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Forest Tree Genetic Conservation Status Report 1 *In Situ* Conservation Status of All Indigenous British Columbia Species

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ABSTRACT

The primary strategy for long-term conservation of British Columbia's biodiversity is through an extensive network of protected areas (PAs). These parks and ecological reserves have been established in all of the major ecological units within the province. The driver behind such a "coarse filter" conservation approach is usually the conservation of species. Conservation of genetic diversity within species often receives relatively little attention, yet it is genetic diversity within populations that provides the capacity for native species to adapt to new environmental conditions. This is particularly important given the predicted rates of climate change for British Columbia in the next century.

In this document we evaluate how well British Columbia's protected areas meet the goal of conserving genetic diversity of all indigenous tree species in all major biogeoclimatic units (zones) in which they occur. Most tree species have high levels of genetic diversity but also show clinal variation with latitude, elevation, or distance to the ocean, which allows for adaptation to temperature and moisture conditions. Ensuring that several large populations are conserved within each major ecological unit should conserve high levels of genetic diversity and enable adaptation to rapidly changing conditions.

Thresholds for adequate conservation have been developed based on population genetic theory. This approach evaluates minimum effective population sizes needed to maintain current levels of genetic diversity indefinitely under an equilibrium between losing genetic variation due to genetic drift and gaining genetic variation via mutation. Population sizes presented in this document are estimates based on provincial botanical plot data extrapolated across ecological units, derived from species cumulative cover rather than population size (which is not directly measured during ecological data collection). We used the cumulative cover of species to estimate numbers of mature individuals; therefore, these estimates include unquantified errors and do not fully reflect differences in tree stature and spatial distribution among species, ecosystems, and ages.

When we evaluated estimated sizes of populations protected in each biogeoclimatic zone against the thresholds determined for adequate conservation, many gaps in conservation became apparent. We focussed on clear conservation shortfalls within the core of species ranges; however, these are not the only places where protection may fall short. Many gaps occur at the margins of species ranges where species span ecological mapping units. This creates the impression that protection is scarce in ecological units where these species are uncommon. We took a pragmatic approach in evaluating such gaps and categorized them based on information beyond the botanical plot data. First, we identified gaps that are critical to a species' protection in ecosystems where the species is commonly found. Second, we identified potential gaps where estimates indicated that conservation populations may fall short of targeted sizes in ecosystems that are important to a species' provincial distribution, and recommended verification of population sizes using other sources of information (e.g., recent ecological mapping projects, expert knowledge, or ground truthing). Finally, we recognized the need to identify and conserve disjunct, marginal populations, which may contain unique

genotypes. The current data were inadequate to address this need; therefore, the collective knowledge of field foresters, botanists, and ecologists, as well as other sources of data, will be required to identify disjunct populations. It is our hope that, through this prioritization process, critical gaps will be identified clearly and addressed first through additional conservation efforts. This is the first of what should be a series of analyses that will be updated at regular intervals.

The results of this study are summarized in Table 1, which shows *in situ* conservation priority rankings for all indigenous tree species across all biogeoclimatic ecosystem classification (BEC) zones in British Columbia. This is followed by a summary of *in situ* conservation priorities for tree species of conservation concern based on the results.

TABLE 1 In situ *conservation priorities for indigenous tree species in British Columbia. Priority ranking:* x *protection required,* ? *= verification required. The top priority zone for each species where there are multiple conservation concerns is outlined in bold; cells shaded in grey indicate that < 1% of the species' range (cumulative cover estimated from the data set) occurs in the zone.*

	Biogeoclimatic zones[a]													
	AT	BG	BWB	CDF	CWH	ESSF	ICH	IDF	MH	MS	PP	SBP	SBS	SWB
Conifers														
ABIEAMA[b]														
ABIEGRA							?							
ABIELAS														
CHAMNOO														
JUNISCO				?							x			
LARILAR														
LARILYA														
LARIOCC														
PICEENG														
PICEGLA														
PICEMAR														
PICESIT														
PINUALB														
PINUBAN			x											
PINUCON														
PINUFLE						?		?						
PINUMON														
PINUPON														
PSEUMEN														
TAXUBRE														
THUJPLI														
TSUGHET														
TSUGMER														
Broadleaves														
ACERCIR														
ACERGLA														
ACERMAC														
ALNUINC														
ALNURUB														
ALNUVIR														
ARBUMEN				?	?									
BETUNEO														
BETUOCC			?											
BETUPAP														
CORNNUT				?										
CORYCOR														
CRATDOU		?		?	?			?						
MALUFUS				?										
POPUBAL														
POPUTRE				?	?									
POPUTRI														
PRUNEMA								?						
PRUNPEN			?				?						?	
PRUNVIR							?				?			
QUERGAR														
RHAMPUR				?			?							
SALIBEB														
SALIDIS		?				?	?	x		?		?	?	
SALILUC								?						
SALISCO														
SALISIT														

a Full names for the BEC zone codes are provided in each Section and in Resource 3 on the Centre for Forest Conservation Genetics website: www.genetics.forestry.ubc.ca/CFCG/resources.html

b Species codes are defined in Appendix 1.

Conifers

***Abies grandis* (ABIEGRA), grand fir**

ABIEGRA occurs at the northern extent of its range in British Columbia, and has a narrow, disjunct distribution in the province. It is most abundant and adequately protected on the coast (CWH and CDF zones) but lacks protection in the smaller interior portion of its provincial range. In the interior, it is under-protected in both the ICH and IDF zones but is identified as a species of concern only in the ICH zone. Its effective population size in the IDF is the smallest of all zones, and the species is predicted to decline in abundance and become maladapted with climate warming. Population verification is recommended for this species in the ICH zone.

***Juniperus scopulorum* (JUNISCO), Rocky Mountain juniper**

JUNISCO is found in many interior zones in southern British Columbia, where it is mostly well protected, especially in the IDF zone. In the interior, verification and increased protection in the PP zone are recommended. Coastal populations of JUNISCO, recently proposed as *Juniperus maritima* [Adams], are considered to be important for genetic conservation but are under-protected in the CDF zone. Pure stands are rare on the coast, and the species is not expected to be present at set threshold levels within protected areas; however, it has a patchy distribution but consistent presence along shorelines, where it could be protected through covenants.

***Pinus banksiana* (PINUBAN), jack pine**

PINUBAN is a rare, blue-listed species in British Columbia, although it is common and abundant in the rest of the Canadian boreal forest. The western edge of the species' range extends into the BWBS zone in the northeastern corner of the province. The level of protection in British Columbia is low; therefore, ground truthing is recommended for this species. This may indicate that additional protected areas need to be created to protect this peripheral population.

***Pinus flexilis* (PINUFLE), limber pine**

PINUFLE has a very limited distribution in British Columbia. The northern edge of its western North American range extends into the southeastern portion of the province, where it is very sparsely distributed in the ESSF, MS, and IDF zones. It is under-protected in all three zones. Field verification is recommended in the IDF zone and in large protected areas that span at least two zones: the IDF/MS zones and the MS/ESSF zones. Considering that there are serious insect and fungal threats to this species, it would be prudent to increase *ex situ* conservation and implement active management efforts for this species.

Broadleaves

***Arbutus menziesii* (ARBUMEN), arbutus or Pacific madrone**

The northern edge of the range of ARBUMEN extends into the CDF and CWH zones in southern British Columbia. Based on the calculated occurrence levels, it is recommended that the occurrence of this species in protected areas in the CDF zone be verified. Given that ARBUMEN has been observed in many smaller protected areas (e.g., Spectacle Lake, Mount Tzouhalem Ecological Reserve, Mount Maxwell Park and Reserve, Woodley Range Ecological Reserve, Ladysmith Bog Ecological Reserve, Arbutus Grove, Boyle Point), in numerous regional parks around southeastern Vancouver Island, and on Crown and private land that is not viable for forestry, it is likely that actual protection levels for this species are adequate. A comprehensive re-evaluation of protection status of all species in the CDF zone should be conducted prior to any field verification efforts. Verification, and if required, increased protection, are also recommended in the CWH zone, where this species has the potential to increase with climate warming.

***Betula occidentalis* (BETUOCC), water birch**

BETUOCC occurs in many zones, but in low numbers. It is most common in the IDF zone. It is under-protected in several zones, but is identified as a species of concern and is recommended for verification only in the IDF and in the northern part of its range in the BWBS zone, where calculated protection levels are near zero.

***Cornus nuttallii* (CORNNUT), western flowering dogwood**

At the northern edge of its range, CORNNUT is found mainly in the CDF and CWH zones. It also occurs infrequently in transitional subzones of the IDF zone in southern coastal British Columbia. It is recommended for ground truthing in protected areas in the CDF zone, where protection is expected only at lower threshold values. However, it is recommended that a comprehensive re-evaluation of protection status of this species in the CDF zone be conducted prior to field verification in this zone. While under-protected in the IDF zone, CORNNUT is not recommended for ground truthing because the protected area coverage level in suitable IDF subzones is already very high.

***Crataegus douglasii* (CRATDOU), black hawthorn and other *Crataegus* spp.**

CRATDOU occurred at such low frequency in the data set that estimated protection levels are low or near zero in all zones except the IDF. Verification is recommended in the BG, CDF, CWH, and even the IDF zones, but not in the ICH and PP zones, where occurrence is particularly low. It is recommended that conservation efforts be directed first to the BG zone. CRATDOU observations could represent one of six proposed native black-fruited hawthorns. We suggest that the taxonomic complexity and the presence of this early-seral species in rural settings, modified habitats, and smaller regional or district parks be addressed when determining the conservation needs for this species group. Also, a comprehensive re-evaluation of protection status and conservation needs for this species in the CDF zone is recommended prior to field verification in the zone.

***Malus fusca* (MALUFUS), Pacific crab apple**
MALUFUS occurs in coastal British Columbia, mainly in the CDF and CWH zones, with some extension into the ICH zone on the north coast. It is well protected in the CWH zone. While protection is low in both the ICH and CDF zones, MALUFUS is identified as a potential species of concern and is recommended for ground truthing only in the ICH zone. A comprehensive re-evaluation of protection status and needs for this species in the CDF zone is recommended prior to field verification in the zone.

***Populus tremuloides* (POPUTRE), trembling aspen**
Protection levels for POPUTRE are very high across the province except in the CDF zone, where it is rare. Verification of this species in the CDF zone is recommended. Remnant populations threatened by urban development in the Fraser Valley should be considered for increased protection because pollination success may decline as the distance between female or male clonal clusters increases.

***Prunus emarginata* (PRUNEMA), bitter cherry**
PRUNEMA is adequately protected on the coast in the CWH zone but likely not in the CDF where verification is recommended. In the interior, it is adequately protected in the ICH zone. In the more arid interior, protection is lacking in the BG and PP zones, and is low in the IDF zone. PRUNEMA is not expected to occur in any IDF, PP, or BG zone portion of a large, multi-zone protected area, nor is it protected in the southern Rocky Mountain Trench. Ground truthing is recommended in the IDF zone.

***Prunus pensylvanica* (PRUNPEN), pin cherry**
In central British Columbia, PRUNPEN is well protected in the IDF zone. However, in the SBS zone, in the core of its British Columbia range, PRUNPEN is protected only at threshold values below 10 hectares cumulative cover (the threshold deemed adequate for large trees to conserve adequate population sizes). Ground truthing is recommended first in the SBS zone, and then in the BWBS and ICH zones.

Prunus virginiana (PRUNVIR), choke cherry
PRUNVIR is generally adequately protected in the BWBS, SBS, IDF, and BG zones, where it occurs most frequently. In the Rocky Mountain Trench, protection is sufficient in the higher-elevation MS zone but not in the PP or IDF zones. Ground truthing in the PP and ICH zones is recommended.

***Rhamnus purshiana* (RHAMPUR), cascara**
On the coast, RHAMPUR is well protected in the CWH but not in the CDF zone, where ground truthing is recommended. However, as protection appears lacking for interior populations, ground truthing efforts in the ICH zone, starting in the Shuswap area, should be given higher priority.

***Salix discolor* (SALIDIS), pussy willow**

SALIDIS occurs with sufficiently low frequency that calculated population sizes are very small in almost all zones within its range. As a result, ground truthing is recommended for the following zones, listed in order of decreasing priority: IDF, ICH, SBS, SBPS, MS, ESSF, BG.

***Salix lucida* (SALILUC), shining or Pacific willow**

SALILUC has a wide distribution (larger and more contiguous than indicated by the data) and is well protected in many zones. It is recommended for ground truthing in the IDF zone, at least for verification in a multi-zone protected area that extends through the BG, PP, and IDF zones.

APPENDICES

TABLES

FIGURE

1.1 Introduction

In this document we identify the most significant *in situ* conservation gaps for British Columbia's approximately 50 native tree species and provide information to direct field verification of actual protection levels. Reported *in situ* protection levels were estimated using a GIS approach, where protected area spatial coverage data were intersected with species spatial frequency data (Hamann et al. 2005). The protected areas data set used was from 2002, and was comprised of approximately 800 permanently protected areas, national parks, ecological reserves, provincial parks, and recreation areas. The species frequency data set was generated by intersecting the B.C. Ministry of Forests (MFR) botanical inventory database (34 000 sample plots) with biogeoclimatic ecosystem classification (BEC) coverage (version 4) to obtain average frequency values (percent cover) by biogeoclimatic variant. The resulting species coverages (i.e., digital range maps), which represent the spatial distribution of the 20th-century climatic range of each species, were used to calculate conservation status statistics, such as the proportion of a species' total range that is protected (in hectares) expressed as a proportion of the province or of a biogeoclimatic zone. Species cumulative cover (CC)—a more direct measure of species abundance that should be highly correlated with population size—was used to determine whether populations within protected areas were of sufficient size to include at least 5000 reproductively mature trees and thus maintain genetic diversity over many generations. Species distributions were calculated using cumulative cover for each biogeoclimatic variant, and then were tallied by zone and for the entire province. Species cumulative cover estimates for protected areas were calculated separately for the area of each variant within a protected area and then tallied by protected area, zone, and the province. The gap analysis and assessment of *in situ* conservation status was carried out by zone since most tree species in British Columbia are not expected to show substantial adaptive genetic differentiation at a finer level of landscape or climate classification. Zones are a useful surrogate since genecological data are lacking for most species other than commercial conifers.

1.2 Organization and Presentation of Materials

In situ genetic conservation statistics are summarized by zone for each species. Zones are organized alphabetically with the two predominantly non-forested zones (AT zone—since split into three regional zones—and BG zone) presented first. Each zone summary has four sections. The first provides a brief general overview of the climate and forests of the zone. This is followed by a brief description of protected areas within the zone. The levels of species representation in those protected areas are presented next, and species are classified as having either adequate or low levels of representation. Gaps in protection are highlighted, and those considered to be of primary concern in terms of genetic conservation are identified. For easy reference, a summary table showing species range and protected area statistics is provided for each zone. The last section identifies top-priority species that require either increased protection or protected area population size verification. Information and suggestions to guide ground truthing efforts are provided, and, where applicable, the need for new protected areas is addressed. A list of electronically available supplementary resources is provided for each section. Much of the reference material is posted on the Centre for Forest Conservation Genet-

ics (CFCG) website (www.genetics.forestry.ubc.ca/CFCG/resources.html). In general, only the supporting materials for ground truthing are contained in this report; they are provided in the appendices. The approach, content, and information sources used to compile the four sections of each zone summary are described below.

1.2.1 Overview The overview section briefly describes the general physical characteristics (location, size, and climate) and vegetation of each biogeoclimatic zone. Location and general climate characterizations are based on information in Ecosystems of British Columbia (Meidinger and Pojar 1991). Mean annual precipitation and temperature values and ranges were derived using ClimateBC (Hamann and Wang 2005; Wang et al. 2006). A complete list of these and other derived variables (e.g., mean warmest and coldest month temperatures, continentality index, heat:moisture index) for all subzones and variants (Resource 1) is posted on the CFCG website.[1] Biogeoclimatic units can be differentiated based on ClimateBC-derived variables using canonical discriminant analysis. This is illustrated by a plot differentiating the various subzones based on continentality, moisture, and temperature on the website (Resource 2). More information on ClimateBC and the methods used to generate high-resolution climate data can be found in Wang et al. (2006). The full names for the biogeoclimatic unit codes (Resource 3) and subzone and variant maps (Resource 4) are also posted on the website.

A brief vegetation description highlights the common forest types and the major and minor tree species of each zone. For brevity, British Columbia plant species codes (Meidinger et al. 2004) are used in place of full scientific or common names. The code is generated from the first four letters of the genus name plus the first three letters of the species name. The codes, full names, selected species attributes, and status ranks (provincial, sRank, and gRank) are provided in Appendix 1. Resources consulted when compiling the vegetation descriptions included species range maps (Resource 5), subzone and variant distribution charts (Resource 6), Meidinger and Pojar (1991), Klinka et al. (2000), and the MFR biogeoclimatic ecosystem classification ecology brochures for each zone (B.C. Ministry of Forests 1995–2006). The species distribution charts, indicating the relative abundance of species in each subzone or variant, were generated from percent cover values.

1.2.2 Protected areas For each zone, protected areas are described in terms of overall coverage levels (percentage of land protected) and numbers of protected areas (total and percentage by size class). Total coverage levels include all land classes (e.g., water and non-forested land). Large protected areas are those greater than 250 ha. For conifers in British Columbia, this area is considered to be large enough to contain a census population size of 5000 individuals (Yanchuk and Lester 1996). Protected area distribution and coverage is presented by subzone, and when appropriate, is discussed in relation to subzone disturbance levels. Subzone disturbance is inferred from a comparison of the forest age class distribution on land outside of protected areas to the overall age class distribution within protected areas in the zone. Subzone

1 www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

and protected area maps for each BEC zone (Resource 4) and subzone protected area coverage levels and forest age class information (Resource 8) are posted on the CFCG website. When evaluating protected areas and land use patterns, a simplified biogeoclimatic ecosystem classification system was used: some subzones and variants were grouped if the units were small, geographically adjacent, similar in species composition, and relatively similar in climatic conditions (indicated in text, with a slash e.g., xh2/xh3/xw1). It was assumed that genetic differentiation among populations in these combined ecosystem units is minor.

In each zone, the top 10 protected areas that have the largest contributions to genetic conservation are listed. Protected area importance is calculated using a modified species evenness index (analogous to the Shannon index), which takes into account the number of populations (species–zone combinations) protected and the redundancy in protection:

$$I = \sum_{i=1}^{S} r_i \text{ and } r_i = \frac{1}{N_i}$$

where I is protected area importance, S is the total number of species protected in the zone at a set threshold population size, r_i is the redundancy value for species i, and N_i is the number of protected areas in the zone containing species i at the set threshold population size.

A threshold population area of 10 ha cumulative cover (CC) was used for the important protected areas listed in this section. A complete list of protected areas in the zone and their ranks based on 5 and 10 ha cumulative cover is posted on the CFCG website (Resource 8). Included in this list is their British Columbia–wide importance rank (Hamann et al. 2005), which is also based on 5 and 10 ha cumulative cover.

1.2.3 Species representation in protected areas All species present in the zone (i.e., recorded as present in the data set) are classified as having either adequate or low protected area representation based on the number of protected areas they occur in at set threshold values. A threshold of three protected areas per zone is considered to be the safe minimum redundancy given the potential for catastrophic losses (e.g., fires), and a threshold population size of 10 ha cumulative cover is considered to be adequate to ensure the long-term conservation of genetic resources. It has been calculated that for common large commercial conifers, 10 ha of cumulative cover will likely contain a census population size larger than 5000 breeding individuals, and thus will maintain an effective population size of $N_e \geq 1000$ (Hamann et al. 2004).

Based on this analysis, we identified the primary gaps in protection in terms of genetic conservation. Species distribution, protected area coverage levels, and predicted future potential presence in the zone were all considered when identifying priorities. A variety of species range descriptors and protection levels are provided in a summary table (Figure 1). Included is a measure of the species' relative importance in both the province and zone (Figure 1, items 1 and 2). These values represent the percentage contribution of a species towards the total tree cumulative cover in British Columbia and in the particular zone, respectively. The relative importance of the zone in a species' distribution is represented by the proportion of the species' total provincial cumulative cover distribution that occurs in the zone (Figure 1, item 3). The

calculated species range values in the zone and in protected areas of the zone are presented in hectares of cumulative cover (Figure 1, item 4). Range in terms of areal cover of the distribution (ha) not reflecting species density can be found in the "Conservation status" insets of the species range maps from Hamann et al. (2005) posted on the CFCG website (Resource 5). Small-statured trees could achieve an effective population size of 5000 individuals at cumulative cover values lower than 10 ha, whereas larger trees may require higher values; therefore, the total cumulative cover protected and the number of expected protected areas at thresholds of 2.5, 5, and 50 ha cumulative cover are also presented (Figure 1, item 5). The last items in the summary table are the future frequency predictions for species in the zone (Hamann and Wang 2006: Table C1). Expected changes in species frequencies are expressed as a change in percent cover in 2055 compared to the 1961–1990 period using a moderate-scenario global circulation model (CGCM1gax) to generate environmental variables expected under future climate conditions, and predict the species' range and distribution based on those future conditions. Values in bold type indicate a potential for a species to double in frequency; those underlined indicate a predicted decrease by more than 90%. It is important to note that these predictions are based on climatic suitability alone and do not consider the complex web of factors that determine a species' realized niche. Such factors include seed availability, presence of suitable conditions for establishment and growth (e.g., exposed soil, fire, light levels), site charac-

1 2 3 4 5 6

TABLE X *Estimated occurrence levels, number of protected areas, and future frequency predictions for species in the CWH zone.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
CRATDOU	< 0.01	< 0.01	4.8	74	4	5.6					0.0
SALIBEB	0.40	< 0.01	0.1	102	4	3.9	1				-0.1
CORYCOR	0.14	< 0.01	1.1	417	20	4.8	4	1			-0.1
POPUTRE	4.30	< 0.01	0.1	1017	14	1.4	2				-0.2
ARBUMEN	0.02	0.02	20.3	1 208	24	2.0	2				1.1
RHAMPUR	0.01	0.02	55.0	1 366	95	7.0	11				0.1
SALISCO	0.53	0.05	2.6	3 918	147	3.7	8				-0.1
PICEENG	3.50	< 0.01	0.1	537	89	16.6	6				-0.7
PRUNEMA	0.01	0.03	59.6	2 608	117	4.5	10				0.0
BETUOCC	0.04	0.02	10.3	1 284	76	5.9	6				-0.5
ALNUINC	1.83	0.04	0.7	3 309	239	7.2	6				-0.8
CORNNUT	0.03	0.05	52.2	3 863	214	5.5	16	10	6	1	0.2
SALILUC	0.09	0.05	15.7	4 000	298	7.4	14	11	7		-0.1
PINUMON	0.11	0.10	23.0	7 587	660	8.7	35	24	13	1	0.0
ABIEGRA	0.09	0.10	28.8	7 932	328	4.1	22	11	4	1	0.5
BETUPAP	1.00	0.11	3.1	8 667	703	8.1	27	18	10	2	0.1

Species above the line are those estimated to lack adequate protection (<3 protected areas at 10 ha cumulative cover), and those below are adequately protected.

FIGURE 1 *An example illustrating components of the species range and protection level summary table presented in each zone section. The calculation of items 1 to 6 is described in the text above.*

teristics (e.g., appropriate soil type, moisture and nutrient conditions), effects of interspecific competition, facilitation, and interactions with disease and insects. More details on the methods and climate variables used to model species ranges and biogeoclimatic subzone climate envelopes can be found in Hamann and Wang (2006).

As previously stated, low protected area representation does not necessarily confer under-protected status. Species that have both a very minor presence or a limited distribution in a zone and that are not expected to increase with climate warming, and adequate protected area representation in adjoining or other zones where the species are more common, are often considered to be transitional or fringe species. As such, they are not identified as high-priority concerns. For example, SALIBEB (*Salix bebbiana*) contributes < 1% towards total tree cover in the CWH zone (Figure 1, item 2), has < 1% of its provincial cumulative cover distribution in the zone (Figure 1, item 3), is recorded in only one subzone (Appendix 4.3), and is not predicted to increase with climate warming (Figure 1, item 6). It has a narrow distribution in the zone and is recorded only in the vegetation inventory sample plots located in areas transitional to the IDF zone (Resource 4: subzone maps; Resource 6: subzone species distribution charts; Appendix 4.3: subzone species percent cover values). As it is adequately protected in the adjoining IDF zone (Table 9—expected in 14 protected areas in the IDF zone at 10 ha cumulative cover), where it occurs more frequently, it is not identified as a species of concern in the CWH zone.

Not all under-protected species with significant predicted future frequency increases are flagged as species of concern. For example, THUJPLI (*Thuja plicata*) is common at lower elevations in the CWH zone but occurs in the adjoining MH zone with a sufficiently low frequency that it is calculated to occur in only one protected area at 10 ha cumulative cover (see Table 10). Despite its predicted potential to at least double in frequency with climate warming, the current lack of protection for this species in the MH zone is not identified as a cause of concern. In this case, the high protected area coverage levels for the MH zone (in 2002, 14% of the zone was protected, and levels have recently been increased on the central and north coast) and the many large multi-zone protected areas covering both the MH and CWH zones are considered to be sufficient to provide future protection should range expansion occur.

In some zones, generally those with low protected area coverage levels, verification of protected area populations is not always recommended for non-fringe species with verifiably low protected area representation. This recommendation is made if the species is calculated to occur in some portion of a large multi-zone protected area that either adjoins or covers portions of the zone in question. While not ideal, this may be the most achievable minimum standard in highly populated, disturbed, or altered zones, or it may serve as a temporary measure until *in situ, inter situ,* or *ex situ* protection levels can be increased.

In two cases, species protected above minimum thresholds (greater than three protected areas at 10 ha cumulative cover) were identified as being of concern. Protected area population verification has been recommended when the zone in question represents one of a few protection opportunities or the only protection opportunity for the species across the province. This applies particularly to minor species with (1) a discontinuous distribution

within or across zones, (2) low frequency occurrence throughout a zone, or (3) narrow site requirements. For these species, population estimates derived using this GIS approach will have a higher degree of uncertainty and therefore err more than those for widely occurring species. Verification has sometimes been recommended for adequately protected species if they are near the threshold of three protected areas and are of commercial value (e.g., ABIEGRA) or are predicted to dramatically increase with climate warming. A summary of protected area numbers for a threshold of each species in all BEC zones is provided in Appendix 2.1 for a population size of 10 ha cumulative cover and in Appendix 2.2 for 5 ha cumulative cover.

1.2.4 Top conservation priorities The top species of concern in each zone are identified as requiring either additional protection or population size verification. Very few species, even those calculated to occur in no protected areas, were immediately assigned to the protection-requiring class. For many of the small-statured and infrequently occurring species, and those with very specific site requirements, it is recommended that their absence in protected areas first be verified. The protected area population estimates derived using subzone-level data were calculated under the assumptions that (1) the species range as predicted from the inventory plots is representative; (2) the distribution of the botanical sample plots reflects the actual environmental distribution across the landscape (subzone); (3) the distribution of site types in protected areas is similar to the overall pattern across the landscape (subzone); and (4) species exist where they have the potential to germinate, grow, and reproduce (i.e., landscape features, historic events, meta-population dynamics, or other factors have not excluded them from suitable habitats). These assumptions are less likely to be met for very infrequently occurring species than for more common ones. For example, CRATDOU is estimated to have 5% of its provincial cumulative cover distribution in the CWH zone, but because it occurs with low frequency (low percent cover in the database in only one variant, which happens to have a low protected area coverage), it is not expected to occur in any protected area at even the lowest cumulative cover threshold of 2.5 ha (see Figure 1 above). This species is, however, known to occur in other CWH subzones (see Royal British Columbia Museum records mapped by E-Flora [Klinkenberg 2007]). To obtain reliable population estimates for this species, field surveys would need to be conducted in protected areas with suitable habitats. To help direct these ground truthing efforts, the top 10 protected areas with the highest estimated cumulative cover values are provided in Appendix 3. These are essentially the largest protected areas in the subzones where the species has a recorded presence (in this data set), and for certain species, will not necessarily be the best places to search. Species percent cover values by subzone (Appendix 4), site or terrestrial ecosystem mapping (TEM), aerial or digitized photos, and local knowledge should be consulted prior to ground truthing.

Species requiring protection or recommended for ground truthing or data verification are listed in order from highest to lowest priority based on the calculated species genetic conservation status across the province (e.g., under-protected in many zones vs. in one zone) and on its distribution (e.g., substantial vs. minor portion of its provincial range in the zone). Consideration of the overall species status (B.C. Ministry of Environment Conservation Data Centre–CDC species listing), habitat conservation status (CDC eco-

system listing), or specific threats (e.g., insect, disease, harvesting) could yield different results. The top-priority species in each zone is shown in bold, and the top priority zone for each species is indicated by an underlined species name. A brief comment or general recommendation is usually given for each species. If particular protected areas for ground truthing are not mentioned, we recommend considering those listed in Appendix 3.

Where appropriate, general comments are given on protected area coverage levels, gaps in protection, and the need for new protected areas. Species percent cover values by subzone (Appendix 4) were consulted to provide suggestions on possible locations for new protected areas.

2 AT ZONE

2.1 Overview

The alpine zones cover 18% of the province. They occur at high elevations throughout British Columbia and have very harsh, cold, snowy, windy climates with a mean annual temperature of only -2°C. Cold temperatures and short growing seasons limit tree growth. The zones lack a warm season (mean temperature of the warmest month is < 10°C) and have a very short frost-free period. Mean annual precipitation is 2000 mm (range = 700–3000 mm) and falls mainly as snow. The alpine zones vary considerably in precipitation and continentality among the coast (CMA: Coastal Mountain-heather Alpine zone), Northern Interior (BAFA: Boreal Altai Fescue Alpine zone), and Southern Interior (IMA: Interior Mountain-heather Alpine zone). The climate is generally drier and colder in the BAFA zone and snowier and milder in the CMA zone. In the IMA zone, snowfall is highest in the interior wet belt and lowest in the Kootenays and in the lee of the Coast Mountains. In this analysis, the older classification system was used; hence, the three zones are treated as one, hereafter referred to as the AT zone.

The AT zone is considered to be non-forested, but trees in stunted or krummholz form occur at lower elevations on sites with shallow or early-melting snow. While many species can form timberline (PINUALB, LARILYA, TSUGMER, ABIELAS, PICEENG, PINUCON, CHAMNOO, PICEGLA, POPUBAL, and POPUTRE), only PINUALB and LARILYA were consistently present in the botanical data set. The landscape can be well or sparsely vegetated with cushion or trailing shrubs, herbs, grasses, sedges, bryophytes, and lichens.

Online resources (p. 54): 1, 2, 3†

2.2 Protected Areas

The AT zone has the highest protected area coverage of all zones. It ranks second after the CWH for total number of protected areas (> 200) and third after the MH and SWB for percentage of large protected areas (75%). The protected areas are well-distributed throughout the zone and between the coast, interior, and northern areas. The top 10 protected areas in terms of genetic conservation for LARILYA and PINUALB are Cathedral, Snowy, Bugaboo, Height of the Rockies, Kootenay, Mount Assiniboine, Purcell Wilderness

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

Conservancy, Babine Mountains, Big Creek, and E.C. Manning. Only the first two protected areas are expected to contain both species, the next five only LARILYA, and the final three only PINUALB. Protected area ranking was calculated based on protected areas that are expected to contain a species at a threshold presence of ≥ 10 ha cumulative cover, and on the total number of protected areas for each species at this threshold. As LARILYA has a narrower range than PINUALB and is expected to occur in fewer protected areas, the protected areas in southeastern British Columbia, where this species occurs more frequently, score higher.

Online resources (p. 54): 3, 4, 7, 8†

2.3 Species Representation in Protected Areas

2.3.1 Adequate representation (2 of 2 species) Both LARILYA and PINUALB are expected to occur in more than three protected areas at a cumulative cover of 10 ha, which is likely excessive for a stunted tree. LARILYA is well protected in the AT zone throughout its range. In contrast, protection for PINUALB in the AT zone occurs mostly in western and central British Columbia. However, considering the existing high protected area coverage in the alpine, the adequate protection levels for this species in the adjoining ESSF zone in eastern British Columbia, and the pest and pathogen threats to this species, verifying or increasing *in situ* conservation levels for this species in the AT zone is not recommended. Given all the threats to *in situ* populations, this species should be the focus of an integrated conservation plan.

Online resources (p. 54): 5, 6†; summary information: Table 2, Appendix 2

TABLE 2 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the AT zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
LARILYA	0.03	31.90	15.28	1 419	475	33.5	9	9	7	4	0.1
PINUALB	0.25	68.10	3.99	3 028	1109	36.6	22	20	14	5	0.7

2.4 Conservation Priorities

Considering species rarity, distribution, protected area coverage levels, and predicted future potential presence, neither LARILYA nor PINUALB are identified as species of concern.

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

3.1 Overview

The small, semi-arid Bunchgrass (BG) zone occurs in the very dry valley bottoms in the Southern Interior along the Chilcotin, Fraser, lower Thompson, Nicola, Similkameen, and lower Kettle Rivers, as well as along Okanagan Lake. The mean annual temperature, annual precipitation, and summer precipitation for the BG zone are 5.9°C, 337 mm, and 163 mm, respectively. The winters are cool with little to no snowpack, and the summers are long, warm to hot, and very dry. Evapotranspiration rates are in excess of precipitation, and grassland and shrub-steppe vegetation dominate the landscape. Summer precipitation evaporates too quickly to replenish soil water stores, and generally only riparian, seepage, or coarse-textured soil sites or cool aspects can support tree growth. The two BG subzones occupy different topographic positions: the lower-elevation grasslands (BGxh) are warmer and drier, and have more sagebrush, than the middle grasslands (BGxw).

Forests cover only 15% of this zone and are found only on wetter sites. Most of the tree species are restricted to riparian sites, wetland sites, or toe slopes with seepage inputs. PINUPON is the most common tree species, and together with PSEUMEN can be commonly found outside of riparian areas in moist draws or on gentle to steep slopes that have coarse-textured soils and seepage. Wetlands, mostly alkaline meadows and salt ponds, are rare in the dry valleys and are estimated to cover < 1% of the land base. The BG zone contains many rare plant and animal species that are at the northern edges of their ranges.

Online resources (p. 54): 1, 2, 3†

3.2 Protected Areas

On average, 10% of the land in the BG zone is protected. While this is lower than the provincial average, it is substantially higher than in the other two small, highly populated, and disturbed zones—the CDF and PP, which have 3% and 4% protected area coverage, respectively. There are 40 protected areas in the BG zone, but 75% of them are small. The nine larger protected areas, which account for 98% of the total protected area coverage in the zone, are generally widely and evenly distributed. Each subzone has at least two large protected areas, of which at least one extends into the IDF zone or beyond. The largest gap in protection is in the BGxw1 between Merritt and Kamloops. The top 10 protected areas for genetic conservation are Churn Creek, Lac du Bois Grasslands, Junction Sheep Range, South Okanagan Grasslands (PA), Edge Hills, Elephant Hill, Haynes Lease (ER), Okanagan Mountain, Vaseux (PA), and White Lake. However, not all of these protected areas are expected to contain species other than PINUPON at a threshold of > 2.5 ha cumulative cover in the BG portion of their area. Churn Creek, Lac du Bois Grasslands, and South Okanagan Grasslands are also important for genetic conservation at the provincial level (top 30 protected areas for British Columbia).

Online resources (p. 54): 3, 4, 7, 8†

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

3.3 Species Representation in Protected Areas

3.3.1 Adequate representation (10 of 16 species) The species percent cover frequencies in the BG zone are low enough that only the largest protected areas are expected to contain sufficient population sizes. As a result, the redundancy or degree of protection (i.e., number of protected areas) in the BG zone is much lower than in other zones. While we estimate that many of the species that contribute the most towards tree cover in the BG zone are adequately protected, the protected area numbers are close to the minimum threshold (three protected areas with 10 ha cumulative cover). Also, considering the environmental conditions in the BG zone and the site requirements of many tree species (restricted to wetter sites), the confidence attached to the protected area population size predictions is probably lower in the BG than in other zones. For more reliable estimates of population sizes and the availability of suitable habitat, recent mapping inventories should be considered. Even the smaller protected areas centred on rare or unique riparian or wetland features could be assessed.

3.3.2 Low representation (6 of 16 species) Most of the six under-protected species (excluding BETUPAP) contribute very little toward the total tree cover in the BG zone and have < 1% of their provincial cumulative cover distribution in the zone. BETUPAP is the most common species and has a consistent minor presence on riparian sites. However, considering its provincial distribution, potential for protection in the BG and PP zones at 5 ha cumulative cover, and expected adequate protection in the IDF portions of several, widely separated, multi-zone protected areas (Churn Creek, Lac du Bois Grasslands, Okanagan Mountain, Snowy), it is not considered to be a species of top concern in terms of genetic conservation. SALISCO is also expected to be protected in the IDF portions of the same multi-zone protected areas and is not considered to be a top-priority concern. PRUNEMA is considered to be a fringe species in the BG zone and is recommended for verification in the IDF and PP zones, where it occurs more frequently. SALIDIS has a minor portion of its range in the BG zone (4%) and occurs most frequently in the Fraser River basin (BGxh3, xw2). If SALIDIS is absent from the IDF portion of Churn Creek (IDFdk4, xm), local populations in the BG zone could be important. Although SALILUC has only a small portion of its range in the BG zone, the zone may offer the best protection opportunities for this species in the semi-arid or drier, cool temperate portions (PP and IDF zones) of south-central British Columbia. Of all the under-protected species, CRATDOU has the highest portion (8%) of its range in the BG zone. It is potentially under-protected in many zones and is recommended for population verification in the BG zone.

Online resources (p. 54): 5, 6†; summary information: Table 3, Appendix 2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 3 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the BG zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
PRUNEMA	0.01	0.05	0.30	13	1	7.7					0.0
CRATDOU	< 0.01	0.46	8.17	127	7	5.4	1				0.1
SALISCO	0.50	0.25	0.05	69	13	18.8	2	1			-0.1
SALILUC	0.09	0.57	0.61	158	19	11.9	3	2			-0.1
SALIDIS	0.01	0.50	3.73	139	26	18.7	2	2	1		-0.2
BETUPAP	1.00	2.83	0.28	785	59	7.5	6	3	2		0.1
SALIBEB	0.37	2.49	0.67	691	72	10.4	5	4	3		0.0
PRUNVIR	0.06	3.81	5.88	1 056	86	8.1	6	4	3		0.2
ALNUTEN	1.80	1.64	0.09	455	93	20.4	4	4	3	1	-0.2
JUNISCO	0.05	4.69	8.75	1 300	149	11.4	5	4	3	1	-0.4
ACERGLA	0.41	5.17	1.17	1 432	167	11.7	5	4	3	1	-0.2
BETUOCC	0.04	3.01	6.70	835	161	19.3	5	4	3	1	0.0
POPUTRE	4.30	11.25	0.26	3 119	287	9.2	6	5	5	2	-0.4
PSEUMEN	6.60	18.17	0.26	5 036	582	11.6	8	5	5	3	-1.4
POPUTRI	0.56	13.15	2.07	3 645	271	7.4	10	7	6	2	0.9
PINUPON	0.30	31.97	9.44	8 863	480	5.4	17	14	7	2	0.1

a underline indicates > 90% decrease

3.4 Conservation Priorities

? population verification required CRATDOU, SALILUC, SALIDIS

Verification for CRATDOU is recommended first in the large, multi-zone protected areas (e.g., Edge Hills or Churn Creek, South Okanagan Grasslands or Snowy, and Lac du Bois Grasslands). As CRATDOU is potentially protected in the IDF portion of Churn Creek and Edge Hills along the Fraser River, it is recommended that field verification be conducted first in the BGxh2/xw1 along the Thompson River and in the BGxh1 in the southern Okanagan. Verification for SALILUC is recommended in the IDFdm2 in the Rocky Mountain Trench and in the BG zone in the Fraser/Chilcotin, Thompson/Nicola, and Okanagan River basins in the Central Interior. Verification for SALIDIS is recommended in the BG xw2/xh3 in Junction Sheep Range. If the species is absent in the IDF portion of Churn Creek or Edge Hills, verification is recommended in the BG zone portions of those protected areas.

High levels of development, agriculture, cattle grazing, recreation, invasive species, and fire suppression have altered or affected many of the natural ecosystems in the BG zone. It contains many threatened or endangered plant and animal species, and most of the natural forested and grassland ecosystems in the zone are considered to be at risk. Forests with species other than PINUPON are generally restricted to small, wetter areas such as wetlands, riparian areas, or sites with very coarse soils, cool aspects, or seepage. Private land ownership and land use is extensive in the zone, particularly along the waterways and terraces where most of the tree species occur. The encouragement of good stewardship practices on private lands and those held by environmental non-governmental organizations (ENGOs), and the creation of

corridors along the waterways, are needed to increase protected area connectivity. In highly disturbed and fragmented landscapes, species populations on protected private land may need to be considered when verifying protection levels.

Support materials for field verification: Appendix 3, Appendix 4

4 BWBS ZONE

4.1 Overview

The Boreal White and Black Spruce (BWBS) zone, the largest forested zone in British Columbia, covers 16% of the province. It occurs on the vast Alberta Plateau in northeastern British Columbia and in the main valleys west of the Rocky Mountains. The BWBS zone has a cold continental to hypercontinental boreal climate with long, very cold winters and short (~3 months) but warm summers. Precipitation is lower than in most of the adjoining zones, and ranges from summer-dry to summer-wet. Mean annual temperature and precipitation is 0.4°C (range = -1–3°C) and 638 mm (range = 450–1300 mm), respectively. The centrally located dk subzone is the driest and coolest subzone; the vk in the northwest is the warmest and wettest. The wk subzone in the east occupies higher elevations than the other subzones (800–1200 m) on the mid to lower slopes and foothills of the Rocky Mountains, and lies below the ESSF or SWB zones and above the extensive lowland BWBSmw (300–1000 m).

Fires are frequent in the upland forests and leave a variety of forest ages and types on the landscape. Mixed stands of PICEGLA and POPUTRE or PICEMAR and PINUCON are the most common in upland areas. PICEMAR-dominated mossy forests are common on wetter sites; open PINUCON–lichen forests are common on drier sites. PICEGLA and POPUBAL stands occur on richer, well-drained river benches and valleys. LARILAR is a minor species of importance. It forms pure stands on rich fens and swamps, and occurs as a minor component in stunted PICEMAR stands, which are very common on poorly drained organic soils in lowland areas. ABIELAS is a common minor species in certain subzones. The occurrence of willow, alder, and birch are restricted to specific sites. Grassland and scrub communities occur on steep, warm-aspect slopes.

Online resources (p. 54): 1, 2, 3†

4.2 Protected Areas

This zone has just over 100 protected areas, 70 of which are larger than 250 ha. Many of British Columbia's largest parks cover parts of the BWBS zone (11 of the top 30), but average protected area coverage in the zone is low and not evenly distributed. With the exception of the BWBSdk1, vk1, and un with 25% protected area coverage collectively, all other units have < 6% protected area coverage. The proportion of older forests is also highest in the dk1, vk1, and un. Due to fire and harvesting activities, forests older than age 120 occur on < 20% of the land area in most units. The BWBSmw1, mw2, and wk2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

are the least protected units, with < 3% protected area coverage. While the BWBSwk2 is a relatively small unit, the mw1 and mw2 are substantial, and together cover more than 10% of the province. Compared to other parts of the BWBS zone, protected areas in the Alberta Plateau region are smaller and very sparsely distributed. Protected area coverage is also notably low in the dk2 across a vast portion of the Liard Plain. The top 10 protected areas in the BWBS zone are Dune Za Keyih, Stikine River, Bearhole Lake, Gwillim Lake, Klua Lakes (PA), Liard River, Maxhamish Lake (PA), Northern Rocky Mountains, Peace River/Bodreau, and Peace-Moberly.

Online resources (p. 54): 3, 4, 7, 8†

4.3 Species Representation in Protected Areas

4.3.1 Adequate representation (15 of 19 species) Most of the common species in the BWBS potentially occur in three or more protected areas with an expected cumulative cover of 10 ha, although less than 10% of their cumulative cover within the zone is typically protected.

4.3.2 Low representation (4 of 19 species) SALIDIS, PRUNPEN, and BETUOCC are all wide-ranging species in British Columbia, and are more common in zones with sub-boreal or temperate climates than in the BWBS zone. Of these species, SALIDIS has the largest portion of its provincial cumulative cover in the BWBS (11%), and it is expected to be adequately protected at a lower cover threshold of 5 ha cumulative cover. PRUNPEN and BETUOCC have smaller portions of their provincial cumulative cover in the BWBS (6 and 2%, respectively) and are not expected to occur in any protected areas. While both species are expected to have adequate protection at 5 ha cumulative cover in one adjoining zone (the SWB or SBS zone), populations in the northeastern portions of their range on the vast Alberta Plateau region of British Columbia are considered to be important for genetic conservation.

PINUBAN is common in the boreal forests across most of Canada. In British Columbia, it is restricted to the northeastern portion of the BWBS zone, where it is estimated to account for < 0.01% of the total zonal tree cumulative cover. Predictions of future frequency changes have not been calculated for this species, but it is likely that with climate warming the species will decline in the area. However, considering its rarity in British Columbia, local populations are considered to be important for genetic conservation.

Online resources (p. 54): 5, 6†; summary information: Table 4, Appendix 2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 4 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the BWBS zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
PINUBAN	< 0.01	< 0.01	100.00	1	0	2.0					n/c
PRUNPEN	0.01	< 0.01	6.35	175	3	1.5					0.0
BETUOCC	0.04	0.01	2.08	259	6	2.3					n/c
SALIDIS	0.01	1.01	10.94	407	67	16.3	9	5	2		0.0
PRUNVIR	0.06	0.19	48.83	8 767	117	1.3	8	6	4		-0.1
BETUNEO	0.03	0.17	100.00	7 999	189	2.4	10	8	4	1	0.0
LARILAR	0.38	1.97	94.54	93 018	2 205	2.4	29	20	14	10	-0.2
SALILUC	0.09	0.21	38.77	9 890	2 311	23.4	24	22	20	10	0.0
SALISCO	0.53	0.88	27.53	41 669	3 469	8.3	41	36	31	12	-0.2
SALIBEB	0.37	1.36	63.29	64 164	3 537	5.5	46	36	31	14	0.0
BETUPAP	1.00	1.80	30.55	84 911	4 758	5.6	51	46	36	19	0.0
ABIELAS	16.44	2.34	2.24	110 688	16 947	15.3	47	42	38	26	-0.2
ALNUVIR	2.89	5.67	32.25	267 642	11 991	4.5	67	56	48	30	-0.9
ALNUINC	1.83	5.29	49.62	249 855	13 503	5.4	67	56	48	30	-0.1
POPUBAL	1.34	7.35	81.79	347 051	15 178	4.4	74	60	52	30	-0.5
PINUCON	10.24	11.96	18.93	564 758	48 781	8.6	74	66	60	37	-0.7
PICEMAR	5.14	22.43	74.77	1 059 021	52 826	5.0	81	72	67	40	-1.1
POPUTRE	4.32	16.03	62.63	756 815	37 987	5.0	81	75	64	41	-1.8
PICEGLA	6.35	22.32	58.56	1 053 901	76 195	7.2	84	77	66	46	-3.0

a n/c: not calculated

4.4 Conservation Priorities

× protection required PINUBAN
? population verification required PRUNPEN, BETUOCC

It is recommended that populations of PINUBAN in the northern BWBSmw2 be verified, especially in the larger protected areas (e.g., Thinahtea and Maxhamish), and, if required, protection levels should be increased. Verification for PRUNPEN is recommended in protected areas along the Peace River and in the southern BWBSmw1. If protection levels are low in the adjoining or nearby eastern portions of the SBS, verification is also recommended in protected areas in the northern Rocky Mountain Trench. Verification for BETUOCC populations is recommended in the BWBSmw1 (e.g., Gwillim Lake, Butler Ridge, Bearhole Lake) and BWBSmw2 (Klua Lakes).

Overall protected area coverage is very low in both the mw1 and mw2 variants. A protected area increase in these large variants could improve the conservation status of all three of these species.

Support materials for field verification: Appendix 3, Appendix 4

5.1 Overview

The small Coastal Douglas-fir (CDF) zone (< 1% of the province) occurs at low elevations (0–260 m) on the Gulf Islands, the southeastern coast of Vancouver Island, and parts of the southern mainland coast. It has a cool mesothermal climate with mild, wet (800 mm) winters and long, warm, sunny and dry (200 mm) summers. Mean annual temperature is 10°C, and ranges from 3°C in the coldest month to 17°C in the warmest month.

PSEUMEN is the most common species in upland forests throughout the zone. It occurs on a wide range of sites and is well adapted to fires, which were historically frequent. Although less common, QUERGAR and ARBUMEN are the most well-known and distinctive species in this zone. They are largely restricted to the CDF zone and occur on the driest sites, in clearings, meadows, and seaside parklands and on rocky bluffs. Many rare plant and invertebrate species are found in the Garry oak meadows and on dry herbaceous bluffs throughout this zone. THUJPLI, TSUGHET, ABIEGRA, ALNURUB, ACERMAC, CORNNUT, RHAMPUR, MALUFUS, PRUNEMA, CRATDOU, TAXUBRE, POPUTRI, and POPUTRE occur to varying degrees in the moister, forested areas. Other infrequently occurring species include JUNISCO, PINUMON, SALISCO, SALISIT, and PICESIT.

Online resources (p. 54): 1, 2, 3†

5.2 Protected Areas

The CDF is the least protected zone in British Columbia; as of 2002, it had only 3% protected area coverage. It has about 80 protected areas and ranks ninth in British Columbia for total number of protected areas (more than in the MS, BG, SWB, PP, SBPS, SWB zones), but ranks last for the number of large protected areas. It has only five protected areas > 250 ha, which together protect only 1% of the land in the zone. The remaining protected areas are comprised mainly of small, isolated land parcels surrounded by developed areas. Logging, agriculture, grazing, mining, and residential development have converted almost one third of the land area in the zone from forest to other land types and uses. Less than 10% of the forested land is more than 120 years old, and < 1% is old growth, which occurs in small, highly fragmented patches. Many of the ecosystems and a large number of plant and wildlife species in the zone are considered to be threatened or endangered. Fire suppression and invasive species have also altered the presence and integrity of certain ecosystems, such as the fragile Garry oak meadows. Climate warming will likely also have an impact by altering the frequency of occurrence of many plant and animal communities. A more robust and interconnected network of actively managed protected areas, including wildlife management areas and old-growth management areas, is greatly needed in the CDF zone.

In terms of forest genetic conservation, the 10 most important protected areas in the CDF zone (which has only one identified subzone) are Gowland Tod, Ruckle, Simson, South Texada Island, Lasqueti Island, Newcastle Island Marine, Princess Margaret Marine, South Otter Bay, Goldstream, and Mount Tuam (importance reflects park size only, and several have since been incorporated into the Gulf Islands National Park Reserve). When consider-

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

ing genetic conservation in all zones, Gowlland Tod ranks as the tenth most important protected area in the province. In terms of size, none of these protected areas rank in the top 300 in the province. New protected areas established since 2002 have not been included in this analysis but likely have little effect on the overall protected area statistics for the CDF zone.

Online resources (p. 54): 3, 4, 7, 8†

5.3 Species Representation in Protected Areas

Small protected areas and regional or municipal parks were not included in this analysis. However, for the small, highly populated, disturbed CDF zone, it may be appropriate to consider species representation in the network of small land parcels or ecosystems protected by the *Forest and Range Practices Act,* conservation covenants, city or regional parks, and ENGO holdings of private lands with active conservation management plans. Protected areas established since 2002 (e.g., Gulf Islands National Park Reserve) were also not considered in this study. As most of the protected areas in the CDF are small, a useful prioritization exercise would be to perform a series of complementary, species-specific evaluations considering mating systems, landscape/environmental features, and land use practices of protected area requirements such as number, size, acceptable levels of fragmentation, connectivity, ecosystem integrity, complexity, and disturbance. Data from the recently completed terrestrial ecosystem mapping (TEM) of the entire CDF zone will also allow for the calculation of protection levels on a finer scale, such as site series and successional stage, rather than the subzone/variant approach used in this analysis. It may also be possible to use the TEM data to assess the impacts of climate warming on species conservation and the distribution of various ecosystems. Future species frequency predictions (Hamann and Wang 2006) have not been calculated for the CDF zone because there are no drier mesothermal climates (e.g., those associated with white fir or blue oak–grey pine ecosystems in California) in British Columbia that can be used for comparison.

5.3.1 Adequate representation (8 of 23 species) Only eight of the common species in the zone are expected to be adequately represented in protected areas. Overall protection is very low given the few large protected areas present and the low protected area coverage. A review of recent inventory data or extensive field inspections is needed to confirm estimated protection levels.

5.3.2 Low representation (15 of 23 species) The CDF zone has a very high percentage of under-protected and Red- and Blue-listed species. The 15 species with low protected area representation can be grouped into three categories based on similarities in distribution and protection levels: (1) species characteristic of the coastal region (CDF or CWH zones); (2) widely distributed species potentially under-protected in other coastal zones; and (3) widely distributed species adequately protected in other coastal zones.

ARBUMEN, CORNNUT, MALUFUS, RHAMPUR, PICESIT, and PINUCON (var. *contorta*) are grouped into the first category. Of these, ARBUMEN is considered to be the least protected species across its entire British Columbia range and is considered to be a high priority in terms of genetic conservation. CORN-

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

NUT, MALUFUS, and RHAMPUR are also considered to be high-priority species. While they are adequately protected in the adjoining CWH zone, the under-protected CDF portions of their distributions are significant: 11–47% of their provincial cumulative cover occurs in the CDF zone. Conversely, PICESIT and PINUCON, which are much more common and extremely well-protected in the CWH zone, are considered to be the lowest-priority species in the CDF in terms of genetic conservation.

CRATDOU, JUNISCO, and POPUTRE fall into category 2. They occur in a number of zones in British Columbia with varying protection levels but are all potentially under-protected on the coast. In the disjunct coastal portions of their provincial ranges (CDF or CWH zones), populations are very small and are not expected to be sufficiently represented in any protected areas at the lowest cover value of 2.5 ha. For example, JUNISCO, recently proposed as seaside juniper (*Juniperus maritima* [Adams]), is known to occur in several protected areas but only in one at a population size of several hundred trees (Adams 2007).

Species in category 3 are adequately protected in the adjacent CWH zone at 5 ha (SALISCO) or 10 ha cumulative cover (PRUNEMA, SALISIT, ACERGLA, TAXUBRE, PINUCON, and PINUMON), and are often adequately protected in most other zones where they are common. All of these species occur infrequently in the CDF zone, and only PRUNEMA, SALISIT, and TAXUBRE have > 1% of their ranges in the zone. Except for PICESIT and PINUCON, these species are considered to be of lower priority in terms of genetic conservation than species in categories 1 and 2.

Online resources (p. 54): 5, 6†; summary information: Table 5, Appendix 2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 5 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the CDF zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
JUNISCO	0.05	0.01	0.11	17	0	2.7	0				n/c
PINUMON	0.11	0.01	0.06	19	1	2.7	0				n/c
CRATDOU	< 0.01	0.06	6.48	100	3	2.7	0				n/c
PRUNEMA	0.01	0.07	2.77	121	3	2.7	0				n/c
ACERGLA	0.41	0.11	0.15	183	5	2.7	0				n/c
SALISCO	0.53	0.16	0.17	265	7	2.7	0				n/c
POPUTRE	4.30	0.36	< 0.01	611	17	2.7	0				n/c
PINUCON	10.24	0.41	0.02	702	19	2.7	1				n/c
SALISIT	0.28	0.53	1.11	907	25	2.7	1				n/c
RHAMPUR	0.01	0.62	42.51	1 056	29	2.7	1				n/c
TAXUBRE	0.21	0.72	1.99	1 218	33	2.7	1				n/c
PICESIT	1.44	0.98	0.39	1 662	45	2.7	3	1			n/c
MALUFUS	0.06	1.24	11.42	2 099	57	2.7	5	1			n/c
CORNNUT	0.03	2.04	46.70	3 458	93	2.7	10	4	1		n/c
ARBUMEN	0.02	2.80	79.74	4 754	128	2.7	18	5	1		n/c
TSUGHET	14.88	4.53	0.17	7 687	208	2.7	24	13	4		n/c
POPUTRI	0.56	4.39	1.32	7 733	209	2.7	24	13	4		n/c
QUERGAR	0.04	7.32	100.00	12 416	336	2.7	35	21	8		n/c
ACERMAC	0.18	7.69	24.31	13 047	353	2.7	35	21	10	1	n/c
ABIEGRA	0.09	9.49	58.57	16 107	435	2.7	37	24	14	1	n/c
ALNURUB	0.93	12.79	7.85	21 705	587	2.7	39	32	20	1	n/c
THUJPLI	6.55	18.89	1.68	32 050	866	2.7	44	37	24	3	n/c
PSEUMEN	6.58	24.62	2.17	41 782	1 129	2.7	48	39	32	5	n/c

a n/c: not calculated

5.4 Conservation Priorities

? population verification required ARBUMEN, CORNNUT, MALUFUS, RHAMPUR, CRATDOU, JUNISCO, POPUTRE

A comprehensive re-evaluation of species conservation status is recommended for the CDF zone when new ecosystem mapping data become available. In the interim, verification is recommended only for species that have low protected area representation levels in both the CDF and the CWH zones. The need for population verification of the minor species that are more prevalent and adequately protected in other BEC zones should be reassessed later. Furthermore, population size requirements for POPUTRE growing in clonal patches will need to be investigated. In addition to the protected areas listed in Appendix 3.3, verification is recommended for smaller protected areas (i.e., those not considered in this analysis) and in areas with unofficial protection status, such as regional or city parks or recreational areas with suitable sites, and on managed or protected private land (e.g., with riparian, wetland, shoreline, or meadow components).

The number of under-protected species and threatened ecosystems in the CDF zone is very high because of the low number of protected areas, small percentage of land protected, and high levels of disturbance and land con-

version due to forestry, mining, agriculture, development, and fire suppression. There is an obvious and urgent need for (1) the establishment of new protected areas in the CDF zone; (2) a review of protection requirements on a species-by-species basis; and (3) a re-analysis of protection status using site-level inventory and ecosystem data. Increasing the public awareness of and incentives for conservation on private land and the connectivity of protected areas would also improve protection levels in the CDF zone. ENGOs have been very active in this zone, and their conservation lands should be evaluated in this context.

Support materials for field verification: Appendix 3

6 CWH ZONE

6.1 Overview

The Coastal Western Hemlock (CWH) zone occurs at low to mid elevations along much of British Columbia's coast and covers 11% of the province. It occurs along major river valleys, but is found mostly west of the Coast Mountains. In general, the climate in the CWH zone is moderate (cool mesothermal). The summers are cool; the winters are mild. Continentality varies from hypermaritime along the outer coast to submaritime on the leeward side of the Coast Mountains. The wetter subzones occur on the coast; the drier ones occur in the rain shadows of the Olympic, Insular, and Coast Mountains. Mean annual temperature and precipitation are 5.5°C (range = 2.4–9.3°C) and 2200 mm (range = 1200–3300 mm), respectively.

Wind is the most common mechanism of natural disturbance in this zone, and, unlike fire, tends to affect single trees or small patches of forest except during extreme events. As a result, most of the natural forests are old; only the MH zone has a higher proportion of older forests. TSUGHET is the most common tree species, and together with THUJPLI generally occurs frequently throughout the zone. The cover of other major species generally varies with climate (e.g., PSEUMEN, ABIEAMA, CHAMNOO), local conditions (PINUCON, ALNURUB) or both (PICESIT). Some of the less common species occur at low frequency on specific sites (RHAMPUR, SALISIT, SALILUC, MALUFUS); others occur on a wide range of sites (PINUMON, TAXUBRE, PRUNEMA, CORNNUT, CORYCOR, ABIEGRA). Other less common species occur with high frequency on specific sites (ARBUMEN, ACERMAC, ACERCIR, BETUOCC) or on a wide range of sites (BETUPAP), but only in certain climates or under specific disturbance regimes. Other minor species occur at high frequency in many different climates but only on very specific sites (e.g., POPUTRI). ALNUINC, ABIELAS, PICEENG, POPUTRE, and SALIBEB occur infrequently. They are characteristic of the other zones and generally occur only in transitional areas of the CWH zone.

Online resources (p. 54): 1, 2, 3†

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

6.2 Protected Areas

There are more than 300 protected areas in the CWH zone, half of which are large. In 2001, prior to the most recent protected area expansion on the north and central coast, 12% of the CWH zone was protected. At that time, the top 10 protected areas in terms of *in situ* conservation were Strathcona, Desolation Sound Marine, Pinecone Burke, Homathko River–Tatlayoko, Pacific Rim, Golden Ears, Garibaldi, Mehatl Creek, Nahatlatch, and Birkenhead Lake.

In most subzone/variant groups, the large protected areas are representative and well distributed. This is not the case in the CWHmm1/2, which has only two large reserves located centrally in very close proximity to each other. In terms of land protected, six of the 13 subzone/variant groups are under-represented and have less than 10% protected area coverage. Four of these (xm1, xm2, dm, vm) also have relatively high levels of disturbance due to settlement and/or forest harvesting. The most heavily settled and disturbed subzone, the CWHxm1, has only 2% protected area coverage. In contrast, the three groups with the highest protected area coverage (vm3, vh1, wh1/wh2) are relatively undisturbed. Subzones with representative levels of protection (10–15%) vary from relatively undisturbed (vh2) to quite disturbed (mm1/mm2, ds1/ds2, ms1/ms2).

Online resources (p. 54): 3, 4, 7, 8†

6.3 Species Representation in Protected Areas

6.3.1 Adequate representation (27 of 34 species) Most of the species in the CWH zone are predicted to occur in three or more protected areas with an expected cumulative cover of 10 ha. More than half of these species have < 10% of their cumulative cover in protected areas. ABIEGRA and PRUNEMA have the lowest levels of cumulative cover protected—less than 5%. While considered to be minor species in the CWH zone, both have a significant portion of their ranges in the CWH zone, and their frequencies in this zone are predicted to double by 2055.

6.3.2 Low representation (7 of 34 species) CORYCOR, POPUTRE, SALIBEB, SALISCO, and CRATDOU are widely distributed species in British Columbia. They all have only minor portions of their ranges in the CWH zone, and none is predicted to dramatically increase in frequency in the CWH zone by 2055. CORYCOR, POPUTRE, and SALIBEB each have only 1% of their cumulative cover in the zone, and local populations are not of primary concern in terms of conservation genetics except for rare clonal stands of POPUTRE in the Fraser Valley. Also, these species are expected to occur in the IDF portions of at least three large, multi-zone protected areas that span the transition from maritime to continental climates. For example, at mid latitudes, SALIBEB and POPUTRE are expected to occur in the IDF portions of Tweedsmuir (South), Tsyl-os', and Homathko River–Tatlayoko at > 10 ha cumulative cover, and CORYCOR is expected to occur in Birkenhead at 8 ha. At lower latitudes, POPUTRE is expected to occur in E.C. Manning at > 10 ha cumulative cover, and CORYCOR is expected to occur in both Skagit Valley and E.C. Manning at > 10 ha. SALISCO is also not of primary concern as it is expected to occur in four protected areas at 5 ha cumulative cover, which may be sufficient for this smaller-statured tree. CRATDOU is the only species in this group for which

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

field verification is recommended. It is not expected to occur in any protected areas at even 2.5 ha cumulative cover in the CWH or CDF zones, or in the IDF portions of multi-zone protected areas that span the CWH zone.

In contrast to these species, ARBUMEN and RHAMPUR are narrowly distributed and have significant portions of their provincial ranges in the CWH zone. Protection levels for these species are also low in the CDF zone, which contains most of the remaining portions of their ranges. Current protection levels for both of these species in the CWH should be verified, especially for ARBUMEN, which is predicted to double in frequency with climate warming.

Online resources (p. 54): 5, 6†; summary information: Table 6, Appendix 2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 6 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the CWH zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
CRATDOU	< 0.01	< 0.01	4.8	74	4	5.6					0.0
SALIBEB	0.40	< 0.01	0.1	102	4	3.9	1				-0.1
CORYCOR	0.14	< 0.01	1.1	417	20	4.8	4	1			-0.1
POPUTRE	4.30	< 0.01	0.1	1017	14	1.4	2	1			-0.2
ARBUMEN	0.02	0.02	20.3	1 208	24	2.0	2	1			**1.1**
RHAMPUR	0.01	0.02	55.0	1 366	95	7.0	11	5	2		0.1
SALISCO	0.53	0.05	2.6	3 918	147	3.7	8	4	2		-0.1
PICEENG	3.50	< 0.01	0.1	537	89	16.6	6	3	3		-0.7
PRUNEMA	0.01	0.03	59.6	2 608	117	4.5	10	6	3		**0.0**
BETUOCC	0.04	0.02	10.3	1 284	76	5.9	6	5	4		-0.5
ALNUINC	1.83	0.04	0.7	3 309	239	7.2	6	6	4	2	-0.8
CORNNUT	0.03	0.05	52.2	3 863	214	5.5	16	10	6	1	0.2
SALILUC	0.09	0.05	15.7	4 000	298	7.4	14	11	7		-0.1
PINUMON	0.11	0.10	23.0	7 587	660	8.7	35	24	13	1	0.0
ABIEGRA	0.09	0.10	28.8	7 932	328	4.1	22	11	4	1	**0.5**
BETUPAP	1.00	0.11	3.1	8 667	703	8.1	27	18	10	2	**0.1**
ACERGLA	0.41	0.12	7.8	9 560	1 056	11.1	28	20	17	4	0.0
MALUFUS	0.06	0.21	88.6	16 279	1 935	11.9	49	36	23	10	**0.2**
ABIELAS	16.44	0.28	0.4	21 855	2411	11.0	21	20	18	13	-1.6
TAXUBRE	0.21	0.32	41.1	25 191	2 840	11.3	64	45	33	8	0.0
SALISIT	0.28	0.33	31.4	25 619	1 914	7.5	49	36	24	11	0.0
ACERCIR	0.10	0.34	93.5	26 947	2 008	7.5	30	26	17	11	**1.1**
ACERMAC	0.18	0.51	74.6	40 014	2 460	6.1	69	51	36	16	**1.1**
POPUTRI	0.56	0.79	35.46	62 412	4 405	7.1	66	55	43	17	0.3
ALNUVIR	2.89	1.24	11.8	97 546	10 075	10.3	67	56	51	21	-1.4
PINUCON	10.24	2.14	5.6	168 295	18 931	11.2	105	93	65	29	-0.1
TSUGMER	3.69	2.28	16.0	179 555	19 990	11.1	99	85	69	44	-1.6
ALNURUB	0.93	3.24	92.2	254 894	20 982	8.2	145	118	95	49	**0.9**
PICESIT	1.44	5.25	96.9	413 071	48 562	11.8	157	134	105	64	-0.3
CHAMNOO	2.02	5.51	70.2	433 258	47 646	11.0	106	93	77	46	-3.0
PSEUMEN	6.58	7.58	30.9	595 828	46 624	7.8	164	141	116	62	**6.1**
ABIEAMA	5.99	13.88	60.0	1 091 598	106 635	9.8	151	137	119	75	-5.6
THUJPLI	6.55	15.40	63.4	1 211 087	123 628	10.2	210	189	167	95	1.1
TSUGHET	14.88	39.99	71.4	3 144 377	315 019	10.0	234	213	194	134	-6.5

a **bold** indicates an increase of > 100%; underline > 90% decrease

6.4 Conservation Priorities

? population verification required ARBUMEN, CRATDOU, RHAMPUR, POPUTRE

Population verification is recommended for ARBUMEN. If verified protection levels are low in existing protected areas, populations on rocky outcrops along unprotected areas of the Alberni Canal, Horne Lake, Cameron Lake, Comox Lake, Buttle Lake, and Muchalat Inlet should be surveyed and considered for acquisition/provincial protection. Protection levels for CRATDOU are expected to be low; however, considering the species' small stature and site requirements, it is recommended that its absence in protected areas be

verified first, especially in the smaller protected areas (i.e., those not considered in this analysis), on private lands with a conservation objective, and in regional, district, or city parks or recreational areas that contain suitable sites. RHAMPUR is potentially protected at 5 ha cumulative cover, which may be sufficient for this small tree. However, as the CWH is likely the only zone that offers protection for coastal populations of this species, protected area population verification is recommended.

Most of the species requiring increased protection or protection-level verification occur most frequently in the drier and milder subzones or variants (xm1, xm2, dm, ds1, ds2). These units also have the lowest levels of protected area coverage and high levels of disturbance. New protected areas on suitable sites in the xm1, xm2, and dm subzones and variants could potentially increase protection for ARBUMEN, RHAMPUR, POPUTRE, and CRATDOU.

Support materials for field verification: Appendix 3, Appendix 4

7 ESSF ZONE

7.1 Overview

The Engelmann Spruce–Subalpine Fir (ESSF) zone covers 15% of the province and occurs at high elevations on all of the major mountains surrounding the Interior Plateau. On the Cascade and Coast Mountains in western British Columbia, the ESSF zone merges with the MH zone. In the north, it merges with the SWB zone, and at higher elevations, with the AT zone. The ESSF can occur above the MS, SBS, ICH, or BWBS zones. In the northwest, it can occur at elevations as low as 500 m, and, in some southern subzones, as high as 1400 m. The climate is subalpine boreal with long, cold winters and short, cool summers (temperatures are above 10°C for only 0–2 months of the year). Mean annual temperature and precipitation are 0.8°C (range = -0.5–2.3°C) and 1100 mm (range = 600–1600 mm), respectively. In the forested subzones, mean annual precipitation is highest in the Coast Mountains and in areas of the Columbia and Rocky Mountains, and lowest near the Chilcotin, south-central British Columbia, and in some northern interior areas.

PICEENG and ABIELAS are dominant species throughout the lower-elevation forested portions of the zone. At higher elevations, in wetter areas, and in parkland ecosystems, ABIELAS can be more common. PINUCON is a common minor species that is abundant in seral stands following wildfire and on drier sites throughout the zone. LARILYA, PINUALB, and PINUFLE are minor species that are characteristic of higher-elevation forests. TSUGHET, TSUGMER, THUJPLI, PSEUMEN, ABIEAMA, PINUMON, PICEMAR, PICEGLA, LARIOCC, and POPUTRE are minor or transitional species that occur only in certain subzones. The more common minor deciduous species include SALIBEB, SALISIT, SALISCO, ALNUINC, ALNUVIR, and ACERGLA.

Online resources (p. 54): 1, 2, 3†

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

7.2 Protected Areas

The ESSF zone has one of the highest levels of protected area coverage in the province. At 15% coverage it ranks third after the AT and SWB zones. It has both a high total number of protected areas (> 190) and a high proportion (70%) of large ones (> 250 ha). Many of British Columbia's largest protected areas (e.g., Spatsizi, Tweedsmuir, Wells Gray, Atlin, Tsyl-os', Mount Edziza, Mount Robson, Purcell, Kakwa, Bowron) overlap the ESSF zone. The top 10 protected areas in the ESSF in terms of *in situ* conservation are the Purcell Wilderness Conservancy, E.C. Manning, Graham Laurier, Kianuko, Gwillim Lake, Kakwa, Butler Ridge, Wapiti Lake, Tweedsmuir (South), and Stein Valley. These protected areas are on the periphery of the ESSF: one is located in the southeast, three in the coast-interior transition, and five in the northeast (in the ESSFwk2, mv2, and mv4) bordering the eastern BWBS. Except for the centrally located ESSFvc subzone, all units with < 10% protected area coverage are located in the north (ESSFwv, mv). Disturbance levels in these northern units vary from low in the vc and wv to high in the mv2, where most of the forests outside of protected areas are less than 120 years old.

Online resources (p. 54): 3, 4, 7, 8†

7.3 Species Representation in Protected Areas

7.3.1 Adequate representation (25 of 32 species) All species that are characteristic of the ESSF zone are predicted to occur in three or more protected areas at a cumulative cover of 10 ha. Most species have more than 15% of their cumulative cover protected.

7.3.2 Low representation (7 of 32 species) PINUPON, CORYCOR, and JUNISCO occur infrequently at lower elevations in the southern ESSF. Each species has less than 1% of their total provincial cumulative cover in this zone, and they are not expected to occur in any protected areas at 10 ha cumulative cover. However, several large protected areas in the west (e.g., Cathedral, Manning), Central Interior (Myra–Bellevue), and east (Gladstone, Valhalla, West Arm, Kianuko, Kootenay, Purcell, Goat Range), which span the ESSF and the MS, IDF, or ICH zones, may provide protection if these species increase in the ESSF with climate warming. CHAMNOO is rare in the ESSF zone. It has an isolated occurrence in the Valhalla Range of the Selkirk Mountains, some of which is protected, and infrequent occurrences in transitional subzones bordering the CWH and MH zones. None of these species is considered to be a top conservation concern.

PINUFLE has a very narrow distribution in British Columbia. It occurs mainly in the southern Rocky Mountain Trench in the IDFdk5, MSdk, and ESSFdk units. Despite the high protected area coverage in the ESSFdk (> 20%), protection for this sparsely distributed species is estimated to be adequate only at a threshold of 2.5 ha cumulative cover. Protection levels in the adjoining MS zone are unknown because this species was not adequately represented in the data. Populations of PINUFLE in the ESSFdk are thus of concern in terms of genetic conservation.

SALIDIS and BETUOCC are wide-ranging species that have minor portions of their provincial ranges in the ESSF (4–5% cumulative cover). BETUOCC is not considered to be a species of top concern because it may be protected in several single or multi-zone protected areas at > 5 ha cumulative cover

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

at mid to high elevations in eastern British Columbia (e.g., Kootenay and Yoho—MS portions) and in the Southern Interior (e.g., Manning—ESSF, Cathedral—MS, Silver Star—ESSF). Protection for BETUOCC is potentially low on the northern edge of the Interior Plateau (< 5 ha cumulative cover in Edge Hills, Marble Range, Bonaparte); however, conservation efforts for this species may be more effective in verifying or increasing its protection in the IDFxh2 and dm2 where its frequency is 10 times higher than in the ESSF, or in the northern part of its range in the BWBS zone. Unlike BETUOCC, SALIDIS is not expected to occur in any protected areas in the adjoining MS zone at 2.5 ha cumulative cover, and it is potentially under-protected in several other adjoining zones (ICH, IDF, SBPS). It is most likely to be under-protected in southern British Columbia. In the southeast portion of the ESSF zone and in the MSdk, IDFdm2, and eastern ICH subzones, SALIDIS is predicted to occur in only one protected area (Cariboo).

Online resources (p. 54): 5, 6† ; summary information: Table 7, Appendix 2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 7 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the ESSF zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
PINUPON	0.30	< 0.01	0.04	35	2	5.7					0.2
CORYCOR	0.14	< 0.01	0.26	101	6	5.9					**0.3**
JUNISCO	0.05	< 0.01	0.09	13	3	23.1	1				**0.1**
PINUFLE	0.00	< 0.01	65.17	158	25	15.6	3	1	1		0.0
CHAMNOO	2.02	< 0.01	0.03	186	30	16.1	1	1	1		-0.2
BETUOCC	0.04	0.01	4.00	499	31	6.2	3	2	1		-0.1
SALIDIS	0.01	< 0.01	4.73	176	22	12.5	3	2	1		0.0
LARIOCC	0.24	0.04	2.65	1 995	246	12.3	6	5	3	1	**0.8**
BETUPAP	1.00	0.02	0.43	1 201	100	8.3	7	6	3		**0.3**
SALILUC	0.09	< 0.01	0.75	194	67	34.7	4	4	4		0.0
LARILAR	0.38	0.10	5.46	5 368	414	7.7	4	4	4	5	-0.7
SALIBEB	0.37	0.02	1.03	1 039	242	23.3	8	5	5	1	0.0
PINUMON	0.11	0.05	7.85	2 593	502	19.4	18	13	7	2	**0.5**
PICEMAR	5.14	0.51	1.88	26 586	2 104	7.9	8	8	7	7	1.6
POPUTRI	0.56	0.09	2.79	4 903	589	12.0	19	15	10	3	**0.3**
ACERGLA	0.41	0.09	4.06	4 955	1 102	22.2	11	11	10	4	0.1
LARILYA	0.03	0.15	84.72	7 866	1 701	21.6	11	10	10	10	-2.2
PICEGLA	6.35	0.60	1.74	31 293	2 347	7.5	17	14	12	12	-0.2
ABIEAMA	5.99	0.95	2.74	49 812	15 871	31.9	13	13	13	20	**9.9**
SALISIT	0.28	0.17	11.19	9 113	1 639	18.0	32	22	17	6	0.3
TSUGMER	3.69	3.09	14.34	161 229	13 331	8.3	26	25	21	33	-5.0
POPUTRE	4.32	0.76	3.28	39 649	3 265	8.2	37	28	23	12	**0.5**
SALISCO	0.53	0.20	6.74	10 205	1 482	14.5	31	27	24	5	-0.1
TSUGHET	14.88	1.06	1.26	55 471	4 469	8.1	37	34	29	13	**18.3**
ALNUINC	1.83	0.44	4.57	23 033	2 094	9.1	43	33	29	14	0.1
THUJPLI	6.55	0.37	0.99	19 221	3419	17.8	49	40	30	16	**9.5**
PSEUMEN	6.58	0.58	1.57	30 277	6 694	22.1	49	43	40	9	**3.3**
PINUALB	0.25	1.40	96.01	72 953	17 387	23.8	72	61	51	12	-1.6
ALNUVIR	2.89	3.11	19.57	162 421	23 387	14.4	112	101	88	51	0.2
PINUCON	10.24	9.63	16.87	503 208	87 137	17.3	148	138	120	80	0.7
PICEENG	3.50	17.43	84.12	910 349	148 960	16.4	145	137	128	96	0.0
ABIELAS	16.44	59.11	62.52	3 088 043	421 129	13.6	170	164	156	126	-9.9

a **bold** indicates an increase of > 100%; underline > 90% decrease

7.4 Conservation Priorities

? population verification required **PINUFLE**, SALIDIS

Population verification is recommended for PINUFLE in protected areas of the ESSF zone that overlap the MS zone portions of Yoho, Kootenay, and Height of the Rockies. In the British Columbia portion of its range, pathogen and pest hazards are high and increasing. Increased active management, including the selection and deployment of disease-resistant individuals, and *ex situ* conservation, is suggested because the long-term benefits are predicted to be greater than increasing *in situ* conservation levels in unmanaged reserves. For SALIDIS, verification is recommended first in the southeast in larger protected areas that span more than one biogeoclimatic zone (e.g., Cariboo, Bowron, Wells Gray, Purcell, Height of the Rockies, Kootenay). Verification is

also recommended for one protected area in each of the northeastern (Graham Laurier or Omineca), western (Sutherland, then Rubyrock Lake and Entiako), and interior portions (Myra–Bellevue) of the ESSF zone.

Support materials for field verification: Appendix 3, Appendix 4

8 ICH ZONE

8.1 Overview

The Interior Cedar–Hemlock (ICH) zone is relatively small (5% of British Columbia). It occurs at low to mid elevations in basins of northwestern British Columbia, on lower slopes of the Columbia and Rocky Mountains in the southeast, and on parts of the Shuswap and Quesnel Highlands. The zone has a continental, cool to warm temperate climate with cool winters, warm, dry summers, and a 3- to 5-month growing season. Mean annual temperature and precipitation are 3.3°C and 780 mm, respectively. Precipitation is significantly less than in the CWH zone, but the hydrological conditions in forested ecosystems are comparable.

The warm summer temperatures and soil moisture conditions contribute to high forest productivity and tree species diversity. The dominant species are TSUGHET and THUJPLI, with ABIELAS and PICEENG frequent in wetter and cooler areas. PSEUMEN, PINUCON, PINUPON, PINUMON, and LARIOCC are common and often persistent seral species. Other common species include ACERGLA and TAXUBRE (most common in the south), POPUTRE and BETUPAP (mainly in drier areas), and ALNUINC and ALNUVIR (most common in the northeast). ABIEAMA, PICESIT × PICEGLA (hybrid Sitka × white spruce), TSUGMER, and MALUFUS are mostly coastal taxa that occur in the northwestern subzones. Non-forested communities occur infrequently.

Online resources (p. 54): 1, 2, 3†

8.2 Protected Areas

There are more than 190 protected areas in the ICH zone, a third of which are larger than 250 ha. On average, 10% of the total land area in ICH zone is protected. At the subzone/variant level, protected area coverage ranges from 26% in the ICHmw3 to < 1% in the ICHvc/wc. Half of the units have < 5% protected area coverage. These poorly protected units range from relatively undisturbed remote northern units (e.g., ICHvc/wc) to heavily populated or disturbed units, where less than 15% of the land outside of protected areas is occupied by forests older than 120 years (e.g., ICH dw/xw, mk1/mk2, mk3/dk, mw1). Many of these poorly protected units contain very few large protected areas and very few ranked in the top 10 in terms of genetic conservation. In particular, the ICHvc/wc, mw1, and mm do not contain any top-ranked protected areas. In terms of *in situ* conservation, the top 10 protected areas are Wells Gray, West Arm, Gladstone, Bowron Lake, Cariboo Mountains, Purcell Wilderness Conservancy, Nisga'a Memorial Lava Bed, Seven Sisters, Mount Revelstoke, and Syringa.

Online resources (p. 54): 3, 4, 7, 8†

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

8.3 Species Representation in Protected Areas

8.3.1 Adequate representation (23 of 37 species) More than half of the species in the ICH zone potentially occur in three or more protected areas with an expected cumulative cover of 10 ha, although most species have less than 10% of their cumulative cover protected.

8.3.2 Low representation (14 of 37 species) PINUALB, TSUGMER, PICESIT, PICEGLA, and MALUFUS occur with low frequency in parts of the ICH zone. They are considered to be transitional species that are characteristic of other zones where they are generally adequately protected. They are not predicted to increase in the ICH zone with climate warming, and are not considered to be species of concern in terms of genetic conservation. If MALUFUS is identified as a local-interest species in the northern subzones or is determined to have potential for range expansion, conservation populations in ICHmc, vc, and the adjoining CWHws subzone could be of future importance.

JUNISCO, BETUOCC, CRATDOU, RHAMPUR, PRUNVIR, PRUNPEN, and SALIDIS are all small-statured, generally very site-specific tree species with narrow subzone distributions in the ICH zone. Only PRUNVIR is predicted to increase in frequency of occurrence due to climate warming. JUNISCO, BETUOCC, and CRATDOU populations in the ICH zone are not considered to be of primary importance in terms of genetic conservation. These species have only 1–3% of their cumulative cover in the ICH zone and are protected in the neighbouring IDF zone, where they are more common (> 40% cumulative cover). RHAMPUR, which also has only 3% of its distribution in the ICH zone, is considered to be important because protection opportunities for interior populations do not exist elsewhere. Populations of PRUNVIR, PRUNPEN, and SALIDIS in the ICH zone are also considered important. These species have higher proportions of their ranges (5–6%) in the ICH zone, and are potentially under-protected in the adjoining units of the IDF or SBS (IDFdm2, SBSmm/mc1/dw1/wk1, mw), where protected area coverage levels are low.

PRUNEMA and ABIEGRA have larger proportions of their provincial ranges in the ICH zone (20 and 10%, respectively). PRUNEMA is potentially protected at 5 ha cumulative cover, which may be adequate for this relatively small tree. ABIEGRA is calculated to occur in only two protected areas at 5 ha cumulative cover. The ICH zone may present the best protection opportunities for interior populations of this species.

Online resources (p. 54): 5, 6†; summary information: Table 8, Appendix 2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 8 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the ICH zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
MALUFUS	0.06	< 0.01	0.07	13	1	7.7					?
RHAMPUR	0.01	< 0.01	2.52	63	5	7.9					0.0
BETUOCC	0.04	0.01	1.36	170	4	2.5					0.0
PICEGLA	6.35	0.05	0.07	1 294	84	6.5					-0.3
PINUALB	0.25	< 0.01	0.13	97	5	5.2	1				-0.1
CRATDOU	0.00	< 0.01	3.03	47	6	11.9	1				0.0
PRUNPEN	0.01	0.01	6.01	166	9	5.3	1				0.0
JUNISCO	0.05	0.01	2.04	303	11	3.7	1				0.0
SALIDIS	0.01	0.01	5.91	220	11	5.0	3				0.0
PRUNVIR	0.06	0.03	4.82	866	24	2.8	3	1			**0.1**
TSUGMER	3.69	0.08	0.20	2 247	15	0.7	2	1			-0.6
ABIEGRA	0.09	0.10	9.65	2 653	39	1.5	2	2	1		0.0
PICESIT	1.44	0.11	0.69	2 991	129	4.3	3	2	1	1	-0.5
PRUNEMA	0.01	0.03	19.73	863	58	6.7	7	3	1		**0.0**
SALILUC	0.09	0.05	5.11	1 303	157	12.0	4	4	3	1	-0.3
PICEMAR	5.14	0.19	0.37	5 239	401	7.7	6	3	3		-0.4
PINUPON	0.30	0.15	4.49	4 216	152	3.6	7	5	5	1	**3.4**
ABIEAMA	5.99	0.92	1.39	25 370	1 630	6.4	7	5	5	4	-1.9
SALIBEB	0.37	0.13	3.57	3 615	433	12.0	17	13	8	3	-0.1
SALISCO	0.53	0.26	4.69	7 095	1 127	15.9	17	11	9	3	-0.2
LARIOCC	0.24	1.51	55.28	41 612	2 258	5.4	34	23	16	9	-0.6
SALISIT	0.28	0.70	23.45	19 106	3 167	16.6	36	24	18	7	-1.5
CORYCOR	0.14	0.92	63.97	25 369	1 785	7.0	33	25	20	5	**0.2**
PINUMON	0.11	0.76	63.40	20 950	1 337	6.4	33	25	21	7	**0.2**
POPUTRI	0.56	0.92	14.31	25 180	1 639	6.5	41	34	21	8	-0.2
TAXUBRE	0.21	1.27	56.95	34 929	3 169	9.1	44	31	24	11	-0.3
POPUTRE	4.32	2.05	4.67	56 454	3 300	5.8	51	38	29	9	-0.2
PICEENG	3.50	2.69	6.82	73 792	6 010	8.1	63	49	33	20	-1.1
ALNUVIR	2.89	1.58	5.23	43 428	3 912	9.0	55	41	35	14	-0.6
ALNUINC	1.83	1.74	9.52	47 938	3 329	6.9	51	43	36	15	-0.9
ACERGLA	0.41	1.55	34.83	42 525	3 346	7.9	60	46	36	16	**0.8**
BETUPAP	1.00	2.74	27.07	75 238	6 853	9.1	65	55	43	21	**1.1**
PINUCON	10.24	4.01	3.70	110 259	10 341	9.4	78	62	46	23	0.0
PSEUMEN	6.58	7.49	10.68	205 720	20 058	9.8	88	75	56	28	**6.6**
ABIELAS	16.44	8.70	4.84	238 930	18 206	7.6	100	84	64	33	-4.2
TSUGHET	14.88	37.09	23.14	1 019 289	94 757	9.3	115	106	96	61	-9.9
THUJPLI	6.55	22.46	32.30	617 150	63 821	10.3	118	108	97	55	-4.8

a **bold** indicates an increase of > 100%; underline > 90% decrease; ? indicates that no frequency change estimates were available for this species

8.4 Conservation Priorities

? population verification required ABIEGRA, RHAMPUR, PRUNPEN, PRUNVIR, SALIDIS

Interior populations of ABIEGRA require population verification. It is recommended that population sizes in protected areas of the ICHdw/xw subzones (Champion Lakes, West Arm, and Kokanee Creek) or the IDFww/dw subzones (the other interior zone where it occurs) be verified, and if required, protection levels for this species should be increased. It is recommended that populations outside of protected areas in riparian zones (which may receive protection through legislation governing sensitive areas) be surveyed if protection levels are determined to be low. Population verification is recommended for the infrequently occurring and potentially declining populations of RHAMPUR in the ICHmw2 and mw3 variants. These variants may represent the only protection opportunities for interior populations of this culturally significant and otherwise mostly coastal species. Verification is recommended for Prunus species in the northwestern (e.g., Seven Sisters or Nisga'a), northeastern (Dunn Peak, Wells Gray, Bowron, Purden Lake, Sugar Bowl, West Twin, or Mount Robson), and southeastern ICH (Purcell and Gladstone). It is recommended that SALIDIS be verified first in all three protected areas where it is expected to occur at 2.5 ha cumulative cover (Nisga'a, Seven Sisters, Cariboo Mountains). If SALIDIS is under-protected in the eastern portion of the ICH zone (Cariboo Mountains), field verification should occur next in multi-zone protected areas that span the ESSF, IDF, SBS, or MS subzones (e.g., Kootenay, Wells Gray, Bowron, Myra–Bellevue), where protection levels are also expected to be low.

An immediate increase in protected area coverage is recommended only for ABIEGRA populations in the ICHdw/xw. Increasing protected area number or size in all subzone/variant units with low protected area coverage (except the ICHmc2) is not expected to significantly improve the conservation status of any of the infrequently occurring or minor species in the ICH zone: CRATDOU, SALIDIS, JUNISCO, and RHAMPUR generally occur with higher frequencies (in the data set) in units with > 15% protected area coverage. The ICHmc2 is the only subzone/variant unit with < 5% protected area coverage and where increasing protected areas could potentially benefit more than two species, given that PRUNEMA, PRUNPEN, PRUNVIR, and MALUFUS are all recorded at their highest frequencies in this unit. However, the need for increased protection in this part of the ICH zone should be evaluated after species presence here and in existing and recently established protected areas of neighbouring or nearby CWH subzones is quantified.

Support materials for field verification: Appendix 3, Appendix 4

9.1 Overview

The Interior Douglas-fir (IDF) zone is relatively small (6% of British Columbia) and is located in the southern half of the province. It occurs at low to mid elevations in the southern Rocky Mountain Trench, on the southern portion of the Interior Plateau, and up the lower leeward slopes of the Coast Mountains. In the north, it adjoins the colder SBS and SBPS zones. To the east, in the Central Interior, or to the north, in the Rocky Mountain Trench, it adjoins the wetter ICH zone. At higher elevations, it grades into the MS or the CWH zones. It generally occurs above the drier and warmer PP or BG zones. The IDF has a cool temperate climate. Mean annual temperature and precipitation are 4.2°C (range = 2–6°C) and 500 mm (range = 350–900 mm), respectively. The growing season is warm, dry, and relatively long (3–5 months) with nighttime frost occurrences. Winters are cool with little snow.

PSEUMEN is the most common species in fire-maintained upland forests of the IDF zone. Depending on fire history and climate, other dominant or common species include PINUCON (widespread seral species at higher elevations), PINUPON (in hot and dry areas), LARIOCC (in the south and east), POPUTRE, BETUPAP, and ACERGLA (throughout the zone), and THUJPLI and PICEENG (in areas transitional to the CWH, ICH, and MS zones). Some of the more common minor species that are restricted to specific areas or sites include ABIEGRA, POPUBAL, PINUMON, JUNISCO, BETUOCC, CRATDOU, and several species of cherries, alders, and willows (e.g., PRUNVIR, PRUNEMA, ALNUINC, ALNUVIR, SALIBEB, SALISCO). Extensive grasslands, non-forested wetlands, and marshes or carrs with willow and alder scrub are common.

Online resources (p. 54): 1, 2, 3†

9.2 Protected Areas

There are more than 160 protected areas in the IDF zone, 66 of which are larger than 250 ha. While the number of protected areas is high, overall coverage is low. The IDF is the third least protected zone in British Columbia with only 5% protected area coverage—far below the provincial average. Coverage is very high in the wettest subzones and variants at the coast–interior transition (IDFww/dw: 37%), but more than half of the units have < 5% coverage of protected areas. The lowest levels (1%) are found in the IDFdm2 (and the adjoining PPdh2), which leaves the geographically isolated cool temperate and semi-arid ecosystems in the Rocky Mountain Trench vastly under-protected. Protected area coverage levels are also very low in the north-central portion of the IDF zone in the IDFdk3 and dk4 (< 2%) and in the adjoining SBSdw2/dw1, SBPSmk, xc, dc, and nearby portions of the ICHdk/mk3. In terms of *in situ* conservation, the top 10 protected areas are Skagit Valley, Churn Creek, E.C. Manning, Okanagan Mountain, Arrowstone, South Okanagan Grasslands, Tweedsmuir (South), Homathko River–Tatlayoko, Tsyl-os', and Cathedral. Their distributions tend to be skewed, with most protected areas situated in the west or southwestern portion of the

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

zone. With the exception of the highly protected IDFww/dw, all subzone/variant units rank in the top 30 most disturbed units in British Columbia in terms of amount of converted land or proportion of older forests.

Online resources (p. 54): 3, 4, 7, 8†

9.3 Species Representation in Protected Areas

9.3.1 Adequate representation (22 of 37 species) The proportion of species ranges that are protected in the IDF is low for the most common species. Of the 22 adequately protected species, only five (LARIOCC, PINUPON, POPUTRE, PINUCON, PSEUMEN) are expected to occur in the Rocky Mountain Trench (IDFdm2) at 10 ha cumulative cover. Of the 17 remaining species, only six (CRATDOU, PRUNPEN, PRUNVIR, CORYCOR, TSUGHET, PICEGLA) are not expected to occur in a multi-zone protected area that extends into the IDFdm2 (MS portion of Kootenay National Park) or in a protected area in the PPdh2 (Wasa Lake); therefore, they are considered to be locally under-protected in the Trench. Populations of PRUNPEN, PRUNVIR, CORYCOR, TSUGHET, and PICEGLA in the IDFdm2 may be genetically important and are recommended for sampling if genecological testing is conducted for these species. For CRATDOU, population verification is recommended in protected areas throughout the IDF zone because the species is most abundant in this zone (78% of its provincial cumulative cover) and is potentially under-protected elsewhere in British Columbia.

9.3.2 Low representation (15 of 37 species) ABIEAMA, ALNURUB, CORNNUT, ACERMAC, and ACERCIR are cool mesothermal or subalpine boreal species that are characteristic of the coastal CDF, CWH, and/or MH subzones. In the IDF, they are found in the ww and dw subzones at the coast–interior transition. With the exception of ACERCIR, these species are considered to be transitional in the IDF because only 1% of their provincial cumulative cover occurs there, and they are likely to be well protected in at least two other zones where they occur with higher frequency. Furthermore, the very high protected area coverage in the ww and dw subzones (> 30%) will likely be more than adequate for those species with potential for range expansion into the IDF. ACERCIR has 7% of its cumulative cover in the IDF zone and is potentially protected at 5 ha cumulative cover, which may be sufficient for this small tree. It is well protected in the CWH, where it is most common. Populations in the IDF are not considered to be of primary importance for genetic conservation.

PINUALB, which is characteristic of colder, high-elevation climates, is atypical in the IDF. While this species is in decline in British Columbia, its rare and sporadic occurrence in the IDF is not of primary concern in terms of conservation genetics. ABIELAS, which is also characteristic of snowier and colder climates, is a robust and widespread species. It is very well protected in all other zones; populations in the IDF are not of primary importance.

PINUMON is well protected in the CWH, ESSF, ICH, and MH zones, which together contain 96% of its provincial cumulative cover. In the IDF, PINUMON occurs in a variety of subzones but attains its highest frequency in the already well-protected IDF ww/dw. Furthermore, this species may, over the long

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

term, benefit more from increased *ex situ* protection and continued active management efforts (selection, breeding, and deployment for rust resistance) than from increasing *in situ* protection, especially in zones where it occurs more frequently.

PINUFLE is a rare and very narrowly distributed species in British Columbia. In the IDF zone, it occurs with very low frequency in the IDFdm2 variant in the southern Rocky Mountain Trench. Owing to its sparse distribution and the low number and small size of protected areas in the IDFdm2, protection is calculated to be extremely low (< 2.5 ha cumulative cover). Because protection for this species is also low in the other biogeoclimatic zones, populations of PINUFLE in the IDF are considered to be of primary importance.

RHAMPUR, TAXUBRE, and ABIEGRA occur in mesothermal (coastal) and cool temperate (interior) climates, and have wide but disjunct distributions across the southern portion of British Columbia. In the IDF zone, ABIEGRA occurs mainly in the western subzones (IDFww/dw). RHAMPUR and TAXUBRE have their lowest cumulative cover cover values in the IDF zone (< 1%) and could be considered transitional species. They are found in eastern (IDFxh1, mw1/mw2) and western (IDFww/dw) subzones and variants bordering the ICH and CWH, where they occur up to 10 times more frequently. Populations of TAXUBRE in the ICH zone are not considered to be of primary importance in terms of genetic conservation. The species is well protected in the CWH and ICH zones, where it occurs more frequently, and in several protected areas in transitional areas (e.g., Wells Gray, Gladstone, Homathko River–Tatlayoko, Nahatlatch). RHAMPUR and ABIEGRA populations in the ww/dw subzones, where protected area coverage is > 30%, could be considered important if protection levels for these species were found to be low in the nearby CWH subzone.

PRUNEMA is most abundant in the CWH zone, where it is potentially protected at 10 ha. It is less common in the ICH and IDF zones. In the ICH zone, PRUNEMA is predicted to occur in three protected areas at 5 ha cumulative cover, which may be adequate for small trees, but, in the IDF zone, it is expected to occur in only one protected area.

SALIDIS and SALILUC are minor species with discontinuous distributions across a number of zones in British Columbia. SALIDIS has a major proportion of its cumulative cover (25%) within the IDF zone, and is expected to occur in only one protected area. It is also under-protected in a number of other zones, even at the lowest cover values. In contrast, SALILUC has only a small portion of its range (4%) in the IDF zone, and is adequately protected in other zones.

Online resources (p. 54): 5, 6†; summary information: Table 9, Appendix 2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 9 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the IDF zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
RHAMPUR	0.01	< 0.01	0.54	14	2	13.7					0.0
PINUFLE	< 0.01	< 0.01	34.83	85	1	1.0					-0.1
ABIELAS	16.44	0.04	0.01	505	11	2.2	1				-0.1
TAXUBRE	0.21	0.01	0.13	79	4	5.1	1				**0.1**
ACERMAC	0.18	0.05	1.13	608	6	1.1	1				0.4
CORNNUT	0.03	0.01	1.12	83	9	11.1	1	1			0.0
SALILUC	0.09	0.09	4.10	1 045	10	0.9	2				-0.2
SALIDIS	0.01	0.08	24.97	929	43	4.6	1	1	1		0.0
PINUMON	0.11	0.06	2.12	699	53	7.6	2	1	1		0.0
PRUNEMA	0.01	0.06	15.19	665	36	5.4	2	1	1		0.0
ABIEAMA	5.99	0.01	0.01	126	39	31.0	2	2	1		0.0
PINUALB	0.25	< 0.01	0.07	52	23	44.2	3	2	1		-0.1
ALNURUB	0.93	0.03	0.14	390	92	23.6	2	2	2	1	**0.5**
ABIEGRA	0.09	0.07	2.93	807	156	19.3	3	2	2	1	-0.7
ACERCIR	0.10	0.16	6.49	1 869	349	18.7	4	3	2	1	-1.1
CRATDOU	0.00	0.10	77.52	1 200	113	9.4	4	4	3		-0.2
PRUNPEN	0.01	0.06	27.27	753	174	23.1	4	3	3	2	-0.1
PRUNVIR	0.06	0.24	15.71	2 821	120	4.3	12	5	3		**0.2**
CORYCOR	0.14	0.24	7.09	2 811	217	7.7	7	5	4	1	-0.1
TSUGHET	14.88	0.43	0.11	5 002	1 397	27.9	8	6	4	2	**2.4**
PICEGLA	6.35	0.88	0.56	10 211	490	4.8	12	10	5	1	-0.6
LARIOCC	0.24	1.47	22.65	17 053	480	2.8	16	12	8	3	-1.9
BETUOCC	0.04	0.45	41.87	5 222	217	4.2	15	11	8		**0.3**
JUNISCO	0.05	0.96	74.61	11 091	558	5.0	32	21	10	1	-0.1
SALIBEB	0.37	0.77	8.84	8 957	441	4.9	25	17	14	1	-0.1
SALISCO	0.53	0.75	5.75	8 711	955	11.0	26	19	14	5	-0.2
ALNUINC	1.83	1.26	2.91	14 642	546	3.7	38	27	18	1	-0.2
ALNUVIR	2.89	0.90	1.25	10 412	596	5.7	32	27	18	1	-0.2
PICEENG	3.50	1.86	1.99	21 559	1 290	6.0	35	23	20	7	-1.1
THUJPLI	6.55	4.37	2.65	50 661	6 419	12.7	41	33	22	12	-1.1
BETUPAP	1.00	2.49	10.40	28 911	2 054	7.1	60	35	25	10	0.0
POPUTRI	0.56	1.35	8.90	15 668	1 465	9.3	46	35	25	5	**0.5**
ACERGLA	0.41	2.86	27.14	33 135	2 387	7.2	58	40	27	15	**0.0**
PINUPON	0.30	4.07	50.31	47 222	2 809	5.9	58	45	39	14	**4.9**
POPUTRE	4.32	5.55	5.33	64 411	3 851	6.0	64	53	44	12	-1.2
PINUCON	10.24	11.19	4.35	129 846	6 980	5.4	84	65	49	32	0.0
PSEUMEN	6.58	57.05	34.36	661 764	41 038	6.2	119	109	100	61	-4.8

a **bold** indicates an increase of > 100%; underline > 90% decrease

9.4 Conservation Priorities

× protection required **SALIDIS**
? population verification required PINUFLE, CRATDOU, PRUNEMA, SALILUC

SALIDIS has 25% of its total provincial cumulative cover located in the IDF zone, and is predicted to occur in only one protected area at > 2.5 ha cumulative cover (Churn Creek). As this species is potentially under-protected in several zones, verification is recommended first in multi-zone protected areas in the west, south, and east (e.g., Nazko, Myra–Bellevue, Kootenay). For PINUFLE, ground truthing is recommended first in the protected areas around Canal Flats and Golden, where it has been noted to occur in higher concentrations (e.g., Columbia Lake Ecological Reserve [ER]), and then in larger multi-zone protected areas with MS or ESSF zone portions, where it may be more likely to persist under climate warming. This analysis suggests that protection levels for CRATDOU are adequate in the IDF zone; however, population verification is recommended because the IDF zone is where CRATDOU occurs most frequently, and it is potentially the only zone where the species is adequately protected. Population verification for PRUNEMA is recommended throughout the IDF, particularly in the IDFdm2, where expected cumulative cover values are 1 ha or less.

An immediate protected area increase is recommended in the IDFdk3/dk4 or xm/xw, where SALIDIS and CRATDOU frequently occur. Targeting appropriate areas in the dk3 and dk4 would have more value than in the xm/xw because protected area coverage is very low and protected areas are widely spaced in the dk3 and dk4, which is also the case in the adjacent SBS and SBPS subzones. Increased protected area coverage there could also benefit PRUNVIR and PRUNPEN, which are expected to have low protection levels in the IDFdk3/dk4, and in the adjoining SBS, SBPS, and ICH subzones. Increased protected area coverage in those variants could also benefit other common IDF species (e.g., PSEUMEN, BETUPAP), which are predicted to increase in the adjoining zones with climate warming.

Appropriate areas of the IDFdm2 should also be targeted for new protected areas if populations of PRUNEMA, SALILUC, or PINUFLE are underprotected in the IDFdm2, MSdk, and adjoining ICH subzones. A new, large multi-zone protected area covering the PPdh2, IDFdm2, ICHmk or mw, and southern MSdk in the Rocky Mountain Trench would improve the conservation status of a number of species.

Support materials for field verification: Appendix 3, Appendix 4

10 MH ZONE

10.1 Overview

The Mountain Hemlock (MH) zone occurs at subalpine elevations on the Insular Mountains of Vancouver Island and the Queen Charlotte Islands, along the Coastal Mountains, and in areas along the Boundary Range. It has a maritime, subalpine boreal climate with short, cool summers and wet, cool winters, and a deep, long-lasting, heavy snowpack. Average precipitation varies from 1900 mm on the lee side of the Coast Mountains to 3600 mm on the windward side to over 4500 mm in the MHwh, making it one of the wettest climates in Canada. The lower elevational limit of the zone varies greatly with

latitude, distance from the coast, and exposure. On average, the zone occupies an elevational band from 400 to 1000 m in the north, and 900 to 1800 m in the south. Mean annual temperature varies from 5°C on the outer coast to 1.4°C on the leeward side of the Coast Mountains.

The growing season in the MH zone is short. At upper elevations or in areas with a prolonged snowpack, parkland ecosystems develop. Subalpine heath, herb meadows, and wetlands are the dominant vegetation in parkland ecosystems, with trees confined to isolated patches or "islands" with earlier snowmelt. TSUGMER is the most common species. It is prevalent both in forested and parkland ecosystems throughout the zone. ABIEAMA is most common in the drier and cooler MHmm, and CHAMNOO occurs most frequently in the milder and wetter MHwh, especially on wetter sites. TSUGHET is most abundant at lower elevations, whereas ABIELAS is most common in colder, drier areas that are transitional to the ESSF zone. Other typically low-elevation or transitional minor species include PICESIT, PINUMON, THUJPLI, and PINUCON. The forests are rarely disturbed by fire, especially at higher elevations, and old-growth ecosystems are common.

Online resources (p. 54): 1, 2, 3†

10.2 Protected Areas

In 2002, 14% of the MH zone was protected by a relatively small number (< 80) of protected areas. The recent protected area expansion on the north and central coast has significantly increased protection levels, particularly in the MHwh subzone. Protected area coverage in the small MHun (an unclassified portion of the MH zone) is still low (3%), but this area is remote and has low disturbance and a high proportion of forests older than 120 years. The top 10 protected areas in terms of genetic conservation for species in the MH zone all occur in the MHmm: Garibaldi, Golden Ears, Strathcona, Pinecone Burke, Kitlope Heritage Conservancy, Clendinning, Seven Sisters, Tweedsmuir North, Upper Lillooet, and Fiordland. Garibaldi and Tweedsmuir North also rank in the top 10 when considering all species and protected areas in British Columbia. Tweedsmuir, Strathcona, and Kitlope Heritage Conservancy are among the top 10 largest protected areas in British Columbia.

Online resources (p. 54): 3, 4, 7, 8†

10.3 Species Representation in Protected Areas

10.3.1 Adequate representation (9 of 11 species) Protection levels in the MH zone are very high. Eight of nine species (all but PINUMON) classified as adequately protected are expected to occur in > 10 protected areas at 10 ha cumulative cover.

10.3.2 Low representation (2 of 11 species) On the coast, PINUCON and THUJPLI are typically lower-elevation species that are characteristic of the CWH zone. THUJPLI is most common on medium to rich, moist sites. PINUCON occurs most frequently on poorer, wetter sites, where it is often a dominant species in bog forests, bog woodlands, and bogs. On the north and central coast, these species occur at higher elevations, but mostly just in the MHwh subzone. Protection levels for these species (based on the 2002

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

protected area database) are calculated to be low in most of the wh subzone: only in Gwaii Haanas are cumulative cover values > 10 ha. With the recent protected area expansion along the north and central coast, protection levels and opportunities for range expansion are likely adequate in several areas: the northern portion of the MHwh subzone in the new protected areas around Work Channel, the Ecstall River, Stephens, or Kennedy Island; in the central CWH on Pitt Island, Princess Royal Island, or on the mainland along Granville Channel; and in the south around Roscoe Inlet, the Koeye River, or Draney Inlet.

Online resources (p. 54): 5, 6† ; summary information: Table 10, Appendix 2

TABLE 10 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the MH zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
PINUCON	10.24	0.08	0.05	1 570	82	5.2	4	1	1	1	0.6
THUJPLI	6.55	0.09	0.09	1 838	96	5.2	4	2	1	1	**10.1**
PINUMON	0.11	0.04	2.28	753	159	21.1	6	4	4	0	0.0
PICESIT	1.44	0.66	3.10	13 217	1 510	11.4	38	26	18	0	**1.6**
SALISIT	0.28	0.68	16.68	13 592	1 916	14.1	36	26	20	17	-0.3
ALNUVIR	2.89	2.54	6.12	50 813	8 392	16.5	47	41	33	0	-0.7
ABIELAS	16.44	5.50	2.22	109 875	12 684	11.5	28	26	23	20	-3.0
TSUGHET	14.88	9.30	4.22	185 961	24 429	13.1	58	55	52	1	**23.0**
CHAMNOO	2.02	9.18	29.76	183 543	27 753	15.1	41	40	36	33	-4.3
ABIEAMA	5.99	32.72	35.92	653 973	92 331	14.1	55	54	52	4	-0.3
TSUGMER	3.69	39.21	69.70	783 743	108 546	13.8	59	59	58	134	-19.0

a **bold** indicates an increase of > 100%; underline > 90% decrease

10.4 Conservation Priorities

Considering rarity, distribution, protected area coverage, and predicted future potential presence, none of the species in the MH zone require increased protection or population verification.

Support materials for field verification: Appendix 3, Appendix 4

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

11.1 Overview

The Montane Spruce (MS) zone is small and covers 3% of the province. It occurs on the high plateaus in central and southern interior British Columbia, on the lee of the Coast and Cascade Mountains, on the southern Rocky Mountains, and in the Rocky Mountain Trench. The MS zone was originally treated as the drier and warmer, low-elevation portion of the ESSF zone but is now considered to be a separate zone, transitional between the ESSF and the IDF zones. It has a continental climate with cold winters and short (2–4 months), dry, warm summers. Mean annual temperature and precipitation is 1.5°C (range = 0– 3°C) and 690 mm (range = 530–960 mm), respectively.

The climatic variation and transitional nature of this zone is reflected in its tree species and their distributions. PINUCON is the major and most consistently occurring species throughout the zone, and forms extensive even-aged seral stands following fire. PICEENG and ABIELAS (longer-lived species characteristic of higher-elevation forests) and interior spruce (characteristic of northern zones) occur on wetter, cool-aspect, or seepage sites. PSEUMEN (characteristic of lower-elevation forests) occurs on warmer, drier sites. POPUTRE, LARIOCC, THUJPLI, ACERGLA, BETUPAP, and PINUMON are restricted to or are most prevalent in the eastern subzones. Other minor species that are common to specific sites throughout the zone are ALNUVIR, ALNUINC, SALISCO, SALIBEB, and POPUTRI.

Online resources (p. 54): 1, 2, 3†

11.2 Protected Areas

There are just over 60 protected areas in the MS zone, half of which are larger than 250 ha. On average, 8% of the MS zone is protected—less than the provincial average. Protected area coverage is greatly skewed, ranging from 26% in the MSdc1/dc2/dv/un to < 4% in the MSdm1 and dm2. The top 10 protected areas in terms of genetic conservation are Kootenay, Yoho, Purcell Wilderness Conservancy, Whiteswan Lake, Height of the Rockies, Myra–Bellevue, Bonaparte, Cathedral, Snowy, and Tsyl-os'. Six of these protected areas also rank in the top 10 considering all species and protected areas in British Columbia. The MSdm1 is the least protected unit. It has < 2% protected area coverage, only two large protected areas, neither of which rank highly, and a high proportion (70%) of land covered by forests younger than 120 years.

Online resources (p. 54): 3, 4, 7, 8†

11.3 Species Representation in Protected Areas

11.3.1 Adequate representation (14 of 24 species) Most of the common species in the MS zone potentially occur in three or more protected areas with an expected cumulative cover of 10 ha. The proportion of species cumulative cover protected in the MS zone is generally < 10%.

11.3.2 Low representation (10 of 24 species) THUJPLI, TAXUBRE, and PINUMON have wide but disjunct distributions across southern British Columbia. They occur most frequently in mesothermal and cool temperate climates.

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

More than 80% of their provincial cumulative cover is located in the CWH and ICH zones, where they are very well protected. Their presence in the MS zone, which contributes to < 2% of their total provincial cumulative cover, is limited to the warmer and wetter subzones bordering the ICH zone. Despite the predicted frequency increase in THUJPLI and PINUMON in this zone due to climate warming (Hamann and Wang 2006), all three species are considered to be transitional, and protected area populations of these species in the MS zone are not of primary concern in terms of conservation genetics. THUJPLI is a common, robust, and generally well-protected commercial species. PINUMON may be better protected over the long term by increasing active management (selection, breeding, deployment) rather than through passive conservation management efforts that protect natural peripheral populations since the major threat to this species is an introduced fungus.

Protected area populations of PINUALB in the MS zone are also not of primary concern for genetic conservation. PINUALB is more common in the wetter, higher-elevation AT and ESSF zones than in the MS zone, which contains < 1% of the species' total provincial cumulative cover. PINUALB is also predicted to have limited potential for persistence in the MS zone under climate warming conditions, and, as with PINUMON, may benefit most from increased active management and *ex situ* conservation. Although PINUFLE is known to occur in southeastern British Columbia, the data set used in this analysis had no location records of the species in the MS zone. PINUFLE is considered to be a species of importance because it has low protection levels in the adjoining IDF and ESSF zones, where it is recommended for ground truthing in the Rocky Mountain Trench (see "Conservation priorities" subsections in the IDF and ESSF zone sections).

JUNISCO and PINUPON occur more commonly in the cool temperate or semiarid climates of the IDF or PP zones, respectively, than in the MS zone, where they are found in the drier subzones. JUNISCO has a significant portion of its range in the MS zone (9% of its provincial cumulative cover). It is well protected in the IDF and in the MS zones at 5 ha cumulative cover, which may be adequate for this small tree. PINUPON has < 1% of its provincial cumulative cover in the MS zone and is currently under-protected. However, several large protected areas spanning both the MS and IDF zones (Cathedral, Okanagan Mountain, Myra–Bellevue, Trepanier, and Kootenay) will likely provide adequate protection if PINUPON increases in the MS zone with climate warming.

SALIDIS, SALISIT, BETUOCC, and PRUNVIR are wide-ranging species that are found in several zones in British Columbia. Of these species, SALIDIS has the highest proportion of its range in the MS zone (8%). It is potentially under-protected in many adjoining zones—in the IDF zone, which contains a substantial portion of its cumulative cover (25%), and in the ESSF and ICH zones, which together contain another 10%; therefore, protected area populations of SALIDIS in the MS zone could be important in terms of genetic conservation. In contrast, SALISIT has a very small proportion of its cumulative cover in the MS (< 1%), is well-protected in the adjoining ESSF and ICH zones, and is not considered to be a primary concern. PRUNVIR is also not considered to be a primary concern in the MS zone. It is more characteristic of lower-elevation forests and has only a minor proportion (3%) of its range in the MS zone. It is potentially protected at > 5 ha cumulative cover in central British Columbia in the IDF portion of several large multi-zone

protected areas that span the MS zone (e.g., Snowy, Stein, Myra–Bellevue) and at > 10 ha cumulative cover in eastern British Columbia in the MS zone (e.g., Kootenay and Yoho). BETUOCC is also potentially protected in several higher-elevation single or multi-zone protected areas at > 5 ha cumulative cover in the Southern Interior (e.g., Manning: ESSF, Cathedral: MS portion, Silver Star: ESSF) and in eastern British Columbia (e.g., Kootenay and Yoho: MS zone). While BETUOCC is not well protected on the northern edge of the Interior Plateau (e.g., < 5 ha cumulative cover in Edge Hills, Marble Range, Bonaparte), conservation efforts for this species may be better directed at verifying or increasing protection in the IDFxh2 and dm2, or in the northern part of the species' range in the BWBS zone.

Online resources (p. 54): 5, 6†; summary information: Table 11, Appendix 2

TABLE 11 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the MS zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
PINUMON	0.11	0.06	1.40	462	0	0					**0.9**
SALIDIS	0.01	0.03	7.60	283	8	3.0					-0.1
TAXUBRE	0.21	0.07	0.85	530	7	1.4	1				0.1
PINUPON	0.30	0.04	0.31	290	32	11.0	5	2			**1.5**
SALISIT	0.28	0.10	0.96	787	32	4.0	3	2	1		-0.2
BETUOCC	0.04	0.08	5.38	671	51	7.6	3	2	2		-0.1
PRUNVIR	0.06	0.07	3.33	599	54	9.1	2	2	2		0.0
PINUALB	0.25	0.07	0.70	537	94	17.5	8	4	2		-0.1
THUJPLI	6.55	0.42	0.17	3 373	343	10.2	3	3	2	2	**10.2**
JUNISCO	0.05	0.17	9.44	1 403	153	10.9	9	5	2	2	0.0
POPUTRI	0.56	0.34	1.57	2 759	267	9.7	5	4	3	2	**0.3**
BETUPAP	1.00	0.93	2.71	7 539	759	10.1	5	5	5	2	2.4
ACERGLA	0.41	1.17	7.72	9 429	822	8.7	7	7	5	2	1.4
LARIOCC	0.24	1.81	19.42	14 618	940	6.4	7	7	6	8	0.9
SALIBEB	0.37	0.54	4.32	4 382	346	7.9	10	7	6	2	0.0
SALISCO	0.53	0.35	1.86	2 811	229	8.2	12	9	6	2	0.1
PICEGLA	6.35	0.54	0.24	4 379	580	13.2	9	8	7	5	-0.1
POPUTRE	4.32	3.18	2.13	25 714	2 311	9.0	19	17	13	10	**1.3**
ALNUINC	1.83	1.67	2.68	13 505	1 093	8.1	25	23	15	2	0.1
ALNUVIR	2.89	3.60	3.51	29 115	1 970	6.8	35	29	25	5	-0.4
PICEENG	3.50	9.45	7.07	76 490	3 308	4.3	43	38	30	13	-2.1
PSEUMEN	6.58	15.03	6.32	121 644	10 249	8.4	43	40	35	19	**10.0**
ABIELAS	16.44	14.36	2.35	116 202	9 146	7.9	47	40	35	23	-3.6
PINUCON	10.24	45.94	12.46	371 776	27 533	7.4	52	50	48	33	-8.4

a **bold** indicates an increase of > 100%; underline > 90% decrease

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

11.4 Conservation Priorities

? population verification required **SALIDIS**

Verification is recommended for SALIDIS in multi-zone protected areas in the south and east that span the IDF, ESSF, or ICH zones, where protection levels are also expected to be low (e.g., Trepanier, Myra–Bellevue, Purcell, Kootenay, or Yoho). An increase in protected area coverage in the MSdm or southern MSdk is recommended if protection levels for SALIDIS are found to be low in existing protected areas.

Support materials for field verification: Appendix 3, Appendix 4

12 PP ZONE

12.1 Overview

The small Ponderosa Pine (PP) zone (< 1% of British Columbia) occurs in the dry valleys of the Southern Interior along the Fraser, lower Thompson, Nicola, Similkameen, and lower Kettle Rivers, along Okanagan Lake, and in the Rocky Mountain Trench south of Elko. It is the driest forested zone in British Columbia and often occurs between the grasslands of the BG zone and the moister, cooler IDF zone. The climate is summer-dry, continental cool temperate. The summers are very long (5–6 months) with hot days (highest daytime temperatures in British Columbia) and cool nights (low precipitation, dry air, and clear skies promote radiative cooling). Moisture deficits are large because there is little snowfall in winter, and summer precipitation, which is often produced by high-intensity storms, contributes little to plant growth on fine-textured soils. Summer precipitation is limited, ranging from 130 mm in the PPxh2 to 220 mm in the PPdh1. Mean annual precipitation is 410 mm (range = 350–530 mm), and mean annual temperature is 6.5°C (range = 5.9–7.4°C).

The vegetation pattern in this zone is a mosaic of grassland or shrub-steppe on gentle slopes, with forested ecosystems often developing on steeper terrain. The open park-like forests are dominated by PINUPON and graminoids. PSEUMEN is the principal companion species on dry sites or is a dominant species on wetter, water-receiving sites associated with gullies, draws, and streams. POPUTRE is commonly found on cool sites and seepage sites or near riparian areas. POPUTRI, ACERGLA, and BETUOCC occur most frequently on seepage sites or floodplains. LARIOCC and PINUCON occur infrequently and are localized to certain areas. Most of the minor species are associated with wetter sites or riparian areas (e.g., BETUPAP, PRUNVIR, PRUNPEN, PRUNEMA, SALIBEB, ALNUINC, CRATDOU). Wetlands, the most common type supporting alkaline salt ponds, are rare in this zone.

Online resources (p. 54): 1, 2, 3†

12.2 Protected Areas

Private land ownership, land use conversion, agriculture (primarily grazing), fire suppression, invasive species, and recreational impacts are very common throughout the PP zone; on average, only 5% of the land is protected. Natural

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

and undisturbed grasslands, wetlands, and riparian ecosystems, and many plant and animal species are rare and under-protected in the dry Southern Interior. This situation may worsen as the climate warms and development in the area intensifies. The PP zone ranks second in British Columbia for lowest total protected area coverage and number (< 40) of protected areas, and third for the lowest percentage (25%) of large protected areas (> 250 ha). Protected area coverage ranges from < 9% in the PPxh1 to almost 0% in the PPdh1 and PPdh2. Johnstone Creek protects only 30 ha in the PPdh1, and Wasa Lake protects only 135 ha in the PPdh2. The PPxh2 has < 4% protected area coverage with gaps in protection along the Fraser and Nicola River valleys. The top 10 protected areas in terms of genetic conservation are Lac du Bois Grasslands, Okanagan Mountain, South Okanagan Grasslands, Vaseux, White Lake Grasslands, Anarchist, Antoine/Fred, Arrowstone, Arthur Seat, and Myra–Bellevue. Many of the protected areas in the PP zone span several zones that cover both the more arid BG zone and the moister IDF zone. Five of the protected areas in the PP zone also rank in the top 30 for all of British Columbia.

Online resources (p. 54): 3, 4, 7, 8†

12.3 Species Representation in Protected Areas

12.3.1 Adequate representation (6 of 19 species) PINUPON, PSEUMEN, POPUTRE, POPUTRI, ACERGLA, and BETUOCC are expected to occur in at least three protected areas, but only a small percentage (< 6%) of their cumulative cover is protected and only in specific regions. For example, none of these species is protected in the PPdh1. In the PPdh2, only PSEUMEN, PINUMON, and POPUTRE are expected to occur at 10 ha cumulative cover in Wasa Lake. Protection levels for POPUTRI, ACERGLA, and BETUOCC are also expected to be low in the adjoining IDFdm2: in Premier Lake or Kikomun Creek (the closest protected areas), cumulative cover values are 6, 5, and 2 ha, respectively. Local populations of these three species are considered to be important in terms of genetic conservation. Protected area population verification is recommended in the IDFdm2.

12.3.2 Low representation (13 of 19 species) LARIOCC, PINUCON, PICEENG, THUJPLI, BETUPAP, SALIBEB, ALNUINC, CORYCOR, and CRATDOU each have < 1% of their provincial cumulative cover within the PP zone. These species generally occur more frequently in or are characteristic of wetter zones. In the PP zone, many of these species are found in cooler or wetter areas and on moist to very wet sites (gullies, draws, seepage, riparian, or wetland sites). With the exception of SALIBEB, these species are not predicted to increase with climate warming. The increase predicted for SALIBEB is considered to be an analytical or sampling artifact (i.e., it is probably a reflection of the species' habitat being more common and/or intensively sampled in the BG zone). The model assumes that, as the climate of the PP zone approaches that of the BG zone, SALIBEB will have similar frequency in both zones, but it does not account for habitat availability. It is unlikely that the frequency of occurrence of SALIBEB habitat and wetter sites, many of which are rare, altered, and threatened by development, agriculture, and grazing, will increase with climate warming. SALIBEB is also estimated to occur in four protected areas

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

at 2.5 ha cumulative cover, which may be sufficient for a small tree. Together, these nine species account for 4% of the total tree cumulative cover in the zone. PINUCON and BETUPAP are the most common species, contributing 50% of the value. While under-protected in the PP zone, PINUCON and BETUPAP are expected to be adequately protected in the IDF portion of at least three multi-zone protected areas in the PP zone (Stein Valley, Lac du Bois Grasslands, Okanagan Mountain). Taking into account the small proportions of their provincial distributions and predicted declines in the PP zone, and their generally higher occurrence and overall protection levels in the neighbouring IDF zone, populations of these nine species in the PP zone are not considered to be of primary importance for genetic conservation. If protection levels for ALNUINC and SALIBEB are found to be low in the IDF zone, and similarly in either the BG or IDF zones for CRATDOU, the importance of these local populations may increase. Of these three species, CRATDOU has the narrowest distribution and the least protection across its provincial range.

Compared to the above species, PRUNVIR, PRUNEMA, PRUNPEN, and JUNISCO have greater proportions of their provincial cumulative cover distributions in the PP zone (2–5%). Of these species, JUNISCO is considered to be the most characteristic of cool semi-arid climates. It has the highest proportion of its range (5%) in the PP zone and 75 and 9% in the adjoining IDF and BG zones, respectively. It is also the most tolerant of dry sites and is the most likely to increase or persist with climate warming, although this is not supported by the predictive models. Of the cherries, PRUNVIR is considered to be of higher importance because it is found in all PP subzones, has the highest cover values, and has a significant presence (6% cumulative cover) in the drier BG zone. PRUNEMA and PRUNPEN are predicted to decline with climate warming, and even though they are not expected to occur at more than 2 ha cumulative cover in any portion (PP, IDF, or BG) of the multi-zone protected areas in the PP zone, local populations are not considered to be of high importance. These species are recommended for verification in cooler, less arid zones, where they are more common.

Online resources (p. 54): 5, 6†; Summary information: Table 12, Appendix 2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 12 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the PP zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
ALNUINC	1.83	0.22	0.03	166	0	0.0					-0.2
CORYCOR	0.14	0.05	0.08	34	0	0.0					-0.2
CRATDOU	< 0.01	< 0.01	0.22	3	0	0.0					0.1
LARIOCC	0.24	0.28	0.28	209	0	0.0					-1.5
PICEENG	3.50	0.10	0.01	76	0	0.0					-0.6
THUJPLI	6.55	0.47	0.02	357	6	1.7					-0.4
PRUNEMA	0.01	0.15	2.66	117	6	5.3					0.0
PRUNPEN	0.01	0.10	2.68	74	7	8.8					-0.1
PRUNVIR	0.06	0.59	2.48	445	13	3.0	2				**0.3**
JUNISCO	0.05	1.02	5.16	767	25	3.3	1	1			-0.2
SALIBEB	0.37	0.40	0.29	299	25	8.4	4	2			**0.2**
BETUPAP	1.00	1.28	0.34	968	32	3.3	3	3			-0.5
PINUCON	10.24	0.95	0.02	720	66	9.2	5	4	2		-0.7
POPUTRI	0.56	4.31	1.85	3 252	103	3.2	10	7	3		**0.8**
POPUTRE	4.32	4.11	0.26	3 102	143	4.6	8	5	5		-0.4
BETUOCC	0.04	3.43	20.77	2 590	145	5.6	11	7	5		-0.3
ACERGLA	0.41	4.08	2.52	3 075	168	5.5	12	8	5		-1.2
PSEUMEN	6.58	33.98	1.33	25 643	1 133	4.4	23	22	18	5	-6.9
PINUPON	0.30	44.48	35.76	33 570	1 499	4.5	25	22	19	5	1.2

a **bold** indicates an increase of > 100%; underline > 90% decrease

12.4 Conservation Priorities

× protection required JUNISCO
? population verification required **PRUNVIR**

The minimum but most pragmatic and easily attainable strategy for genetic conservation would be to ensure that adequate protection levels exist in any biogeoclimatic zone portion (PP, IDF, and BG) of one large multi-zone protected area per geographic area (Thompson River basin, Okanagan basin, and Kettle River and Kootenay River portions of the Columbia River basin). This may not be achievable in the PPdh2 or dh1 because protected area coverage is low and there are no large multi-zone protected areas. In the PPdh2, verification is recommended in Wasa Lake and in the adjacent IDFdm2 in Kikomun Creek and Premier Lake. New protected areas in the PPdh2 and dh1 or the expansion of two existing ones (Kikomun Creek: dh2, Johnstone Creek: dh1) could improve the conservation status of several of these species and increase protected area coverage in these severely under-represented subzones. Also, very small (< 5000 individuals) but known occurrences of these species outside of protected areas (e.g., JUNISCO pocket south of Kamloops Lake) should be surveyed and considered for provincial protection.

When further assessing species protection levels in the small, highly populated, and heavily used PP zone, it may be necessary to consider the network of privately held land parcels or ecosystems protected in conjunction with the *Forest and Range Practices Act* (i.e., wildlife habitat, wetland, ripar-

ian, and old-growth management areas), city or regional parks, private lands with covenants or active conservation management plans, or lands held by ENGOs. Considering that many of the species with low protected area representation occur on wetter sites, that riparian sites are often threatened (e.g., cottonwood-dominated riparian ecosystems), and that a large percentage of land in the PP zone is privately owned, it is suggested that *in situ* protection may be increased by enhancing the incentives and legislation associated with conservation covenants, the Riparian Areas Regulation, and other similar tools. Actively planning to increase the connectivity between protected areas may be required to improve conservation status of under-protected species and provide corridors for future dispersal.

Support materials for field verification: Appendix 3, Appendix 4

13 SBPS ZONE

13.1 Overview

The Sub-Boreal Pine–Spruce (SBPS) zone is a small montane zone (3% of British Columbia) located mainly on the high, rolling Nechako and Fraser Plateaus in the Chilcotin, and in a long strip east of 100 Mile House. It occurs below the MS and ESSF zones and beside or below the SBS zone, and grades into the IDF zone at lower elevations in the south. It occurs between 850 and 1250 m elevation in the north and 900 and 1500 m in the south and west. The zone is located in the rain shadow of the Coast Mountains, and has dry summers with a subcontinental to continental sub-boreal climate. The growing season is shorter (1–3 months), cooler, and drier than in the adjacent SBS zone, and nighttime frosts are frequent. Mean annual temperature and precipitation range from 1.5°C and 411 mm in the SPSPxc to 2.5°C and 540 mm in the SBPSmk subzone, respectively.

Tree species diversity is low, and PINUCON is the only consistently dominant species throughout the zone. In many areas, dry conditions and frequent fires promote extensive, dense, even-aged, single-storeyed stands of pure PINUCON. Other tree species in this zone generally occur only in small pockets on specific site types or in certain geographic areas. PICEGLA and interior spruce occur on wetter sites bordering wetlands and streams or in wetter northern areas. POPUTRE is found on wetter sites or as a seral species. PICEMAR occurs in colder areas and wetlands in the north, and PSEUMEN occurs on warm-aspect slopes in the south. ALNUVIR and ALNUINC are more common in the wetter subzones. POPUTRI occurs most frequently on floodplains. Natural grasslands, wetlands, and carrs dominated by willows and scrub birch are very common in this zone.

Online resources (p. 54): 1, 2, 3†

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

13.2 Protected Areas

There are 17 protected areas in the SBPS zone, 11 of which are larger than 250 ha. On average, 9% of the SBPS zone is protected. Protected area coverage ranges from extremely high (50%) in the SBPSmc to < 6% in the dc and xc, and 0% in the mk subzone. Disturbance levels due to harvesting and fire are very high in this zone, and most of the forests both inside and outside of protected areas are less than 120 years old. The top 10 protected areas for *in situ* genetic conservation are Nunsti, Entiako (park and protected area), Tweedsmuir (South), Tweedsmuir (North), Kluskoil Lake, Nazko Lake, White Pelican, Narcosli Lake, and Big Creek.

Online resources (p. 54): 3, 4, 7, 8†

13.3 Species Representation in Protected Areas

13.3.1 Adequate representation (8 of 16 species) The most common species in the SBPS zone are adequately protected in three or more protected areas at 10 ha cumulative cover. Redundancy is low and close to the threshold of three protected areas for most species. For all species, protection is lacking in the eastern SBPS. Species that occur infrequently in the highly protected SBPSmc have < 5% of their cumulative cover protected.

13.3.2 Low representation (8 of 16 species) PICEENG, PRUNPEN, PRUNVIR, BETUPAP, POPUTRI, and SALISCO each have < 1% of their provincial cumulative cover within the SBPS zone. All are considered to be infrequently occurring or transitional species that are characteristic of neighbouring zones, and none are of primary concern in terms of conservation genetics. PRUNPEN and PRUNVIR are uncommon, contribute little towards tree cover in the SBPS zone, and are identified as conservation concerns in the neighbouring IDF zone. PICEENG is predicted to decline with climate warming. Although BETUPAP, POPUTRI, and SALISCO currently occur infrequently, they are predicted to increase with climate warming. These species are generally well protected in the SBS, IDF, and ICH zones. However, there are few large protected areas in the neighbouring subzones (SBSdw1/2 and IDFdk3, dk4, ICHmk3/dk) and few multi-zone protected areas in the SBPS in these transitional areas, which may cause concern in the future.

PSEUMEN has a very small proportion of its provincial cumulative cover in the SBPS zone (1%), but it occurs with much higher frequency than the species discussed above. It accounts for 6% of the total tree cumulative cover in the SBPS zone and is predicted to increase with climate warming. Currently, it is protected in the south (IDF portion of Churn Creek, > 10 ha cumulative cover) and in the east (SBS or ICH portions of Schoolhouse, > 5 ha). If its frequency increases with climate warming, existing protected areas should provide adequate protection in all subzones except the isolated SBPSmk, where protected area coverage is particularly low.

SALIDIS has a substantial proportion (10%) of its provincial cumulative cover in the SBPS zone. Protection levels for this species are estimated to be low in most zones where it occurs, including the adjoining SBS and IDF zones, where more than half of its provincial cumulative cover distribution is located. SALIDIS populations in the SBPS could be very important if verified protection levels in the SBS and IDF are low, or if it is absent from the large

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

multi-zone protected areas in transitional areas in the north and south (e.g., Entiako, Churn Creek).

Online resources (p. 54): 5, 6†; summary information: Table 13, Appendix 2

TABLE 13 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the SBPS zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
PRUNPEN	0.01	< 0.01	0.13	4	0	0					n/c
PRUNVIR	0.06	< 0.01	0.10	17	0	0					n/c
BETUPAP	1.00	0.08	0.10	285	0	0					**2.6**
PICEENG	3.50	0.11	0.04	415	0	0					-0.2
SALIDIS	0.01	0.10	10.12	376	8	2.2	2				0.0
SALISCO	0.53	0.31	0.75	1 154	19	1.6	2	1	1		**0.1**
PSEUMEN	6.58	5.92	1.15	22 085	39	0.2	4	2	1		**11.1**
POPUTRI	0.56	0.25	0.54	947	33	3.5	4	3	1		**0.4**
SALIBEB	0.37	1.04	3.84	3 888	146	3.7	6	4	4		0.0
ABIELAS	16.44	0.88	0.07	3 284	455	13.9	4	4	4	4	0.4
ALNUINC	1.83	1.36	0.99	5 057	1 281	25.3	8	6	5	5	0.3
ALNUVIR	2.89	4.56	2.05	17 007	301	1.8	8	7	6	1	-0.1
PICEGLA	6.35	2.54	0.52	9 459	1 154	12.2	7	7	7	4	**0.4**
PICEMAR	5.14	6.61	1.74	24 640	3 632	14.7	8	8	8	6	-2.1
POPUTRE	4.32	7.55	2.33	28 163	1 004	3.6	11	11	10	6	**1.3**
PINUCON	10.24	68.67	8.58	256 013	21 414	8.4	14	13	11	11	-7.9

a **bold** indicates an increase of > 100%; n/c: not calculated

13.4 Conservation Priorities

? population verification required **SALIDIS**

Protection for SALIDIS is expected at > 10 ha cumulative cover in multi-zone protected areas in the north (ESSF or SBS portions of Entiako and Tweedsmuir) and south (IDF portion of Churn Creek) but not in the western or central SBPS zone. In the western SBPSmk subzone, where SALIDIS attains its highest frequency, verification is recommended only in the small Green Lake complex. Other nearby protected areas (e.g., Schoolhouse, Taweel, Emar, Moose Valley, Flat Lakes, Bonaparte) do not span the SBPS zone. In the central SBPS, verification is recommended in Kluskoil, Nazko, and White Pelican.

An immediate increase in protected area coverage is recommended for the SBPSmk. Protected area coverage is virtually absent in this subzone and is extremely low in the neighbouring IDFmk3 and SBSmm, mc1, and dw1/2. In addition to SALIDIS, all the infrequently occurring or transitional species in the SBPS with low protected area coverage are found in this subzone.

Support materials for field verification: Appendix 3, Appendix 4

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

14.1 Overview

The Sub-Boreal Spruce (SBS) zone is the third largest forested zone in British Columbia (11% of the province). It is a montane zone located mainly on the rolling landscape of British Columbia's Central Interior. It covers a wide latitudinal and longitudinal range and transitions to many different zones, which is reflected in the number of SBS subzones and their climatic variation. Mean annual precipitation nearly doubles from 500 mm in low-lying areas in the west (SBSdk) to 950 mm in mountainous terrain in the east (SBSvk). Mean annual temperatures average 2.3°C and range from 0.7°C in southeast to 4.6°C in the south-central region. Overall, the climate is mild continental, less extreme with a longer growing season than in the BWBS zone, and wetter and slightly warmer than the SBPS zone.

Most of the zone is covered with upland coniferous forests. PICEGLA × PICEENG and ABIELAS are the major species in older forests, and PINUCON, POPUTRE, and BETUPAP are common in younger forests. PICEMAR and POPUTRI are found on wetter and alluvial sites, respectively, and PSEUMEN occurs on warm, dry, and rich sites in the south. ALNUVIR is common in forests, and ALNUINC occurs most frequently along streams and in bogs. Other common minor deciduous species include a variety of upland and wetland willows (SALISIT, SALISCO, SALIBEB, SALILUC), ACERGLA, and PRUNVIR. Wetlands containing scrub willows and birch with sedge and moss communities occur on flats and water-receiving sites.

Online resources (p. 54): 1, 2, 3†

14.2 Protected Areas

There are more than 130 protected areas in the SBS zone, 45% of which are larger than 250 ha. On average, only 6% of the total land area is protected, which is less than half the provincial average. The SBS zone is the fourth least protected zone in British Columbia after the IDF, PP, and CDF zones. Protected area coverage is greatly skewed, ranging from 14% in the SBSmc2 to < 1% in the SBSmw. Most of the units (70%) have less than 5% protected area coverage and a substantial portion of the land base covered with forests younger than 120 years. The SBSdw, mw, and mh are the least protected units with < 2% protected area coverage, and they have few large protected areas (four, one, and one, respectively). The adjacent IDFdk3, dk4, and ICHmk3 have similarly low levels of protection. The high coverage in the mc2 and mc3 is mostly accounted for by only two protected areas: Tweedsmuir and Entiako, which are not only large but ranked high in terms of genetic conservation in both the SBS and across all of British Columbia. The top 10 protected areas for *in situ* genetic conservation in the SBS are Entiako, Tweedsmuir North, Schoolhouse Lake Park, Fraser River, Rubyrock Lake, Bowron Lake, Sutherland River, Uncha Mountain–Red Hills, Tweedsmuir (South), and Nation.

Online resources (p. 54): 3, 4, 7, 8†

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

14.3 Species Representation in Protected Areas

14.3.1 Adequate representation (18 of 25 species) Most of the species in the SBS zone potentially occur in three or more protected areas with an expected cumulative cover of 10 ha, although on average, these species have only 5% of their cumulative cover protected.

14.3.2 Low representation (7 of 25 species) PINUALB is most common in high-elevation forests of the ESSF and AT zones, where it is adequately represented in protected areas. The species is very atypical, uncommon, and unlikely to persist in the SBS with anticipated climate warming. PRUNEMA also occurs at such low frequencies that it is predicted to have a total cumulative cover of only 3 ha in the entire zone. Neither PINUALB nor PRUNEMA in the SBS is considered to be of concern for conservation genetics.

BETUOCC also occurs very infrequently in the SBS zone (< 1% of its provincial cumulative cover); it is recorded mainly in the northern SBSmk2. However, considering the possible lack of protection in the BWBS zone, populations near Williston Lake or elsewhere in the Peace River watershed could become important. THUJPLI is also presently uncommon in the SBS zone but is predicted to increase. While it is very well protected in the ICH zone, there are few large protected areas in areas of the SBS bordering the ICH zone that will provide future protection opportunities (e.g., wk1: Bowron, Purden, Sugarbowl-Grizzly Den; mm: Emar Lakes, Taweel; mc1: Schoolhouse; vk: Kakwa; dh: Mount Robson; mw: none).

In contrast, CORYCOR, SALIDIS, and PRUNPEN have significant proportions of their provincial cumulative cover distributions in the SBS zone: 28, 32, and 58%, respectively. In the SBS, all three species are potentially protected at 5 ha cumulative cover, which may be sufficient for small-statured species. SALIDIS and PRUNPEN are the least protected species province-wide, with potentially low levels in six (BG, ESSF, ICH, IDF, MS, SBPS) and five (BWBS, ICH, IDF, PP, SBPS) other zones, respectively. Considering their possibly poor province-wide protection and the low protected area coverage in this centrally located zone, populations of SALIDIS and PRUNPEN in or near the SBS zone are considered to be of primary importance.

Online resources (p. 54): 5, 6† ; summary information: Table 14, Appendix 2

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 14 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the SBS zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
PRUNEMA	0.01	< 0.01	0.06	3	0	0.0					?
BETUOCC	0.04	< 0.01	0.19	23	1	4.3					**0.2**
PINUALB	0.25	0.01	0.29	224	80	35.7	2	2	1		?
SALIDIS	0.01	0.05	31.99	1 190	53	4.5	6	5	1		0.0
PRUNPEN	0.01	0.06	57.68	1 592	69	4.4	5	3	2		0.0
CORYCOR	0.14	0.42	27.89	11 058	195	1.8	3	3	2	1	-1.9
THUJPLI	6.55	0.11	0.14	2 801	158	5.6	6	5	2	1	**10.1**
TSUGHET	14.88	0.16	0.09	4 176	161	3.9	7	7	3	1	**11.2**
PRUNVIR	0.06	0.13	18.94	3 401	151	4.4	10	7	5		0.0
PICEENG	3.50	0.21	0.50	5 424	246	4.5	8	7	5	1	0.5
SALILUC	0.09	0.35	36.35	9 275	305	3.3	11	9	6	1	-0.8
SALISIT	0.28	0.50	16.12	13 136	538	4.1	9	7	7	3	-1.3
SALIBEB	0.37	0.54	14.09	14 282	718	5.0	26	18	15	4	-0.1
ACERGLA	0.41	0.68	14.73	17 985	679	3.8	27	22	17	5	**1.3**
SALISCO	0.53	1.12	19.51	29 527	1 813	6.1	35	31	20	8	-0.1
POPUTRI	0.56	1.88	28.12	49 496	2 841	5.7	35	30	22	13	0.0
BETUPAP	1.00	2.76	26.15	72 672	2 696	3.7	50	39	31	13	**1.7**
ALNUVIR	2.89	5.75	18.25	151 468	9 581	6.3	67	47	37	17	-1.0
ALNUINC	1.83	5.87	30.70	154 572	9 796	6.3	62	51	37	21	-0.8
PICEMAR	5.14	6.60	12.27	173 782	9 235	5.3	64	47	38	21	-2.1
PSEUMEN	6.58	8.41	11.49	221 342	4 835	2.2	48	43	35	24	**10.7**
POPUTRE	4.32	7.55	16.44	198 617	8 825	4.4	59	45	38	26	-0.3
PICEGLA	6.35	7.95	11.62	209 183	7 177	3.4	60	45	36	29	-2.2
PINUCON	10.24	24.50	21.62	645 000	40 664	6.3	90	80	64	38	-3.7
ABIELAS	16.44	24.39	13.00	642 145	50 379	7.8	86	75	57	40	-4.4

a **bold** indicates an increase of > 100%; underline > 90% decrease; ? no data were available to estimate frequency change

14.4 Conservation Priorities

? population verification required **PRUNPEN**, SALIDIS

Verification for PRUNPEN is recommended in the western half of the SBS in Entiako or Tweedsmuir (i.e., large multi-zone protected areas), and in Babine Corridor, Uncha, or Francois Lake. In the eastern half of the zone, verification is recommended in Mount Robson, Bowron, Arctic Pacific Lakes, or Pine Le Moray (large multi-zone protected areas), and in Carp Lake, Heather-Dina, or Purden. As SALIDIS in potentially under-protected in many other zones, verification is also recommended first in large multi-zone protected areas—in the northeast in Omineca, Chase, or Graham Laurier, covering either the ESSF, BWBS, or SBS; in the southeast in Bowron, covering the SBS, ESSF, and ICH, then in Heather-Dina or Carp; and in the southwest in Entiako, Rubyrock Lake, or Southerland, covering the SBS, ESSF, or SBPS. In the southern SBS, where there are no large multi-zone protected areas, verification is recommended for Schoolhouse, Taweel, and Emar.

Additional protected area coverage in the SBSmh, dw2/1, and mw could potentially improve the protection status of SALIDIS, PRUNPEN, and CORYCOR, and possibly benefit other infrequently occurring species (e.g., THUJPLI, BETUOCC, PRUNEMA). It will also improve the low protected area coverage throughout a large area of the Interior Plateau.

Support materials for field verification: Appendix 3, Appendix 4

15 SWB ZONE

15.1 Overview

The Spruce–Willow–Birch (SWB) zone is a large subalpine zone covering 8% of British Columbia. It occurs in the north on the Yukon, Liard, and Stikine Plateaus, on the upper slopes of the northern Rocky Mountains, the Cassiar Mountains, northern Omineca and Skeena Mountains, and parts of the St. Elias Mountains. With a mean annual temperature of only 1.0°C, the SWB zone is the coldest forested zone in British Columbia. The winters are very cold and long, and the summers are cool and extremely short (only 1 month long in many parts of the zone). Mean annual temperature and precipitation range from near 0°C and 2500 mm in the northwest to -2.0°C and 600 mm in the central portion of the zone, respectively. In most areas, the lower elevation limit is around 800 m, but it can be as low as 300 m in the northwest.

PICEGLA and ABIELAS are the most common species in the zone. Most forests on lower slopes and valley bottoms are dominated by PICEGLA with mixtures containing PINUCON, PICEMAR, or POPUTRE. Pure stands of PINUCON occur on the driest and poorest sites, whereas POPUTRE stands occur on drier sites and PICEMAR stands occur on poor sites. On upper slopes and base-rich soils, forests of ABIELAS are common. Open ABIELAS forests and woodlands are found on steep, moist, cold slopes, whereas grasslands develop on steep warm-aspect slopes. POPUBAL occurs mostly in the northwest where, together with POPUTRE, it can form timberline. Alders, scrub birch, and arctic and subalpine willows associate with open-canopy stands and form dense thickets in cold-air pockets and in higher-elevation scrub/parkland ecosystems. Swamp, fen, and marsh ecosystems are more common than bogs.

Online resources (p. 54): 1, 2, 3†

15.2 Protected Areas

Compared to other zones of similar areal extent, the SWB has relatively few protected areas (< 40) but a high percentage (80%) of very large protected areas. With an average of 20% protected area coverage, the SWB zone is the second most protected zone in British Columbia. The small vk/dk unit in the northwest is almost entirely (92%) protected by Tatshenshini–Alsek. Even the least protected unit, the un (15%), has greater protection than the provincial average. The top 10 protected areas in terms of *in situ* conservation are Dune Za Keyih, Kwadacha Wilderness, Muncho Lake, Northern Rocky Mountains, Redfern–Keily, Atlin, Chase, Chukachida, Denetiah, and Finlay Russel. Most of the top protected areas are located in the mk subzone, reflecting the higher species diversity. All but Redfern–Keily are multi-zone protected areas that

† www.genetics.forestry.ubc.ca/cfcg/proj_cataloguing/status_report/1_resources.html

TABLE 14 *Estimated occurrence levels, number of protected areas (PAs), and future frequency predictions for species in the SBS zone. See section 1.2.3 "Species representation in protected areas" on page 3 for information on calculation methods and units.*

	Species contribution to tree cover (%)		Species range (%)	Species range (ha CC) and % of range protected			Number of PAs with at least × ha CC				Frequency change in 2055[a]
Species	BC	zone	zone	zone	PA	%	2.5	5	10	50	%
PRUNEMA	0.01	< 0.01	0.06	3	0	0.0					?
BETUOCC	0.04	< 0.01	0.19	23	1	4.3					**0.2**
PINUALB	0.25	0.01	0.29	224	80	35.7	2	2	1		?
SALIDIS	0.01	0.05	31.99	1 190	53	4.5	6	5	1		0.0
PRUNPEN	0.01	0.06	57.68	1 592	69	4.4	5	3	2		0.0
CORYCOR	0.14	0.42	27.89	11 058	195	1.8	3	3	2	1	-1.9
THUJPLI	6.55	0.11	0.14	2 801	158	5.6	6	5	2	1	**10.1**
TSUGHET	14.88	0.16	0.09	4 176	161	3.9	7	7	3	1	**11.2**
PRUNVIR	0.06	0.13	18.94	3 401	151	4.4	10	7	5		0.0
PICEENG	3.50	0.21	0.50	5 424	246	4.5	8	7	5	1	0.5
SALILUC	0.09	0.35	36.35	9 275	305	3.3	11	9	6	1	-0.8
SALISIT	0.28	0.50	16.12	13 136	538	4.1	9	7	7	3	-1.3
SALIBEB	0.37	0.54	14.09	14 282	718	5.0	26	18	15	4	-0.1
ACERGLA	0.41	0.68	14.73	17 985	679	3.8	27	22	17	5	**1.3**
SALISCO	0.53	1.12	19.51	29 527	1 813	6.1	35	31	20	8	-0.1
POPUTRI	0.56	1.88	28.12	49 496	2 841	5.7	35	30	22	13	0.0
BETUPAP	1.00	2.76	26.15	72 672	2 696	3.7	50	39	31	13	**1.7**
ALNUVIR	2.89	5.75	18.25	151 468	9 581	6.3	67	47	37	17	-1.0
ALNUINC	1.83	5.87	30.70	154 572	9 796	6.3	62	51	37	21	-0.8
PICEMAR	5.14	6.60	12.27	173 782	9 235	5.3	64	47	38	21	-2.1
PSEUMEN	6.58	8.41	11.49	221 342	4 835	2.2	48	43	35	24	**10.7**
POPUTRE	4.32	7.55	16.44	198 617	8 825	4.4	59	45	38	26	-0.3
PICEGLA	6.35	7.95	11.62	209 183	7 177	3.4	60	45	36	29	-2.2
PINUCON	10.24	24.50	21.62	645 000	40 664	6.3	90	80	64	38	-3.7
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a **bold** indicates an increase of > 100%; underline > 90% decrease; ? no data were available to estimate frequency change

14.4 Conservation Priorities

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Verification for PRUNPEN is recommended in the western half of the SBS in Entiako or Tweedsmuir (i.e., large multi-zone protected areas), and in Babine Corridor, Uncha, or Francois Lake. In the eastern half of the zone, verification is recommended in Mount Robson, Bowron, Arctic Pacific Lakes, or Pine Le Moray (large multi-zone protected areas), and in Carp Lake, Heather-Dina, or Purden. As SALIDIS in potentially under-protected in many other zones, verification is also recommended first in large multi-zone protected areas—in the northeast in Omineca, Chase, or Graham Laurier, covering either the ESSF, BWBS, or SBS; in the southeast in Bowron, covering the SBS, ESSF, and ICH, then in Heather-Dina or Carp; and in the southwest in Entiako, Rubyrock Lake, or Southerland, covering the SBS, ESSF, or SBPS. In the southern SBS, where there are no large multi-zone protected areas, verification is recommended for Schoolhouse, Taweel, and Emar.

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1. Subzone/variant climate data derived using ClimateBC
2. Subzone/variant climate analysis
3. Subzone and variant names and codes
4. Subzone/variant and protected area maps for each BEC zone
5. Species range maps including *in situ* conservation statistics (from Hamann et al. 2005)
6. Species distribution pie charts by zone and subzone
7. Protected area and land use statistics for subzone/variant groupings by BEC zone
8. Protected area rankings by BEC zone

APPENDIX 1 Species codes, names, alternate taxonomic classifications, and conservation status ranks

Code	Scientific name	Authority	Common name	BC rank[a]	SRank[b]	GRank[c]
Conifers						
ABIEAMA	*Abies amabilis*	(Dougl. ex Loud.) Dougl. ex Forbes	amabilis fir		S5	G5
ABIEGRA	*Abies grandis*	(Dougl. ex D. Don) Lindl.	grand fir		S4	G5
ABIELAS	*Abies lasiocarpa*	(Hook.) Nutt.	subalpine fir		S5	G5T5
CHAMNOO	*Chamaecyparis nootkatensis*	(D. Don) Spach	yellow-cedar		S4	G4
JUNISCO	*Juniperus scopulorum*[d]	Sarg.	Rocky Mountain juniper		S3S4	G5
LARILAR	*Larix laricina*	(Du Roi) K. Koch	tamarack		S4	G5
LARILYA	*Larix lyallii*	Parl.	subalpine larch		S4	G4
LARIOCC	*Larix occidentalis*	Nutt.	western larch		S5	G5
PICEENG	*Picea engelmannii*	Parry ex Engelm.	Engelmann spruce		S5	G5
PICEGLA	*Picea glauca*	(Moench) Voss	white spruce		S5	G5
PICEMAR	*Picea mariana*	(P. Mill.) B.S.P.	black spruce		S5	G5
PICESIT	*Picea sitchensis*	(Bong.) Carr.	Sitka spruce		S5	G5
PINUALB	*Pinus albicaulis*	Engelm.	whitebark pine	Blue	S3?	G4
PINUBAN	*Pinus banksiana*	Lamb.	jack pine	Blue	S2S3	G5
PINUCON	*Pinus contorta*[e]	Dougl. ex Loud.	lodgepole pine		S5	G5
PINUFLE	*Pinus flexilis*	James	limber pine		S3S4	G5
PINUMON	*Pinus monticola*	Dougl. ex D. Don	western white pine		S4	G5
PINUPON	*Pinus ponderosa*	Dougl. ex P. & C. Lawson	ponderosa pine		S5	G5
PSEUMEN	*Pseudotsuga menziesii*[f]	(Mirbel) Franco	Douglas-fir		S5	G5
TAXUBRE	*Taxus brevifolia*	Nutt.	western yew		S5	G4G5
THUJPLI	*Thuja plicata*	Donn ex D. Don	western redcedar		S5	G5
TSUGHET	*Tsuga heterophylla*	(Raf.) Sarg.	western hemlock		S5	G5
TSUGMER	*Tsuga mertensiana*	(Bong.) Carr.	mountain hemlock		S5	G5
Broadleaves						
ACERCIR	*Acer circinatum*	Pursh	vine maple		S5	G4G5
ACERGLA	*Acer glabrum*[g]	Torr.	Douglas maple		S5	G5T5
ACERMAC	*Acer macrophyllum*	Pursh	bigleaf maple		S5	G5
ALNUINC	*Alnus incana*[h]	(L.) Moench	mountain alder		S5	G5T5
ALNURUB	*Alnus rubra*	Bong.	red alder		S5	G5
ALNUVIR	*Alnus viridis*[i]	(Vill.) Lam. & DC.	Sitka alder		S5	G5T5
ARBUMEN	*Arbutus menziesii*	Pursh	arbutus		S5	G5
BETUNEO	*Betula neoalaskana*	Sarg.	Alaska paper birch		S4	G4G5
BETUOCC	*Betula occidentalis*	Hook.	water birch		S4	G4G5
BETUPAP	*Betula papyrifera*	Marsh.	paper birch		S5	G5
CORNNUT	*Cornus nuttallii*	Aud. ex T. & G.	western flowering dogwood		S5	S5
CORYCOR	*Corylus cornuta*	Marsh.	beaked hazel		S5	G5T5
CRATDOU	*Crataegus douglasii*[j]	Lindl.	black hawthorn		S4	G4G5
MALUFUS	*Malus fusca*	(Raf.) Schneid.	Pacific crab apple		S5	G5
POPUTRE	*Populus tremuloides*	Michx.	trembling aspen		S5	G5
POPUBAL	*P. balsamifera* ssp. *balsamifera*[k]	L.	balsam poplar		S5	G5
POPUTRI	*P. balsamifera* ssp. *trichocarpa*[l]	Torr. & Gray ex Hook	black cottonwood		S5	G5
PRUNEMA	*Prunus emarginata*	(Dougl.) Walp.	bitter cherry		S5	G5
PRUNPEN	*Prunus pensylvanica*	L. f.	pin cherry		S4	G5
PRUNVIR	*Prunus virginiana*	L.	choke cherry		S5	G5
QUERGAR	*Quercus garryana*	Dougl.	Garry oak		S5	G5
RHAMPUR	*Rhamnus purshiana*	DC.	cascara		S5	G4
SALIBEB	*Salix bebbiana*	Sarg.	Bebb's willow		S5	G5

APPENDIX 1 *Continued*

SALIDIS	*Salix discolor*	Muhlenb.	pussy willow	S5	G5
SALILUC	S*alix lucida*	Muhl.	shining willow	S5	G5
SALISCO	*Salix scouleriana*	J. Barratt ex Hook.	Scouler's willow	S5	G5
SALISIT	*Salix sitchensis*	Sanson ex Bong.	Sitka willow	S5	G5

a BC rank: for information, see www.env.gov.bc.ca/atrisk/red-blue.htm

b SRank: for more information on Subnational or Provincial Rank, see wlapwww.gov.bc.ca/wld/documents/ranking.pdf
- S1 Critically Imperiled provincially; vulnerable to extinction; typically 5 or fewer occurrences or very few remaining individuals
- S2 Imperiled provincially; vulnerable to extinction; typically 6 to 20 occurrences or few remaining individuals (1000 to 3000)
- S3 Vulnerable provincially; very rare and local throughout its range, or with restricted range (even if abundant at some locations); vulnerable to extinction; typically 21 to 100 occurrences or between 3000 and 10,000 individuals
- S4 Uncommon but not rare, and usually widespread; possible longterm concern; typically more than 100 occurrences or more than 10,000 individuals
- S5 Common, typically widespread and abundant

c GRank: for more information on Global Rank, see www.natureserve.org/explorer/ranking.htm#global
- G1 Critically Imperiled—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors
- G2 Imperiled—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
- G3 Vulnerable—At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors
- G4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors
- G5 Secure—Common; widespread and abundant

d Includes *Juniperus maritima* (Adams)—seaside juniper (Adams 2007)

e Includes var. *contorta*—shore pine, and var. *latifolia*—lodgepole pine

f Includes var. *glauca*—Rocky Mountain Douglas-fir, and var. *menziesii*—coastal Douglas-fir

g Current nomenclature: *Acer glabrum* var. *douglasii* (Hook.) Dippel

h Current nomenclature: *Alnus incana* ssp. *tenuifolia* [Nutt.] Breit. [L.] Moench

i Current nomenclature: *Alnus viridis* ssp. *sinuata* (Regel) A.& D. Löve

j Could be one of six proposed species of native black-fruited hawthorn trees or shrubs (*C. douglasii, C. suksdorfii, C. okanaganesis, C. enderbyensis, C. okennonii, C. phippsii* [Phipps et al. 2003])

k Records of *Populus balsamifera* in the BWBS and SWB zones are treated as ssp. *balsamifera*—balsam poplar

l Records of *Populus balsamifera* in all zones except the BWBS and SWB zone are treated as ssp. *trichocarpa* ((Torr. & Gray ex Hook.) Brayshaw)—black cottonwood

Appendix 2.1 Number of protected areas with an expected cumulative cover (CC) of 10 ha. Shaded cells indicate that < 1% of the species' range (CC) occurs in the zone

	Biogeoclimatic zones													
	AT	BG	BWB	CDF	CWH	ESSF	ICH	IDF	MH	MS	PP	SBP	SBS	SWB
Conifers														
ABIEAMA					119	13	5		52					
ABIEGRA				14	4		1	2						
ABIELAS			38		18	156	64		23	35		4	57	35
CHAMNOO					77	1			36					
JUNISCO		3		0		0	0	10		2	0			
LARILAR			14			4								
LARILYA	7					10								
LARIOCC						2	16	8		6	0			
PICEENG					3	128	33	20		30	0	0	5	
PICEGLA			66			12	0	5		7		7	36	35
PICEMAR			67			7	3					8	38	24
PICESIT					105		1		18					
PINUALB	14					51	0	1		2				
PINUBAN			0											
PINUCON			60	0	65	120	46	49	1	48	2	11	64	32
PINUFLE						1		0						
PINUMON				0	13	7	21	1	4	0				
PINUPON		7				0	5	39		0	19			
PSEUMEN		5		32	116	40	56	100		35	18	1	35	
TAXUBRE				0	33		24	0		0				
THUJPLI				24	167	30	97	22	1	2	0		2	
TSUGHET				4	194	29	96	4	52				3	
TSUGMER					69	21	0		58					
Broadleaves														
ACERCIR					17			2						
ACERGLA		3		0	17	10	36	27		5	5		17	
ACERMAC				10	36			0						
ALNUINC		3	48		4	29	36	18		15	0	5	37	
ALNURUB				20	95			2						
ALNUVIR			48	51	88	35	18	33	25			6	37	8
ARBUMEN				1	0									
BETUNEO			4											
BETUOCC		3	0		4	1	0	8		2	5		0	5
BETUPAP		2	36		10	3	43	25		5	0	0	31	
CORNNUT				1	6			0						
CORYCOR					0	0	20	4			0		2	
CRATDOU		0		0	0		0	3			0			
MALUFUS				0	23		0							
POPUBAL			52											27
POPUTRE		5	64	0	0	23	29	44		13	5	10	38	23
POPUTRI		6		4	43	10	21	25		3	3	1	22	
PRUNEMA		0		0	3		1	1			0		0	
PRUNPEN			0				0	3			0	0	2	
PRUNVIR		3	4				0	3		2	0	0	5	
QUERGAR				8										
RHAMPUR				0	2		0	0						
SALIBEB		3	31		0	5	8	14		6	0	4	15	5
SALIDIS		1	2			1	0	1		0		0	1	
SALILUC		0	20		7	4	3	0					6	
SALISCO		0	31	0	2	24	9			6		1	20	23
SALISIT				0	24	17	18		20	1			7	

Appendix 2.2 Number of protected areas with an expected cumulative cover (CC) of 5 ha. Shaded cells indicate that < 1% of the species' range (CC) occurs in the zone

	Biogeoclimatic zones													
	AT	BG	BWB	CDF	CWH	ESSF	ICH	IDF	MH	MS	PP	SBP	SBS	SWB
Conifers														
ABIEAMA					137	13	5	1	54					
ABIEGRA				24	11		2	2						
ABIELAS			42		20	164	84	0	26	40		4	75	36
CHAMNOO					93	1			40					
JUNISCO		4		0		0	0	21		5	1			
LARILAR			20			4								
LARILYA	9					10								
LARIOCC						5	23	12		7	0			
PICEENG					3	137	49	23		38	0	0	7	
PICEGLA			77			14	0	10		8		7	45	35
PICEMAR			72			8	3					8	47	27
PICESIT				1	134		2		26					
PINUALB	20					61	0	2		4			1	
PINUBAN			0											
PINUCON			66	0	93	138	62	65	1	50	4	13	80	34
PINUFLE						1		0						
PINUMON				0	24	13	25	1	4	0				
PINUPON		14					5	45		2	22			
PSEUMEN		5		39	141	43	75	109		40	22	2	43	
TAXUBRE				0	45		31	0		0				
THUJPLI				37	189	40	108	33	2	3	0		5	
TSUGHET				13	213	34	106	6	55				7	
TSUGMER					85	25	1		59					
Broadleaves														
ACERCIR					26			3						
ACERGLA		4		0	20	10	46	40		7	5		22	
ACERMAC				21	51			0						
ALNUINC		4	56		6	33	43	27		23	0	6	51	
ALNURUB				32	118			2						
ALNUVIR			56		56	101	41	27	41	29		7	47	
ARBUMEN				5	1									
BETUNEO			8											
BETUOCC		4	0		5	2	0	11		2	7		0	5
BETUPAP			46		18	6	55	35		5	3	0	39	
CORNNUT				4	10			1						
CORYCOR					1	0	25	5			0		3	
CRATDOU		0		0	0		0	4			0			
MALUFUS				1	36		0							
POPUBAL			60											30
POPUTRE		5	75	0	1	28	38	53		17	5	11	45	28
POPUTRI		7		13	55	15	34	35		4	7	3	30	
PRUNEMA		0		0	6		3	1			0		0	
PRUNPEN			0				0	3			0	0	3	
PRUNVIR		4	6				1	5		2	0	0	7	
QUERGAR				21										
RHAMPUR				0	5		0	0						
SALIBEB			36		0	5	13	17		7	2	4	18	5
SALIDIS		2	5			2	0	1		0		0	5	
SALILUC			22		11	4	4	0					9	
SALISCO		1	36	0	4	27	11	19		9		1	31	23
SALISIT				0	36	22	24		26	2			7	

APPENDIX 3 Top ten protected areas (PAs) with estimated cumulative cover (CC) in hectares for species with low PA representation (< 3 PAs with 10 ha CC) in each biogeoclimatic zone

Appendix 3.1 Top 10 PAs for species with low PA representation in the BG zone

Species	
BETUPAP	Churn Creek 18, Lac du Bois Grasslands 14, Junction Sheep Range 7, South Okanagan Grasslands (PA) 5, Edge Hills 4, Elephant Hill 3, French Bar Creek 2, Juniper Beach 2, Arthur Seat 1, White Lake 1
CRATDOU	South Okanagan Grasslands (PA) 3, Lac du Bois Grasslands 2, White Lake < 1, Elephant Hill < 1, Vaseux (PA) < 1, Haynes Lease (ER) < 1, Okanagan Mountain < 1, White Lake Grasslands (PA) < 1, Vaseux < 1, Okanagan Lake < 1
PRUNEMA	Lac du Bois Grasslands 1, Elephant Hill < 1, Arrowstone < 1, Pritchard Park < 1, Juniper Beach < 1, McQueen Creek (ER) < 1, Arthur Seat < 1, Painted Bluffs < 1, Epsom Park < 1, Steelhead < 1
SALIDIS	Churn Creek 17, Junction Sheep Range 7, Big Creek (ER) < 1, French Bar Creek < 1, Doc English Bluff (ER) < 1
SALILUC	Churn Creek 9, Lac du Bois Grasslands 5, Junction Sheep Range 4, Elephant Hill 1, Big Creek (ER) < 1, French Bar Creek < 1, Doc English Bluff (ER) < 1, Arrowstone < 1, Pritchard Park < 1, Juniper Beach < 1
SALISCO	Churn Creek 9, Junction Sheep Range 4, Big Creek (ER) < 1, French Bar Creek < 1, Doc English Bluff (ER) < 1

Appendix 3.2 Top 10 PAs for species with low PA representation in the BWBS zone

Species	
BETUOCC	Northern Rocky Mountains 2, Liard River 2, Maxhamish Lake (PA) 1, Klua Lakes (PA) 1, Sikanni Chief < 1, Sikanni Old Growth < 1, Scatter River Old Growth < 1, Maxhamish Lake < 1, Muncho Lake < 1, Grayling River Hotsprings (ER) < 1
PINUBAN	Thinahtea South (PA) < 1, Thinahtea North (PA) < 1
PRUNPEN	Peace-Moberly 1, Gwillim Lake < 1, Peace River-Bodreau < 1, Bearhole Lake < 1, Milligan Hills < 1, Bearhole Lake (PA) < 1, Omineca < 1, Finlay Russel < 1, Peace River Corridor - Peace River < 1, Chinchaga Lakes < 1
SALIDIS	Stikine River 15, Dune Za Keyih 10, Omineca 6, Mount Edziza 6, Tatshenshini-Alsek 5, Spatsizi Plateau Wilderness 4, Upper Stikine Spatsizi Ext. 3, Finlay Russel 3, Atlin 3, Kwadacha Wilderness 2

Appendix 3.3 Top 10 PAs for species with low PA representation in the CDF zone

Species	
ACERGLA	Gowlland Tod 1, Ruckle < 1, Simson < 1, South Texada Island < 1, Newcastle Island Marine < 1, South Otter Bay < 1, Princess Margaret Marine < 1, Lasqueti Island (ER) < 1, Mount Tuam (ER) < 1, Goldstream < 1
ARBUMEN	Gowlland Tod 18, Ruckle 9, Simson 9, South Texada Island 7, Newcastle Island Marine 6, South Otter Bay 5, Princess Margaret Marine 4, Lasqueti Island (ER) 4, Mount Tuam (ER) 4, Goldstream 4
CORNNUT	Gowlland Tod 13, Ruckle 7, Simson 7, South Texada Island 5, Newcastle Island Marine 4, South Otter Bay 3, Princess Margaret Marine 3, Lasqueti Island (ER) 3, Mount Tuam (ER) 3, Goldstream 3
CRATDOU	Gowlland Tod < 1, Ruckle < 1, Simson < 1, South Texada Island < 1, Newcastle Island Marine < 1, South Otter Bay < 1, Princess Margaret Marine < 1, Lasqueti Island (ER) < 1, Mount Tuam (ER) < 1, Goldstream < 1
JUNISCO	Gowlland Tod < 1, Ruckle < 1, Simson < 1, South Texada Island < 1, Newcastle Island Marine < 1, South Otter Bay < 1, Princess Margaret Marine < 1, Lasqueti Island (ER) < 1, Mount Tuam (ER) < 1, Goldstream < 1
MALUFUS	Gowlland Tod 8, Ruckle 4, Simson 4, South Texada Island 3, Newcastle Island Marine 3, South Otter Bay 2, Princess Margaret Marine 2, Lasqueti Island (ER) 2, Mount Tuam (ER) 2, Goldstream 2
PICESIT	Gowlland Tod 6, Ruckle 3, Simson 3, Newcastle Island Marine 2, South Texada Island 2, South Otter Bay 2, Princess Margaret Marine 2, Lasqueti Island (ER) 1, Mount Tuam (ER) 1, Goldstream
PINUCON	Gowlland Tod 3, Ruckle 1, Simson 1, South Texada Island 1, Newcastle Island Marine 1, South Otter Bay 1, Princess Margaret Marine 1, Lasqueti Island (ER) 1, Mount Tuam (ER) 1, Goldstream 1
PINUMON	Gowlland Tod < 1, Ruckle < 1, Simson < 1, South Texada Island < 1, Newcastle Island Marine < 1, South Otter Bay < 1, Princess Margaret Marine < 1, Lasqueti Island (ER) < 1, Mount Tuam (ER) < 1, Goldstream < 1
PRUNEMA	Gowlland Tod < 1, Ruckle < 1, Simson < 1, South Texada Island < 1, Newcastle Island Marine < 1, South Otter Bay < 1, Princess Margaret Marine < 1, Lasqueti Island (ER) < 1, Goldstream < 1, Mount Tuam (ER) < 1
RHAMPUR	Gowlland Tod 4, Ruckle 2, Simson 2, South Texada Island 2, Newcastle Island Marine 1, South Otter Bay 1, Princess Margaret Marine 1, Lasqueti Island (ER) 1, Goldstream 1, Mount Tuam (ER) 1
SALISCO	Gowlland Tod 1, Ruckle 1, Simson 1, South Texada Island < 1, Newcastle Island Marine < 1, South Otter Bay < 1, Princess Margaret Marine < 1, Lasqueti Island (ER) < 1, Goldstream < 1, Mount Tuam (ER) < 1
SALISIT	Gowlland Tod 3, Ruckle 2, Simson 2, South Texada Island 1, Newcastle Island Marine 1, South Otter Bay 1, Princess Margaret Marine 1, Lasqueti Island (ER) 1, Mount Tuam (ER) 1, Goldstream 1
TAXUBRE	Gowlland Tod 5, Ruckle 2, Simson 2, South Texada Island 2, Newcastle Island Marine 1, South Otter Bay 1, Princess Margaret Marine 1, Lasqueti Island (ER) 1, Mount Tuam (ER) 1, Goldstream 1

Appendix 3.4 Top 10 PAs for species with low PA representation in the CWH zone

Species	
ARBUMEN	Desolation Sound Marine 7, Elk Falls 3, Cowichan River 2, Ha'thayim Marine 2, Read Island 1, South Texada Island 1, Koksilah River 1, Little Qualicum Falls 1, Mount Maxwell < 1, Halkett Bay < 1
RHAMPUR	Homathko River -Tatlayoko 13, Pacific Rim 10, Strathcona 9, Golden Ears 6, Pinecone Burke 6, Garibaldi 4, Clendinning 4, Desolation Sound Marine 4, Carmanah Walbran 3, Hesquiat Peninsula 3
ABIEGRA	Strathcona 123, Main Lake 34, Desolation Sound Marine 22, Pinecone Burke 13, Golden Ears 9, Strathcona Westmin 9, Small Inlet 8, Elk Falls 7, Gold Muchalat 6, East Redonda Island (ER) 6
CRATDOU	Pinecone Burke 1, Golden Ears 1, East Redonda Island (ER) < 1, Desolation Sound Marine < 1, Inland Lake < 1, Cultus Lake < 1, Sasquatch < 1, Tantalus < 1, Duck Lake (PA) < 1, Spipiyus < 1
PRUNEMA	Strathcona 12, Desolation Sound Marine 11, Pinecone Burke 11, Golden Ears 8, Homathko River -Tatlayoko 8, Kitlope Heritage Conservancy 5, East Redonda Island (ER) 5, Cultus Lake 3, Elk Falls 3, Inland Lake 3
BETUOCC	Garibaldi 22, Birkenhead Lake 13, Nahatlatch 12, Mehatl Creek 10, Chilliwack Lake/Greendrop 8, Skagit Valley 4, Nairn Falls 2, Chilliwack Lake 1, Coquihalla Canyon 1, Coquihalla River 1
CORYCOR	Garibaldi 7, Birkenhead Lake 4, Nahatlatch 4, Mehatl Creek 3, Skagit Valley 1, Nairn Falls < 1, Coquihalla Canyon < 1, Coquihalla River < 1, Silver Lake < 1, Nahatlatch (PA) < 1
SALISCO	Strathcona 73, Desolation Sound Marine 18, Elk Falls 7, Craig Headwaters 6, Cowichan River 4, Ha'thayim Marine 4, Read Island 3, South Texada Island 3, Great Glacier 2, Strathcona Westmin 2

Appendix 3.5 Top ten PAs for species with low PA representation in the ESSF zone

Species	
BETUOCC	E.C. Manning 16, Silver Star 7, Cascade 3, High Lakes Basin 1, Snowy (PA) 1, Cathedral 1, Marble Range < 1, Bonaparte < 1, Graystokes (PA) < 1, Porcupine Meadows < 1
BETUPAP	Graham Laurier 28, Omineca 21, Mount Robson 16, Sustut 8, Chase 7, Mount Blanchet 5, Finlay Russel 4, Valhalla 2, Nation 1, Goat Range 1
CHAMNOO	Valhalla 30, Evans Lake < 1
CORYCOR	Valhalla 2, Goat Range 1, Glacier National Park 1, Kokanee Glacier < 1, Gladstone < 1, Syringa < 1, Lew Creek (ER) < 1, Stagleap < 1, Granby < 1
JUNISCO	Cathedral 3, Graystokes (PA) 1, Graystokes < 1
LARIOCC	Purcell Wilderness Conservancy 191, Kianuko 27, St. Mary's Alpine 10, Akamina-Kishinena 6, Lockhart Creek 6, Gilnockie 3, Top of the World 1
PINUFLE	Purcell Wilderness Conservancy 10, Height of the Rockies 5, Kootenay 4, Elk Lakes 2, Akamina-Kishinena 2, Bugaboo 1, Top of the World 1, Mount Assiniboine 1
PINUPON	E.C. Manning 2, Silver Star 1, Cascade < 1, Bonaparte < 1, Porcupine Meadows < 1, Skihist Park Extension < 1
SALIDIS	Graham Laurier 12, Entiako 5, Rubyrock Lake 4, Sutherland River (PA) < 1, Sutherland River 1, Sutherland < 1
SALILUC	Wells Gray 21, Bowron Lake 15, Cariboo Mountains 15, Stein Valley 14, Kakwa 1, Mehatl Creek 1, Duffey Lake < 1, Cerise < 1, Mount Tinsdale (ER) < 1

Appendix 3.6 Top 10 PAs for species with low PA representation in the ICH zone

Species	
ABIEGRA	West Arm 17, Champion Lakes 8, Syringa 2, Pilot Bay 2, Lockhart Creek 2, Valhalla 2, Kootenay Lake 2, King George VI 1, Kokanee Creek 1, Ryan 0
BETUOCC	Kianuko 1, Monashee (PA) 1, Silver Star 1, Gilnockie < 1, Wap Ck Delta Floodplain < 1, Enderby Cliffs (PA) < 1, Cinnemousun Narrows < 1, Glacier National Park < 1, Cummins Lakes < 1, Cinnemousun Narrows (PA) < 1
CRATDOU	Bowron Lake 3, Mount Revelstoke National Park 1, Wells Gray < 1, Cariboo Mountains < 1, Upper Adams River < 1, Cariboo River < 1, Glacier National Park < 1, Mud Lake Delta < 1, Mount Griffin (PA) < 1, Mount Griffin (ER) 0
JUNISCO	Gladstone 3, Ansty Hunakwa (PA) 2, Upper Adams River 1, Silver Star 1, Myra–Bellevue (PA) 1, West Arm < 1, Momich Lakes < 1, Purcell Wilderness Conservancy < 1, Dunn Peak < 1, Syringa < 1
PRUNEMA	Wells Gray 16, Nisga'a Memorial Lava Bed 8, Seven Sisters (PA) 7, Goat Range 4, Gladstone 4, Purcell Wilderness Conservancy 3, Valhalla 3, Granby 2, West Arm 1, Gingietl Creek (ER) 1
PRUNPEN	Nisga'a Memorial Lava Bed 3, Seven Sisters (PA) 2, Bowron Lake 1, Gladstone 1, Gingietl Creek (ER) < 1, Cariboo Mountains < 1, Kitwanga Mountain < 1, Cariboo River < 1, Ross Lake < 1, Kalamalka Lake (PA) < 1
PRUNVIR	Gladstone 5, Nisga'a Memorial Lava Bed 4, Seven Sisters (PA) 4, Purcell Wilderness Conservancy 1, West Arm 2, Ansty Hunakwa (PA) 1, Syringa 1, Champion Lakes 1, Gingietl Creek (ER) 1, Upper Adams River 1
RHAMPUR	Ansty Hunakwa (PA) 1, Goat Range 1, Mount Revelstoke National Park 1, Valhalla 1, Purcell Wilderness Conservancy 1, Gladstone < 1, Granby < 1, West Arm < 1, Eagle River South Side < 1, Kokanee Glacier < 1
SALIDIS	Nisga'a Memorial Lava Bed 3, Cariboo Mountains 3, Seven Sisters (PA) 3, Gingietl Creek (ER) 1, Kitwanga Mountain < 1, Ross Lake < 1, Wells Gray < 1, Mount Robson < 1, Goosegrass Creek (ER) < 1, Mount Robson (Swift Current River) < 1

Appendix 3.7 Top 10 PAs for species with low PA representation in the IDF zone

Species	
SALIDIS	Churn Creek 36, Nazko Lake 2, Nunsti 2, French Bar Creek 1, Bull Canyon 1, Junction Sheep Range < 1, Westwick Lake (ER) < 1, Big Creek (ER) < 1
CRATDOU	Chasm 48, Edge Hills 34, Arrowstone 16, Churn Creek 6, Chasm (ER) 2, Downing 1, Okanagan Mountain 1, South Okanagan Grasslands (PA) 1, Snowy (PA) 1, French Bar Creek < 1
PRUNEMA	Skagit Valley 11, E.C. Manning 3, South Okanagan Grasslands (PA) 2, Stein Valley 2, Okanagan Mountain 2, Snowy (PA) 2, Cathedral 1, Trepanier (PA) 1, Darke Lake 1, Lac du Bois Grasslands 1
ABIEGRA	Skagit Valley 136, E.C. Manning 12, Nahatlatch 3, Skagit River Forest (ER) 2, Ross Lake (ER) 1, Skagit River Rhododendrons (ER) 1, Alexandra Bridge 1, Stoyoma Creek (ER) < 1
RHAMPUR	Skagit Valley 2, E.C. Manning < 1, Nahatlatch < 1, Skagit River Forest (ER) < 1, Ross Lake (ER) < 1, Roderick Haig-Brown < 1, Skagit River Rhododendrons (ER) < 1, Alexandra Bridge < 1, Niskonlith Lake < 1
SALILUC	Premier Lake 3, Kikomun Creek 3, Kootenay 2, Columbia Lake 1, Norbury Lake < 1, Burges & James Gadsden < 1, Thunder Hill < 1, Crowsnest < 1, Elko < 1, Dry Gulch < 1
PINUMON	Skagit Valley 39, E.C. Manning 3, Birkenhead Lake 2, Fintry (PA) 1, Nahatlatch 1, Enderby Cliffs (PA) 1, Stein Valley 1, Myra–Bellevue (PA) 1, Kalamalka Lake (PA) 1, Skagit River Forest (ER) < 1
PINUFLE	Premier Lake < 1, Kikomun Creek < 1, Kootenay < 1, Columbia Lake < 1, Windermere Lake < 1, Norbury Lake < 1, Thunder Hill < 1, Crowsnest < 1, Dry Gulch < 1, Elko < 1
ACERCIR	Skagit Valley 306, E.C. Manning 26, Nahatlatch 7, Skagit River Forest (ER) 4, Ross Lake (ER) 2, Skagit River Rhododendrons (ER) 2, Alexandra Bridge 2, Stoyoma Creek (ER) < 1

Appendix 3.8 Top 10 PAs for species with low PA representation in the MH zone.

Species	
PINUCON	Gwaii Haanas 68, Gamble Creek (ER) 5, Vladimir J. Krajina (ER) 4, Hakai 3, Lowe Inlet Marine 2, Klewnuggit Inlet Marine 1
THUJPLI	Gwaii Haanas 79, Gamble Creek (ER) 5, Vladimir J. Krajina (ER) 5, Hakai 3, Lowe Inlet Marine 2, Klewnuggit Inlet Marine 1

Appendix 3.9 Top 10 PAs for species with low PA representation in the MS zone

Species	
BETUOCC	Kootenay 20, Yoho 17, E.C. Manning 4, Cathedral 2, Bonaparte 2, Purcell Wilderness Conservancy 2, Whiteswan Lake 1, Eneas Lakes 1, Trepanier (PA) 1, Height of the Rockies 1
JUNISCO	Kootenay 59, Yoho 50, Cathedral 7, Snowy (PA) 7, Purcell Wilderness Conservancy 5, Marble Range 5, Bonaparte 4, Whiteswan Lake 4, Height of the Rockies 2, Edge Hills 3
PINUALB	Tsyl-os' 47, Homathko River-Tatlayoko 16, Cathedral 7, E.C. Manning 6, Tweedsmuir South 5, Snowy (PA) 4, Big Creek 3, Marble Range 3, Spruce Lake (PA) 1, Arrowstone 1
PINUMON	Crowsnest < 1
PINUPON	Cathedral 8, Snowy (PA) 6, E.C. Manning 4, Marble Range 4, Bonaparte 4, Edge Hills 2, Antoine/Fred 1, Eneas Lakes 1, Marble Canyon 1, South Okanagan Grasslands (PA) < 1
PRUNVIR	Kootenay 26, Yoho 22, Purcell Wilderness Conservancy 2, Height of the Rockies 1, Whiteswan Lake 2, Myra–Bellevue (PA) < 1, Ram Creek (ER) < 1, Okanagan Mountain < 1, Crowsnest < 1, Conkle Lake < 1
SALIDIS	Kootenay 2, Yoho 2, Myra–Bellevue (PA) 1, Okanagan Mountain < 1, Whiteswan Lake < 1, Conkle Lake < 1, Height of the Rockies < 1, Pukeashun (PA) < 1, Ram Creek (ER) < 1, Premier Lake < 1
SALISIT	E.C. Manning 13, Cathedral 7, Bonaparte 5, Dunn Peak 2, Eneas Lakes 2, Trepanier (PA) 2, Fintry (PA) < 1, Brent < 1, Pennask (PA) < 1, Trepanier < 1
TAXUBRE	Myra–Bellevue (PA) 3, Okanagan Mountain 1, Conkle Lake < 1, Pukeashun (PA) < 1
THUJPLI	Yoho 202, Kootenay 116, Myra–Bellevue (PA) 9, Okanagan Mountain 2, Conkle Lake 1, Pukeashun (PA) < 1

Appendix 3.10 Top 10 PAs for species with low PA representation in the PP zone

Species	
ALNUINC	Wasa Lake < 1
BETUPAP	White Lake Grasslands (PA) 6, Lac du Bois Grasslands 6, Okanagan Mountain 5, Vaseux (PA) 2, South Okanagan Grasslands (PA) 2, Shorthorn Creek 2, Arrowstone 1, Arthur Seat 1, Stein Valley 1, Snowy (PA) 1
CORYCOR	Johnstone Creek < 1
CRATDOU	Johnstone Creek < 1
JUNISCO	Lac du Bois Grasslands 9, Shorthorn Creek 2, Arrowstone 2, White Lake Grasslands (PA) 2, Okanagan Mountain 2, Arthur Seat 1, Stein Valley 1, Antoine/Fred 1, Skihist 1, Vaseux (PA) 1
LARIOCC	Johnstone Creek < 1
PICEENG	Johnstone Creek < 1
PINUCON	White Lake Grasslands (PA) 21, Okanagan Mountain 19, Vaseux (PA) 9, South Okanagan Grasslands (PA) 7, Snowy (PA) 3, Anarchist (PA) 1, Myra–Bellevue (PA) 1, White Lake 1, Skaha Bluffs 1, Bear Creek 1
PRUNEMA	White Lake Grasslands (PA) 2, Okanagan Mountain 1, Vaseux (PA) 1, Lac du Bois Grasslands 1, South Okanagan Grasslands (PA) 1, Snowy (PA) < 1, Shorthorn Creek < 1, Arrowstone < 1, Stein Valley < 1, Arthur Seat < 1
PRUNPEN	White Lake Grasslands (PA) 2, Okanagan Mountain 2, Vaseux (PA) 1, South Okanagan Grasslands (PA) 1, Anarchist (PA) < 1, Myra–Bellevue (PA) < 1, White Lake < 1, Bear Creek < 1, Turnbull Creek < 1, Skaha Bluffs < 1
PRUNVIR	White Lake Grasslands (PA) 3, Vaseux (PA) 1, Okanagan Mountain 3, Lac du Bois Grasslands 1, South Okanagan Grasslands (PA) 1, Snowy (PA) < 1, Arrowstone < 1, Shorthorn Creek < 1, Arthur Seat < 1, Wasa Lake < 1
SALIBEB	White Lake Grasslands (PA) 8, Vaseux (PA) 3, Okanagan Mountain 7, South Okanagan Grasslands (PA) 3, Snowy (PA) 1, Anarchist (PA) < 1, Myra–Bellevue (PA) < 1, White Lake < 1, Skaha Bluffs < 1, Bear Creek < 1
THUJPLI	Lac du Bois Grasslands 2, Antoine/Fred 1, Stein Valley 1, Skihist 1, Skihist (ER) < 1, Johnstone Creek < 1, Shorthorn Creek < 1, Buse Lake (PA) < 1, North Thompson Oxbows Jensen Island < 1, McQueen Creek (ER) < 1

Appendix 3.11 Top 10 PAs for species with low PA representation in the SBPS zone

Species	
BETUPAP	Green Lake < 1
PICEENG	Green Lake < 1
POPUTRI	Nunsti 12, Kluskoil Lake 8, Big Creek 5, White Pelican 2, Nazko Lake 5, Churn Creek 1, Narcosli Lake < 1, Cardiff Mountain (ER) < 1, Puntchesakut Lake < 1, Green Lake < 1
PRUNPEN	Green Lake < 1
PRUNVIR	Nunsti < 1, White Pelican < 1, Nazko Lake < 1, Green Lake < 1
PSEUMEN	Nunsti 21, Big Creek 9, White Pelican 3, Nazko Lake 3, Churn Creek 2
SALIDIS	Entiako (PA) 3, Tweedsmuir North 3, Entiako 2, Tweedsmuir South 1, Green Lake < 1
SALISCO	Kluskoil Lake 10, Nazko Lake 5, Nunsti 2, White Pelican 1, Big Creek 1, Narcosli Lake < 1, Churn Creek < 1, Green Lake < 1, Puntchesakut Lake < 1, Cardiff Mountain (ER) < 1

Appendix 3.12 Top 10 PAs for species with low PA representation in the SBS zone

Species	
BETUOCC	Muscovite Lakes < 1, Heather-Dina Lakes < 1, Blackwater Creek (ER) < 1, Raspberry Harbour (ER) < 1, Heather-Dina Lake < 1, Patsuk Creek (ER) < 1, Omineca < 1, Chunamon Creek (ER) < 1
CORYCOR	Fraser River 143, Schoolhouse Lake Park 40, Fort George Canyon 8, Ten Mile Lake 2, Pinnacles 1, Cottonwood River 1, Cinema Bog (ER) 1, Ruth Lake < 1
PINUALB	Tweedsmuir North 57, Tweedsmuir (South) 23, Andrews Bay < 1
PRUNEMA	Schoolhouse Lake Park < 1, Ten Mile Lake < 1, Pinnacles < 1, Cottonwood River < 1, Cinema Bog (ER) < 1, Ruth Lake < 1, Fraser River < 1, Finger Tatuk < 1, Fort George Canyon < 1
PRUNPEN	Tweedsmuir North 24, Entiako (PA) 20, Uncha Mountain Red Hills 10, Francois Lake 5, Tweedsmuir (South) 4, Nechako Canyon (PA) 2, Entiako 1, Muscovite Lakes 1, Bowron Lake 1, Carp Lake 1
SALIDIS	Entiako (PA) 13, Tweedsmuir North 9, Sutherland River 8, Uncha Mountain Red Hills 6, Rubyrock Lake 6, Francois Lake 3, Sutherland River (PA) 2, Bowron Lake 2, Nechako Canyon (PA) 1, Entiako 1
THUJPLI	Taweel 96, Emar Lakes 31, Bowron Lake 7, Jackman Flats 7, Kakwa 6, Arctic Pacific Lakes 4, Mount Robson 2, Lower Raush 1, Mount Robson (Swift Current River) 1, Monkman 1
TSUGHET	Bowron Lake 55, Kakwa 47, Arctic Pacific Lakes 28, Monkman 7, Sugarbowl-Grizzly Den 6, Purden Lake 6, Carp Lake 6, Tacheeda Lakes (ER) 1, Slim Creek 1, Heather-Dina Lakes 1

APPENDIX 4 Species frequency (% cover) values for species with low protected area (PA) representation (< 3 PAs with 10 ha cumulative cover) in each biogeoclimatic zone. The subzone/variant grouping with the highest recorded frequency is shaded. An empty cell indicates that the species does not occur in the unit. Units in the same table column were analyzed together due to similarities in climatic and ecological characteristics.

Appendix 4.1 Species frequency values (%) for species with low PA representation in the BG zone

Species	xh1	xh2/xh3/ xw1/xw2
BETUPAP	0.25	0.27
CRATDOU	0.16	0.01
PRUNEMA		0.01
SALIDIS		0.06
SALILUC		0.06
SALISCO		0.03

Appendix 4.2 Species frequency values (%) for species with low PA representation in the BWBS zone

Species	dk1/vk/ un	dk2	mw1	mw2	wk1	wk2	wk3
BETUOCC				< 0.01			
PINUBAN				< 0.01			
PRUNPEN	< 0.01		0.01			< 0.01	
SALIDIS	0.01		0.01			0.05	

Appendix 4.3 Species frequency values (%) for species with low PA representation in the CWH zone

Species	dm	ds1/ ds2	mm1/ mm2	ms1/ ms2	vh1	vh2	vm/ vm3	vm1/ vm2	wh1/ wh2	wm	ws1/ ws2	xm1	xm2
ABIEGRA	0.21		0.03									0.68	1.17
ARBUMEN												0.27	
CORYCOR		0.21											
CRATDOU	0.02												
POPUTRE										0.01	0.16		
PRUNEMA	0.17	0.04	0.01				0.01					0.28	0.06
RHAMPUR	0.09	0.11		0.10	0.05			0.01				0.06	0.02
SALIBEB										0.06			
SALISCO			0.14							0.13		0.69	0.06

Appendix 4.4 Species frequency values (%) for species with low PA representation in the ESSF zone

Species	dk	mc	mm1/ mm2	mv2	mv3/ mv1	mv4	mw/ mk	vc	wc2	wc3	wc4/ wc1	wk1	wk2	wm	wv	xc/ dc2/ dc1	xv1/ xv2/ dv
BETUOCC																0.10	
BETUPAP			0.04		0.04	0.06					0.01						
CHAMNOO											0.13						
CORYCOR											0.01						
JUNISCO																0.01	
LARILAR				0.96													
LARIOCC	0.08													0.34			
PINUFLE	0.02																
PINUPON																0.01	
SALIBEB		0.02			0.00		0.03									0.02	0.10
SALIDIS					0.01	0.03											
SALILUC							0.03			0.06							

Appendix 4.5 Species frequency values (%) for species with low PA representation in the ICH zone

Species	dw/ xw	mc1	mc2	mk1/ mk2	mk3/ dk	mm	mw1	mw2	mw3	vc/ wc	vk1	vk2/ wk3	wk1	wk2/ wk4
ABIEGRA	0.84													
RHAMPUR								< 0.01	0.02				0.01	
BETUOCC							0.01	0.05						
CRATDOU													0.02	< 0.01
JUNISCO	0.02			0.05				0.01	0.03					
PRUNEMA	0.03		0.12					0.02	0.01				0.01	
PRUNPEN			0.04	0.02	< 0.01									0.00
PRUNVIR	0.08		0.06	0.07				0.01	0.02					0.00
MALUFUS			< 0.01											
SALIDIS			0.05			0.01					0.02			0.02

Appendix 4.6 Species frequency values (%) for species with low PA representation in the IDF zone

Species	dk1/dk2	dk3	dk4	dm2/un	mw2/mw1	ww/dw	xh1	xh2	xm/xw	dm1
SALIDIS		0.01	0.12						0.14	
CRATDOU							0.01		0.37	0.01
RHAMPUR						0.01	< 0.01			
PRUNEMA	0.03			0.02		0.08	0.05	0.02		
ABIEGRA						1.01				
SALILUC				0.36		0.01				
PINUFLE				0.07						
PINUMON	0.02				0.07	0.29		0.09	0.02	
ACERCIR						2.26				

Appendix 4.7 Species frequency values (%) for species with low PA representation in the MH zone

Species	mm1	mm2	un	wh
PINUCON				0.82
THUJPLI				0.96

Appendix 4.8 Species frequency values (%) for species with low representation in the MS zone

Species	dc1/dc2/ dv/un	dk	dm1	dm2	xk	xv
BETUOCC		0.07		0.08	< 0.01	
JUNISCO		0.22		0.02	0.06	
PINUALB	0.16			0.10	0.04	0.02
PINUMON		0.18				
PINUPON				0.07	0.05	
PRUNVIR		0.10	0.04			
SALIDIS		0.01	0.11			
SALISIT				0.23		
TAXUBRE			0.21			
THUJPLI		0.89	0.73		< 0.01	

Appendix 4.9 Species frequency values (%) for species with low PA representation in the PP zone

Species	dh2	xh1/dh1	xh2
ALNUINC	0.25		
BETUPAP	0.30	0.30	0.27
CORYCOR		0.03	
CRATDOU		< 0.01	
JUNISCO	0.21	0.05	0.40
LARIOCC		0.16	
PICEENG		0.06	
PINUCON		0.56	
PRUNEMA	0.04	0.04	0.03
PRUNPEN		0.06	< 0.01
PRUNVIR	0.24	0.15	0.06
SALIBEB	0.03	0.21	0.01
THUJPLI		0.05	0.41

Appendix 4.10 Species frequency values (%) for species with low PA representation in the SBPS zone

Species	dc	mc	mk	xc
BETUPAP			0.20	
PICEENG			0.54	
POPUTRI	0.05		0.03	0.07
PRUNPEN			< 0.01	
PRUNVIR			< 0.01	< 0.01
PSEUMEN			4.28	0.11
SALIDIS		0.01	0.07	
SALISCO	0.07		0.15	0.01

Appendix 4.11 Species frequency values (%) for species with low PA representation in the SBS zone

Species	dk	dw2/ dw1	dw3	mc2	mc3	mh	mk1	mk2	mw	un	vk/ dh1/ dh2	wk1/ mm/ mc1	wk2	wk3
BETUOCC								0.01						
CORYCOR		0.44				7.40			0.18					
PINUALB				0.04										
PRUNEMA		< 0.01												
PRUNPEN	0.14			0.01			< 0.01	0.01			< 0.01	< 0.01		
SALIDIS	0.09	< 0.01				0.02			0.02		< 0.01	0.01		
THUJPLI									0.08		0.20	0.22		
TSUGHET											0.49	0.20		