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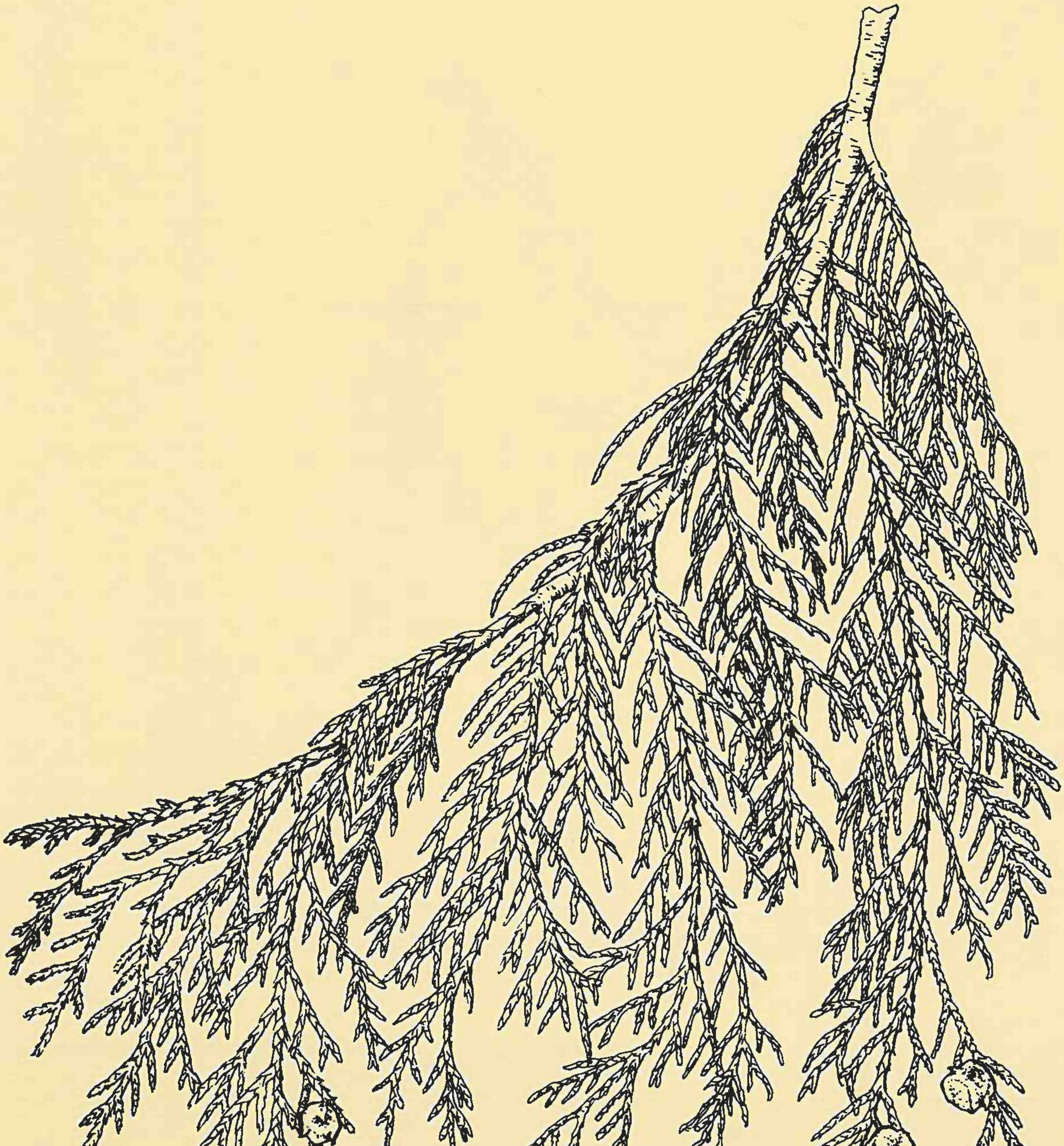
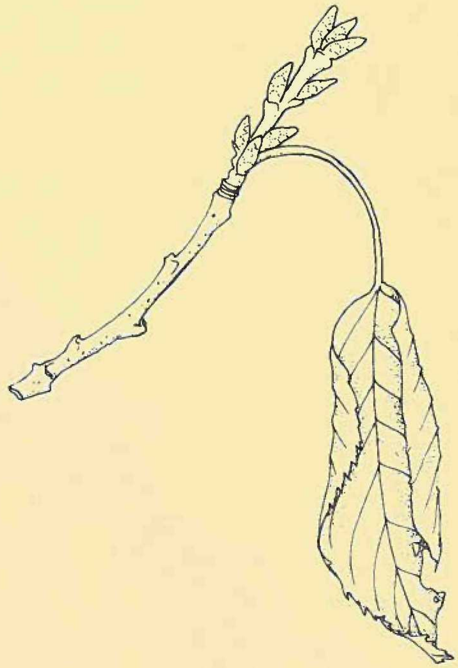


Cover:
A branch of *Chamaecyparis nootkatensis,* the Yellow Cedar.



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The Biogeoclimatic Zones of British Columbia

CHARLES E. BEIL, ROY L. TAYLOR
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The biogeoclimatic zonal system developed by Dr. V.J. Krajina is used by the Botanical Garden as a means of describing the distribution of British Columbian vascular plants. We have often been asked, "What is the biogeoclimatic zonal system?" This article is a response to that question, and provides a basis for understanding the principles underlying the establishment of the zones. In addition, a brief description of each of the zones is given. Other systems for classifying vegetation also exist, including those that are based essentially on climatic data and are intended for the horticulturist and plant grower. A short review of some of these is included.

The Conceptual Basis of the Biogeoclimatic Zonal Classification

The biogeoclimatic classification system developed and elaborated by Krajina (1959, 1965, 1969) provides an ecological framework for the province of B.C. Although the system is widely used, the conceptual basis for it is poorly understood. The only published explanation of the system is a brief account written by Krajina (1965). The conceptual basis for this classification system is described below.

The system deals with two distinct levels of ecological classification: biogeoclimatic and biogeocoenotic. At the biogeoclimatic level, the basic units are climatically defined zones and subzones. The biogeocoenotic level is a community classification in which the basic units are biogeocoenoses (Sukachev 1945), which are concrete segments of the earth's surface composed of a uniform biota and environment. As used by Krajina, they are considered to be uniform in vegetation and soil composition. These units are distinguished by significant differences in floristic and/or soil composition. The biogeocoenosis is equivalent to the plant association (sensu Braun-Blanquet), and can be regarded as the smallest recognizable ecological land unit for the purposes of convenient resource management.

In the B.C. classification system, the biogeoclimatic and biogeocoenotic classification levels are used in an interrelated and complementary fashion in defining and determining the distribution of the biogeoclimatic zones. Initially the biogeoclimatic classification is established. Climate, which forms the basis for this level of classification, is recognized as the overall controlling environmental parameter. The basic unit at this level, the zone, is determined by temperature and precipitation pattern. Each zone is divided into two or more subzones according to the variation in precipitation pattern (although it appears that for some of the northern zones, the subzones are recognized on the basis of temperature). The zone and subzone are the operational units of the biogeoclimatic classification. Since the zones are essentially climatic units, the significance of adding the prefex *biogeo* only becomes apparent after considering the application of the biogeocoenotic level of classification to the overall system.

The zones are in turn grouped together into the broader climatic units of formations and regions. These super-units are strictly geographical and are of little ecological importance.

Within each climatically uniform area (zone or subzone) there will exist numerous distinct habitats. Each habitat consists of a uniform physical environment (i.e., soil, microclimate, topographic position) and supports a uniform plant community. Thus each climatic unit is composed of numerous biogeocoenoses.

The biogeocoenoses of each zone are ranked according to their moisture status into a series ranging from xeric to hygric. Such a ranking also reflects the potential of the sites for production of vegetation. In practice, ranking of the biogeocoenoses is approximated by reference to soil texture characteristics and topographic position. In this ranking system the mesic sites, i.e., those with intermediate soil texture and slope position, are considered to be the ones most in equilibrium with the macroclimate of the zone. Thus climate is thought to be the major factor controlling their development, with neither soil texture nor topography exercising a dominant influence.

Each zone or subzone has only one mesic habitat and biogeocoenosis. All other biogeocoenoses are more xeric or more hygric. The mesic or zonal biogeocoenosis is of paramount importance in defining and naming the zone.

It should be emphasized that the ranking of biogeocoenoses as mesic, xeric or hygric is relative, and is dependent on the macroclimate. What is rated as mesic in a very dry climate might be xeric in a wetter climate. Thus, this ranking of biogeocoenoses can only be used satisfactorily *within* a given zone or subzone, and different amounts of precipitation will be used to set the boundaries on the habitat classes in different zones.

The final step in the system is to consider the successional trends operating within the zones. Each habitat (uniform physical environment) within a zone is considered to have a unique successional sequence culminating in a climax community. The climax community occupying the mesic or zonal habitat is referred to as the climatic climax community. Each zone (or subzone) will have a single climatic climax biogeocoenosis, so called because climate is considered to be the controlling environmental factor in the mesic habitat. Other climax communities within the zone will occupy more xeric or hygric habitats. The controlling environmental factors on these sites will be soil or topographic factors. Thus their climax biogeocoenoses are referred to as edaphic or topographic climaxes. The vegetation of a zone in climax condition is potentially composed of many climax biogeocoenoses, only one of which is the climatic climax biogeocoenosis. All the rest are either topographic or edaphic climaxes. Of course, at any given time a zone will be composed of a series of both successional and climax biogeocoenoses. However, in the classification system, the climax biogeocoenoses are given most weight because they are considered to represent the potential in vegetative growth for each habitat.

The climatic climax biogeocoenosis is most important in the biogeoclimatic system. It is regarded as the central concept of the zone and is representative of the development potential of the zone. All other biogeocoenoses present, either successional or climax, are considered to be evolving towards this end product. Thus each zone can be regarded as an area potentially occupied by a single climax biogeocoenosis, i.e., the climatic climax biogeocoenosis. This unit has a distinct soil type and a distinct community, hence the zones are referred to as *biogeo*climatic.

A biogeocoenosis is classed as climax if the dominant species is reproducing successfully so as to continue dominance. In British Columbia the dominant species of most climax communities are trees. If the dominant tree is well represented in all size classes in the understory, a community is classed as climax. For any given habitat, the tree species that are capable of growing on it can be classed as successional or climax species depending on whether or not they are able to continue to reproduce successfully on the site after forming the overstory. The climax species of the mesic biogeocoenosis of a particular zone is referred to as the climatic climax species of that zone. Theoretically, this species is considered to be the potential climax species for the entire zone. That is, since the mesic biogeocoenosis of each zone is regarded as the central concept of the zone towards which all other biogeocoenoses are evolving, then the climax species of it is regarded as the potential climax for the whole zone.

Each zone is named for the climatic climax tree species, i.e., the tree species which forms the climax on the mesic biogeocoenosis. For example, the Coastal Douglas Fir Biogeoclimatic Zone has Coast Douglas fir as the climatic climax species, since this tree is the species best adapted to continued reproduction on the mesic habitat of this zone. Within the same zone, Douglas fir will be present on other habitats, either more xeric or more hygric. However, it will not become a climax species on such sites because it is not capable of continued reproduction there. These more xeric or hygric sites will be climaxed by other species better adapted to the particular environmental conditions. Such species are referred to as edaphic or topographic climax species.

TABLE 1. An illustration of the effect of shade tolerance on the climax status of a species.

	Biogeoclimatic Zone		
	Ponderosa Pine — Bunchgrass Zone	Interior Douglas Fir Zone	Interior Western Hemlock Zone
Biogeocoenosis	(Dry)	(Humid)	(Perhumid)
Xeric		Ponderosa Pine (topoclimax — shade tolerant) / Douglas Fir (successional — shade requiring)	Douglas Fir (topo-climax — shade tolerant)
Mesic	Ponderosa Pine (climatic climax — shade tolerant) / Douglas Fir (successional — shade requiring)	Douglas Fir (climatic climax — shade tolerant) / Ponderosa Pine (successional — shade intolerant)	Western Hemlock (climatic climax — shade tolerant) / Douglas Fir (successional — shade intolerant)
Hygric	Douglas Fir (topoclimax — shade tolerant) / Ponderosa Pine (successional — shade intolerant)	Western Hemlock (topoclimax — shade tolerant) / Douglas Fir (successional — shade intolerant)	

The coastal variety of Douglas fir will also grow in other biogeoclimatic zones and can become climax on certain habitats. However, it will never be a climax species on the mesic habitat in these other zones. It will always be an edaphic or topographic climax species, since in other climatic zones Douglas fir is not the species best adapted to regeneration under the prevailing climate.

The ranking of dominant species as successional or climax according to their performance on various habitats is important to the conceptual basis of the biogeoclimatic zonal classification. It is based on the proposition that all species have unique ecological amplitudes due to their particular tolerance to environmental factors, and as habitat conditions change, the species distribution patterns will vary. The degree of shade-tolerance a species can maintain on a given habitat determines whether or not it will be a successional or climax species. All climax tree species must be shade-tolerant in order to be able to regenerate under the canopy they create. Successional species are generally shade-intolerant, and therefore unable to regenerate under a closed canopy. Another category, which can also be regarded as successional, contains species which are shade-requiring. Such species can only survive under an existing canopy and therefore will never become climax.

On the mesic site in the Interior Douglas Fir Zone, *Pseudotsuga menziesii* var. *glauca* (Rocky Mountain Douglas fir) is shade-tolerant and forms the climatic climax. On xeric sites in the same zone, it becomes shade-requiring and can only grow as a subcanopy tree. On these drier sites it is suggested that *Pinus ponderosa* is shade-tolerant and will be climax. On hygric sites in the Douglas Fir Zone, Douglas fir is shade-intolerant and therefore capable only of being a successional, pioneer species. On these moister sites, it is suggested that Western hemlock will form the climax. Only on the mesic sites will Douglas fir be shade-tolerant, and hence capable of being a climax species. This is summarized in Table 1.

According to Krajina, the degree of shade-tolerance exhibited by a particular species is closely related to its moisture tolerance, which is kept in balance by its ability to transpire. Douglas fir is adapted to mesic sites in the Douglas Fir Zone and on these intermediate-moisture sites can grow successfully as an understory species. However, when Douglas fir is established on a hygric site in the same climatic zone, it can only tolerate the moist conditions by maintaining a highly increased transpirational rate. In order to do this it must be fully exposed to the sunlight and wind currents. If the tree is placed in a subcanopy position, the humid atmosphere will result in a decreased transpirational rate and Douglas fir will succumb to over-moist soil conditions. As a result, on hygric sites of this climatic zone Douglas fir can only grow as a pioneer species. Conversely, on xeric sites in the Douglas Fir Zone, Douglas fir will only be able to survive by conserving moisture, which is accomplished by decreasing its transpirational rate. The species therefore becomes shade-requiring on these sites. Under an existing canopy a more humid atmosphere is present, thus permitting a reduced transpirational rate.

As previously mentioned, *Pseudotsuga menziesii* var. *glauca* also grows in other biogeoclimatic zones. In these zones however, because of the different macroclimate, it will never be shade-tolerant (and hence climax) on the mesic habitats. For example, in the Ponderosa Pine — Bunchgrass Zone (which is drier than the Interior Douglas Fir Zone), Rocky Mountain Douglas fir is able to become shade-tolerant only on the hygric sites. It therefore becomes a topographic climax species in this zone. On the mesic habitats of the Ponderosa Pine Zone, Ponderosa pine is shade-tolerant and is thus the climatic climax species. On these mesic sites, which are considerably drier than the mesic sites of the Douglas Fir Zone, Douglas fir must conserve water in order to survive. Therefore it becomes a shade-requiring species, incapable of being climax. Similarly, in the Interior Western Hemlock Zone (which is wetter than the Douglas Fir Zone) Douglas fir is never shade-tolerant on the mesic habitats. These sites are considerably wetter than the mesic sites of the Interior Douglas Fir Zone because of the overall higher precipitation of the zone. As a result, Douglas fir will develop here only as a pioneer (successional) species. In the Western Hemlock Zone, Western hemlock (which has a higher moisture tolerance than Douglas fir) is shade-tolerant on the mesic sites and hence becomes the climatic climax species of the zone. However, in this wetter zone, Douglas fir is shade-tolerant only on the xeric sites.

In summary then, in a given climatic zone only one species is shade-tolerant on the mesic sites and capable of becoming the climatic climax species. This species may also occur on xeric or hygric sites within the zone, but on such sites (due to its moisture tolerance requirement) it will never be shade tolerant and thus is incapable of being climax. This same species may be shade tolerant in neighbouring zones, but only on habitats either drier or wetter than the mesic habitat as controlled by the macroclimate of the zone. On the mesic sites of these neighbouring zones another species will be shade tolerant and it will form the climatic climax. Thus each biogeoclimatic zone has a particular species (or group of species) which is adapted to being shade-tolerant on the mesic sites. This species will therefore become the climax dominant of the mesic biogeocoenosis, which is the climatic climax biogeocoenosis and is regarded as representing the ecological potential of the zone. The species which climaxes this biogeocoenosis is used to name the zone.

Other Classification Systems

A useful classification system for forested regions of Canada was first developed by Halliday (1937). This was refined and published as *Forest Regions of Canada* by Rowe (1972). The system is widely used by the Canadian Forest Service and includes descriptive data on soils, geology and climate. Regions are equivalent to "climaxes" as defined by Clements (1928), and are stable, climatically uniform formations characterized by the presence of certain tree species, the climax dominants. The regions are large geographic forest units. Each region is subdivided into forest sections that are marked by the consistent presence of certain plant associations that differ from other associations found in the forest region. These associations are recurring communities of one or more tree species. Eight forest regions are recognized in Canada along with a grassland region and an arctic and alpine tundra region. Five forest regions are found in British Columbia.

The natural vegetation to the south of British Columbia in Washington and Oregon has recently been divided into major regions, each consisting of several zones, by Franklin and Dyrness (1973). The four major groupings or regions are based on physiognomic characters (appearance of the vegetation, its height, colour and luxuriance, and its leaf size and shape). The groupings, which include Forest, Steppe, Timberline and Alpine regions, and the Interior Valleys of Western Oregon, are further subdivided into either vegetation zones or geographical subdivisions. The authors have used the zone as defined by Daubenmire (1968) to represent an area in which one plant association is the climatic climax. Such zones have essentially uniform macroclimates and occur sequentially along moisture and temperature gradients that extend through broad regions. Seven or eight of the zones proposed by Franklin and Dyrness would be found in British Columbia.

For many horticulturists, two systems often referred to are (1) The plant hardiness zones of Canada, produced by Ouellet and Sherk (1967); and (2) The hardiness zones of the United States and Canada, compiled by the Arnold Arboretum, Harvard University and published in Wyman (1971).

The first hardiness zone system was developed by the Plant Research Institute of the Research Branch, Agriculture Canada, and is published in Sherk and Buckley (1968). Separate maps can also be obtained from the Information Division, Agriculture Canada, Ottawa. The zones are essentially climatic, and are based on a formula that takes into consideration the various meteorological factors affecting the hardiness of a plant at a given location. These factors include length of frost-free period, summer rainfall, maximum temperatures, snow cover and wind. The most important factor is the minimum temperature during the winter. The system recognizes that small microclimates may occur within each major zone and sharp changes in topography may also cause differences in hardiness not able to be reflected in the zone delimitation. Indicator shrubs are provided for each zone. Canada is divided into 10 zones, numbered from 0 to 9 (0 being the coldest). Each zone has been divided into 2 subzones. All zones are found in British Columbia.

The second hardiness zone system was originally developed by the U.S. Department of Agriculture (1936) and modified by plant performance records compiled by the Arnold Arboretum. The United States and Canada are divided into 10 zones, 9 of which occur in the United States. The zones are based on 5, 10, or 15 degree differences in the average annual minimum temperatures. Local microclimates representing different plant hardiness zones may be found in all major zones. Zones 1 - 9 occur in British Columbia.

Since these two plant hardiness systems do not conform, care must be exercised to ensure that hardiness rating is correlated with the system used by the author of a particular publication.

The horticulturist, plant breeder and propagator, or botanist may have difficulties reconciling the differences between the various classification schemes. The choice of system depends upon the use that is to be made of it. The systems used by Sherk and Buckley (1968) and Wyman (1971) are basically climatic, and are intended to provide the plant grower with information on potential plant hardiness in relation to geography. The systems proposed by Krajina (1959, 1965, 1969, 1973, 1976), Rowe (1972), and Franklin and Dyrness (1973) are methods of classifying existing natural vegetation, and are based on climatic, geological and topographic factors as shown by the distribution of associations of plant species. They provide useful ecological information (for example, soil preferences and moisture requirements) about native species for which the propagation requirements are poorly known.

The following section describes the biogeoclimatic zones of British Columbia, as formulated by Krajina (1969, 1973, 1976). Both climatic and vegetational characteristics are described for each zone.

The Biogeoclimatic Zones

(1) The Alpine Tundra Zone

The Alpine Tundra Zone is found on high mountains throughout the province, above the subalpine zones. In the northwestern part of the province it occurs above 900 m; in the northeast and southwest, above 1650 m; and in the southeast, above 2250 m.

FIGURE 1. Subalpine parkland in the southern subzone of the Engelmann Spruce — Subalpine Fir Zone.

FIGURE 2. An example of climax *Pinus ponderosa* forest in the Ponderosa Pine — Bunchgrass Zone.

FIGURE 3. A forest understory in the Coastal Western Hemlock Zone on the Queen Charlotte Islands.

In this zone the climatic conditions are quite harsh and the growing season short. The mean annual temperature is between -0.4 and -1.5°C. The mean monthly temperature is below 0°C for 7 to 11 months of the year. The absolute minimum and absolute maximum temperatures are -45 to -33°C and 21 to 28°C respectively. The number of frost-free days varies from 25 to 105, but at higher elevations frost may occur at any time. The total annual precipitation in this zone varies from 700 to 2800 mm, most of this (72%-74%) falling as snow.

The vegetation consists almost entirely of herbs, bryophytes and lichens, with some low shrubs. Although the zone is essentially treeless, krummholz forms of a number of subalpine species do occur. There are two subzones, the Coastal Subzone (with heavy snow cover) and the Interior Subzone (with relatively lighter snow cover). In the Coastal Subzone, krummholz growth may be formed by *Tsuga mertensiana, Abies lasiocarpa* or *Pinus albicaulis*. This subzone is wet in the winter and drier in the summer. In the Interior Subzone, which has a wet summer but dry spring or fall, *Abies lasiocarpa, Pinus albicaulis, Picea engelmannii* and *Larix lyallii* occur.

(2) The Mountain Hemlock Zone

This zone occurs along the Pacific coast, at elevations of 900 to 1800 m in the south (lower on windward slopes, and higher on leeward slopes), and from 300 to 900 m in the north.

In the Mountain Hemlock Zone the mean annual temperature varies from 3 to 7°C. The mean monthly temperature is below 0°C for 1 to 4 months of the year, and above 10°C for 1 to 4 months. The absolute minimum and absolute maximum temperatures are -35 to -23°C and 24 to 30°C, respectively. The number of frost-free days is 110 to 210. The annual total precipitation is 1780 to 4320 mm, of which 20% to 70% is snow. In this zone the spring and/or summer seasons are usually dry, whereas the autumn and/or winter seasons are wet.

The most commonly encountered trees in this zone are *Tsuga mertensiana, Abies amabilis* and *Chamaecyparis nootkatensis*. They occur in areas where the ground remains unfrozen beneath the snow cover. Other trees that may occur are *Tsuga heterophylla, Thuja plicata, Picea sitchensis* and *Pseudotsuga menziesii* (at lower elevations); *Pinus monticola* (in the south); *Pinus contorta* (on very dry sites); and *Abies lasiocarpa* and *Pinus albicaulis* (near timberline). This zone is divided into two subzones. The first of these, the Coastal Subalpine Forest Subzone, is at the lower elevations and consists of closed forest stands with only occasional treeless communities. The second, the Coastal Subalpine Parkland Subzone, occurs at higher elevations. In this subzone the trees form clumps or small stands, interspersed with *Carex*, mountain-heather or krummholz *Tsuga mertensiana* communities. Trees are absent where the snowpack remains very late in the spring or where the ground freezes under the snow.

(3) The Engelmann Spruce — Subalpine Fir Zone

This zone occurs across most of the province, at elevations of 1260 to 2250 m in the southeast, 1200 to 2100 m in the southwest, 1050 to 1650 m in the northeast, and 900 to 1500 m in the northwest.

The climate is more continental than in the Mountain Hemlock Zone. The mean annual temperature is 1 to 4°C, and the mean monthly temperature is below 0°C for 5 to 6 months of the year and above 10°C for 1 to 3 months. Absolute minimum temperatures range from -56 to -35°C, and absolute maximum temperatures from 32 to 37°C. On the average there are 100 to 150 frost-free days per year. In this zone the annual total precipitation is 410 to 1830 mm, of which 43% is snow. (Snow cover is considerably less than in the Mountain Hemlock Zone.) The driest and wettest seasons of the year in this zone vary according to the particular region of the province.

Trees found in this zone must be able to tolerate relatively severe winters with a long period of frozen ground. These include *Picea engelmannii, Abies lasiocarpa, Pinus contorta, Pinus albicaulis, Larix lyallii* and (rarely) *Pinus flexilis*. There are two subzones. The southern subzone extends from 49°N to about 52°N, and is characterized by the above tree species, as well as *Pinus monticola* and (less commonly) *Tsuga heterophylla* and *T. mertensiana, Pseudotsuga menziesii* var. *glauca* and *Thuja plicata*. The northern subzone occurs from 53°N to 57°30'N, and supports *Picea* *engelmannii, Abies lasiocarpa, Pinus contorta* and *Pinus albicaulis*, as well as *Betula glandulosa*. In both of these subzones the lower elevations are characterized by continuous forest, and the higher elevations by parkland. The clumps of trees in the parkland areas occur where the snow cover is particularly heavy, with a resulting increase in the moisture supply during the growing season.

(4) The Spruce — Willow — Birch Zone

This zone occurs in the far northern part of the province (north of 57°10'N), at elevations from 900-1100 m to 1500-1700 m (higher to the south and east). It is the highest subalpine zone in this region, and occupies a position comparable to that of the Engelmann Spruce — Subalpine Fir Zone further south.

The mean monthly temperature is below 0°C for 7 months of the year, and above 10°C for only 1 month. The average number of frost-free days is 100. The annual total precipitation is 700 mm, with 58% of this falling as snow. (Climatic data are available from only 1 station.)

In this zone are found mainly *Picea glauca, Picea mariana,* several *Salix* species, and *Betula glandulosa*, with *Abies lasiocarpa* and *Alnus incana* ssp. *tenuifolia* also present. There are two subzones in this zone. The upper (shrub) subzone is characterized by the predominance of willows and scrub birch. (Summer night temperatures are higher in the Spruce — Willow — Birch Zone than in the Engelmann Spruce — Subalpine Fir Zone, and this promotes the occurrence of deciduous shrubs.) The lower (forest) subzone is characterized by the spruce species mentioned above, mixed with *Abies lasiocarpa* on alkaline sites. *Picea engelmannii* is absent.

(5) The Boreal White and Black Spruce Zone

This northern zone occurs from 54°20'N to the Yukon border in the eastern part of the province, and from about 57°N in the west. Almost all of the Peace River region belongs in this zone. Elevations range from 165 m to 840 m.

The mean annual temperature is -3 to 3°C. The average temperature is below 0°C for 5 to 7 months of the year, and above 10°C for only 3 to 4 months (but is quite high during the peak of summer). Absolute minimum temperatures are -59 to -42°C, and absolute maximum, 30 to 41°C. The number of frost-free days is 20 to 150. The winters are very severe and the growing season short. The average annual precipitation is 283 to 1273 mm, with 36% to 54% of this falling as snow.

In this zone the ground is deeply frozen for a large part of the year, and permafrost lenses occur in the high moor bogs. The short vegetative season gives rise to poor tree growth. The major tree species are *Picea glauca, Picea mariana, Pinus contorta, Larix laricina* and *Abies lasiocarpa. Picea mariana* is dominant on poor, acid soils and *Abies lasiocarpa* on richer soils. *Pinus banksiana* (Jack pine) occurs rarely on dry sites in this zone. *Larix laricina* is generally found in alkaline bogs or on limestone. Deciduous trees and shrubs include *Populus tremuloides, Populus balsamifera, Betula* species and *Alnus* species. High moors and bogs are common in this zone. On glacial outwash soils along major rivers, an edaphic climax vegetation consisting of aspen-white spruce parkland is often encountered.

(6) The Sub-Boreal Spruce Zone

This zone occurs at middle elevations in the northern interior of the province, between 52°30'N and 57°10'N latitude. Elevations run fron 330 to 950 m in the northeast and to 1100 m in the northwest.

The winters are less severe than in the Boreal White and Black Spruce Zone, and the summers cooler. The mean annual temperature is 1 to 3°C, and the average temperature is below 0°C for 4 to 5 months of the year and above 10°C for 3 to 4 months. The absolute minimum temperature is -50 to -41°C and the absolute maximum temperature is 32 to 37°C. The number of frost-free days is 30-100(-150). The total annual precipitation is 450 to 621 mm, of which 25% to 49% is snow.

This zone has a less continental climate than the Boreal White and Black Spruce Zone. Consequently, the growing season is slightly longer, and tree growth is more vigorous. Low moors commonly occur, but never with permafrost. The major conifer species are *Picea glauca, Pinus contorta, Abies lasiocarpa, Picea mariana* and *Pseudotsuga menziesii* var. *glauca*. Deciduous trees include *Populus tremuloides, Populus balsamifera, Betula papyrifera, Betula glandulosa* and *Alnus* species.

(7) The Cariboo Aspen — Lodgepole Pine Zone

This zone extends across the central interior of the province between 51°10'N and 54°15'N, at elevations of 510 to 1070 m.

It is drier than the Sub-Boreal Spruce Zone, with warmer summers, but winters are still severe. The mean annual temperature is 2 to 5°C. The average temperature is below 0°C for 4 to 5 months of the year and above 10°C for 3 to 5 months. The absolute minimum and absolute maximum temperatures are -52 to -38°C and 33 to 41°C, respectively. The number of frost-free days is 107 to 179. The total annual precipitation is 264 to 575 mm, of which 27% to 47% occurs as snowfall.

Pinus contorta, Populus tremuloides, Pseudotsuga menziesii var. *glauca* and *Picea glauca* are common in this zone. There are two subzones; the cooler northern subzone has *Picea glauca* as the climax species on mesic sites, and the southern and slightly warmer subzone has *Pseudotsuga menziesii* var. *glauca* as the climatic climax tree. The northern subzone also has *Picea mariana* on hygric habitats, showing its affinity to the Sub-Boreal Spruce Zone further north. In the southern subzone the growth of trees is often poor, and grassland communities are frequently seen. The vegetation in this subzone resembles in some ways that of the Interior Douglas Fir Zone, except that several tree species (including *Pinus ponderosa, Pinus monticola, Thuja plicata, Tsuga heterophylla* and *Abies grandis*) do not occur. *Abies lasiocarpa* and *Picea engelmannii* may be encountered in this zone, but only at the highest elevations.

(8) The Interior Western Hemlock Zone

This zone extends from 49°N to 54°10'N, between the Rocky Mountains and the Monashee Mountains. In elevation it ranges from 360 to 1260 m. It is the wettest and most productive forest zone in the interior of the province, and is often called the "Interior wet belt". In many ways it resembles the Coastal Western Hemlock Zone, but the vegetative season is much shorter.

The mean annual temperature in the Interior Western Hemlock Zone is 3 to 8°C. The temperature averages below 0°C for 3 to 5 months and above 10°C 4 to 5 months of the year. The absolute minimum temperature ranges from -47 to -14°C, and the absolute maximum temperature varies from 35 to 41°C. The number of frost-free days is 141 to 244. The annual mean precipitation is 574 to 1452 mm, with 25% to 51% in snowfall.

This zone is divided into two subzones. The Western Larch Subzone is the drier subzone, with an annual total precipitation of 574 to 890 mm. A number of conifer species occur abundantly here, including *Pseudotsuga menziesii* var. *glauca, Larix occidentalis, Pinus monticola, Tsuga heterophylla, Pinus contorta, Thuja plicata,* and *Abies grandis*. The Western Hemlock Subzone (the wetter subzone) lacks some of the tree species mentioned above. Present are *Pseudotsuga menziesii* var. *glauca, Pinus monticola, Pinus contorta, Thuja plicata, Tsuga heterophylla, Picea engelmannii, Picea glauca, Picea mariana* and *Abies lasiocarpa*. *Populus balsamifera, Populus tremuloides* and *Betula papyrifera* are commonly encountered in both subzones.

(9) The Interior Douglas Fir Zone

This zone occurs in the southern third of the province, at middle elevations in the drier parts of the Interior and in the Rocky Mountain Trench. The elevations range from 600 to 1200 m in the southwest, from 300 to 1350 m in the southeast, and from 450 to 900 m in the north.

The mean annual temperature is 4 to 9°C. The average temperature is below 0°C for 3-5 months, above 10°C for (3-)4-5(-6) months. The absolute minimum and absolute maximum temperatures are -46 to -32 and 36 to 43°C respectively. This zone is the warmest of the Interior biogeoclimatic zones after the Ponderosa Pine — Bunchgrass Zone. The number of frost-free days is 151 to 260. The average annual precipitation is 359 to 565 mm, of which 24% to 51% falls as snow. Sometimes this zone occurs when there is even heavier rainfall, in areas where freezing before or after the snowfall prevents Interior Western Hemlock vegetation from becoming established.

This zone contains two subzones. The Pinegrass Subzone (the drier of the two, with annual precipitation of 359 to 480 mm) has only two major conifer species, *Pseudotsuga menziesii* var. *glauca* and *Pinus ponderosa*. In the False Boxwood Subzone, the most productive tree is the pioneer species *Pinus ponderosa*. Other species commonly found are *Pinus contorta, Pinus monticola, Abies grandis, Larix occidentalis, Thuja plicata, Picea glauca, Picea engelmannii* and *Abies lasiocarpa*. *Pseudotsuga menziesii* var. *glauca* is the dominant species in this zone, but it is slower-growing than in the Interior Western Hemlock Zone. Deciduous trees and shrubs frequently seen in the Interior Douglas Fir Zone include Trembling aspen, Balsam poplar, Douglas maple, Paper birch and Scrub birch.

(10) The Ponderosa Pine — Bunchgrass Zone

The Ponderosa Pine — Bunchgrass Zone is the driest zone in the province, and has the warmest summer temperatures. It occurs at the lower elevations (270 to 750 m) in the southern Interior, in the Fraser, Thompson, Nicola, Similkameen, Okanagan and Kootenay River Valleys.

The mean annual temperature in this zone is 6 to 10°C. The mean monthly temperature is above 10°C or 5 to 7 months and below 0°C for 2 to 4 months. The absolute minimum temperature is between -41 and -21°C, and the absolute maximum temperature ranges from 38 to 44°C. The number of frost-free days is 219 to 251. The average annual precipitation is 213 to 352 mm, with 16% to 29% as snowfall.

Pinus ponderosa is the predominant conifer in the zone. This tree is shade-tolerant even on hygric sites (which are, of course, much drier than hygric sites in other zones). *Pseudotsuga menziesii* var. *glauca* is found as a shade-requiring or shade-tolerant tree on the wet sites. *Thuja plicata* and *Larix occidentalis* occur rarely in the wettest pockets of this zone or along the rivers, where Balsam poplar, Trembling aspen, and birches may also be found. On finer soils trees are often absent, and the predominant vegetation consists of Bluebunch Wheat grass *(Agropyron spicatum)*, Antelopebush *(Purshia tridentata)* and in more heavily grazed areas, Sagebrush *(Artemisia tridentata)*.

(11) The Coastal Douglas Fir Zone

This zone occurs along the eastern (rain shadow) side of Vancouver Island, on the Gulf Islands and on adjacent portions of the mainland, from 48° to 50°20′N latitude. Elevations range from sea level to 150 m in the north, and to 450 m in the south.

The climate in this zone is mesothermal, with a mild winter. The driest part of the year is the summer. The mean annual temperature is 9 to 11°C; the mean monthly temperature is greater than 10°C for 5 to 7 months of the year, and seldom goes below 0°C at all. The absolute minimum temperature is -25 to -13°C, the absolute maximum 33 to 41°C. The number of frost-free days is 244 to 354. The average annual precipitation is 657 to 1524 mm, of which 2.2 to 8.8% falls as snow.

This zone has two subzones. The Garry Oak — Douglas Fir Subzone has a rainfall of 657 to 1016 mm. The characteristic tree species include *Pseudotsuga menziesii* var. *menziesii, Abies grandis, Thuja plicata, Quercus garryana, Arbutus menziesii, Pinus contorta,* and the deciduous trees *Prunus emarginata, Alnus rubra, Acer circinatum* and *Acer macrophyllum*. The Madrone — Douglas Fir Subzone, with a rainfall of 1016 to 1524 mm, almost completely lacks the Garry oak that is typically found in the drier subzone. The other trees mentioned above are frequent, however, as is *Pinus monticola*. *Tsuga heterophylla* is a climax tree on hygric sites.

(12) The Coastal Western Hemlock Zone

The Coastal Western Hemlock Zone occurs at low to middle elevations west of the coastal mountains, from the southern end of Vancouver Island north to 60°N. It includes much of Vancouver Island and all but the highest elevations of the Queen Charlotte Islands. Elevations extend up to 900 m on exposed slopes in the south (1050 m on leeward slopes), and to 300 m in the north.

This is the wettest biogeoclimatic zone in B.C., and like the Coastal Douglas Fir Zone it has mild winters. The summers are cool. The mean annual temperature is 5 to 9°C. The mean monthly temperature is above 10°C for 5 to 6 months of the year, and below 0°C very seldom in the south but for 2 months or more in the north. The absolute minimum temperature ranges from -30 to -7°C, and the absolute maximum temperature from 26 to 40°C. The number of frost-free days is 186 to 344. The mean annual precipitation is 1550 to 4400 mm (or more in a few areas). Of this, 0.7% to 14% (or as much as 42% in the northern parts of the zone) occurs as snowfall.

The zone has two subzones. The drier of these (the Douglas Fir-Western Hemlock Subzone) is characterized by the following trees: *Pseudotsuga menziesii, Tsuga heterophylla, Thuja plicata, Abies grandis, Picea sitchensis, Pinus monticola* and *Pinus contorta. Arbutus menziesii* may occur on the driest sites. *Abies amabilis* is absent. Deciduous trees include *Alnus rubra, Acer circinatum, Acer macrophyllum, Prunus emarginata* and *Populus balsamifera.* The wetter subzone (the Pacific Silver Fir — Western Hemlock Subzone) has the above species as well as *Abies amabilis, Tsuga mertensiana,* and (rarely) *Chamaecyparis nootkatensis. Prunus emarginata* and the two *Acer* species are less common than in the drier subzone.

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Chamaecyparis nootkatensis (D. Don) Spach

Yellow Cedar
Member of the Family Cupressaceae

Natural Distribution

Chamaecyparis nootkatensis occurs from Wells Bay in Prince William Sound, Alaska (147°28′30″W,60°53′30″N) south to Siskiyou County in northwestern California. It is found along the coast and islands of western British Columbia, western Washington and the Cascades of Oregon, with localized occurrences in the Blue and Wallowa Mountains of northeast Oregon. In Alaska it is particularly common on Admiralty, Baranof and Chichagof Islands and extends northward in discontinuous isolated groups, a distribution which suggests that the present-day occurrences may be remnants of more extensive stands which were destroyed during recent glacial advances. In British Columbia the species occurs as scattered individuals or in small stands, in a narrow coastal belt along the islands and on the western side of the mainland Coast and Cascade Mountains. It is distributed throughout the wet coastal and mountain forests of the Queen Charlotte Islands. It occurs on the mainland as far inland as Silver Mountain near Yale, where it is found at elevations of 1200 to 1500 m. There is also an isolated stand at 1554 m elevation near Slocan Lake, about 450 miles inland.

Habitat

Chamaecyparis nootkatensis commonly occurs on deep moist rocky or gravelly soils of rivers, valleys and gulches, and on mountain slopes, benches and tablelands — often on northern or western exposures. It occurs from sea level to timberline northward from Knight Inlet (150°30′N), and from 610 to 2134 m southwards. It is an ecologically tolerant species, the tolerance varying with soil, moisture, climatic conditions and age. It will apparently grow on extremely poor soils provided there is an abundance of moisture, but prefers heavy organic soils which are rich in calcium, magnesium and nitrates. The climate is characterized as warm-temperate, very humid to rainy, with usually mild winters but heavy snow cover. In British Columbia the species occurs from sea level to 1350(-1800) m, in the Mountain Hemlock Zone and the wet subzone of the Coastal Western Hemlock Zone. In these zones the mean annual temperature is 3-9°C, with an absolute minimum of -35° to -7°C and absolute maximum of 24° to 40°C. Total precipitation is 178-665 cm, with up to 70% of this falling as snow. The species is considered to be shade-tolerant and is usually found in mixed stands, often with *Tsuga mertensiana* and *Abies amabilis*, although it occurs in pure stands of limited extent.

Description

The species is a medium-sized, monoecious tree (12-)20-40(-60) m tall with a DBH of (0.3-)0.6-1.5(-1.8) m and a graceful pyramidal outline. The crown is narrowly pyramidal with a slender whiplike leader which droops near the tip. The tree has a "weeping" appearance because of the numerous hanging branchlets. The trunk is often slightly twisted and tapers quickly towards the top from a buttressed and often fluted base. It is often clear of branches for one-third to one-half of its total height, although open-grown trees may retain their branches nearly to the ground. Young trees are shrubby and warped but gradually straighten as they mature. On high exposed slopes and crests the species is very much smaller (often 1.5 m or less) and assumes a sprawling or even prostrate habit, with a krummholz appearance.

The root system is deep with many lateral roots, although specimens growing on very thin rocky soil may have shallow roots.

The bark on mature trees is thin (1-2(-3) cm), grayish-brown outside, clear reddish cinnamon-brown inside when broken, fibrous and brittle. The surface is irregularly and rather finely broken by shallow seams into thin flat ridges, with frequent diagonal cross-connections; these flake off into long stiff narrow strips. In young trees the bark is reddish and fairly smooth, and flakes off into thin papery scales.

The branches are few and distant from each other, spreading, and horizontal to more or less drooping, especially at the extremities. The branchlets are slender, pendulous, slightly flattened or ultimately terete to nearly quadrangular, and 2-ranked in a horizontal plane. They are much branched, forming flat spreading sprays which are rather fern-like in appearance. In color they are light-yellow, often tinged with red at first, becoming darker (often bright red-brown) during the third season, and ultimately paler and covered with thin close smooth bark. They are prickly to the touch because of the sharp spreading leaftips. Mature trees are sometimes found with a cluster of rigid branches at the base and on one side; this is a type of juvenile foliage, which remains as more extensive mature growth develops.

The wood is moderately heavy, moderately hard and strong, elastic but somewhat brittle, and often exceedingly fine-grained and even-textured. It is very durable, shrinks little, is easily worked and takes a fine polish. The heartwood is a bright clear yellow which darkens on exposure, whereas the narrow sapwood is nearly white to yellowish-white. The wood has a characteristic sharp resinous fragrance when freshly cut (in the opinion of some, it resembles raw potatoes) and a faint, bitter, somewhat spicy taste.

The winter buds are minute, naked and inconspicuous.

The mature needles are scalelike and opposite in pairs which alternately cross at right angles, giving the appearance of 4 rows. The lateral rows are not greatly differentiated from the dorsi-ventral ones but are somewhat keeled, closely appressed (except on vigorous leading shoots), overlapping and densely imbricate. The needles are 1.5 to 3 mm long (to 6 mm on vigorous leading shoots), usually gray-green to bluish-green, ovate to broadly-ovate, and convex on the back with an acute apex which has a very distinctive sharp spreading point and a smooth finely-serrate margin. The needles are eglandular or glandular-pitted on the back, and are distinctly malodorous with a turpentine-like odor when bruised. They usually die and turn brown after the second or third year, but may persist a few years longer. Juvenile plants may have somewhat awl-shaped needles.

The cones appear in June or July in British Columbia, and from March to late May in more southerly parts of the range. The female or ovulate strobili are numerous, inconspicuous and clustered at the ends of the upper branchlets. They are usually greenish, erect, about 8 mm in diameter and subglobose to globose. There are 3 to 6 opposite pairs of scales, with the pairs alternating at right angles. The scales are soft, peltate, decussate, and more or less glaucous, and have a short conical projection at the apex. The lower pairs of scales are sterile, and the upper bear 1-4(-5) erect ovules at their base. The male or staminate strobili are terminal on lateral branchlets of the previous year's growth, and are often conspicuous by their abundance. They are yellow (or rarely red), about 4 mm long, oblong to globose and are composed of several opposite shield-shaped scales. There are up to 12(-20) microsporangia, which are opposite with the pairs alternating at right angles. The filaments of the microsporangia are short and stout, and are enlarged at the top into ovate, light yellow and slightly erose connectives which more or less cover the globose, pendulous and often reddish pollen sacs.

The mature cones are erect, woody and solitary, and are scattered at the ends of the lateral branches in the upper part of the tree. Each is surrounded at the base by the sterile lower scales of the strobilus. They are brown to purplish- or reddish-brown, rather glaucous, 10-12 mm long and (3-)6-12 mm broad, subglobose to globose and short-stalked. There are 4-6(-12) pairs of scales, which are rounded, decussate and peltate. The apex of each scale is flattened or depressed, with a stiff prominent triangular point (the remnant of the fertile strobilus scale) and they are frequently covered with conspicuous resin glands. It is generally recognized that the cones of *Chamaecyparis nootkatensis*, unlike those of other members of the genus, mature in September to October of the second year. However, there are races or individuals that mature in one year in certain parts of the range, particularly in the south and at lower altitudes in British Columbia. Seeds are normally released during the fall and early winter, but the cones may remain on the tree for several years.

The seeds are (3-)4-6 mm long, brown with a white scar at the base, oblong-ovoid to ovate, acute, slightly flattened and ridged on one side. They are erect, (1-)2-4(-5) per scale and are usually without resin tubercles. There are 2 wings, which are golden-brown, prominent, thin, notched above and about twice as wide as the seed. Some seed production occurs nearly every year, with moderate to good crops at irregular and infrequent intervals.

Propagation

The seeds have only a moderate germination capacity (12%) and transient viability, and may be difficult to germinate. Delayed germination may occur, up to one year after sowing. They may be sown as soon as ripe, or stored dry in an airtight container for up to one year, with stratification at 5°C for 3-12 months. They should be sown in moist soil in a cool greenhouse. One experiment has indicated that warm stratification at alternating temperatures of 20°C and 30°C for 30 days followed by moist stratification at 5°C for 30 days improved germination, but further testing is required. The seedlings require moisture and shade during early development.

Cuttings may be taken from mature wood in the fall and planted in sandy soil in a cool greenhouse, with some bottom heat. However, they root slowly. The plants should be hardened off and planted in a nursery border as soon as they have rooted. Dwarf forms should always be grown from cuttings, but other varieties do not propagate well by this means. Grafting may be used for most varieties except dwarf forms. In Europe, *Chamaecyparis nootkatensis* is propagated by grafting on stocks of *Thuja orientalis.*

The species is known to reproduce vegetatively in nature but this is not common. The formation of adventitious roots has been noted in trees on Vancouver Island. In addition, new stems may originate where roots are exposed, and secondary trunks may develop around the base of a damaged tree.

Transplantation

The genus as a whole does not resent disturbance and may be moved easily, even as a small specimen tree.

Conditions for Cultivation

The growth rate is slow, but trees are very long-lived. Trees with a DBH of 0.4-0.5 m are about 200 to 275 years old and are just reaching marketable size for lumber, and very large trees may be 500 to 600 years old. Some individuals may reach an age of 3500 years. There are Yellow Cedars with a DBH of 1.5-1.8 m which are more than 1000 years old, and may be the oldest trees in Canada. One gnarled monarch in the Howe Sound area of British Columbia was 30 m tall with a DBH of 2 m, and was estimated to be 1030 years old. At higher elevations (over 1200 m), over 100 years may be necessary to add 2.5 cm to the radius of a tree.

The recommended hardiness zone in Canada is Zone 6. The species will grow on extremely poor soils or in the open provided there is an abundant supply of moisture. However, it thrives best on moist, well-drained, non-alkaline (pH 4.0-7.5) soils with plenty of atmospheric moisture in a partly shaded situation, sheltered from dry cold winds. Trees should be planted at least 4.5 to 6.0 m apart, to allow sufficient space and light for development of the lateral branches down to the ground, and to permit proper development of the leader.

Pruning to shape should not be necessary for Yellow Cedar, and severe pruning is undesirable, although some young trees may need pruning of side branches to encourage a good leading shoot. Some cultivars may produce several leaders which are masked by the foliage at first; these should not be pruned, but surreptitious wiring may be used to pull them together later.

Landscape Value

Chamaecyparis nootkatensis is not commonly grown in gardens in North America, although it is one of the most ornamental members of the genus and deserves more recognition horticulturally. When well grown it makes a handsome tree with attractive foliage, almost invariably preserving a

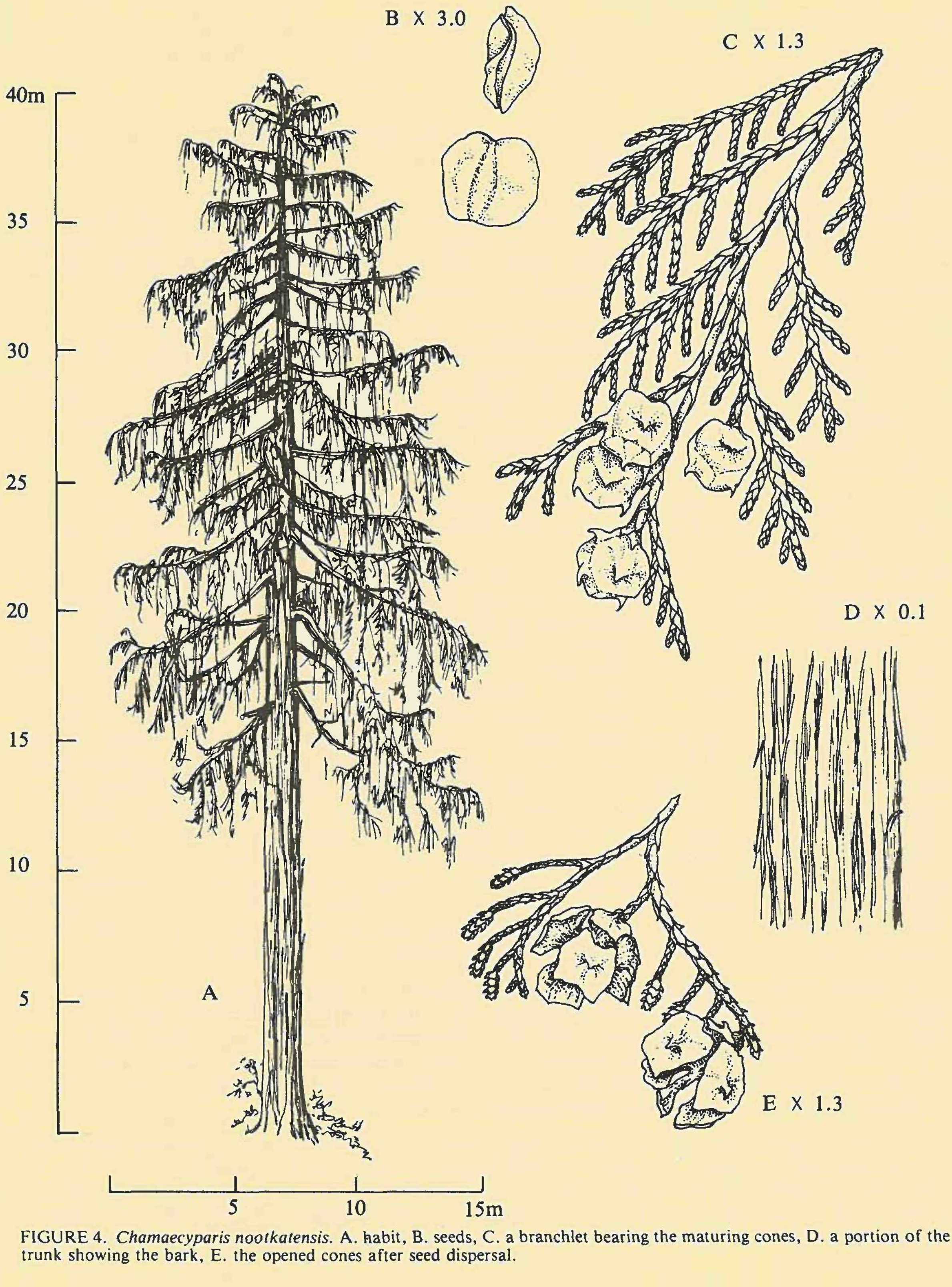

FIGURE 4. *Chamaecyparis nootkatensis*. A. habit, B. seeds, C. a branchlet bearing the maturing cones, D. a portion of the trunk showing the bark, E. the opened cones after seed dispersal.

healthy vigorous appearance. It can be grown either as a single specimen or in a group in a park or large garden. Several of the cultivars, particularly the weeping form 'Pendula', and some of the dwarf forms which may be grown in containers, are more commonly seen.

Availability

Chamaecyparis nootkatensis can be obtained from one or two nurseries in the area, although its cultivars are more commonly available.

Varieties and Ornamental Cultivars

There are no naturally occurring varieties of *Chamacyparis nootkatensis*, but at least 20 cultivars have been developed. About 6 of these are the common forms seen in gardens today, including 'Compacta', a dwarf form of dense habit; 'Lutea', with yellow young shoots; and 'Pendula', which is distinctly drooping and is considered one of the most beautiful of all weeping conifers.

One hybrid between *Chamaecyparis nootkatensis* and *C. lawsoniana* has been reported, *C.* X *nidifera* (Nicholson) Hornibrook (Bird Nest Cypress). This tree originated about 1889 in the Rovelli Bros. Nursery, Pallanza, Italy, allegedly from seed from *C. nootkatensis*. Although it has characteristics of both species, it is closer to *C. lawsoniana* and authorities now disagree as to whether it is really a hybrid or whether the old gardener at the Nursery was mistaken about the origin of the seed. If the latter is true then the tree should be referred to as *Chamaecyparis lawsoniana* 'Nidiformis'.

Three bigeneric hybrids between *Chamaecyparis nootkatensis* and *Cupressus* species, X *Cupressocyparis*, are known in cultivation; all have arisen accidentally in gardens and are not known in the wild. X *Cupressocyparis leylandi* (Jackson & Dallimore) Dallimore, 'Leyland cypress' (*Chamaecyparis nootkatensis* X *Cupressus macrocarpa*), is a tall narrow pyramidal tree with long slender branches and gray-green foliage. It is considered one of the most important tree introductions of recent times, being extremely fast-growing (1.8 m in 3 years, 4.5 to 6 m in 5 years and 30 m after about 100 years) but of unknown ultimate height. It has the hardiness of the *Chamaecyparis* parent and is of great value for hedges and screens; it is expected to replace *Thuja occidentalis* as the ubiquitous evergreen hedge in Europe. This hybrid has actually arisen three separate times, and in both directions. The first cross, with *C. nootkatensis* as the female parent, occurred in 1888 at Leighton Hall, Welshpool, Montgomeryshire, at the home of a Mr. Naylor whose brother-in-law, C.J. Leyland, discovered the hybrids and then grew them at his own home, Haggerston Hall, Northumberland. About 1911, further hybrids with *Cupressus macrocarpa* as the female parent originated at Leighton Hall. Finally, seed from *Cupressus macrocarpa* was raised at a nursery at Stapehill, Ferndown, Dorset, about 1940. A number of clones were raised from these 3 crosses, varying a little in habit from each other but essentially very similar to the parents in their mode of growth. Clones 1 to 5 derive from the 1888 cross; 'Haggerston Grey' (Clone 2) is the commonest form of all in cultivation. Clones 10 and 11 are from the 1911 cross; 'Naylor's Blue' (Clone 10) is the form which most closely resembles *Cupressus macrocarpa*, whereas 'Leighton Green' (Clone 11) is commonly seen in gardens. Clones 20 and 21 are derived from the 1940 Dorset cross.

In Britain the tree is much planted in exposed conditions for windbreaks and hedges, although it is recommended that young slender whippy plants grown in the open ground should be used rather than heavy container-grown plants. It is no longer being recommended for use as an ornamental, because it is subject to windfall due to its shallow root system. Specimens on the University of British Columbia campus have been badly attacked by the Cypress tip moth, *Argyresthia cupressella* Wallingham, in 1976 (Ken Wilson, personal communication).

X *Cupressocyparis notabilis* A.F. Mitchell *(Chamaecyparis nootkatensis* X *Cupressus glabra)* has sinuous upswept branches draped with flattened sprays of dark-green foliage. It grew 7 to 9 m in 14 years and probably will eventually form a medium-sized tree. It was raised at the Forestry Commission Research Station, Alice Hall, Surrey, from seed collected in 1956 from a specimen of *Cupressus glabra* at Leighton Hall. It has recently been introduced into the trade, at least in Britain.

X *Cupressocyparis ovensii* A.F. Mitchell *(Chamaecyparis nootkatensis* X *Cupressus lusitanica)* was raised by Mr. H. Ovens in his nursery at Talybony, Cardiganshire, from seed collected in 1961 from a specimen of *Cupressus lusitanica* at Silkwood, Westonbirt Arboretum, Gloucestershire.

The generic name *Retinispora* (or *Retinospora*) may occasionally be found in horticultural catalogues and references, although it is no longer accepted taxonomically. Some plants of both *Thuja* and *Chamaecyparis* retain their juvenile foliage much longer than usual and these forms were once put into a separate genus. Such juvenile forms may have a use in formal gardens and rockeries where slow-growing and dwarf conifers are desired, but they are short-lived and usually become unsightly with age.

Other Uses

Although the wood of *Chamaecyparis nootkatensis* is beautiful and unusual in color, durable and workable, the limited distribution of the tree and its often inaccessible situation make it of restricted commercial value. It is much used locally in its area of distribution for such things as interior finish, furniture, shingles, piles, novelties and patterns, and is also used for small boat building and greenhouses, where its resistance to decay is advantageous. In many localities the species, with its associates, is of more value as a protective cover on cold high mountain slopes than when manufactured into lumber.

An aromatic oil can be distilled from the branchlets and leaves.

The Indian tribes of coastal British Columbia used various parts of the tree medicinally and in technology. The inner bark is an excellent material for making soft warm clothing and blankets — the Kwakiutl tribe in particular used soft yellow cedar blankets in trading with other tribes. The bark was stripped off the tree, the outer bark removed and the inner soaked in warm salt water in a quiet bay at low water mark for 12 days, before being beaten on a flat stone with a whalebone beater to make it soft and pliable. It was allowed to dry for four days, and then stored until winter, when it was made into blankets, capes, mats and other items. The Bella Coola also used the inner bark for decorating masks and as a covering for poultices, and it could also be used for weaving into baskets and containers.

The wood was used by several tribes for carving, and by the Kwakiutl for canoe paddles, dishes and bows as well as for hoops (after steaming and bending) for nettle-fibre fishing nets.

The Kwakiutl tribe made most use of the species medicinally. They boiled the needles with spruce bark and applied them to a swelling on a woman's kidneys; an extract from the tips of 4 branches was drunk for general illness or used to bathe sores and swellings. Sores and swellings were also rubbed with sharp boughs until the skin was broken, when other medicine such as tobacco or yarrow was applied. If a person was very ill an old cedar blanket was burned, and the ashes mixed with catfish oil and rubbed on the patient, who was then covered by a mat and struck with 4 burning spruce boughs. The Yellow Cedar was believed to give the patient strength to recover. However, the Lillooet tribe believed that the tree, especially the rotten wood, had a very bad odor which caused sickness and diarrhoea with too much exposure to it.

Diseases and Problems of Cultivation

Chamaecyparis nootkatensis does not thrive in climates with cold dry winds and hot summers, and even in the Pacific Northwest should be protected from cold winds. It is subject to root rot when grown on heavy poorly drained soils, and dieback in the centre of the tree may result from too much shade or from red spider mite attacks. The thin bark affords little protection against mechanical damage, sunscald or fire.

The species is relatively free from insect damage, although the defoliator *Halisdota argentata* Pack. has been found in south coastal British Columbia and has caused some damage in nature. Although the tree is usually free from fungal attacks, *Gymnosporangium nootkatense* Arth. (Yellow cypress rust) is known to occur in nature and may cause some damage.

The generic name *Chamaecyparis* is derived from the Greek *chamai*, 'dwarf' or 'on the ground', and *kuparissos*, 'cypress'. It is apparently derived from the Greek name of ground-cypress for *Santolina chamaecyparrisus* L., a dwarf shrubby Old World composite which resembles a dwarf cypress. According to some authorities, the somewhat inapt name of the genus may have been derived from the dwarf juvenile forms. The specific name *nootkatensis* commemorates Nootka Sound on the west side of Vancouver Island, British Columbia, where the species was first found. The common name 'Yellow Cedar' refers to the color of the wood and its fragrance, which is thought to be somewhat similar to that of the true cedar. The bigeneric hybrid X *Cupressocyparis* is formed by a combination of the names of the parents, and *leylandii* commemorates C.J. Leyland who discovered the first hybrids at Leighton Hall.

The type locality is "Nootka Sound", where it was discovered in 1793 by Archibald Menzies (1754-1842), Scottish naval surgeon and botanist on Captain Vancouver's voyage of exploration in the Pacific Northwest (1790-1795). It first appeared in cultivation in the Botanic Garden at St. Petersburg (Leningrad) about 1850, as *Thujopsis tschugatskoi* from the western coast of the Kamchatka Peninsula (where it is in fact not known to exist). From there it appeared in the Jardin des Plantes, Paris, in about 1851 under the name *Thujopsis borealis*, finally being introduced into Great Britain about 1853.

Chamaecyparis nootkatensis is playing an increasingly important role in reforestation programs in British Columbia. The species is becoming more widely used in tree breeding and development programs and may well form a more important part of our forest resources in future.

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FIGURE 5. This Indian carving, of an eagle in high relief, is thought to be made from yellow cedar wood. It is a frontlet (part of a ceremonial headdress) which belonged formerly to a chief of the Kwakiutl tribe in Alert Bay, B.C.

Houttuynia cordata, Dokudami

Houttuynia cordata Thunberg or "Dokudami" is an interesting shade or wetland plant native to Asia (Japan, the Ryukyu Islands, Formosa, China, the Himalayas and Indonesia), and it has now become well established on parts of the University of British Columbia campus. It is a member of the Saururaceae or Lizard's-tail Family, a family of five genera and about seven species found in North America and Asia. Two related genera, *Saururus* and *Anemopsis*, occur naturally in North America. *Saururus cernuus,* "Lizard's-tail", occurs widely in eastern North America, usually in water or muddy soils. *Anemopsis californica*, "Yerba Mansa", grows from California to Colorado and south to northern Mexico.

"Dokudami" was probably introduced to the campus with other plant materials from Japan when the Nitobe Memorial Garden was first constructed. It has now become well-established in the garden and appears to compete well with the native vegetation. It is particularly common in the vicinity of the iris marsh, but is also found in the shady wooded areas along the trail on the west side of the lake. It is a most attractive plant when in flower, especially when naturalized in shaded corners. The four large involucral bracts, which are a striking pure white, appear in June and July. The cordate, reddish-tinged dark green leaves are an attractive addition to marshes and pool edges. The behavior of this plant in our climate is not well known and caution should be exercised when introducing it into a planted area. We have not had problems with rampant growth of the plant in the 16 years since it was introduced into the Nitobe Garden; however, the garden is well stablized and the competitive balance with other plants keeps the "Dokudami" in check.

Index Seminum

The Index Seminum for the 1975 collection year was distributed world-wide to a total of 515 institutions or individuals engaged in research projects. The list was a relatively small one compared to recent years, containing 77 taxa in 31 plant families. Of the 2,943 requests received from 218 institutions we were able to fill less than half, or 1,422. The policy of the Seed Exchange is to list in the Index Seminum all seed of which we have enough for 10 packets or more. Inevitably, therefore, those ordering seed which proves to be the most popular may sometimes be disappointed. The ten most frequently requested taxa were *Lewisia rediviva* (95 requests), *Dodecatheon hendersonii* (92), *Taxus brevifolia* (92), *Fritillaria pudica* (90), *Lilium columbianum* (88), *Fritillaria lanceolata* (80), *Cornus nuttallii* (80), *Trillium ovatum* (77), *Acer macrophyllum* (68), and *Cornus canadensis* (67).

The 1976 Index Seminum has been sent out, and requests for seed are now being received.

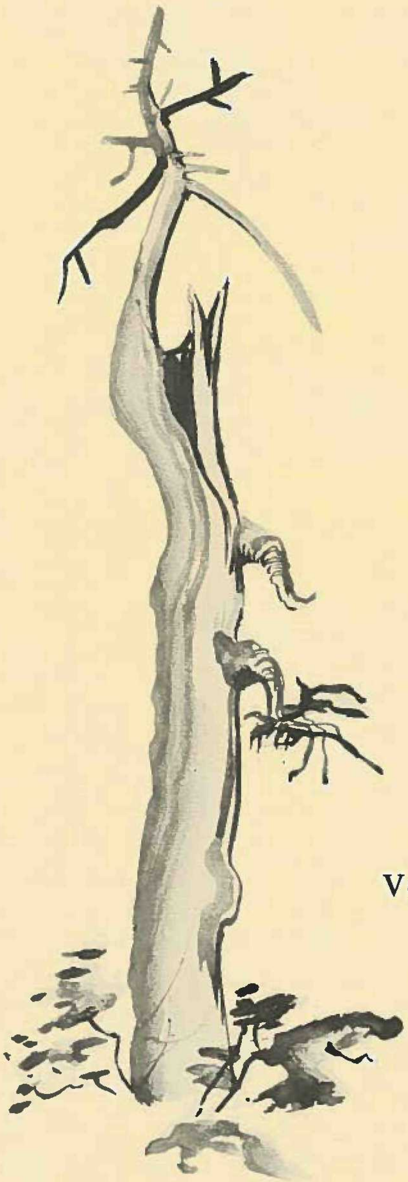
Climatological Summary for 1976*

The weather in 1976 did not differ greatly from that of past years, but a close examination of the monthly records shows some variations of interest. The highest temperature for the year was in April. However, the minimum temperature of -0.5°C for that month was the lowest April temperature recorded for 15 years. The minimum temperature for June (5.0°C) was also the lowest for that month in 15 years. The summer months of June, July and August were slightly cooler than average, though not unusually so. The total rainfall in 1976 was about average, but the last three months of the year were considerably drier than usual. In addition, no snow was recorded for these months. November was an unusually sunny month, but the total amount of sun for the year was the lowest in 15 years.

Data 1976	OCTOBER	NOVEMBER	DECEMBER
Average maximum temperature	12.7°C	9.3°C	7.7°C
Average minimum temperature	7.1°C	3.8°C	3.6°C
Highest maximum temperature	18.3°C	13.9°C	12.8°C
Lowest minimum temperature	2.2°C	-3.3°C	-1.7°C
Lowest grass minimum temperature	-5.0°C	-7.2°C	-5.6°C
Rainfall/no. days with rain	91.4 mm/12	55.8 mm/20	116.8 mm/22
Total rainfall since January 1, 1976	934.7 mm	990.6 mm	1107.4 mm
Snowfall/no. days with snowfall	0	0	0
Total snowfall since October 1, 1976	0	0	0
Hours bright sunshine/possible	117.4/318.4	97.4/268.2	48.5/253.1
Ave. daily sunshine/no. days total overcast	3.8/9	3.2/8	1.6/14

**Site: The University of British Columbia, Vancouver, B.C., Canada*
Position: lat. 49° 15′29″ N; long. 123° 14′58″ W. Elevation: 104.4 m

Opposite: A view of the stream in the Nitobe Memorial Garden, after a fresh snowfall.



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