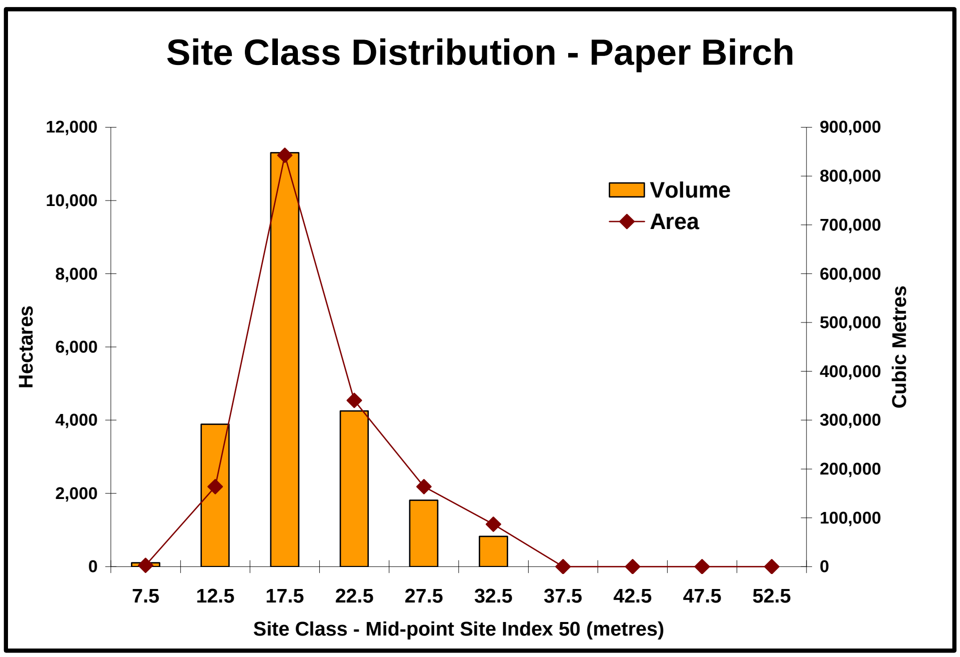

FIGURE 19. Site class distribution of paper birch volume and area on TSA and TFL lands in 1996 (source: Canfi 2001).

Non-timber and Timber Enhancement Values

There are various values associated with the broadleaf tree species which may be enhanced through greater use of these species in the coastal forest. These values include:

- Site Enrichment
- Increased Biodiversity
- Forest Health Amelioration
- Synergistic Benefits for Conifer Associates
- Adaptation to Climate Change

The broadleaf tree species also provided various benefits for the aboriginal peoples. These benefits are not covered here. See Pojar and MacKinnon (1994) for a description of the ethnobotany of the coastal broadleaves.

Site Enrichment

Nutrient cycling rates in broadleaf-dominated stands are often greater than in coniferous stands, a consequence of greater rates of nutrient uptake, litter fall, and litter decomposition (Fried et al. 1990; Peterson et al. 1997; Compton and Cole 1998). This is associated with increased soil fertility.

Red alder enriches a site by fixing atmospheric nitrogen through a symbiotic association with an *actinomycete (Frankia* spp.). Through this relationship, alder may assimilate up to 200 kg of nitrogen per hectare per year (Binkley et al. 1994).[12] The assimilated nitrogen is used by the tree and later recycled to the soil through root decay and leaf litter fall. Nitrogen in forms that can be used by plants is often the limiting nutrient on many coastal sites and as a result the inputs by red alder can increase the site productivity.

Each of the other species enriches a site through accumulation of nutrients and increases in biological cycling. Bigleaf maple absorbs and retains large quantities of nutrients which it returns to a site through litter fall (Fried et al. 1990, Thomas 1999). Paper birch accelerates the cycling of mineral nutrients, carbon, and organic matter *(Peterson et al. 1997).*

Increased Biodiversity

The broadleaf tree species provide a unique contribution to conifer-dominated landscapes (DeBell 2006).

The presence of broadleaf species may enhance biodiversity. Understory plant species richness was greater under pure alder than under pure conifer stands of similar age (Franklin and Pechanec 1968).

Broadleaf litter inputs increased the abundance of invertebrates in streams, increasing fish/salmonid productivity (Piccolo and Wipfli 2002).

Compared to their coniferous associates, coastal broadleaves have different branch structures and foliage characteristics (Hayes and Hagar 2002), greater predisposition to cavity formation (McComb 1994) and seasonality of changes in leaf area. In conifer-dominated forests of western Oregon, diversity and abundance of birds was correlated with the abundance of broadleaves (Huff and Raley 1991).

[12] Up to 320 kg per ha per year are reported in Burns and Honkala 1990.

Forest Health Amelioration

Broadleaf tree species are immune to laminated root rot *(Phellinus weirii*). Planting these species on infected sites can provide desirable benefits, such as fibre, cover and site enhancement, while allowing time for inoculum to die (Thies and Sturrock 1995).

An overstory of red alder may reduce attack by white pine weevils (*Pissodes strobi* (Pk.)) on leaders of Sitka spruce (Almond 2006).

Benefits for Conifer Associates

Mixed stands of broadleaf tree species and shade tolerant conifers can be grown more densely than pure stands because they occupy separate root and crown growing spaces and have different growth rates (Peterson et al. 1997). Given their moderate to high shade intolerance (bigleaf maple is moderately shade tolerant) they may be able to produce a higher overall yield in a mix with shade tolerant conifers such as Sitka spruce (*Picea sitchensis* (Bong. Carr.), western redcedar (*Thuja plicata* Donn.*ex* D. Don *in* Lamb), western hemlock, grand fir (*Abies grandis* (Dougl. *ex* D. Don) Lindl.) or amabilis fir (*Abies amabilis (*Dougl. *ex* Loud.) Forbes) (Klinka pers. comm. 2004).

Mixtures of red alder and their coniferous associates may result in greater whole-stand productivity than in pure conifer stands on nitrogen-limited sites (Binkley 2003; Courtin and Brown 2003, Thomas et al. 2006).

Adaptation to Climate Change

Increased use of broadleaf tree species may provide flexibility for coastal forest managers in coping with possible impacts of climate change via greater diversity and potentially shorter rotations.

Recent climate modeling efforts (Hamann and Wang 2006) suggest the following possible changes to species' ranges due to climate change:

1. Biogeoclimatic zones associated with lower elevations; e.g., the CWH and Coastal Douglas-fir (CDF), will increase in area over the next 50 years; and
2. Increases in the range and frequency of Douglas-fir, bigleaf maple, red alder and bitter cherry (*Prunus emarginata* Dougl. *ex* Hook.) are predicted to be greater than for western hemlock, Sitka spruce, western redcedar and yellow cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) (Hamann and Wang 2006).

Whether the latter changes will occur is unknown, given uncertainties in productivity at a site series level and on insect- or pathogen-host interactions. However, advantages in terms of diversity and short rotations argue for increased research and management of broadleaves as a strategy for coping with possible effects of climate change.

Current Commercial Values and Trends in Value

The current commercial values of the broadleaf tree species on the coast are fairly well-known; the historic trends, however, except for the major themes, are not well-known. There is also a fair bit of variability in the current commercial values of the broadleaves.

The quoted prices paid for broadleaf logs depend on the source of data and the grade of log being referred to. Unlike the conifer log market, the buyers and sellers of broadleaves are not consistent, the transportation distances can be highly variable, the buyer may or may not pay for part of the transportation cost (Morgan pers. comm. 2007) and the log quality is often more variable.

Given that many broadleaf stands are mature or overmature, wood quality is a concern because, apart from firewood, there are currently few uses for poor-quality stemwood from broadleaf tree species (Peterson et al. 1997). In addition, red alder and paper birch can experience fungal staining in as little as two months (Allen 1993) or two weeks (Peterson et al. 1997), respectively. This necessitates rapid harvesting at certain times of the year (staining is worse in the summer) and a potential increase in costs.

Red alder sawlogs have fairly consistent quality characteristics although they must be a minimum size – a seven or eight inch top (17 – 20 cm). Bigleaf maple, on the other hand, can be very finicky with reaction wood (wood fibres that have grown under pressure and deform when milled) and other defects, resulting in a wide range of prices. Similarly, paper birch has very tough bark that decays slowly and hides any defects or decay in the wood.

Current Commercial Values

Based on discussions with personnel with direct knowledge of the purchasing of broadleaf logs in coastal BC (Robert Carl, owner of Carlwood Lumber Limited, Mission, BC, Colin Morgan, log buyer with Northwest Hardwoods, Delta, BC, and Daniel Carson, RPF, forester with Scott Paper Limited., New Westminster, BC) the broadleaves have sold over the past two years (2005 and 2006) for the following range of prices – peak values in brackets:

- Red alder - $73-$78 ($82)
- Bigleaf maple - $50-$75
- Black cottonwood - $30-$45 ($100)
- Paper birch - $60-$65 ($80)

The BC Ministry of Forests and Range coastal log market reports have the following three-month range of prices for the past two years (Figure 20):

- Red alder - $72-75
- Bigleaf maple - $53-62
- Black cottonwood - $34-36

No price data are shown in the coastal log reports for paper birch on the coast.

Typically, only premium bigleaf maple logs sell for over $70. Black cottonwood veneer logs sell for up to USD $85 ($100 Canadian).

In contrast to the Pacific Northwest (Washington and Oregon States) the prices for logs delivered to a mill in BC can be depressed by $5 to $10 for barging costs if harvested in a location without drive-to access. Therefore, the net revenue received by the seller may be less than in an area, such as the Pacific

Northwest, without expensive transportation costs, even if the buyer pays the same amount in both markets. This puts downward pressure on the economic supply of all timber harvested in more remote locations.

Red alder log grades increase with diameter and the amount of clear wood (Kallio 2005) and value increases more with log diameter in alder than in Douglas-fir (Plank and Willits 1994). Prices for clear alder wood may be six to seven times greater than for pallet grade (Mason 2006).

There is no minimum size for black cottonwood. Hybrid poplar is worth more than black cottonwood because the wood has a brighter colour (Carson pers. comm. 2007). The prices for the broadleaves reported by the BC Harvest Billing System include pulp logs but alder, maple and birch are rarely harvested for pulp. There is a market of broadleaf chips in the US and sporadically in Japan (Morgan pers. comm. 2007).

Trends in Commercial Value

The overall trends in the commercial values of the coastal BC broadleaves are fairly well known – the details are not.

Robert Carl of Carlwood Lumber in Mission, BC, who purchases and manufactures lumber from red alder, bigleaf maple and paper birch, and has been doing so for 50 years, indicated that there has been some demand for the three species since the 1950s; the market has been small and the impediments to accessing the timber supply have been significant. For example, given that a broadleaf species such as red alder would be included in a licensee's cut control calculation, any harvesting of red alder would result in a loss of conifer AAC.

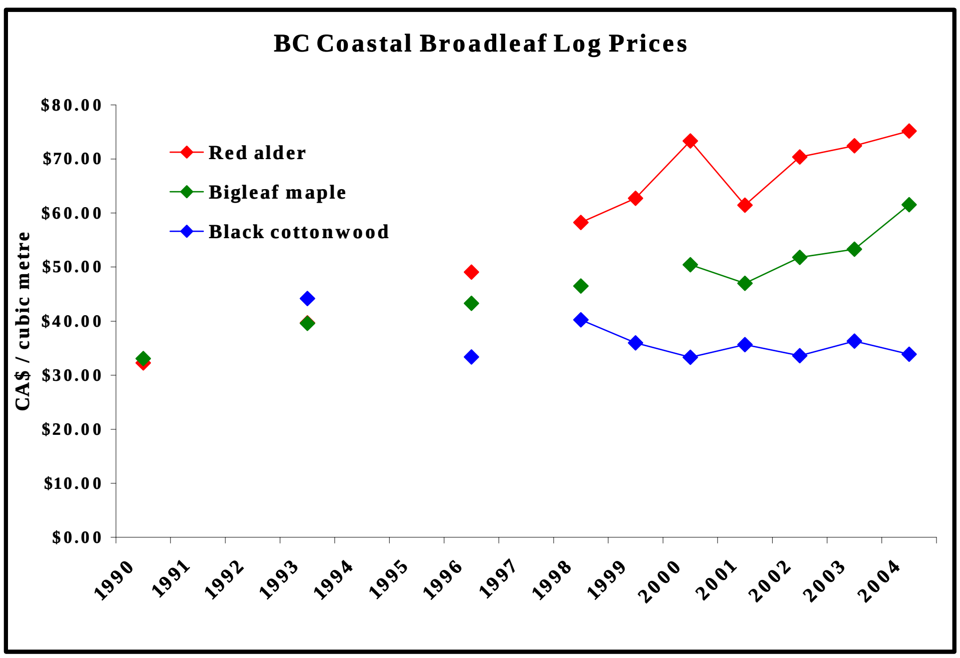

FIGURE 20. BC coastal broadleaf log prices (BC MoFR Harvest Billing System).

The price for red alder sawlogs has increased in the last ten years well above the rate of inflation. Red alder sawlogs sold for $50 to $60 in the 80s and 90s. The price for bigleaf maple and paper birch sawlogs have increased but more slowly and possibly in pace with the rate of inflation. Paper birch, for example, sold for $30 to $35 in the 1960s (Carl pers. comm.). The price trends for black cottonwood are unknown besides the data for the last ten years from the BC MoFR Revenue Branch.

Figure 20 shows the trend in BC coastal broadleaf log prices over the past 15 years based on prices from the BC MoFR Revenue Branch. Based on discussions with Robert Carl, the quoted prices prior to about 2000 are low. Red alder in the early 90s, for example, was over $50 and not the $32 to $40 specified in the data. This may reflect the fact that Robert Carl was preferring higher grade red alder logs with a higher price.

Detailed price data for the coastal broadleaves is unavailable prior to the early 90s, apparently, because there was less volume being harvested and sold prior to the 1990s. Also, licensees, if they harvested any broadleaf volume, could process the wood at their own mill and thus hide the market price, or trade the wood which would also potentially conceal the wood and its value from the government. Lastly, as is indicated above, even today's prices from the BC MoFR Revenue Branch are probably conservative.

Trends in the Commercial Value of Red Alder

The increase in the commercial value of red alder in BC has been matched by a proportional increase in the value of red alder in the Pacific Northwest (Mason 2006). However, there is, and has been, an absolute difference in the value of red alder in the US versus the value in BC (Figure 21).

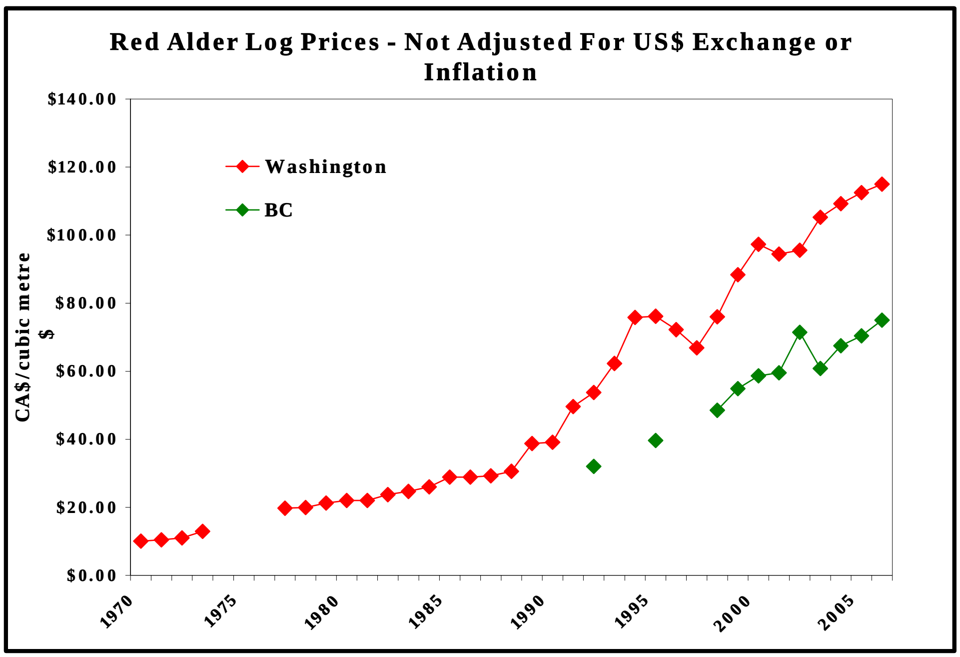

FIGURE 21. Red alder log prices in BC and Washington – not adjusted for the exchange rate. (BC MoFR Harvest Billing System and Loglines)[13]

In order to see the absolute value of this difference, the data for log prices in the US and BC needed to be converted to the same units; it was converted to Canadian dollars per cubic metre.

Red alder log prices in the US are recorded in terms of the volume of lumber that is produced from an average log (foot board measure) rather than a log volume measure (cubic metres) as is done in BC. In order to convert the value of red alder in the US to a cubic metre value a lumber recovery factor (LRF) of

[13] A calculation was performed to adjust the data for the US$ exchange. It had an obvious impact in the past three years, due to the recent large increase in the value of the Canadian dollar, resulting in a decline in the value of red alder in the US in Canadian currency.

190 was used (Carl pers. comm.). This LRF value is consistent with data for coastal Washington from 1970 to 1998 (Spelter 2002). If anything, the LRF in the US would be slightly higher due to greater efficiencies in the US mills.

The difference in price for red alder sawlogs between the US and BC is due in part to the lower transportation costs and also possibly due to concentration of the red alder industry by Weyerhaeuser. Weyerhaeuser is currently appealing an antitrust judgment resulting from attempting to monopolize the red alder log market and manufacturing in the Pacific Northwest. Their actions could have resulted in inflated prices. This difference is evident in price differences for all species indicating that the factors causing this differential are societal and beyond simply the characteristics of the market for one species.

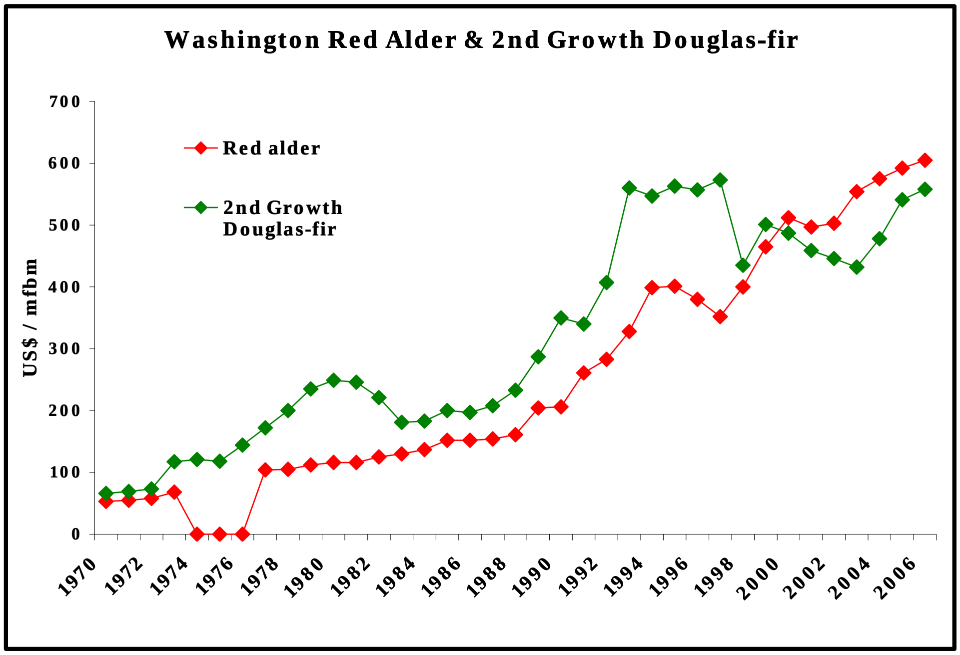

FIGURE 22. Red alder and second-growth Douglas-fir sawlog prices in Washington in US$ mfbm (adapted from Mason 2006).

The increase in the value of red alder can also be seen relative to changes in the value of second-growth Douglas-fir. The value of red alder in the US has exceeded that of second-growth Douglas-fir in the past five years (Figure 22) – possibly a product of the alleged Weyerhaeuser monopoly – but remained below the value of second-growth Douglas-fir and western redcedar in BC (Figure 23). Red alder in BC in the past six years has exceeded the value of second-growth western hemlock.

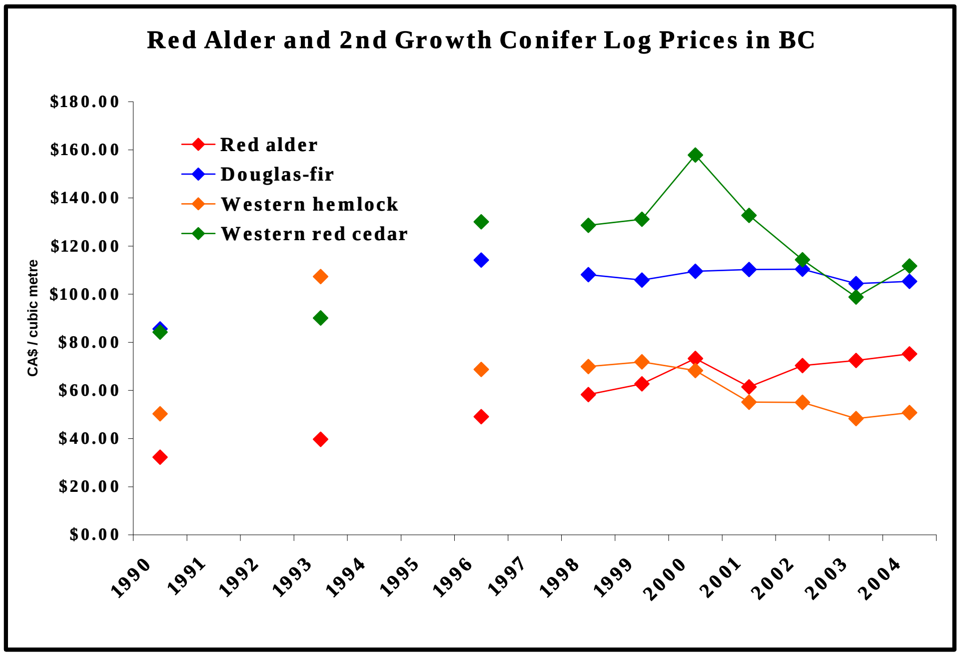

FIGURE 23. Red alder and second-growth conifer log prices in BC

Recent Harvest Levels

The average total harvest of broadleaves from the study area from 1994 to 2005 was 382 000 cubic metres (BC Ministry of Forests and Range, Harvest Billing System); the minimum was 314 000 in 1996 and the maximum was 427 000 in 2004 (Table 11 and Figure 24). This was equivalent to 1.7% of the total average harvest of all species of approximately 23 million cubic metres.

TABLE 11. Annual broadleaf harvest volumes in the study area (BC Ministry of Forests and Range, Harvest Billing System).

Year	Dr	Mb	Act	Ep	Total
1994	244,823	33,730	93,225	4,671	**376,449**
1995	227,099	40,207	103,766	7,197	**378,269**
1996	185,676	41,727	73,139	13,399	**313,941**
1997	242,645	36,675	62,251	11,546	**353,117**
1998	239,033	32,654	53,509	9,724	**334,920**
1999	292,486	39,210	67,203	7,723	**406,622**
2000	314,153	45,029	62,773	10,130	**432,085**
2001	309,243	29,908	72,456	5,705	**417,312**
2002	312,805	35,258	45,050	7,987	**401,100**
2003	245,995	38,055	63,068	14,908	**362,026**
2004	310,776	39,682	65,232	11,963	**427,653**
2005	229,692	34,281	111,759	6,433	**382,165**
Average	**262,869**	**37,201**	**72,786**	**9,282**	**382,138**

TABLE 12. Average broadleaf harvest volumes by forest district – 1999 to 2005 – in order of total volume (BC Ministry of Forests and Range, Harvest Billing System).

Forest District	Dr	Mb	Act	Ep	Total
Campbell River	96,333	4,768	7,366	20	**108,487**
Sunshine Coast	82,809	6,710	7,902	17	**97,438**
Chilliwack	28,537	13,173	28,017	8,654	**78,382**
South Island	61,032	10,977	2,295	11	**74,314**
North Island/Central Coast	13,040	531	12,992	7	**26,570**
Squamish	3,455	1,174	4,580	200	**9,410**
Kalum	1,031	0	5,673	312	**7,015**
Queen Charlotte Islands	1,895	0	0	0	**1,895**
North Coast	21	0	81	0	**102**

The average harvest volume by species was:

- Red alder – 263 000 cubic metres (69%)
- Bigleaf maple – 37 000 cubic metres (10%)
- Black cottonwood[14] – 73 000 cubic metres (19%)
- Paper birch – 9000 cubic metres (2%)

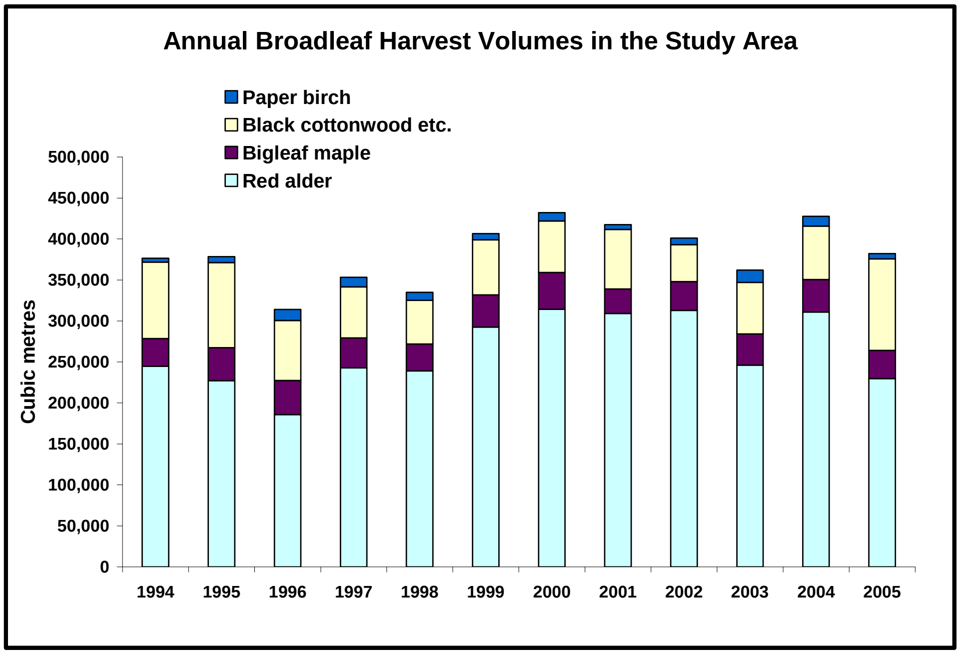

FIGURE 24. Annual broadleaf harvest volumes in the study area (BC Ministry of Forests and Range, Harvest Billing System).

The average volume of red alder – 263 000 cubic metres per year – was 6% of the total volume of red alder harvested throughout the species' range, which was 4.64 million cubic metres. Over 90% of the harvest volume came from Washington and Oregon (Ahrens 2006).

The majority of the broadleaf harvest volume came from the south coast and Vancouver Island area. Table 12 and figure 25 shows the broadleaf harvest volume by forest district from 1999 to 2005.

For this report, we did not have harvest volume data for the broadleaves prior to 1994, nor did we have harvest volume data by forest district prior to 1999. Hence, the volumes for the areas outside of the study area[15] in the old Vancouver Forest Region (the Kalum Forest District and North Coast Forest District) were included in the totals for the old Prince Rupert Forest Region with no sub-divisions by forest district.

To establish totals for the entire study area back to 1994, it was assumed that any red alder harvest volume in the Prince Rupert data prior to 2000 would be from either the Kalum or the North Coast Forest Districts; hence, it could be added to the totals for the Vancouver Forest Region to come up with a total for the study area. Also, there was no maple volume because both forest districts are outside of the range of maple.

[14] Likely included hybrid poplar but not reported.
[15] The study area is the entire Coast Forest Region and the Kalum Forest District.

The black cottonwood and paper birch harvest volumes for the North Coast Forest District were zero except for two years; therefore, it was assumed that any cottonwood or birch harvest volume in the Prince Rupert Forest District prior to 2000 was either from the Kalum or the interior forest districts. In order to ensure an approximate estimate of the total harvest volumes of cottonwood and birch for the study area the average volume of cottonwood (5600 cubic metres per year) and birch (320 cubic metres per year) for the Kalum Forest District for the years 1999 to 2005 was added to the harvest volumes from the Vancouver Forest Region for the years 1994 to 1998 to come up with an approximate harvest volume for those species for the entire study area from 1994 to 2005.

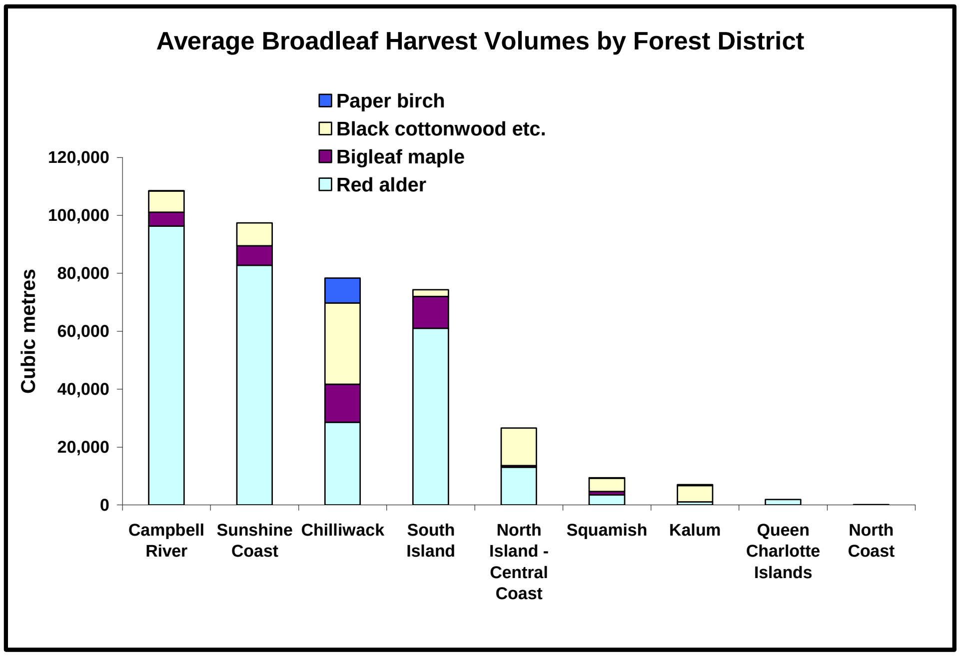

FIGURE 25. Average broadleaf harvest volumes by forest district – 1999 to 2005 (BC Ministry of Forests and Range, Harvest Billing System).

Past Estimates of Harvest Volumes

Massie et al. (1994) predicted a total annual harvest of broadleaves for the Vancouver Forest Region of 567 000 cubic metres. The estimate for each of the four commercially valuable species was as follows:

- Red alder – 448 000 cubic metres (79%)
- Bigleaf maple – 80 000 cubic metres (14%)
- Black cottonwood – 31 000 cubic metres (5%)
- Paper birch – 7000 cubic metres (1%)

The estimates were based on the existing inventories and not on current harvest levels or the impracticalities of harvesting broadleaves.

The estimate for the red alder harvest level would likely have been reduced by the Massie et al. if they had known the pending impact of the Forest Practices Code (introduced in 1995) which resulted in a large area of red alder being removed from the timber harvesting land base and moved into no-harvest riparian areas. Also, recent experience suggests that red alder is prone to a condition known as “red heart” in some portions of its range (the major inlets primarily)[16]. These stands are not merchantable.

The estimate for bigleaf maple harvest level could be high due to the high costs associated with manufacturing maple and thus the disincentive to harvest it.

The black cottonwood and hybrid poplar harvest volumes in recent years are possibly a reflection of the efforts of Scott Paper Limited to grow hybrid poplar, putting more volume into the timber supply, with a resultant increase in the harvest.

Current Allowable Annual Cut

The total allowable annual cut (AAC) for coastal BC broadleaves is approximately 170 000 cubic metres. Northwest Hardwoods has four forest licences that permit the harvesting of red alder leading stands with a total AAC of 130 000 cubic metres (Hughes pers. comm. 2007). Scott Paper Limited has an AAC of 39 900 cubic metres for black cottonwood and hybrid poplar in TFL 43 (source: TFL 43 Timber Supply Review). Approximately one third of the volume harvested under theses tenures consists of volume from conifers.

The broadleaf AAC is equivalent to less than 1% of the total AAC for the study area which is approximately 18 million cubic metres. Besides TFL 43, none of the coastal TFLs have a partition[17] for broadleaves.

Given that the harvest volume is two to three times the broadleaf AAC harvest volumes, a significant amount of the broadleaf volume is produced from tenures without broadleaf AACs.

[16] Red heart is an abiotic condition (probably) that causes a change of colour of the wood of red alder resulting in a reduction in the value of red alder for visual grade material. It does not affect the structural characteristics of the wood (Hughes, pers comm. 2007).
[17] A “partition” is a sub-division of the AAC that specifies a harvest volume that the licensee must achieve for a specific species.

Current Silviculture Practices

The only broadleaves currently being artificially regenerated in coastal BC are red alder, by Northwest Hardwoods, and hybrid poplar, by Scott Paper Limited. With the exception of hybrid poplar and red alder, there is limited experience producing regeneration products – seedlings or vegetative material.

Artificial Regeneration – Red Alder

Northwest Hardwoods is currently growing approximately half a million red alder seedlings at coastal nurseries – the preferred stock type is a half plus a half plug-bareroot or more rarely a 1-0 container stock. Other licensees occasionally plant smaller amounts of red alder for forest health projects, on poor sites or on rehabilitated sites such as slides or deactivated roads

The standard method of red alder artificial regeneration used by Northwest Hardwoods is to plant 1500 to 1600 stems per hectare then thin down to 600 stems per hectare once the live crown reaches approximately two thirds of the tree height. Planting may involve the use of a phosphorus-containing fertilizer (Brown and Courtin 2006). This stand management regime is designed to produce a sawlog in 25 to 35 years on productive sites. Pre-commercial thinning is recommended by the Ministry of Forests and Range for sawlog production of red alder (BC Ministry of Forests 2000).

A wider range of regimes may also produce sawlogs in less than 35 years. Specifically, planting 1000 to 1100 stems per hectare.

Red alder cannot build crown, and stem volume, if not thinned due to its shade intolerance (Harrington 2006). The growth of sawlogs in managed alder plantations exceeds that of natural stands. 17-year-old trees growing on a site with a site index of 35 m had a mean diameter of 15.3 cm. The mean diameter from one 17-year-old managed alder plantation of the same site quality was 23.3 cm, a 66% increase (Bluhm and Hibbs 2006).

For more detailed information on silviculture regimes for red alder please refer to the Hardwood Coop.

Artificial Regeneration – Hybrid Poplar

Scott Paper uses hybrid poplar cuttings (whips) from their stool farm (nursery) in Chilliwack to regenerate their Tree Farm Licence located on the floodplains of the lower Fraser River, Homathco River and the Kingcome River.[18] There are two regimes for growing hybrid poplar: a short rotation intensive (10-14 years) and long rotation extensive (20-25 years) (Thomas et al. 2000). The short rotation regime involves clearing of the land (mechanical site preparation) followed by planting with whips and application of 150 grams of fertilizer at the time of planting (9-40-4)[19]. The long rotation extensive involves no site preparation except a possible spot scarification to create a circle with an area of two square metres and the same planting regime as the short rotation with whips and fertilizer (Carson pers. comm. 2007). No pre-commercial thinning is required for either regime.

Rotation lengths for sawlogs in unmanaged stands are somewhat longer than the rotation lengths in managed stands. For red alder the unmanaged rotation length is 40 to 50 years; for bigleaf maple it is 50

[18] Some licensees on the coast have experimented with small hybrid poplar plantations but no sustained efforts have been made. The Kingcome Band and a group on the Skeena are also managing hybrid plantations (Carson pers. comm. 2007).
[19] Values indicate the rates of nitrogen, phosphate (P2O5) and potash (K2O).

to 60 years (Thomas 1999); for black cottonwood it is 50+ years (Carson pers. comm. 2007) and for paper birch the rotation length is 70 to 80 years (Peterson et al. 1997).

Natural Regeneration

Natural regeneration is the current primary means of regeneration of all the broadleaves – either by seed or sprouting from roots and/or stumps. Although most natural regeneration of broadleaves is removed to make way for conifers[20], it may be a key means of establishing broadleaves in the future. All of the existing broadleaf volume on the coast of BC is from natural regeneration.

For regeneration from seed the requirements are: sufficient seed dispersal, suitable microsites from disturbance, lack of shrub competition and opportunities to meet the germination requirements (Peterson et al. 1997). Natural regeneration from coppices (stumps) or suckers (roots) is dependent on the species.

Natural regeneration of red alder is primarily from seed. Although it can regenerate from coppices, the coppice growth from mature trees is infrequent and often dies after a few years (personal experience).

Bigleaf maple regenerates primarily from coppices on logged-over sites though it can also regenerate from seed in both newly disturbed areas and in existing stands due to its moderate shade tolerance (Thomas 1999). Coppice sprouts are fast growing (five metres in three years) and one stump can produce up to 60 shoots (Burns and Honkala 1990).

Black cottonwood regenerates from both seed and vegetatively. Extensive natural stands of black cottonwood occur on most medium and large floodplains in coastal BC.

Paper birch regenerates primarily from seed, although adventitious buds vigorously sprout from the root collar following cutting or fire. Coppice sprouts are a common mode of regeneration in birch. Fully stocked birch stands often cannot be achieved from coppice. Birch gradually loses its ability to regenerate by coppice after approximately 60 years (Peterson et al. 1997).

Brushing and Weeding

[The following information on brushing and weeding technology is based on the experience of one our us (Buss) except where noted.]

Due to the requirement to manage the majority of forest sites for conifer species in coastal BC, the vast majority of silviculture associated with broadleaves is brushing and weeding (forest vegetation management); that is, removal of plants in competition with crop trees through chemical or manual means prior to the expiration of late free growing.

The general methods of brushing and weeding in coastal BC are:

- Treatments with the herbicide active ingredient glyphosate (occasionally 2-4,D – Jensen pers. comm. 2007)
- Treatments with the herbicide active ingredient triclopyr
- Manual treatments
- Bio-herbicide treatments

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[20] TimberWest in the Johnstone Strait Operation has a recently approved Forest Stewardship Plan that permits the retention of up to 20 hectares per year of naturally occurring red alder.

Glyphosate is applied (or sometimes 2-4,D) in dilution with water via stem injection. This works on all species except bigleaf maple and is difficult with paper birch due that species' tough bark. Glyphosate is also applied in dilution with water as a foliar spray either with backpack sprayer or hose and gun, or with helicopter-mounted aerial spray equipment. This works on all species even bigleaf maple coppices if they are young (less than four years old). A surfactant may be added to increase penetration of bigleaf maple foliage or dust-covered plants.

Triclopyr is applied either in the thinline application method in non-dilute form to treat bigleaf maple coppices. More frequently it is applied in the basal bark application method in dilution in a petroleum-based carrier; it is used on all four species. The herbicide is oil-soluble and passes through the bark without the bark being mechanically ruptured. Paper birch treatment is best done when the plant is less than six years old because the bark becomes impermeable (Hughes pers. comm. 2007).

Various manual treatments can be applied to the treatment of broadleaf species. These various treatment methods have different efficacies depending on the species and the timing of treatment.

Red alder may be treated by girdling (removal of a ring of bark and vascular cambium from the entire circumference) once it reaches a minimum diameter – usually greater than 5 cm. Although it will coppice vigourously if it is cut down when young, it will not coppice, or the coppices will die, if there is an established layer of conifers or other vegetation. These plants provide shade that limits the growth potential of the light requiring red alder coppices.

Bigleaf maple will coppice vigourously at any age. If the stump has full sunlight, girdling of the coppice stems will not kill them because the stump will continue to coppice below the girdle and will keep the root system alive. Possibly the only way to manually treat bigleaf maple is to girdle it a year or two prior to harvesting when light levels are too low to allow for coppicing. Stump excavation using an excavator is also used.

Black cottonwood produces suckers from the roots and stump coppices when cut. A method to avoid this vegetative sprouting after harvesting is to not fell the mature trees and to limit the amount of soil disturbance. Black cottonwood and hybrid poplar on short rotations are mechanically brushed using tractors.

The authors are not aware of any standard procedures for manual brushing and weeding of paper birch possibly due to its infrequency on the south coast.

The Potential for Increased Harvest Levels

The harvest levels of the coastal broadleaves over the past ten years represent the following proportion of the total available volume on TSA and TFL lands in the study area:

- Red alder – 18.7%
- Big-leaf maple – 15.2%
- Black cottonwood – 6.1%
- Paper birch 6.6%

There is a potential short-term increase in the harvest level of the broadleaves on the coast of BC, especially for black cottonwood and paper birch, given the current harvest levels and inventories, and under utilization. However, with the deficit of inventory in the younger age-classes of all the species, the steady harvest pressure and the increasing mortality due to an aging inventory, especially in red alder, the supply will gradually decrease.

It is estimated that without a change in current policies the existing supply of red alder will continue to decline and could drop by 20% over the next 20 years; more if losses due to mortality are factored in (see analysis of age-class distributions in Current Inventories).

The volume in younger age-classes of red alder may be sustained in areas where red alder plantations are being established. Hence, harvest levels may be sustained.

The timber supply review for the Sunshine Coast TSA, the TSA with the largest standing volume of red alder in coastal BC – 9.4 million cubic metres in 1996 (Canfi 2001) – specifies a long-run sustained yield of red alder of 80 000 cubic metres per year declining from an initial harvest of 95 000 cubic metres per year for the first five decades (BC Ministry of Forests 2001). This is equivalent to Northwest Hardwood's AAC in the Sunshine Coast TSA, and is based, presumably, on Northwest Hardwoods continuing to convert harvested red alder stands back into new red alder plantations.[21]

In the short-term, until the new plantations come on line (25 years or more), harvesting of red alder will likely increase in difficulty and cost because easily accessed stands, and stands with higher proportions of sawlogs, are being harvested first.

[21] Discussion with Neil Hughes (2007), forester with Northwest Hardwoods, indicates that the area being harvested for red alder is not being replaced with red alder leading stands.

Possible Changes in Commercial Values

Given current silviculture practices to eliminate most broadleaf trees species from coastal BC commercial forests, the supply of timber from broadleaves on the coast will continue to decline as the existing older age-classes are harvested or die. This will put upward pressure on the prices of all the broadleaves with a commercial value.

As a rule, however, all the broadleaf tree species have the potential to have increased commercial values if managed more widely and more intensively. They have rapid juvenile growth rates and short rotation lengths, and they naturally regenerate prolifically. The highest mean annual increments of any species in Canada occur in the juvenile black cottonwood/hybrid poplar and red alder stands of coastal BC. It would be wise to take advantage of these natural characteristics.

Red Alder

The practices focused on eliminating broadleaves in coastal BC will have the greatest impact on red alder because it is being exposed to the highest harvest pressure and is the shortest-lived. The increasing demand for red alder globally (Mason 2006) coupled with a declining supply over the next two decades (Ahrens 2006) suggests that the price for red alder will continue to experience upward pressure until either the demand lessens or the supply increases.

The supply of sawlogs from plantation red alder in the Pacific Northwest, primarily in the US, will come on-line in the next 20 years. Hence, after approximately 20 years, the gross prices may cease to increase if the supply increases. In BC, establishment of more alder plantations, especially nearer to mills and population centers, and more uniform piece sizes could reduce harvesting, transport and milling costs and therefore increase net commercial values.

Black Cottonwood and Hybrid Poplar

Black cottonwood will be the least impacted by current management practices because it is currently being under utilized (Carson, pers. comm. 2007) and is longer-lived than red alder. Therefore, the older age-classes of trees may remain merchantable while the new stands are not yet merchantable. It also occurs less frequently on upland sites, in competition with conifers, and more often on floodplain sites where it regenerates naturally and is less often in competition with conifers being grown for timber. A similar reduction in harvesting costs as is expected for red alder could reduce the net cost of black cottonwood and hybrid poplar production resulting in lower overall costs. Also, the net value of all the black cottonwood and hybrid poplar could increase as the proportion of the total harvest from the more valuable hybrid poplar occurs as more plantations come on line.

Bigleaf Maple and Paper Birch

Bigleaf maple and paper birch will likely be intermediate in terms of the decline in available supply due to the lower harvest pressure on them, their greater ages and smaller inventories relative to red alder. Therefore, market demand may have a larger impact on future commercial values than supply issues – factors that are beyond the scope of this report.

Bigleaf maple and paper birch also both occur most often on the coast as secondary species in mixed stands with red alder. Also, the primary manufacturing of these species occurs in mills set-up to manufacture red alder. Therefore, it is possible that both of these species will experience price increases as long as the demand for red alder remains high and natural red alder stands, containing maple and birch, continue to be targeted for harvesting.

Intensive silviculture practices could benefit both bigleaf maple and paper birch and, as a result, increase their commercial value. For maple this could be achieved by planting at high densities or breeding stock with low branch-growing tendency, factors that would potentially reduce the defects in maple. Establishing pure plantations of paper birch on the coast would permit the species to grow unimpeded by the faster growing coastal species (like red alder) and provide a concentrated supply to improve the economy of scale of this relatively uncommon species.

Policy and Institutional Impediments to Increasing Broadleaf Presence

There are various policy and institutional impediments to more extensive use of broadleaf tree species in coastal BC. They key impediments are:

- The conifer bias
- Economics of volume-based allocation
- Timber supply analyses
- Free growing standards
- Silviculture costs
- US market access
- Large River Floodplains

The Conifer Bias

The most entrenched impediment to liberalizing the management of broadleaf tree species in coastal BC is the predominance of a conifer-based timber ethic in both government and industry. Essentially, any management activity that impedes the achievement of the conifer-based timber objective is discouraged.

The root of this ethic, most likely, is the previous success of the forest industry in harvesting old growth Douglas-fir in the early part of the 20^{th} century and previously. Given the tendency to base crop tree selection decisions on current commercial values, unfortunately a problem we still have, the earlier foresters were designing forests to emulate the original old growth. The result of this was the planting of Douglas-fir on many sites (even off-site) and the focusing on maximization of large conifers.

Economics of Volume-based Allocation

Our current system rewards large firms with uniform timber supplies. Profits are made not by increasing the profit per unit volume but by increasing the volume of harvest of species. Long-term opportunities are enhanced with a broader range of species in the timber supply, including broadleaves, but the short-term economics and lack of tenure security of the typical licensee requires them to reduce costs and risk; hence, they are reluctant to gamble on greater diversity in the timber supply without incentives.

Lack of Broadleaf Objectives in TFLs

Currently, none of the Tree Farm Licences on the coast of BC, besides Scott Paper Limited's TFL 43 have a requirement to harvest broadleaves or grow them. The problem is that, unlike the coniferous crop, the red alder crop will die and unless there is a requirement to harvest it, it will be wasted. While red alder is providing various non-timber values that will continue to be provided if the species is not harvested, a large portion of the existing red alder is already off-limits from harvesting in un-harvested riparian areas and therefore providing those values without an additional impact on the available timber supply.

The TFLs are the ideal place to grow plantation red alder because they have improved economies of scale. The only licensee currently growing red alder in coastal BC, Northwest Hardwoods, has much higher costs per unit of managed land, than would be the case in TFLs, because their small operations are spread over a huge territory.

Northwest Hardwoods also has potentially higher establishment costs because they are planting red alder on sites that alder was harvested from and so there is often more pre-existing brush (that must be removed) and bark beetles (*Alniphagus aspericollis)* that infect the newly planted seedlings (Hughes pers. comm. 2006). TFL-holders could establish red alder on sites with fewer problems (areas previously covered with conifers) and so avoid the additional costs. They could also create more red alder plantations in one area and therefore improve the economics for future harvesting.

Timber Supply Analyses

The analyses of timber supply, done for Timber Supply Areas by the government and for Tree Farm Licences by licensees, are based solely on the volume of wood. This is a serious flaw in general because it results in uneconomic harvesting of timber, but it is also an impediment to growing more broadleaf species because unless broadleaf tree species are grown on short rotations they result in a reduced mean annual increment and a potential reduction in the AAC. For example, red alder has growth rates that exceed all the conifers in the first 25 years. However, after that the growth rate declines and mean annual increments for the associated conifers will exceed the rates of growth of the red alder. This occurs at approximately 25 years for Sitka spruce, 35 years for western hemlock, 40 years for Douglas-fir and 75 years for redcedar. (Bluhm and Hibbs 2006). As a result, unless red alder is grown on short rotations there is a reduction in the allowable annual cut.

A higher total value may be achieved by growing red alder with redcedar, for example, even though the mean annual increment may be less than a Douglas-fir or hemlock stand of similar age.

A typical timber supply analysis is insensitive to these value-based subtleties.

Free Growing Standards

As a rule, a new plantation on crown forest land in coastal BC is not free growing unless there are virtually no co-dominant or dominant broadleaves. Foresters often prescribe up to 50 red alder per hectare for site enhancement and biodiversity. Recent research results (Thomas et al 2006) indicated that densities of red alder of up to 400 stems per hectare will have negligible impact on Douglas-fir or redcedar but these results have yet to infiltrate the forest policy framework.

Conversely, for the few red alder plantations being established (primarily by Northwest Hardwoods), mixtures with conifers are not permitted (Hughes, pers. comm. 2006). This is a lost opportunity because, as discussed above, growing shade intolerant broadleaves with shade tolerant conifers like redcedar, Sitka spruce or hemlock may produce more net volume than the species alone.

Potentially some of the most productive forest types (from a value point of view) in the current second growth forests of the south coast of BC are a mix of Douglas-fir, redcedar and red alder where the cedar grows beneath the alder and the Douglas-fir grows in clumps or as individuals with crowns above the alder canopy. This has been observed in various locations by various forest managers in both TSAs and TFLs on the south coast.

Silviculture Costs

Licensees harvesting on crown lands in BC are responsible for basic silviculture – that is establishment of a free growing forest on all harvested lands. For all conifer timber crops, except high density lodgepole pine (*Pinus contorta* Dougl. *ex* Loud.) and hemlock[22], the licensee does not pay for pre-commercial thinning. If non-maximum density spacing is done, it is considered to be intensive silviculture and so is not the responsibility of licensees who must only finance the basic silviculture.

The current free growing standards for sawlog red alder (BC Ministry of Forests 2000) specify that the stand must be pre-commercially thinned. This is required to ensure that all red alder crops produce a sawlog without impacting the mean annual increment or the timber supply. Not thinning the stand and letting it grow longer would allow it to reach sawlog dimensions in approximately 45 years but after the mean annual increment has declined. Indeed, there are indications that lower planting densities of red alder – 1000 to 1100 sph – may result in a sawlog in less than 25 years without thinning (Hughes, pers. comm. 2007).

Requiring the licensee to pay for pre-commercial thinning of red alder reduces the likelihood that red alder will be grown at all.

US Market Access

Access to the US market for red alder would, in the short-term at least, result in an increase in the price of red alder in BC. This would increase the incentives to grow red alder although it would make red alder manufacturing in BC less profitable. Hence, it could quickly lead to the devastation of the already fragile broadleaves manufacturing sector and, ironically, a further loss to the incentives to manage sites for broadleaf production.

Riparian Management Standards – Riparian Reserves

Large streams in BC, those with an average width or active floodplain greater than 100 metres wide as per section 47 of the *Forest Planning and Practices Regulation* of the *Forest and Range Practices Act,* do not require a riparian reserve zone. In other words, the entire riparian area adjacent to these rivers may be used for growing black cottonwood and hybrid poplar. The have a 100 metre wide riparian management area. This area must be managed for both timber and riparian values. However, smaller rivers – those with an average width of 20 to 100 metres – require a 50 metre reserve where no harvesting or regeneration is permitted. A reduction in the amount of reserve on these rivers, similar to the requirement on larger rivers, would allow more extensive growing of black cottonwood and hybrid poplar.

All fish-bearing streams in BC with an average width of 1.5 metres to 5 metres require a riparian reserve of 20 metres; streams with an average width of 5 to 20 metres require a reserve of 30 metres. One of the primary reasons for retaining these forest reserves is to recruit large woody debris that will help re-build structure in the stream channel. However, riparian reserves composed of red alder will not provide a long-term supply of woody debris because red alder is short-lived, it decays quickly and it does not reach the sizes required to provide stable structure in the larger streams; a characteristic of the longer-lived and slower decaying sitka spruce and red cedar that dominate these ecosystems overtime. Permitting some harvesting of pure red alder stands followed by planting with sitka spruce and red cedar in these riparian reserves could allow a more rapid development of in-stream coarse woody debris. The greatest and best use for mature red alder in these forests is for timber because it will soon die and will provide no other long-term benefits.

[22] Lodgepole pine and hemlock may require maximum density spacing paid for by the licensee. It is pre-commercial thinning conducted when the number of countable stems exceeds a minimum number – often 10000 stems per hectare for hemlock on the coast.

Pesticide Use Regulation

Unlike private agricultural lands in the lower Fraser Valley, the Ministry of Environment only permits the use of *glyphosate* and *triclopyr* on the forestlands in this area. Other pesticides, such as soil sterilants, have greater utility on lands being grown for black cottonwood or hybrid poplar but they are not permitted. Altering the legislation regarding herbicide use in these area, to bring it in line with practices on agricultural lands, would allow for more cost effective production of black cottonwood and hybrid poplar stands.

Methodology to Guide Future Management and Recommendations for Change

The forest ecosystems of coastal BC are naturally very productive. The potential of the land may be optimized if this natural potential is allowed to express itself. If a particular species of tree is the "best species" on a site it may be wise to retain it regardless of whether or not it can be sold today. This is a prudent course of action because the health of the forest occurs over long periods of time and is influenced by the health of individual trees, whereas the economic viability of the forest products industry is susceptible to many variables only one of which is the species of tree.

Crop tree selection is difficult because long rotation lengths (except in short-rotation crops such as hybrid poplar) make markets difficult to predict. Historically, crop tree choices have been based on the assumption that what is valuable today will be valuable tomorrow. This is often not true. The forester needs a methodology to reduce the risk, and one that is independent of short-term considerations.

The recommendation is to create a heuristic to guide crop tree decisions based on the full gamut of actual and potential values, local needs and global considerations (total supply). It will also incorporate an approach to forest management that involves the use of both intensive and extensive practices distributed across the landscape – intensive activity closer to developed centres and extensive activity further away. This is desirable because more intensive activities are often more expensive and best conducted on sites with low costs and high productivity. It should result in the maintenance of the proportion and distribution of broadleaf stands within the range of natural proportions and distributions found in unmanaged landscapes (Peterson et al. 1997).

The heuristic should give greater weight to the ecological tolerances and amplitudes of the species – the natural strengths and weaknesses – and less to the current commercial values.

The steps to be undertaken now for the broadleaf tree species of coastal BC are:

- Integrate all the commercial broadleaf species, and especially red alder, into the forest policy framework and our forest estate:
- Modify the requirement to remove broadleaf trees from all conifer plantations. Instead require that a proportion of the timber harvesting land base be in pure and mixed-broadleaf stands based on the existing ecosystems; a typical standard might be: "10% of all site series 05 in the CWHdm to be red alder leading";
- Change the timber supply review procedures and AAC determinations to incorporate value and forest management costs;
- Incorporate broadleaf harvest and regeneration requirements into all forest tenures with existing broadleaf inventories or if the tenures contain ecosystems that are preferred for broadleaf production;
- Develop mixed-wood stocking standards and expand the current pure species stocking standards to permit longer rotations, the use of natural regeneration[23] and the growing of all four broadleaf species in appropriate ecosystems;

[23] A US-based company, Merrill and Ring, with forest management operations in coastal BC has demonstrated a method that may be used for reliable natural regeneration of red alder. A site is planted with coniferous species (Douglas-fir, redcedar or Sitka spruce) and if red alder regenerates naturally it may be left if it satisfies various criteria: appropriate density, large enough area to be economic if harvested separately, close to roads and on an appropriate ecosystem (fresh to moist soil moisture regime and medium to rich soil nutrient regime). This method ensures restocking of the site and allows the use of natural regeneration of red alder with reduced costs for brushing and weeding and for red alder planting which is usually more expensive than Douglas-fir artificial regeneration.

- Provide education for foresters and forestry students on the full range of possible crop trees and realization that traditionally non-commercial species often develop values in the future.
- Conduct research on (not an exhaustive list):
    - Broadleaf performance in mixed stands;
    - Performance of natural versus artificial regeneration;
    - Broadleaf tolerance to climate change;
    - Production of broadleaf regeneration products – seedlings or vegetative material;
    - Pests impacting black cottonwood & hybrid poplar; and
    - Cause of red heart in red alder.

Implementation of these policy changes combined with a new approach to crop tree selection would increase the future value of our forests and their resilience.

Conclusions

Supplies of native coastal broadleaved trees are declining – more rapidly for red alder and more slowly for bigleaf maple, black cottonwood, and paper birch. This is due to a steady harvest level of all four species over the last ten years, short life spans of the species, and insufficient regeneration. The harvest level could be increased in the short-term given the available supply in older age-classes and the lack of use of the supply in some forest tenures, but will decline in the future without the creation of new broadleaf stands.

Previous reviews of the broadleaf inventory have used data that significantly over-estimated the supply (red alder by Ahrens 2006) or did not include all the productive forest types (Massie et al. 1994 and 1996). We found no review of past harvest levels but an estimate of potential future harvest levels (Massie et al. 1994), which over-estimated the harvest for red alder and bigleaf maple, under-estimated the harvest for black cottonwood and was generally correct for paper birch.

The demand for red alder in particular has increased in the last decade with a proportional increase in commercial value. The increase in value has been matched by an increasing value in the US, but the value in the US has been proportionately larger.

The broadleaves have a range of non-timber or timber enhancement values. Their inclusion in the forest estate may increase the over-all resilience of the forest.

The broadleaves are not susceptible to pathogens. The cause of “red heart” in red alder is not understood and could be investigated.

There is limited experience with non-brushing and weeding silviculture of broadleaves with the exception of artificially regenerated red alder and hybrid poplar. There is a need for research into management of both natural and artificially regenerated broadleaf stands, both pure and mixed, and the production of seedlings and/or vegetative material.

There are various policy and institutional impediments to liberalizing the use of broadleaves: a conifer bias in the forest industry, lack of broadleaf timber objectives in most TFLs, the current methods of timber allocation and valuation on public lands, inflexible or non-existent stocking standards (the latter for mixed species stands), additional costs, ostensibly to be borne by the forest industry and thus a disincentive to produce broadleaf stands, and a lack of access to the US market.

Past developments in forest policy in BC have demonstrated the tendency to mistakenly direct crop tree decisions on the basis of current commercial values. A preferable approach, one that would argue for increased use of broadleaf tree species in the coastal forest, is to adopt a methodology that incorporates all values and is guided by the natural characteristics of the tree species.

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