

## A Summary of Western Yew Biology with Recommendations for its Management in British Columbia

1995



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Elizabeth Campbell and  
Alison Nicholson



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Prepared by:

Elizabeth Campbell and Alison Nicholson  
Research Branch  
B.C. Ministry of Forests  
31 Bastion Square  
Victoria, B.C. V8W 3E7

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Considerable interest in western yew (*Taxus brevifolia* Nutt.) has been sparked by the recently discovered anti-cancer properties of taxol, a chemical extracted from the bark of this conifer. Clinical trials show that taxol is a successful treatment for approximately 30% of women whose ovarian cancers resist conventional therapies (Stone 1993). Taxol also shows promise in treating breast, head, and neck tumors (Stone 1993). These positive results have greatly increased the demand for taxol obtained from wild western yew trees. Scientists do not expect an alternative taxol source to be available on a commercial scale for about three years.

Wild western yew trees are a limited resource and are not considered as an option for the long-term supply of taxol. They are small, slow growing, and uncommon relative to other commercial tree species. Furthermore, large quantities of bark are required to produce small quantities of taxol. There is concern that continued reliance on naturally occurring western yew will diminish this resource, jeopardizing the supply of taxol and threatening the species. The effect of western yew harvest on ecosystem structure, function, and diversity is also a concern.

Existing Ministry of Forests policy on resource management dictates that western yew can be har-

vested in designated areas (i.e., areas approved for harvesting, and other areas, with a free-use permit). The policy also provides procedures for the acquisition of permits, transfer of harvesting authority, and recording amounts harvested, but does not address significant ecological issues like:

- the landscape and stand-level management of western yew;
- the extent and method of harvest in management areas subject to different silviculture systems; and
- the appropriateness of harvest in particular ecosystems.

These deficiencies and increased pressure to selectively harvest western yew in areas reserved from conventional harvesting have prompted the need for more comprehensive management guidelines in British Columbia.

More information about the distribution, abundance and genetics of western yew in British Columbia was needed to develop management recommendations. In 1991 and 1992, the B.C. Ministry of Forests initiated ecological and genetic studies of western yew. This report summarizes the results of this research and data obtained from the literature. This information forms the basis for management recommendations also presented in this report.

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Western yew (*Taxus brevifolia* Nutt.) has been of negligible commercial importance in British Columbia because of its small size and rarity relative to other commercial tree species. Use of the wood has been restricted to the making of archery bows, canoe paddles, fence posts, musical instruments, carvings, and other miscellaneous novelty items (Bolsinger and Jaramillo 1990). Until recently, only aboriginal peoples of the Pacific Northwest used decoctions of western yew bark for medicinal purposes (Taylor and Taylor 1981; Bolsinger and Jaramillo 1990; Turner et al. 1990).

Through widespread screening of natural products in the late 1960s, the United States National Cancer Institute found the chemical taxol in western yew bark to have significant anti-cancer properties (Wani et al. 1971; Fuchs and Johnson 1978). Clinical trials show taxol to be a successful treatment for approximately 30% of women whose ovarian cancers resist conventional therapies (Stone 1993). Taxol also shows promise in treating breast, head, and neck tumors (Stone 1993).

T.P.L. Phytogen, the pharmaceutical company producing taxol in British Columbia, estimates that they will need 50 000 kg of western yew bark to extract taxol for research, testing, and clinical trials over the next two years (J. Kapitany, T.P.L. Phytogen, pers. comm., 1994). Fifty thousand kilograms of bark will produce about 6 kg of taxol and require the harvest of almost 5000 western yew trees each year for the next two years.<sup>1</sup> This six kilograms of taxol should be sufficient to treat approximately 6000 Canadian cancer patients.

In British Columbia and the United States, the bark of wild western yew trees has been the primary source of taxol. Several alternative sources of taxol, however, are currently under development. These include: large-scale domestic cultivation of western

yew, yew cultivars and exotic yew species (N. Wheeler, Weyerhaeuser, pers. comm., 1992); a newly discovered species of fungus called *Taxomyces andreanae* (Stone 1993); and tissue cultures. Taxol and taxol analogues can also be obtained through partial (Guéuritte-Voegelein et al. 1991) or total synthesis (Wender 1993; Holton et al. 1994a, 1994b; Nicolaou et al. 1994). While much progress has been made with respect to alternative taxol sources, none are able to provide taxol on a commercial scale at this time.

Until an economically viable alternative is available, we will continue to rely on wild western yew as a source of taxol. These trees, however, are frequently small, slow growing and relatively uncommon. Furthermore, large quantities of bark are required to produce small amounts of taxol. There is growing concern, therefore, that continued reliance on wild trees will diminish this resource, jeopardizing the supply of taxol and threatening the species. Whole-tree harvest may also have adverse effects on the structure, function and diversity of western yew ecosystems.

The dependence on this forest-based source of taxol has emphasized the need for a management strategy that will preserve western yew and its associated ecosystems, as well as provide moderate amounts of bark for extraction purposes.

This report provides recommendations for western yew management in British Columbia. These recommendations are based on recently collected biological information. In 1991, the B.C. Forest Service embarked on an ecological survey and a study of western yew genetics (El-Kassaby and Yanchuk 1994). The results of this research and information obtained from the literature are summarized here. A glossary of terms used in this report is provided in Appendix 8.

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<sup>1</sup> Based on western yew harvest statistics provided to the Ministry of Forests, Vancouver Region in 1991.



Existing policy regarding western yew harvest is cited in the Ministry Policy Manual on Resource Management (B.C. Ministry of Forests 1993). This policy dictates that western yew harvest on Crown land can occur in the following areas:

- in areas approved for harvesting under an existing agreement, with the consent of the agreement holder;
- in areas where approval for harvesting is imminent under an agreement, with a free-use permit issued by the District Manager;
- in areas reserved from conventional harvesting, with a free-use permit issued by the District Manager that will authorize the harvest of western yew bark but require a minimum number of stems to be left in a range of age and size classes;
- in young stands, with a free-use permit issued by the District Manager that will authorize the harvest of yew bark but require a minimum number of stems to be left.

The harvesting of western yew needles is administered in the same manner. Needles may be harvested from 50% of western yew trees by diameter class and no more than 50% of the foliage should be harvested from any one tree.

In areas approved for harvest operations under conventional agreements (i.e., tree farm licence, forest licence, or timber sale licences, etc. with valid cutting permits), the licensee may extend cutting authority to permit harvest of western yew by a second party. This permission must be issued in writing and should explicitly identify the areas (on a map) where harvest is authorized. It should also incorporate any specific instructions from the Forest Service (District Manager) or the licensee. Free-use permits are issued by the Forest Service (District Manager) as indicated above. Copies of either a Letter of Authorization (Appendix 1) or a free-use permit should be readily available for viewing by the proper authorities (i.e., the Forest Service or the RCMP) when harvesting and transporting western yew bark. Authority to harvest western yew on private land may be obtained through written permission of the landowner.

To transport special forest products from site of harvest, a Shipping Notice is required (Appendix 2). A copy of this shipping notice should be given to the person authorizing western yew harvest. This docu-

ment, together with the above mentioned permission documents, will attest to the legitimacy of western yew harvesting operations.

A Western Yew Bark Register (Appendix 3) will be kept by collectors and should be submitted annually to the Forest Service (Regional Manager) to document the extent and location of western yew harvest.

The current approach to western yew harvest on approved sites includes removal of western yew before primary harvesting (similar to poling operations) and post-logging salvage of western yew logs. Bark is usually stripped from the trees on the site. If logs are removed from the site, however, they must be scaled and a stumpage will be charged. To encourage regeneration, current policy requires that western yew stumps, at least 15 cm high with the cambium intact, be left to resprout.

The 1991 harvest of western yew in the province yielded approximately 18 000 kg (dry weight) of bark; most of this bark was exported to the United States for taxol extraction. In 1992, when a Canadian facility (T.P.L. Phytogen Inc.) developed the means to extract taxol, the B.C. Ministry of Forests ceased granting bark export permits. T.P.L. Phytogen estimates that they received 40 000 kg of bark in 1992 and 30 000 kg in 1993. They expect to require 50 000 kg of bark over the next two years.

Current western yew harvest policy may not be adequate to accommodate the future need for bark and to ensure sustainable western yew populations. While current policy identifies areas of harvest and requirements for harvest permits, shipping, and record keeping, it does not address significant ecological issues like:

- landscape and stand-level management of western yew;
- the extent and method of harvest in managed areas subject to different silvicultural systems (e.g., clearcutting, seed-tree and selective systems); and,
- the appropriateness of the harvest in particular ecosystems.

These current policy deficiencies and the increased pressure to selectively harvest western yew in areas reserved from conventional harvesting have prompted the need for a more comprehensive management strategy.

### 3.1 Description

Western yew is a long-lived conifer whose growth habit varies from a small tree to a low spreading shrub. The tree form often exhibits a twisted and fluted trunk that may be multi-stemmed. Young trees frequently have a square to rectangular profile becoming more conical with age. Branches are long and slender and tend to stand out straight, drooping only slightly. On trees growing partly or wholly in the open, numerous drooping branchlets form on the branches creating a weeping effect.

Needles are flat, characteristically pointed at the tip and 1–2 cm long. They are spirally arranged on branchlets but have the appearance of being two-ranked. Fruits are produced at the terminal end of branchlets in early fall. The bark on mature trees is 4–6 mm thick, scaly and dark reddish brown (Figure 1).

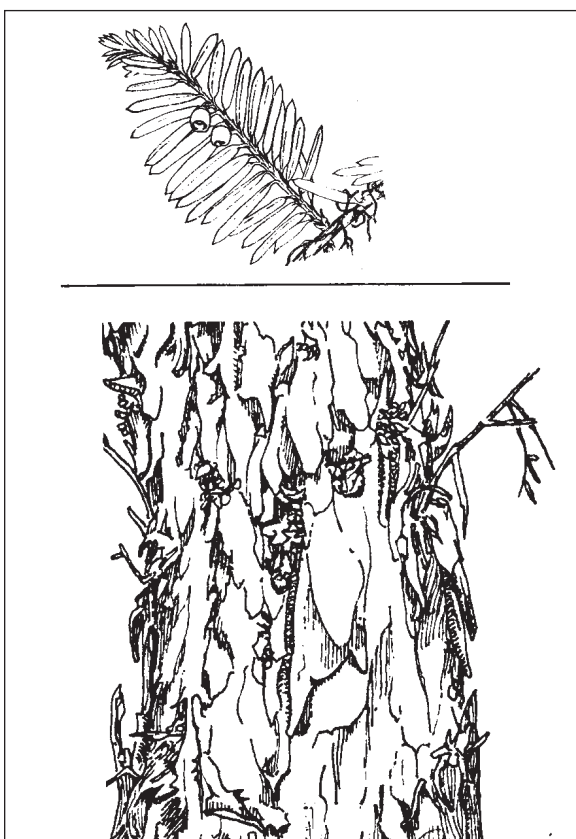


FIGURE 1 *Foliage and bark of a western yew tree.*

### 3.2 Distribution and Abundance

#### 3.2.1 Geographic range

On the coast, western yew occurs as a sub-canopy tree and constitutes a minor component (1–5%) of forested sites. Its range in British Columbia extends along the coast from the United States border north to Portland Inlet (approximately 55°N) and inland to moderate elevations of the coastal mountains (Figure 2). Western yew also occurs on the Queen Charlotte Islands, Vancouver Island, on the islands of the Strait of Georgia, and at the extreme southeastern tip of Alaska. South of the border, the range of western yew on the coast extends into northern California.

East of the Cascade Mountains, western yew grows below the main canopy as a small tree or shrub, also forming a minor component (1–7%) of forests in the interior wet belt. It occurs on the lower slopes of the Columbia Mountains in southeastern British Columbia and extends south to northern Idaho and northwest Montana. At its eastern limit, western yew is found on the western side of the continental divide near Sparwood and Fernie.

Western yew grows at low to moderate elevations and only rarely occurs in subalpine ecosystems in British Columbia. On the coast, it is typically found from sea level to approximately 800 m but has been documented on sites up to 1600 m in altitude. In the interior it is found at altitudes ranging from 350–1200 m.

#### 3.2.2 Biogeoclimatic distribution and abundance

The climate throughout the range of western yew is characterized by long growing seasons, high precipitation and high relative humidity (Taylor and Taylor 1981). On the coast, most of the precipitation falls as winter rain. Western yew is found almost exclusively in the low-lying Coastal Douglas-fir (CDF)<sup>2</sup>, Coastal Western Hemlock (CWH), and the Interior Cedar–Hemlock (ICH) biogeoclimatic zones. It also occurs, albeit rarely, in the Interior Douglas-fir (IDF) zones, and the higher elevation Montane Spruce (MS), Mountain Hemlock (MH), and Engelmann Spruce–Subalpine Fir (ESSF) zones (see Appendix 4).

<sup>2</sup> Biogeoclimatic classification of British Columbia is described in Meidinger and Pojar (editors) 1991.

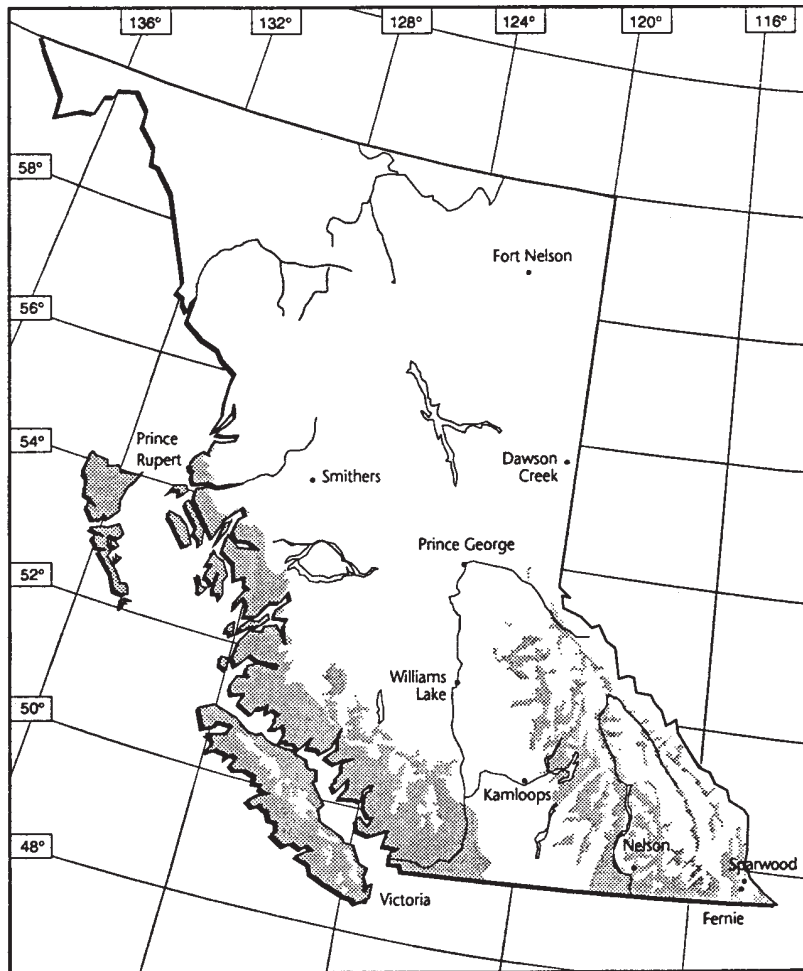


FIGURE 2 Range of western yew in British Columbia.

**Coastal subzones** Western yew is present in most subzones/variants of the CWH zone, with exception of CWHwm,<sup>3</sup> CWHws1, CWHws2, CWHmm2, and CWHds2. The CWHwm and CWHws subzones, north of Portland Inlet, have the coldest winter temperatures and heaviest snowfall of all subzones in the CWH zone. Mean winter temperatures range from -4.2 to -6°C (Meidinger and Pojar [editors] 1991). It is likely that western yew is excluded from these subzones because cold temperatures, combined with exposure to winter sun and dry winds, inflict foliar damage (N. Vance, U.S. Dep. Agric. For. Serv., pers. comm., 1992) or prevent seed germination.

Western yew is most prevalent in the warmer CWHvm1 and CWHvh1 on Vancouver Island and coastal mainland British Columbia, the CWHwh1

and CWHvh2 on the Queen Charlotte Islands, the CWHms2 in the Squamish area, and the CWHds1, which is restricted to a small portion the southern mainland. Western yew is also prevalent in the CDFmmDa subzone confined to southeastern Vancouver Island, the Gulf Islands and the lower mainland. This subzone has the warmest and driest coastal climate. Crown cover is typically about 3% on forested sites in subzones of the CWH and CDF.

Western yew occurs rarely in subalpine ecosystems of the MH zone, which is characterized by short, cool summers and long, wet, snowy winters (Meidinger and Pojar [editors] 1991). It is found in all subzones except the leeward MHmm2 which is the coldest, driest climate in this zone. Crown cover is typically 1% in MH subzones.

<sup>3</sup> See Appendix 4 for definitions of the alphabetic symbols used to designate subzones.

**Interior subzones** In the interior, western yew is concentrated in the Interior Cedar–Hemlock (ICH) zone. It is most prevalent in ICHmw2, ICHdw, ICHwk1,2 and ICHvk1 where the regional climates are relatively warm. Crown cover is typically about 3% in the ICH zone.

Western yew is absent from the coldest sub-zones of the ICH including the ICHdk near Canim Lake, the ICHmk2 near the Thompson River, the ICHwk3 and ICHwk4 in the upper Cariboo River area, the ICHvk2 in the Slim Creek area, and the ICHvc and ICHmc subzones in the Nass Basin.

Western yew is rare in the Montane Spruce zone, occurring exclusively in the MSdk. It is also rare in the Engelmann Spruce–Subalpine Fir (ESSF) zone where it occurs only in the warmest subzone, ESSFmw.

**Site associations** Site associations are groups of related ecosystems that are similar enough in site quality and productivity to produce similar vegetation types at climax. Western yew has been documented in 53 site associations defined within the B.C. Ministry of Forests Biogeoclimatic Ecosystem Classification System. These site associations are listed in Appendix 5.

Western yew is most prevalent on site associations dominated by Douglas-fir (e.g., Fd–Salal, Fd–Oregon grape)<sup>4</sup>, western redcedar (e.g., Cw–Skunk cabbage, CwSs–Skunk cabbage), western hemlock (e.g., HwCw–Deer fern) and interior western redcedar/western hemlock (e.g., CwHw–Devil’s club–Lady fern). It is more rare in coastal amabilis fir and Sitka spruce stands, as well as western hemlock-dominated stands of the interior. Western yew does not occur on dry site associations dominated by shore pine (e.g., Pl–Kinnikinnick), but does occur in wet (e.g., Pl–Sphagnum and PIYc–Sphagnum) site associations.

A pilot inventory conducted in the CWHvm and CWHvh subzones of northern Vancouver Island shows that western yew attains greatest average densities (trees/ha) in mature ecosystems of Yellow-cedar–Shore pine–Sphagnum ( $\mu=19.2$ , Std. Err.=6.23); Western redcedar–Western hemlock–Salal ( $\mu=19.6$ , Std. Err.=15.21); and Western redcedar–Skunk cabbage ( $\mu=21.1$ , Std. Err.=6.03) (R. de Jong, Natural Resources Can., pers. comm., 1994).

Western yew is absent from stands dominated by deciduous species such as Garry oak, red alder, and black cottonwood.

### 3.3 Habitat

#### 3.3.1 Site and soil conditions

Western yew grows on a wide variety of forested site types, from upper rocky sites to lower slopes, moist depressions, and ravines. In warm, dry climates like the CDFmm, it is often restricted to cool, moist habitats. Western yew can also form dense thickets on non-forested talus slopes and lower elevation avalanche chutes.

Because of its slow growth rate, western yew is most frequent in the later successional stages of a forest. Large trees are prevalent in mature and old-growth stands. However, western yew does not apparently require mature or old-growth forests, as suggested by the U.S. Forest Service, (U.S. Dep. Agric. 1992), since it occurs, to a lesser extent, in some seral stages. Seral stands composed of deciduous species like big-leaf maple and red alder tend not to contain western yew. The distribution and abundance of western yew in seral ecosystems, however, requires further research.

Western yew grows on a variety of soil types (i.e., from deep, fine-textured organic soils to shallow, coarse-textured regosols or folisols) but best growth occurs on deep, moist, moderately well-drained soils (Taylor and Taylor 1981). Western yew is most abundant on podzolic soils of the CWH and ICH zones and on brunisolic soils of the CDF zone. It seems to adapt well to slightly acidic or alkaline soil conditions (Taylor and Taylor 1981; Krajina et al. 1982).

#### 3.3.2 Nutrient regime

Little is known of the nutrient requirements of western yew, but it grows best on sites with medium to rich nutrient content. Average growth rates of western yew are significantly greater (up to 0.35 cm/yr) on rich sites.

Western yew, however, occurs more frequently on poor to medium sites. An association of vesicular-arbuscular mycorrhizae with the roots of western yew (U.S. Dep. Agric. 1992) may contribute to this tree’s ability to occupy less-than-optimal sites. Association of this fungus with plant roots permits the retrieval of phosphates and water from the soil more efficiently than uninfected roots (Trappe and Fogel 1977; Begon et al. 1986). Vesicular-arbuscular mycorrhizae are predominantly associated with angiosperm roots, but genera such as *Thuja*, *Juniperus* and *Sequoia* are also associated with this type of fungus (U.S. Dep. Agric. 1992).

<sup>4</sup> See Appendix 5 for tree species abbreviations.

### 3.3.3 Moisture regime

In wet climates like that of the CWHvh, western yew tolerates a wide range of soil moisture conditions, from dry to wet. In drier regional climates such as the CDFmm, CWHxm, and IDfww, lack of soil moisture confines western yew almost entirely to relatively moist or wet sites.

In general, western yew does not occur on poorly drained soils (Alaback and Juday 1989), and on poorly drained Pl–Sphagnum or CwSs–Skunk cabbage sites, western yew is restricted to elevated microsites.

Western yew shows no significant increase in abundance on riparian sites at low to moderate elevations, especially in wetter regional climates. However, at higher elevations western yew appears to be restricted to riparian areas or swampy depressions, and is often associated with yellow-cedar (*Chamaecyparis nootkatensis*) on the coast.

Despite a tendency to occur more frequently in riparian areas in dry regional climates, western yew is generally restricted to high bench positions on floodplain sites. It is mostly absent on the more frequently flooding medium and low bench sites. Mature western yew trees appear to tolerate the periodic flooding on high bench sites. Western yew rarely occurs on sites with strongly fluctuating water tables (e.g., Cw–Swordfern, Cw–Indian plum).

Western yew is not usually found on ocean spray sites of the CWHvh and CWHwh. These sites occur along the outer coast of Vancouver Island, the central mainland, and the Queen Charlotte Islands, and are dominated by Sitka spruce. Western yew is absent from exposed rocky headlands, old beach plains, and marine terraces/scarps.

### 3.4 Determinants of Western Yew Occurrence

Regional climate significantly influences the occurrence of western yew in British Columbia (Appendix 1). In the interior wet belt and on the coast, temperature defines the northern limit of the species, and a combination of insufficient moisture and high summer temperatures limit the extension of western yew into the southern interior of British Columbia.

Western yew grows on a wide variety of site types in seral and climax forests, but it occurs sporadically. While site factors such as soil moisture and

nutrient regimes have some effect on its distribution within a regional climate, these factors do not appear to be the primary determinants of western yew occurrence. Although western yew is more frequent in some site associations (e.g., CwSs–Skunk cabbage, FdBg–Oregon-grape, and CwHw–Falsebox–Feathermoss), it still occurs in less than 35% of plots sampled on most of these sites. Combinations of episodic wildfire or disease events, poor seed crops and pollen or seed dispersal, ungulate browsing, and competition with other species may have a greater effect on western yew occurrence than ecological site factors.

In a forest history study conducted at Marion Lake in southwestern British Columbia, Wainman and Mathewes (1987) suggested that western yew may have been a larger component of forests before the arrival of western redcedar 5400–6500 years ago.

### 3.5 Growth, Development and Reproduction

#### 3.5.1 Growth

Western yew occurs as both an upright tree and a shrub in British Columbia. The tree form is most prevalent on the coast while the shrub form is found most extensively in the interior (especially on steep slopes), as second growth in clearcuts, and on talus slopes. Taylor and Taylor (1981) found that the shrub form is also prevalent on ecologically marginal sites.

Western yew trees are small compared to their common associates. Mature western yew trees measured on the coast average 7.7 m in height and 15.5 cm in diameter (at breast height). Table 1 summarizes average western yew height by diameter class. The largest western yew trees measured reach heights of 12–19 m and diameters (at breast height) of 60–85 cm.

TABLE 1 Average western yew tree height by diameter class for coastal plots

Diameter class (cm) <sup>a</sup>	Average height (m)
0–9	3.2
10–19	7.0
20–29	10.4
30–39	12.4
40–49	14.2
50 +	18 +

<sup>a</sup> Diameters were measured at breast height.

Large western yew trees occur most frequently on the coast (Figure 3). In the interior, the largest trees are found in the southern ICH zone and decrease in size, tending toward shrub form, further north. Less precipitation, and greater frequency and extent of natural fire disturbance in the interior compared to the coast<sup>5</sup>, may account for the observed differences in size distributions.

### 3.5.2 Phenology

Western yew is dioecious (i.e., male and female reproductive structures occur on different trees). Monoecious trees can occur but they are rare. Male trees produce small stalked pollen cones in clusters of six to twelve on the terminal underside of branchlets. Cones mature in April or May and the pollen is wind-dispersed. The female flower is also borne on the terminal underside of branchlets. In its earliest stages it resembles a vegetative bud, but is easily distinguished by an opening at the tip of the pointed, exposed ovule (Chadwick and Keen 1976). A green fruit produced in the summer matures to a red aril in early fall. The presence of female fruit in varying stages of development suggests multiple pollination events or the absence of pollination in some cases.

Sex ratios of 1:1 reported by the U.S. Forest Service (U.S. Dep. Agric. 1992) were not substantiated by ecological research conducted in British Columbia. The sex of many trees could not be determined in the field because of the rarity or lack of reproductive structures.

### 3.5.3 Seed production and dispersal

It is not known when western yew first begins to

produce seed but trees less than 1 m tall and 1.5 cm in diameter rarely produce reproductive parts. Once mature, western yew produces some seed every year and large seed crops at irregular intervals (Taylor and Taylor 1981). It is a prolific seed producer in open canopies. Small mammals and birds generally disperse the seed.

### 3.5.4 Seed viability and germination

Western yew seed germinates slowly, usually not until the second year (Rudolf 1974; Bolsinger and Jarmillo 1990). There is some indication that seed remains dormant for about three years (G. Edwards, Natural Resources Canada, pers. comm., 1993). Western yew seed is more difficult to germinate than the seed of its commonly associated conifers (e.g., Douglas-fir, western redcedar) (Rudolf 1974; U.S. Dep. Agric. 1992). Cold stratification is necessary to break seed dormancy. Exposure to six months of 20°C day and 10°C night temperatures, followed by 5°C temperatures for six months was successful at breaking seed dormancy (U.S. Dep. Agric. 1992).

While Rudolf (1974) indicates that seed germination does not require light, seedlings are more common in open areas such as forest canopy gaps, clearcuts and roadcuts. Seedlings in densely shaded mature and old-growth forests are comparatively rare. Increased soil radiation in open areas may contribute to the breaking of seed dormancy. Seed germination occurs mostly on organic soils but also on decaying wood and mineral soil (Crawford 1983; Bolsinger and Jarmillo 1990).

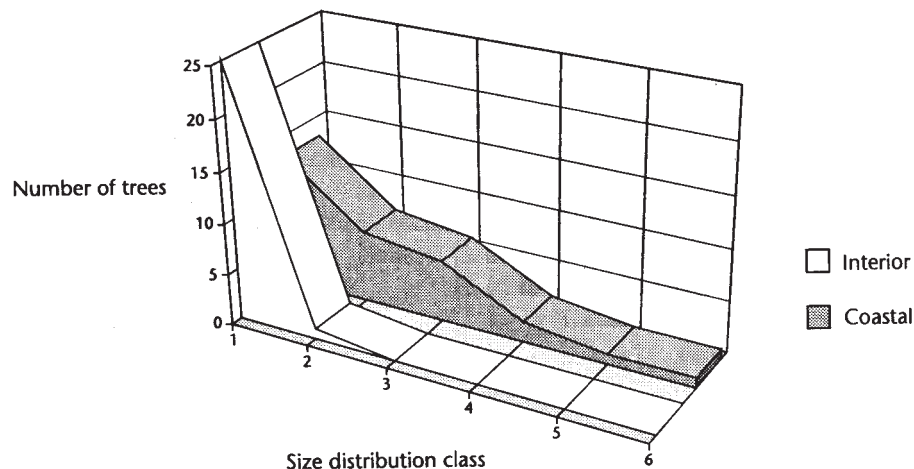


FIGURE 3 Typical size distributions of western yew in 400 m<sup>2</sup> plots surveyed on the coast and in the interior. Diameter classes (cm) are: 1 = 0–9, 2 = 10–19, 3 = 20–29, 4 = 30–39, 5 = 40–49, 6 = 50+.

### 3.5.5 Vegetative reproduction

Western yew is capable of vegetative reproduction by layering and by the sprouting of stumps or live rootstocks. Vegetative reproduction is particularly evident on clearcut sites and on steep slopes, especially in the interior.

On unburned clearcut sites, western yew regenerates well from live rootstocks. Stump sprouting does not appear to be as successful. When exposed to direct sunlight, stumps are prone to desiccation and therefore sprout best in partial shade. Stump sprouts may be extensively browsed by ungulates.

Layering occurs when branches root after being pressed to the ground for a prolonged period. Snowpress likely contributes to the extensive layering observed on steeper slopes in the interior.

Using standard rooting practices, western yew may be propagated vegetatively in a greenhouse from cuttings. Genetic factors, as well as the health and age of the parent tree appear to be important influences on rooting ability. Rooting success in a greenhouse is variable, ranging from 0% to 50%, but is enhanced by partial shading of cuttings (J. Russell, B.C. Min. For., pers. comm., 1994).

## 3.6 Response to Disturbance

### 3.6.1 Forest canopy removal

Western yew is able to grow in both open and shaded areas. Trees growing in the open have fuller crowns and produce more flowers and fruit than trees growing in shaded forests. Canopy removal results in extensive foliage production with extensive sprouting along branches and the tree trunk. Changes in shoot morphology and needle colour with canopy removal suggest an ability of western yew to acclimatize to increased light intensities (A. Mitchell, Natural Resources Can., pers. comm., 1993).

### 3.6.2 Fire

Western yew is sensitive or intolerant to fire because of its thin bark (Taylor and Taylor 1981; Crawford 1983). It is therefore associated with areas having a low incidence of fire disturbance. Western yew increased in frequency with decreasing incidence of wildfire in Washington and Oregon (Scher and Jimerson 1989).

In Idaho, a 92% mortality rate occurred in areas of low to moderately severe broadcast burns. Trees survived burns only when insulated from radiant

heat (Crawford 1983). A study of post-logging forest succession in Oregon indicated that western yew regenerated most rapidly to pre-logging levels on unburned sites (U.S. Dep. Agric. 1992). In areas where western yew survived broadcast burns, the presence of unburned slash and duff immediately surrounding the trees indicated low fire intensity or the absence of fire. However, depending on the site conditions, fire is not always fatal to western yew (Betlejewski 1993). Trees can survive on north aspects and near roads where heat from a burn is least (U.S. Dep. Agric. 1992). The shrub form of western yew seems to be particularly susceptible to fire (Stickney 1980).

On burned clearcuts in British Columbia, regeneration occurs primarily through seed germination, whereas on unburned clearcuts, western yew regenerates by a combination of stump and live rootstock sprouting and seed germination.

### 3.6.3 Soil disturbance

Little is known of the effects of soil disturbance on western yew. It returned to pre-logging levels most rapidly, however, in the absence of soil disturbance (i.e., site preparation) in the H.J. Andrews Experimental Forest in Oregon (U.S. Dep. Agric. 1992).

### 3.6.4 Pests

Disease and insect pests of western yew have received little study. Until recently, this species was considered essentially pest-free. Several potential insect pests and disease-causing organisms associated with western yew in Canada and the United States are listed in Appendix 6.

## 3.7 Wildlife Interactions

Western yew plays several important roles in ecosystem functioning, one being its interaction with wildlife. In coastal forests and in the Columbia River drainage near Revelstoke, it is important forage for black-tailed deer, elk, moose and caribou (Simpson et al. 1988; Nyberg and Janz [editors] 1990). In areas of north-central Idaho, where it forms a sub-canopy beneath a mixed coniferous forest, western yew is the chief food of deer and moose during the winter when deep snow precludes the use of open areas (Pierce 1984; Peek et al. 1987; Simpson et al. 1988).

Where forest management practices favour ungulate habitat, over-browsing severely reduces western yew abundance (Crawford 1983); browsing

removes the reproductive parts on terminal branchlets. Studies of Canadian yew (*Taxus canadensis*) in eastern Canada indicate a decrease in pollen and seed production associated with ungulate browsing (Allison 1990).

Several bird species such as thrasher, blackbirds, waxwings, and nuthatches, as well as many small mammals feed on western yew fruit (Scher and Schwarzschild 1989). Birds presumably aid in long-distance seed dispersal since the seed remains viable after passing through their digestive tracts (Bolsinger and Jarmillo 1990). Passed seed or seed cached by rodents and some birds (e.g., nuthatches) probably account for the clusters of western yew seedlings that are occasionally observed (Crawford 1983).

In northern California, sub-canopies of western yew in riparian areas provide shade to maintain the cool temperatures required by salmonids and several other anadromous fish (Scher and Schwarzschild 1989).

### 3.8 Genetics

#### 3.8.1 Genetic variability of western yew

A study of genetic variation in western yew revealed low within-region genetic diversity relative to other temperate conifers (El-Kassaby and Yanchuk 1994). Significant genetic differences, however, were found between regions of the interior, Queen Charlotte Islands, and Vancouver Island. Western yew in the interior exhibited the lowest levels of genetic diversity. Western yew on eastern Vancouver Island was sufficiently different from the rest of the species range sampled to be considered genetically distinct. This area is an ecologically unique area of British Columbia because of its typically dry coastal environment. The results of this study suggest that most of the genetic variation observed in western yew will be preserved by maintaining representative populations throughout its natural range.

The capture of genetic variation is important because it permits adaptation to long-term environmental changes and resistance to future challenges by pests and pathogens (Ledig 1988, 1993). If western yew is well represented throughout its natural range, limited harvest should not adversely affect the genetic diversity of this species.

#### 3.8.2 Maintenance of genetic diversity

Genetic conservation practices are classified as *in*

*situ* and *ex situ*. The B.C. Ministry of Forests is involved in both types of conservation programs.

***In situ* conservation** *In situ* gene conservation preserves, via protected areas, trees (and their genes) in their natural habitat. Western yew was included in a preliminary survey that estimated the level of protection for several conifers in British Columbia.<sup>6</sup>

Western yew appears adequately represented in protected areas throughout its natural range with the exception of populations occurring in the CWH zone on the mid-coast, and populations in the CDF zone. Peripheral and outlier populations may also require further protection. More data, however, are required to confirm these findings.

***Ex situ* conservation** *Ex situ* gene conservation makes use of botanical gardens, test plantations, seed storage banks, seed orchards, DNA libraries, tissue culture, and clone banks to preserve genetic variation (Ledig 1988). In British Columbia, *ex situ* gene conservation includes the preservation of western yew genotypes in clone banks. From 50 systematically selected stands, representing biogeoclimatic zones and latitudinal gradients, cuttings were collected from 5–15 randomly selected western yew trees per stand. These cuttings are now rooting at the B.C. Ministry of Forests Cowichan Lake Research Station on Vancouver Island. The rooted cuttings will be incorporated into clone banks.

This collection, combined with the western yew preserved in protected areas, will ensure that a large percentage of the genetic variation of this species will be captured (A. Yanchuk, B.C. Min. For., pers. comm., 1993).

### 3.9 Taxol Content and Site Type

On any given site, taxol concentrations in western yew trees are variable (Wheeler et al. 1992). Despite this variability, data from a small sample of western yew show that bark collected from trees on moist sites contains greater concentrations of taxol on average than bark from dry sites (Figure 4). There is little difference in the taxol content in needles from different site types. Genetic and environmental studies in the United States also indicate significant differences in taxol content by ecological groupings (Wheeler et al. 1992). Trees from cool, moist sites had more taxol on average than those from dry, warm sites.

<sup>6</sup> Lester, D.E., E. Campbell, and A. Yanchuk. 1993. A gene conservation strategy for B.C. conifers. Part I. A survey of protected areas for the maintenance of genetic resources of conifers in British Columbia with recommendations. B.C. Min. For., Res. Br., Victoria, B.C. Unpubl. draft rep.



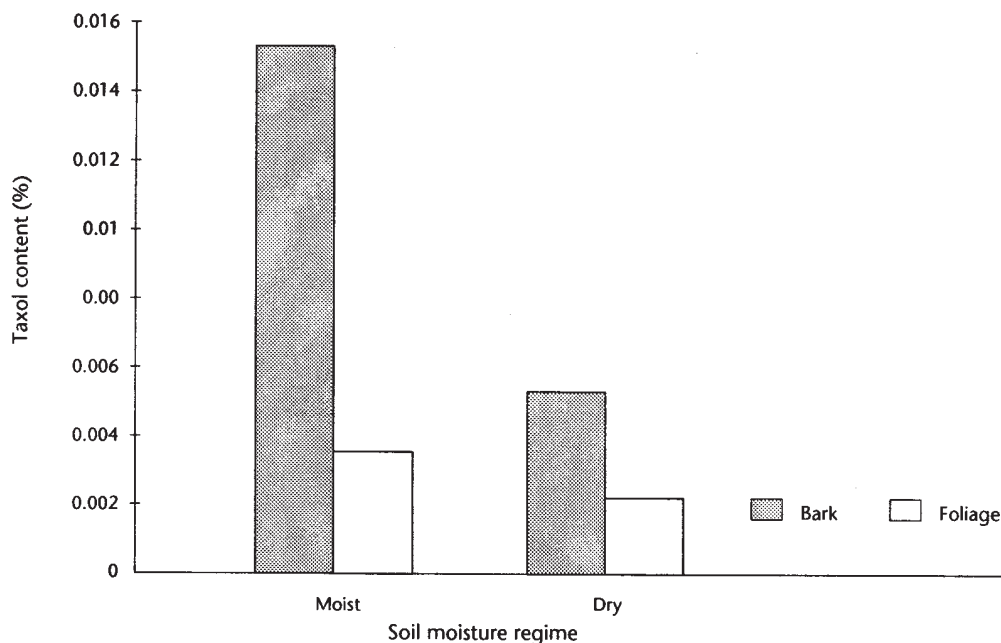


FIGURE 4 Mean taxol content of western yew bark and foliage by site type. Samples were collected in British Columbia.

#### 4 RECOMMENDATIONS FOR WESTERN YEW MANAGEMENT

Western yew is not a threatened or endangered species in British Columbia. Like any other forest resource, however, it must be managed to ensure that sustainable populations are maintained throughout its natural range. Although conservation and management issues are generally addressed in regional and provincial guidebooks<sup>7,8,9</sup> supporting the regulations of the Forest Practices Code, this handbook supplements those guidebooks by providing recommendations specific to western yew management.

The following sections provide recommendations for western yew management in British Columbia, based on the biological information currently available. The recommendations reflect the interim management guidelines developed by the U.S. Forest Service (U.S. Dep. Agric. 1992), but have been modified to incorporate special considerations of western yew occurrence in British Columbia, new biological information, and forest

management in this province.

These recommendations apply to all provincial forests at the stand and landscape levels. They should be flexible and adaptive and should form part of an integrated approach to resource management. Changes to these recommendations will likely occur as more biological and management information becomes available.

##### 4.1 Management Objectives

The management objectives for western yew are:

1. To maintain ecologically and genetically diverse populations of western yew throughout its natural range;
2. To describe a method of western yew harvest that will preserve the biological diversity, integrity, and function of ecosystems where western yew occurs; and
3. To provide a sustainable short-term source of bark and needles for taxol extraction.

<sup>7</sup> B.C. Ministry of Forests. [1995]. Biodiversity guidebook. B.C. Min. For., Victoria, B.C. In prep.

<sup>8</sup> \_\_\_\_\_. [1995]. Riparian management areas guidebook. B.C. Min. For., Victoria, B.C. In prep.

<sup>9</sup> \_\_\_\_\_. [1995]. Managing identified wildlife guidebook. B.C. Min. For., Victoria, B.C. In prep.

## 4.2 Principles and Assumptions for the Recommendations

The impact of harvesting western yew is not fully understood. The management recommendations therefore rest on the following principles and assumptions:

- Maintenance of a broad geographic distribution of western yew ecosystems will sustain its genetic diversity.
- Current information on distribution and abundance supports the assumption that some level of western yew harvest is possible.
- Retention of 50% of western yew on partial harvest sites will provide a sufficient seed source for future regeneration and connectivity between populations.<sup>10</sup>
- Sex ratios do not significantly differ from 1:1 for both the tree and shrub form.
- Western yew is sensitive to fire, and prescribed burning on clearcuts will significantly decrease the potential for regeneration to pre-harvest levels.

## 4.3 Management Recommendations

The following sections provide recommendations for landscape and stand-level management of western yew. Sections 4.3.1, 4.3.2, and 4.3.3 provide recommendations for whole-tree (or shrub) harvest, and Section 4.3.4 provides recommendations for harvesting western yew needles.

### 4.3.1 Management of western yew in landscapes

#### RECOMMENDATION 1:

*Ecosystems where western yew occurs should be represented and maintained in landscapes. To maintain western yew viability, populations should be sufficiently dispersed or connected in the landscape.*

For planning purposes, a landscape is generally defined as a watershed or a series of interacting watersheds up to 100 000 ha in size.

A draft guidebook by the B.C. Ministries of Forests (1995)<sup>11</sup> provides recommendations for maintaining biological diversity in landscapes and proposes the use of Forest Ecosystem Networks (FENs). Establishment of FENs will be part of a long-term management approach to retain a network of representative ecosystems in managed landscapes. A FEN may consist of a variety of areas subject to timber harvesting constraints, including

existing protected areas (e.g., ecological reserves, wilderness areas, and parks), sensitive areas (e.g., riparian areas, wildlife areas, and areas of unstable terrain) and Old-Growth Management Areas. Since the components of a FEN will remain relatively undisturbed and will be designed to interconnect with one another as much as possible, they will be a useful mechanism to achieve landscape-level management goals for western yew.

#### RECOMMENDATION 2:

*Western yew should not be harvested in special ecosystems, including the high-elevation ecosystems of Mountain Hemlock, Montane Spruce, and Engelmann Spruce–Subalpine Fir; dry sites in regional climates like the Interior Douglas-fir (IDFmw and ww); the Coastal Western Hemlock (CWHxm); and the Interior Cedar–Hemlock (ICHxw) biogeoclimatic zones.*

Special ecosystems could include those exhibiting unusual geological, soil, vegetative, and climatic characteristics. For western yew, examples include soils derived from calcareous and serpentine parent materials; populations found at elevations greater than 800 m on the coast and 1200 m in the interior; and those on extremely dry sites.

#### RECOMMENDATION 3:

*Western yew should not be harvested in outlier populations.*

Small populations, disjunct from the main distribution of western yew, may be sufficiently isolated to be identified as outliers. Populations in unique ecological environments, as well as outlier populations, possess the potential for the evolution of new and unique genotypes.

### 4.3.2 The link between landscape and stand-level management

A stand is an area of forested land which is relatively uniform in species composition, structure, age, arrangement, and site quality. While stands subject to timber harvesting constraints (e.g., those areas that may be FEN components) can be important for maintaining western yew populations across the landscape, more intensively managed stands in which silvicultural activities maintain structural diversity, (generally the forested areas outside FENs), can also, in aggregate, contribute significantly to the goal of maintaining biologically diverse western yew ecosystems in a landscape.

<sup>10</sup> Follows the recommendations put forth by the U.S. Dep. Agric. 1992. Further research is required to determine if this level of retention is satisfactory.

<sup>11</sup> B.C. Ministry of Forests. [1995]. Biodiversity guidebook. B.C. Min. For., Victoria, B.C. In prep.

### 4.3.3 Management of western yew in stands

Stand-level management focuses on the maintenance of stand attributes, and requires that particular attention be given to the method and extent of western yew harvest in stands.

#### General recommendations

**RECOMMENDATION 4:** \_\_\_\_\_  
*Where inventory information is not available, it should be obtained before harvesting occurs.*

This information will allow for an evaluation of the effects of harvesting, site preparation, and stand-tending on future western yew populations. Some forest districts are already collecting inventory data on western yew in their regular timber cruises.

**RECOMMENDATION 5:** \_\_\_\_\_  
*Western yew trees should be cut so that stumps are at least 25 cm above ground level, with bark and cambium intact.*

Stumps higher than 25 cm provide more dormant sprout buds than shorter stumps (U.S. Dep. Agric. 1992). Damage to bark and cambium may reduce the stump's ability to resprout.

**RECOMMENDATION 6:** \_\_\_\_\_  
*Bark should be peeled from all harvested trees including branches with end diameters greater than 2.5 cm.*

At present, the wood remaining after bark harvest may be left as logging slash. If there is increased interest in using western yew wood in the future, however, this recommendation may require some adjustment.

**RECOMMENDATION 7:** \_\_\_\_\_  
*Alternatives to broadcast burning (e.g., spot burning, pile and burn, no burn) should be considered for sites where western yew grows. If burning is deemed essential, and 50% of western yew trees or stumps cannot be saved, then western yew in adjacent areas should not be harvested.*

Western yew bark is thin and is not fire-resistant. The use of prescribed fire to remove organic materials from a site often kills stumps and rootstocks, reducing the rate of western yew regeneration.

**RECOMMENDATION 8:** \_\_\_\_\_  
*The success of western yew regeneration should be evaluated in regeneration surveys.*

Protection of some western yew seedlings and sprouting stumps may be required in areas of heavy ungulate browsing.

#### Areas subject to timber harvesting constraints

**RECOMMENDATION 9:** \_\_\_\_\_  
*Western yew may be harvested in some areas subject*

*to timber harvesting constraints (e.g., riparian areas, wildlife areas, Environmentally Sensitive Areas, and Old-Growth Management Areas), but the extent and method of harvest should support the management objectives for these areas.*

a) *In riparian areas, harvesting should incorporate regulations and standards of the Forest Practices Code and the recommendations presented in riparian management area and biodiversity guidebooks. Western yew should not be harvested in the 'reserve zone' of riparian management areas (Forest Practices regulations). In the 'management zone,' when harvest is deemed ecologically suitable, not more than 50% of western yew in each diameter class (4-20, 21-40, 41+ cm) should be harvested.*

Western yew is frequently restricted to stream edges especially in drier climates and higher elevation sites. The extensive root system of western yew may provide for stream bank stability (Scher and Schwarzschild 1989). On Class A and B streams it may provide shading to stream fish.

The proposed Forest Practices regulations dictate that riparian management areas be established along all streams, lakes, and wetlands. Riparian management areas will comprise a reserve zone (in which no harvesting is permitted) and a management zone (permitting harvest, where ecologically suitable, by selection silviculture systems). The minimum size of reserve and management zones will depend on the size of the stream and/or water body.

b) *In wildlife areas, western yew should be harvested only if removal would not have adverse effects on existing wildlife populations. Wildlife biologists should be consulted to assess this risk. Western yew should not be harvested in juvenile or mature stands where there is evidence that it is being extensively utilized by wildlife.*

Western yew in early seral and juvenile second-growth stands are a preferred food source, particularly for deer in summer. In the winter, western yew, in mature forests, is an important source of food when winter snow depths preclude access to open areas (Pierce 1984; Peek et al. 1987; Simpson et al. 1988).

c) *In Environmentally Sensitive Areas (ESAs), western yew harvesting could be considered, but the level of harvest should not exceed the netdown specifications for that ESA.*

In addition to their timber values, ESAs are areas that have high value for other resources like water, wildlife, fisheries, recreation, etc. The contribution of ESAs to timber harvest is limited. Appendix 7 provides a summary of ESAs and their respective netdown limitations.

- d) *In Old-Growth Management Areas (OGMAs), western yew should not be harvested.*

The biodiversity guidebook recommends the establishment of Old Growth Management Areas (OGMAs) if the target old-growth objectives cannot be achieved within existing protected areas or Sensitive Areas. OGMAs are intended to assist in the preservation of a range of ecosystems in mature and old-growth conditions.

Areas subject to more intensive forest management

**RECOMMENDATION 10:** \_\_\_\_\_

*In more intensively managed forests, western yew should be harvested only in areas approved for logging operations (i.e., forested Crown Land with an approved silviculture prescription and cutting permit in place) unless it would otherwise be destroyed (e.g., road or landing construction). The method and extent of western yew harvest will depend on the silvicultural system used for logging operations.*

While the areas described in Recommendation 9 are subject to timber harvesting constraints and may form the components of FENs, the managed forest outside FENs may be subject to more intensive forest management.

Two classes of silvicultural systems direct the method by which timber is harvested in British Columbia: even-aged (e.g., clearcut, shelterwood, and seed-tree silvicultural systems) and uneven-aged systems (e.g., selection systems) (Matthews 1989; B.C. Ministry of Forests 1991).

Even-aged silvicultural systems may retain patches of green trees (group reserves), or scattered green trees (individual tree reserves), or both, throughout the rotation of a cutblock for their biodiversity value or to mimic natural disturbance. Group reserves may also be left in areas that pose problems for harvesting, yarding, or regeneration (i.e., near gullies or rock outcrops).

Under uneven-aged silvicultural systems, mature and immature trees are harvested singly (i.e., partial cut or individual tree selection) or in groups (i.e., group selection).

Recommendations 11, 12, and 13 address levels of

western yew harvest in areas scheduled to be logged using even-aged and uneven-aged silvicultural systems. Western yew may be removed before full-scale logging operations or may be salvaged following logging.

**RECOMMENDATION 11:** \_\_\_\_\_

*In stands subject to even-aged management (e.g., clearcutting, shelterwood silvicultural systems):*

- a) *Scattered, healthy western yew, of various sizes, should be left as individual tree reserves in a cutblock, and group reserves should contain a western yew component.* These trees will contribute to the vertical diversity of future stands and will also act as seed sources.
- b) *Western yew trees along a cutblock boundary should not be harvested.* In addition to any western yew retained within the cutblock, the trees on the cutblock edges will provide a seed source for regeneration.
- c) *If stump sprouting is to be an important method of regeneration on these sites, individual tree reserves (of any species) should be left to provide partial shading for western yew stumps.* Western yew stumps sprout readily in selectively logged forests with moderate amounts of shading. Stumps subjected to direct sunlight are prone to desiccation. Alternative methods of stump shading should be investigated.

**RECOMMENDATION 12:** \_\_\_\_\_

*In stands subject to uneven-aged management, using individual tree selection silvicultural systems:*

- a) *On sites where western yew occurs as a tree, no more than 50% of each diameter class should be harvested. Areas should not be re-entered for additional harvest until pre-harvest levels of western yew are attained.* This step will help to maintain western yew as an important structural component in these stands.
- b) *On sites where western yew occurs as a shrub (e.g., young stands, talus slopes, and matures forests), no more than 50% of shrubs, with basal diameters greater than 2.5 cm, should be harvested. The remaining shrubs should mimic the original distribution patterns in the harvest area, and should be retained undamaged. Areas should not be re-entered for additional harvest until pre-harvest levels of western yew are attained.*

**RECOMMENDATION 13:** \_\_\_\_\_

*In stands subject to uneven-aged management, using group selection silvicultural systems:*

- a) *Western yew should be harvested only from group selection openings.*

- b) *Some healthy western yew of various sizes should be left as individual tree (or shrub) reserves in group selection openings.*
- c) *Western yew should not be harvested from patches of undisturbed forest remaining in the cutblock.*
- d) *Except for individual tree (or shrub) reserves, bark may be harvested from all usable western yew in group selection openings.*
- e) *Individual tree reserves, of any species, should be left in group selection openings to provide partial shading for resprouting western yew stumps.*

**RECOMMENDATION 14:** \_\_\_\_\_

*If western yew is to be harvested in young stands, it should be harvested essentially as a thinning operation before treatments such as spacing, pruning, or brushing occur.* Some unburned, 15 to 25-year-old clearcut sites support extensive populations of the shrub form of western yew. Most of the western yew on these sites regenerate vegetatively, primarily by rootstock sprouting.

- a) *Recommendations for maintaining biodiversity during juvenile spacing should be followed.* A report providing guidelines to maintain biodiversity during juvenile spacing (B.C. Ministry of Environment 1993) and the biodiversity guidebook should be consulted before western yew is harvested in young stands.
- b) *Where western yew occurs in young stands, the recommended harvest levels for the shrub form apply (see Recommendation 12b).*
- c) *Western yew should not be harvested from wildlife screens (e.g., roadside buffers).* It is often an integral component of the screen and conceals wildlife from view.

**4.3.4 Needle harvest**

At present, western yew foliage is not extensively harvested in wild stands. Taxol extraction from

needles now focuses on harvesting needles from domestically cultivated English yew (*Taxus baccata*). Needles harvested from wild stands are not expected to be a major source of taxol.

Where harvest of needles from trees and shrubs in the wild is practical, it may be appropriate to harvest needles in some areas where no or limited whole-tree (or shrub) harvest of western yew occurs (e.g., sensitive areas, Old-Growth Management Areas, managed forests outside FENs that are not approved for logging).

**RECOMMENDATION 15:** \_\_\_\_\_

*In some areas where whole-tree (or shrub) harvest is limited, western yew needles may be harvested.*

- a) *Needles should be harvested from only 50% of western yew trees by diameter class (4–20, 21–40, 41+ cm) and from an equal number of male and female trees.*
- b) *No more than 50% of foliage should be harvested from any one tree (or shrub), evenly distributed throughout the crown to preserve some sexual buds on the new growth. Large main branches should not be cut.*
- c) *Where browsing by ungulates is evident, foliage should be retained up to 2 m above the ground.*
- d) *In areas where the shrub form predominates, no more than 50% western yew crown cover, evenly distributed throughout the stand, should be harvested. The remaining 50% crown cover should be left as undamaged shrubs.*
- e) *Harvested areas should be re-entered only after total foliage recovery, and the same trees (or shrubs) should be harvested at each re-entry.* Repeated foliage harvest may reduce sexual reproduction and natural regeneration. (Allison 1990, U.S. Dep. Agric. 1992). The unharvested trees remaining should provide sufficient seed source.

These recommendations are geared to both providing bark (or needles) for taxol extraction and preserving the biological diversity of western yew and the ecosystems in which it occurs. However, more biological information is required to improve the management of western yew. Some specific areas that require further research include:

- western yew population and stand dynamics (e.g., studies of seedling recruitment and survivorship, growth and reproductive rates, and the factors that affect these rates);
- the impacts of harvesting on western yew populations and ecosystems;

- the effects of natural disturbance (e.g., fire or pests) on western yew populations;
- various aspects of reproductive biology (e.g., seed germination requirements, reproductive strategies, growth, and development);
- general physiology, including studies of the nutritive requirements of western yew; and
- the distribution and abundance of western yew in seral ecosystems.

While the recommendations presented in this report are likely to change as new biological information becomes available, they provide an initial framework for developing more comprehensive management guidelines.

**Letter of Authorization—Western Yew**

Date: \_\_\_\_\_

To whom it may concern:

As a designated agent of \_\_\_\_\_  
(licencee name)

I hereby authorize \_\_\_\_\_  
(name of person and address)

representing \_\_\_\_\_  
\_\_\_\_\_  
(self or company name and address)

to harvest western yew \_\_\_\_\_  
(bark, wood, or bark and wood)

from the following areas which are currently approved by the Ministry of Forests for harvesting operations:

Tenure (Licence No.)	Cutting Permit No.	Cutblock No.

This authorization is only valid for the above noted areas. Operations on any other areas are illegal and may result in charges being assessed. All harvesting is subject to the requirements of the *Forest Act* and all of the conditions of the above-noted tenures. All shipments must be accompanied by a *Shipping Notice* which will serve the same purpose as load destination notices for minor forest products.

This authorization is valid for the following (time) period: \_\_\_\_\_, is not transferable, and may be revoked at any time. Unauthorized operations may result in charges being assessed by the Ministry of Forests.

Signed: \_\_\_\_\_  
(name)  
\_\_\_\_\_  
(position)  
\_\_\_\_\_  
(company)

---

<sup>a</sup> Extracted from the Ministry Policy Manual: Resource Management (B.C. Ministry of Forests 1993).

### Shipping Notice–Western Yew

This form is to be carried with the shipment and must be left with the buyer at destination as a permanent record.

Date of Shipment \_\_\_\_\_

Delivered from \_\_\_\_\_  
(Forest District) (Forest Region)

Producer \_\_\_\_\_  
(Name and Address)

Authorized by \_\_\_\_\_  
 (Licencee) (Company Name[s])

\_\_\_\_\_  
(Name of Company Representative)<sup>b</sup>

\_\_\_\_\_  
(Signature of Company Representative)

Locale(s) of origin (Licence No. Cutting Permit No. Cutblock No.) List	No. of trees harvested	Approximate weight of bark (wet) –kg

Weight of bark \_\_\_\_\_(kg) \_\_\_\_\_ Dry weight  
 (according to payment)

\_\_\_\_\_ Wet weight

Delivered to \_\_\_\_\_  
(Buyer's, or Collector's name)

Location \_\_\_\_\_

\_\_\_\_\_  
(Address)

<sup>a</sup> Extracted from the Ministry Policy Manual: Resource Management (B.C. Ministry of Forests 1993).

<sup>b</sup> Company representative to retain a copy of this completed shipping notice.



**Western Yew Bark Register<sup>a</sup>**

For: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

(Collector's Name, Address and Signature)

Collector's or buyer's record of purchases for the calendar year ended December 31, 19\_\_\_\_.

<b>Date of purchase</b>	<b>Names and addresses of sellers</b>	<b>Weight of bark purchased (kg wet or dry)</b>	<b>Source (location) of bark harvest (Licence No., Cutting Permit No., Cutblock No.)</b>	<b>Names and addresses of person issuing Authorization to Harvest</b>

<sup>a</sup> Extracted from the Ministry Policy Manual: Resource Management (B.C. Ministry of Forests 1993).  
**Note:** A photocopy of this record shall be submitted yearly by the wholesaler or buyer to the Regional Manager as an annual report.

APPENDIX 4 Biogeoclimatic occurrence of western yew in British Columbia

TABLE A1 *Western yew occurrence in coastal biogeoclimatic units*

Biogeoclimatic zone <sup>a</sup>	No. of plots reviewed	Prevalence <sup>b</sup> (%)	Average crown cover (%)
<b>Coastal Douglas-fir:</b>			
CDFmm	396	19	3.8
<b>Coastal Western Hemlock:</b>			
CWHxm1	159	3	3.2
CWHxm2	389	4	3.1
CWHdm	306	12	1.0
CWHds1	40	25	5.4
CWHds2	23	0	0.0
CWHmm1	98	10	2.4
CWHmm2	45	0	0.0
CWHms1	38	21	1.4
CWHms2	112	7	3.7
CWHwh1	197	20	2.0
CWHwh2	79	9	0.8
CWHwm	71	0	0.0
CWHws1	92	0	0.0
CWHws2	160	0	0.0
CWHvh1	294	11	2.7
CWHvh2	419	16	1.0
CWHvm1	749	12	2.4
CWHvm2	191	8	1.6
<b>Mountain Hemlock:</b>			
MHmm1	140	<1	2.0
MHmm2	81	0	0.0
MHwh1	18	<1	2.0
MHwh2	19	5	0.2

<sup>a</sup> The lower-case alphabetic symbols used for subzones designate precipitation (x - very dry, d - dry, m - moist, w - wet, v - very wet) and continentality (h - hypermarine, m - maritime, s - submarine).

<sup>b</sup> Percentage of plots reviewed that contained yew.

APPENDIX 4 (Continued)

TABLE A2 *Western yew occurrence in interior biogeoclimatic units*

Biogeoclimatic zone <sup>a</sup>	No. of plots reviewed	Prevalence <sup>b</sup> (%)	Average crown cover (%)
<b>Interior Douglas-fir:</b>			
IDF <sub>xh1</sub>	137	0	0.0
IDF <sub>xh2</sub>	91	0	0.0
IDF <sub>xw</sub>	29	0	0.0
IDF <sub>xm</sub>	39	0	0.0
IDF <sub>dm1</sub>	89	0	0.0
IDF <sub>dm2</sub>	34	0	0.0
IDF <sub>dk1</sub>	118	0	0.0
IDF <sub>dk2</sub>	130	0	0.0
IDF <sub>dk3</sub>	45	0	0.0
IDF <sub>dk4</sub>	33	0	0.0
IDF <sub>mw1</sub>	74	4	3.2
IDF <sub>mw2</sub>	78	3	0.8
IDF <sub>ww</sub>	84	1	1.0
<b>Interior Cedar–Hemlock:</b>			
ICH <sub>xw</sub>	6	17	2.0
ICH <sub>dw</sub>	71	30	4.7
ICH <sub>dk</sub>	34	0	0.0
ICH <sub>mw1</sub>	37	24	7.5
ICH <sub>mw2</sub>	206	41	4.7
ICH <sub>mw3</sub>	88	19	5.0
ICH <sub>mm</sub>	53	9	0.7
ICH <sub>mk1</sub>	92	6	2.2
ICH <sub>mk2</sub>	42	0	0.0
ICH <sub>mk3</sub>	35	12	1.8
ICH <sub>mc1</sub>	63	0	0.0
ICH <sub>mc1a</sub>	15	0	0.0
ICH <sub>mc2</sub>	175	0	0.0
ICH <sub>wk1</sub>	158	36	2.1
ICH <sub>wk2</sub>	67	40	4.2
ICH <sub>wk3</sub>	56	0	0.0
ICH <sub>wk4</sub>	51	0	0.0
ICH <sub>vk1</sub>	71	41	1.8
ICH <sub>vk2</sub>	64	0	0.0
ICH <sub>vc1</sub>	16	0	0.0
ICH <sub>vc2</sub>	8	0	0.0
<b>Montane Spruce:</b>			
MS <sub>xv</sub>	183	0	0.0
MS <sub>dm1</sub>	172	0	0.0
MS <sub>dm2</sub>	104	0	0.0
MS <sub>dk</sub>	129	<1	1.5
MS <sub>dc</sub>	50	0	0.0
<b>Engelmann Spruce–Subalpine Fir:</b>			
ESS <sub>xc</sub>	66	0	0.0
ESS <sub>xv</sub>	2	0	0.0
ESS <sub>dk</sub>	59	0	0.0
ESS <sub>dc1</sub>	79	0	0.0

APPENDIX 4 (Concluded)

TABLE A2 (Continued)

Biogeoclimatic zone <sup>a</sup>	No. of plots reviewed	Prevalence <sup>b</sup> (%)	Average crown cover (%)
ESSFdc2	45	0	0.0
ESSFdv	70	0	0.0
ESSFmw	40	<1	1.5
ESSFmm	43	0	0.0
ESSFmk	25	0	0.0
ESSFmc	54	0	0.0
ESSFmv1	30	0	0.0
ESSFmv2	45	0	0.0
ESSFmv3	109	0	0.0
ESSFmv4	43	0	0.0
ESSFwm	16	0	0.0
ESSFwk1	97	0	0.0
ESSFwk2	39	0	0.0
ESSFwc1	16	0	0.0
ESSFwc2	83	0	0.0
ESSFwc3	41	0	0.0
ESSFwc4	74	0	0.0
ESSFwv	74	0	0.0
ESSFvc	62	0	0.0
ESSFvv	26	0	0.0

<sup>a</sup> The lower-case alphabetic symbols used for subzones designate precipitation (x - very dry, d - dry, m - moist, w - wet, v - very wet) and temperature (h - hot, w - warm, k - cool, c - cold, v - very cold).

<sup>b</sup> Percentage of plots reviewed that contained yew.

**Amabilis fir forests**

(CWH; occasionally in the ICH along the coast transition)

BaCw–Devil’s club  
BaCw–Foamflower  
BaCw–Oak fern  
BaSs–Devil’s club

**Coastal western redcedar forests**

(CWH, CDF)

Cw–Indian plum  
Cw–Sword fern  
Cw–Skunk cabbage  
Cw–Slough sedge  
Cw–Solomon’s-seal  
Cw–Lady fern  
CwHw–Blueberry  
CwSs–Skunk cabbage  
CwSs–Salal  
CwYc–Goldthread  
CwYc–Salal

**Coastal western hemlock forests**

(CWH)

Hw–Flat moss  
HwBa–Blueberry  
HwBa–Deer fern  
HwBa–Pipecleaner moss  
HwBa–Step moss  
HwCw–Deer fern  
HwCw–Salal  
HwFd–Cat’s-tail moss  
HwFd–Kindbergia

**Interior western redcedar–western hemlock forests**

(ICH and IDF)

CwFd–Devil’s club–Lady fern  
CwFd–Falsebox  
CwHw–Horsetail  
CwFd–Feathermoss  
CwHw–Oak fern  
CwHw–Oak fern–Foamflower  
CwHw–Oak fern–Spiny wood fern  
CwHw–Devil’s club–Lady fern  
HwCw–Falsebox–Feathermoss  
HwCw–Falsebox–Step moss  
HwCw–Spruce–Step moss  
Cw–Foamflower

**Mountain hemlock–amabilis fir forests**

(MH)

BaHm–Oak fern

**Mountain hemlock–yellow-cedar forests**

(MH)

HmYc–Goldthread

**Sitka spruce forests**

(CWH, infrequent in MH)

Ss–Lily-of-the-valley  
Ss–Slough sedge

**Interior Douglas-fir forests**

(mainly IDF but also ICH)

FdCw–Hazelnut  
FdCw–Falsebox–Prince’s pine  
Fd–Pinegrass–Feathermoss

**Coastal Douglas-fir forests**

(CDF and CWH)

Fd–Salal  
FdBg–Oregon grape  
FdHw–Falsebox  
FdHw–Salal  
FdPl–Arbutus

**Interior western redcedar–spruce forests**

(mainly ICH, often IDF)

CwSxw–Devil’s club–Horsetail  
CwSxw–Falsebox–Knight’s plume  
CwSxw–Skunk cabbage

**Shore pine forests**

(CWH and CDF)

Pl–Sphagnum  
PlYc–Sphagnum

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<sup>a</sup> Tree species codes: Ba - amabilis fir, Bg - grand fir, Cw - western redcedar, Fd - Douglas-fir, Hm - Mountain hemlock, Hw - western hemlock, Pl - lodgepole pine, Ss - Sitka spruce, Sxw - spruce hybrid, Yc - yellow cedar.

**Diseases**

**Foliage diseases:** Snow blights caused by *Phacidium taxicola* Dearn. and House, and *Herpotrichia juniperi* (Duby) Petr. result in localized damage to foliage buried under snow for prolonged periods (Farr et al. 1989). Hepting (1971) also cites snow blights caused by *Neopeckia coulteri* (Peck) Sacc.

*Macrophoma taxi* (Berk.) Berl. and Vog. and *Dothiora taxicola* (Peck) Barr. (Farr et al. 1989) are reported to cause needle blights on western yew in British Columbia (Taylor and Taylor 1981). *Herpotrichia juniperi* (Duby) Petr., *Dothiora taxicola*, *Mycosphaerella taxi* (Cooke) Lind, and *Phyllosticta concentrica* Sacc., were identified in the United States (Hepting 1971; Farr et al. 1989).

**Stem diseases:** Twig blights are attributed to *Phylospora gregaria* Sacc. (Funk 1981) and *Phyllosticta concentrica* (Farr et al. 1989). *Diplodia taxi* (Sowerby) De Not. is reported to cause stem cankers (Hepting 1971).

**Root Diseases:** *Armillaria ostoyae* (Romag.) Herink causes root rot (U.S. Dep. Agric. 1992). *Phaeolus schweinitzii* (Fr.:Fr.) Pat. was docu-

mented to cause root rot in Idaho. *Phytophthora lateralis*, which causes root disease in Port Orford-cedar in southwestern Oregon and northern California, was isolated and identified in several dying western yew trees (U.S. Dep. Agric. 1992).

**Insect pests**

**Mites:** *Cecidophyopsis psilaspis* Nel., the western yew big bud mite, attacks buds, producing distinctive morphological changes in foliage (A. Mitchell, Natural Resources Canada, pers. comm.). To date, these mites have been observed in coastal samples but not in samples collected from interior populations. Spider mites (Tetranychidae) are also reported in association with western yew in British Columbia (Taylor and Taylor 1981).

**Weevils:** *Otiorhynchus singularis* L., the clay coloured weevil, causes shoot dieback (B. Duncan, Natural Resources Canada, pers. comm.).

**Moths:** *Argyrotaenia citrana* Fern., the orange tortrix, damages buds (B. Duncan, Natural Resources Canada, pers. comm.).

Environmentally sensitive areas are shown on forest cover maps and have been used for harvest planning and timber supply review and Annual Allowable Cut calculations. ESAs will, however, be replaced with designated sensitive areas.

**Soils - Es**

- Es1 Areas having extremely fragile or unstable soils. Harvesting is likely to be severely limited in these areas because it would lead to unacceptable site deterioration. Netdown is usually 90%.
- Es2 Areas having significantly fragile or unstable soils but less than those designated Es1. Harvesting is conditional. This designation is for “red flagging” areas for further field examination. Netdown is usually 50%.

**Forest regeneration - Ep**

- Ep1 Areas where climatic conditions cause severe forest regeneration problems, making them unavailable for sustained timber harvesting. Netdown is usually 90%.
- Ep2 Areas where brush, wildlife, or cattle cause severe forest regeneration problems. Sustained harvesting of these areas requires special management of these biotic factors. Netdown is usually 50%.

**Snow Avalanche - Ea**

- Ea This category is intended to protect constructed and natural resources from snow avalanches. Resources include roads, railways, industrial and residential areas, recreational sites, and forest land of medium to high site quality. Netdown is usually 90%.

**Recreation - Er**

- Er1 Areas having exceptionally high value for recreation or viewing, where harvesting is likely to be severely limited. Netdown is usually 90%.
- Er2 Areas having high value for recreation or viewing, but less than Er1. Forest harvesting is conditional in these areas. Netdown is usually 50%.

**Wildlife - Ew**

- Ew1 Areas of critical importance to wildlife for

food, shelter, and reproduction. Included are habitat areas for endangered and threatened species; deer, elk, and moose winter ranges; and other special wildlife areas identified by the B.C. Ministry of Environment, Lands and Parks. Netdown is usually 100%.

- Ew2 Areas where a significant portion of the timber is important to wildlife. Included are deer winter ranges in low snowfall areas; grizzly bear habitat; Riparian Management Zones; areas for Forest Ecosystem Network linkages; and areas under short-term deferral to protect nesting sites for eagles, ospreys, or herons, and under temporary deferral (until further data are available) for marbled murrelet nesting corridors. Netdown is usually 50%.

**Watershed-Eh**

- Eh1 Areas where timber harvesting would have long-term adverse effects on water quality, quantity, or the seasonal distribution of its consumptive use. Netdown is usually at least 80%.
- Eh2 Areas that have high water values for consumptive use and are sensitive to timber harvesting (though less sensitive than Eh1 areas). Harvesting in Eh2 areas is subject to special management conditions. Netdown is usually 50%.

**Fisheries - Ef**

- Ef1 Areas along streams that have fish spawning and highly productive rearing areas. These areas or buffers are known as Streamside Management Zones and are highly sensitive to timber harvesting. Included are 30 m buffers around lakes and estuaries. Netdown is usually at least 80%.
- Ef2 Areas containing braided stream channels and floodplains that are suitable for spawning and fish rearing. These areas are known as Fisheries Sensitive Zones. They are not as sensitive to timber harvesting as Ef1 areas. Netdown is usually 50%.

<sup>a</sup> Extracted from: B.C. Ministry of Forests. [1995]. Biodiversity guidebook (draft version). B.C. Min. For., Victoria, B.C. In prep.

- abundance:** in this report, abundance is expressed as the % cover of a plot in a defined area (i.e., 400 m<sup>2</sup>), or the number of tree stems contained in a hectare.
- anadromous:** pertaining to fish that migrate from salt water to fresh water streams to spawn (e.g., salmon).
- angiosperm:** a flowering plant.
- biogeoclimatic zone:** a geographic unit with a broadly homogeneous macroclimate.
- Class A stream:** a stream or portion of a stream frequented by anadromous salmonids and/or resident sport fish or regionally significant fish species (i.e., a species designated in a special management plan or identified as rare or endangered); or a stream that has been identified for fishery enhancement in an approved fishery management plan. Stream gradient is usually less than 12%.
- Class B stream:** a stream or portion of a stream that is populated by resident fish not currently designated as sport fish or regionally significant fish. Stream gradient is usually 8–20%.
- clearcutting system:** an even-aged silvicultural system in which all trees are removed from an area of forested land in a single cut.
- climax:** the mature or stabilized stage of natural forest succession in which communities are self-perpetuating and species composition remains relatively constant over time; ecosystems arrive at climax through a process called succession.
- clone:** any of two or more individuals with identical genetic makeup, propagated from a single ancestor or parent.
- clone bank:** a place of storage for clones; in forestry, generally refers to the collection and storage of rooted cuttings, from any tree species, outside their natural habitat in greenhouses or common gardens.
- Crown land:** a category of land ownership under which provincial legislation, regulation, and policy set the guidelines directing management and administration. Approximately 95% of land in British Columbia is Crown land.
- cutblock:** a forested area of land designated for timber harvesting.
- cutting permit:** a permit, authorized under the *Forest Act*, that provides a licensee with the right to harvest trees in areas with an approved management plan.
- duff:** the litter and decomposed organic matter making up the forest floor.
- endangered species:** any species threatened with imminent extinction or extirpation throughout all, or a significant portion of, its British Columbia range (see also extirpated, extinct, threatened, and vulnerable species).
- Environmentally Sensitive Areas (ESAs):** include potentially fragile or unstable soils that may deteriorate after forest harvesting, and areas of high value to non-timber resources such as fisheries, wildlife, water, and recreation.
- even-aged management:** forest management practices that create stands of trees of the same age or of the same age class. Includes clearcutting, shelterwood, and seed-tree silvicultural systems.
- ex situ:** with reference to gene conservation of forest trees, the preservation of genetic material outside its natural habitat (e.g., in botanical gardens, test plantations, tissue cultures, or clone banks).
- extinct species:** a species formerly indigenous to British Columbia that no longer exists anywhere.
- extirpated species:** a species no longer existing in the wild in British Columbia but occurring elsewhere.
- floodplain:** the level or nearly level land that borders a stream or river and is subject to flooding.

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<sup>a</sup> Some of the definitions in this glossary have been extracted from the following publications: B.C. Ministry of Forests 1991; Environment Canada 1993; B.C. Ministry of Forests [1995]. Biodiversity guidebook. B.C. Min. For., Victoria, B.C. In prep.



- Forest Ecosystem Network (FEN):** a planned landscape zone that serves to maintain or restore the natural connectivity within a landscape unit. A FEN consists of a variety of fully protected areas, Environmentally Sensitive Areas, and Old-Growth Management Areas.
- forest licence:** a forest tenure administered by the B.C. Ministry of Forests that grants the licensee the right to harvest a specific volume of timber each year. The licence may require that the licensee be responsible for regeneration and stand-tending activities.
- genotype:** the genetic constitution of an organism.
- green tree retention:** the maintenance of live trees retained after harvest for various biodiversity values (e.g., for wildlife or as a source of coarse woody debris).
- group selection silvicultural system:** a silvicultural system in which clumps of mature trees are harvested continuously over short periods of time, resulting in an uneven-aged stand structure. Group selection openings resemble small clearcuts but are generally not larger than one or two tree lengths wide.
- individual tree selection silvicultural system:** a silvicultural system in which scattered, single trees of various diameter classes are harvested continuously or over short intervals, resulting in an uneven-aged stand structure.
- in situ:** with reference to gene conservation of forest trees, the preservation of genetic material in its natural habitat (e.g., in protected areas).
- juvenile spacing:** the reduction of tree density in pre-commercial stands.
- landscape:** in this report, a watershed or a series of interacting watersheds up to 100 000 ha in size.
- landscape-level management:** a level of forest management concerned with maintaining diversity of age classes, species mix, and ecosystems over landscapes.
- managed forest:** that portion of the landscape outside protected areas where forestry operations occur.
- management zone:** the outer portion of a riparian management area situated adjacent to a stream, lake, or wetland and established to conserve and maintain the productivity of aquatic and riparian ecosystems when harvesting is permitted.
- morphology:** shape and form.
- mychorrhizae:** an association between a fungus and the roots of a higher plant which may be located on or in the root.
- netdown:** an estimate of the amount of timber reserved from harvesting.
- protected area:** permanent geographic areas that are legally designated as protected from certain specified activities.
- poling operation:** the removal of trees of a specified diameter to produce special forest products such as fence posts, rails, or utility poles.
- reserve zone:** the inner portion of a riparian management area situated adjacent to a stream, lake, or wetland and established to conserve and maintain the productivity of aquatic and riparian ecosystems when harvesting is not permitted.
- riparian area:** an area adjacent to the high water mark that borders streams, rivers, lakes, or ponds, and the surrounding portion of land influenced by the water body.
- riparian management area (RMA):** a classified area of specified width surrounding or adjacent to streams, lakes, riparian areas, and wetlands. The RMA includes, in many cases, adjacent upland areas. It extends from the top of the streambank (bank full height) or from the edge of a riparian area or wetland, or the natural boundary of a lake, outward to the greater of: 1) the specified RMA distance, 2) the top of the inner gorge, or 3) the edge of the floodplain. Where a riparian area or wetland occurs adjacent to a stream or lake, the RMA is measured from the outer edge of the wetland.

**salmonids:** pertaining or belonging to the Salmonidae family of fishes, including Pacific salmon and trout.

**seed-tree silvicultural system:** an even-aged silvicultural system in which selected standing trees are left scattered throughout the cut block after a harvest operation to act as seed sources for natural regeneration.

**seral:** pertaining to the stages of natural succession that occur before the development of the climax community.

**shelterwood system:** an even-aged silvicultural system in which groups of trees in mature stands are removed in a series of 2–3 cuts. Trees that remain standing provide openings and partial cover for the regenerating understorey.

**silvicultural system:** a process by which forests are harvested, regenerated, and tended.

**slash:** the residue left on the ground after felling and tending or that accumulates as a result of storm, fire girdling, poisoning, disease, or pests.

**stand-level management:** a level of forest management by which a relatively homogeneous geographic unit can be managed under a single silvicultural prescription or set of treatments. Stands are rarely larger than 100 ha.

**succession:** the progressive development of ecosystems towards a climax state where species composition remains relatively constant.

**threatened species:** a species likely to become endangered in British Columbia if the factors affecting its vulnerability are not reversed.

**tree farm licence:** a form of forest tenure; a 25-year licence conveying exclusive rights to harvest by the licensee in a specific area of Crown land.

**uneven-aged management:** management practices that create stands of three or more intermingled age classes; many of the habitat attributes of mature forests may be maintained with uneven-aged management.

**ungulate:** any hoofed wildlife (e.g., deer, moose, elk).

**viability:** with reference to populations, those that are self-sustaining with a high probability of survival despite effects of demographics, changing environments, and natural disasters.

**vesicular-arbuscular:** a type of mycorrhizal fungi that have globular swellings (vesicles) and small, finely branched projections (arbuscles) that infect host cells.

**vulnerable species:** a species that is particularly at risk because of low or declining numbers, small range, or for some other reason, but is not a threatened species.

**watershed:** the entire basin area drained by a stream or a lake.

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