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Biodiversity of the Prince Rupert Forest Region

and

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Biodiversity of the Prince Rupert Forest Region

G. Radcliffe, B. Bancroft, G. Porter, and C. Cadrin

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1 INTRODUCTION

The Prince Rupert Forest Region occupies slightly more than one-quarter of the land area of British Columbia. The region encompasses a broad spectrum of physiographic and climatic units, and a multitude of landscapes, ecosystems, and habitats. Unique among the Ministry of Forests' forest regions in British Columbia, it embraces the full range from hypermaritime climates in the extreme west (one of the wettest climates in North America), to continental climates in the interior. Superimposed on this are elevational ranges from sea level to mountain peaks of several thousand metres, and a latitudinal gradient spanning 7°. This wide range of geographic diversity, combined with a variety of natural and artificial or human-induced disturbances, is reflected in an immense assortment of vegetation communities and associated fauna.

The objectives of this project were to identify and document the major known components of terrestrial biological diversity (biodiversity) in the Prince Rupert Forest Region, and to identify major information gaps. Biodiversity can be defined as the diversity of organisms, ecosystems, and interrelated processes. An understanding of the components of biodiversity is essential for developing future management strategies to maintain or enhance it, and to identify research needs. The emphasis in this study was on ecosystem and species diversity in forested areas. No attempt was made to address other components of biodiversity, such as genetic, structural, or landscape diversity. To some extent these are reflected in species and ecosystem diversity.

Two major classification systems are in use in the Prince Rupert Forest Region. The biogeoclimatic ecosystem classification (BEC) system (Meidinger and Pojar 1991) is used extensively by the Ministry of Forests and to a lesser degree by the Ministry of Environment, Lands and Parks. The ecoregion/ecosection classification, incorporating the Wildlife Habitat Classification (WHC) (see, for example, Fuhr and Edie 1989; Harcombe and Lea 1990), is used mainly by Environment. The BEC system has largely provided the framework for this project. However, through the process of producing an ecosystem synopsis, the WHC has been correlated with the BEC wherever possible, to facilitate future cross-referencing. Appendix 1 correlates ecoregions and ecosections with subzones and variants for the Prince Rupert Forest Region.

Vascular plant diversity was not specifically examined, other than for rare and endangered species. For vertebrates, our objectives were to document species diversity within forested subzones and variants, determine habitat affinities of species of interest, and develop possible management guilds and management indicator species for forestry management. The taxonomy, abundance, and distribution of both fungi and invertebrates in the region were also investigated. Marine species were excluded from the study, as were freshwater vertebrates, although they are an extremely important component in the biodiversity and productivity of forested watersheds.

2 AREAL EXTENT OF CLASSIFIED UNITS

2.1 Zones, Subzones, and Variants

Biogeoclimatic ecosystem classification is available for the whole region at a scale of 1:500 000 (Pojar and Nuszdorfer 1988). This information has been digitized by Shearwater Mapping. Areal estimates for zones, subzones, and variants are provided in Table 1 and summarized by zone in Figure 1.

Estimates are from summed digital information from database attribute files provided by the Ministry of Forests, Smithers. Areas of subzones and variants occurring on the Queen Charlotte Islands were subtracted from the regional totals. Where necessary, these areas were estimated with the use of a digital planimeter.

2.2 Ecoregions and Ecosections

Ecoregion and ecosection areal estimates within the region are provided in Table 2, and ecoregion areas are illustrated in Figure 2. Areal estimates for ecosections contained wholly within the region were taken directly from Vold (1990). For all ecosections dissected by the regional boundary, areas were estimated from the average of three readings obtained with a digital planimeter.

TABLE 1. Areal estimates for zones, subzones, and variants[a]

Zone	Area (ha)	Subzone	Area (ha)	Variant	Area (ha)
BWBS	2 476 628	BWBSdk	2 473 714	BWBSdk2	1 027 268
				BWBSdk1	1 446 445
		BWBSvk	2 914		
CWH	2 656 142	CWHwm	310 375		310 375
		CWHws	780 477	CWHws1	246 935
				CWHws2	533 542
		CWHvh	747 645		747 645
		CWHvm	817 641	CWHvm	590 513
				CWHvm1	131 592
				CWHvm2	95 536
ESSF	2 551 111	ESSFwv	1 689 733		1 689 733
		ESSFmk	149 427		149 427
		ESSFmc	711 951		711 951
ICH	1 121 007	ICHmc	880 178	ICHmc1	527 867
				ICHmc2	352 310
		ICHvc	240 830		240 830
		ICHwc[b]			
MH	1 668 113	MH und.	238 126		238 126
		MHmm	1 304 483	MHmm1	734 399
				MHmm2	570 084
		MHwh	125 505		125 505
SBPS	66 008	SBPSmc	66 008		66 008
SBS	2 577 165	SBS und.	163 196		163 196
		SBSdk	854 941		854 941
		SBSmc	1 559 028		1 559 028
SWB	5 191 080	SWB	5 191 080		5 191 080
AT	7 634 230	AT	7 579 510		7 579 510
		ATp	54 720		54 720
Total area 25 941 485 ha					

[a] Abbreviations as per Section 3.2.
[b] Area of ICHwc included in ICHvc.

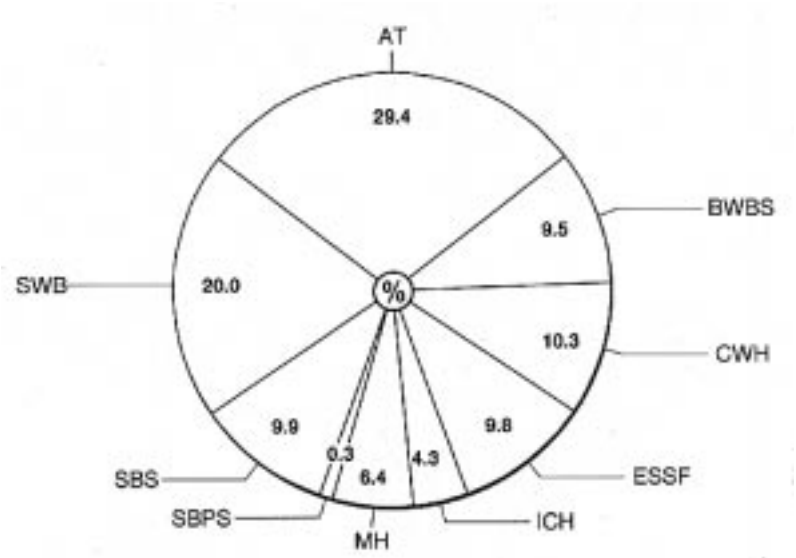

FIGURE 1. Total area by biogeoclimatic zone.

TABLE 2. Total area by ecoregion and ecosection

Ecoregion	Area (ha)	Ecosection	Abbr.	Area (ha)
Northern Coastal Mountains	3 529 500	Boundary Ranges[a]	BOR	3 529 500
Coastal Gap	4 251 817	Hecate Lowland	HEL	1 177 203
		Kitimat Ranges	KIR	3 074 614
Nass Basin	840 800	Nass Basin	NAB	840 800
Nass Ranges	1 030 300	Nass Ranges	NAR	1 030 300
Bulkley Ranges	436 200	Bulkley Ranges	BUR	436 200
Fraser Plateau	2 043 990	Bulkley Basin	BUB	899 873
		Nazko Upland	NAU	79 647
		Nechako Plateau	NEP	1 064 470
Fraser Basin	933 900	Babine Upland	BAU	933 900
Skeena and Omineca Mountains	1 980 122	Eastern Skeena Mountains	ESM	14 489
		Omineca Mountains	OMM	58 579
		Western Skeena Mountains	WSM	1 907 054
Tatshenshini Basin	352 400	Tatshenshini Basin	DUD	352 400
Liard Basin	1 159 523	Liard Plain	LIP	1 159 523
Northern Mountains and Plateaus	7 843 924	Cassiar Ranges	CAR	1 252 280
		Ketchika Mountains	KEM	817 504
		South Boreal Plateau	SBP	2 197 540
		Stikine Plateau	STP	1 888 100
		Teslin Plateau	TEP	643 400
		Tuya Range	TUR	1 045 100
Northern Rocky Mountains	305 413	Muskwa Ranges	MUR	305 413
Yukon-Stikine Highlands	1 736 000	Tahltan Highland	TAH	1 736 000
Total area 26 443 889 ha				

[a] Boundary Ranges area incorporates Alsek Ranges and Icefield Ranges.

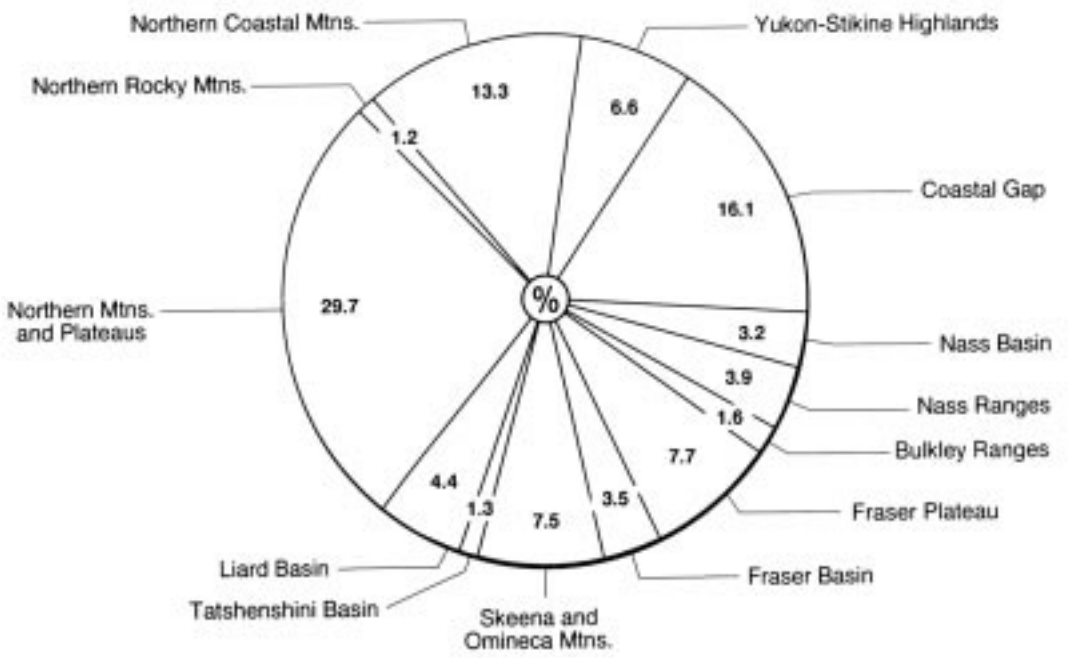

FIGURE 2. Total area by ecoregion.

3 ECOSYSTEM SYNOPSES

Ecosystems for the region are described in detail by Banner *et al*. 1993, and are not repeated here. The following discussion and descriptions highlight some of the features of interest, and provide an overview. Habitat classes mentioned follow Fuhr and Edie (1989).

3.1 Overview

Within a subzone, wildlife habitat classes do not usually correspond directly to BEC site series/associations. Some exceptions are the spruce-cottonwood riparian habitats, some wetland categories (generally bog types), and grasslands. Typically, a forested habitat class includes several site series, and possibly site associations, whereas a wetland site association may include more than one habitat class.

Several habitat classes, mostly with seral vegetation, have no specific counterparts in the BEC system (e.g., talus slope, rock, and trembling aspen copse). Human disturbances generally decrease natural habitat diversity and often reduce overall diversity. In some cases, however, overall habitat diversity is increased by the introduction of artificial habitats. These habitats are included in the wildlife habitat classification (e.g., Urban, Cultivated Field), although such ‘‘ecosystems’’ have not been sampled in the BEC system.

Some zones and subzones have greater ecosystem diversity than others, both in the number of habitat classes and the number of site series. For example, the CWHvh has 22 defined site series, corresponding to at least 7 habitat classes, while only 9 site series are defined for the ESSFmk, encompassing only 2 habitat classes. Habitats such as avalanche tracks are included in site series in some variants, but not in others. For this report, the more general term ‘‘site unit’’ is used to include both described BEC site series, as well as other ecosystems not yet incorporated into the BEC. A summary of the number of site units by biogeoclimatic unit is provided in Table 3.

TABLE 3. Number of site units described by zone, subzone, and variant

Zone	Site units	Subzone	Site units	Variant	Site units	Remarks
BWBS	25	BWBSdk	25	BWBSdk1	14	
				BWBSdk2	11	
		BWBSvk				Not described.
CWH	93	CWHvh	22	CWHvh1	–	Wertland units include several
				CWHvh2	22	distinct plant communities.
		CWHvm	31	CWHvm1	14	Many unclassified wetlands.
				CWHvm2	17	
		CWHwm	13	CWHwm1		Includes avalanche tracks.
				CWHwm2		
				CWHwm3	13	
		CWHws	27	CWHws1	13	
				CWHws2	14	Includes avalanche tracks.
ESSF	32	ESSFmc	12	ESSFmc	12	Subalpine meadows,
		ESSFmk	9	ESSFmk	9	avalanche tracks
		ESSFwv	11	ESSFwv	11	not included.
		ESSFmcp		ESSFmcp		Not described, at least 3.
		ESSFmkp		ESSFmkp		
		ESSFwvp		ESSFwvp		
ICH	45	ICHmc	24	ICHmc1	7	
				ICHmc1a	3	
				ICHmc2	14	
		ICHvc	9	ICHvc	9	Includes avalanche tracks.
		ICHwc	12	ICHwc	12	
MH	38	MH und.		MH und.	unknown	
		MHmm	22	MHmm1	11	
				MHmm2	11	
		MHwh	10	MHwh1	10	
				MHwh2		
		MHmmp	6	MHmmp1	3	
				MHmmp2	3	
		MHwhp		MHwhp		None described.
SBPS	9	SBPSmc	9	SBPSmc	9	
SBS	31	SBS und.	4	SBS und.	4	Probably more.
		SBSdk	14	SBSdk	14	
		SBSmc	13	SBSmc2	13	
SWB	21	SWB	21	SWB	21	
Total site units	**294**					

Overall, the CWH zone has the most ecosystem level units, with a total of at least 93 site units described within 4 subzones and 8 variants. This contrasts with 31 described site units in the SBS, which occupies a similar area within the region (10.3% for the CWH vs. 9.9% for the SBS). The BWBS and ESSF zones also occupy close to 10% of the region and contain 25 and 32 site units, respectively.

Site associations, the basic unit of site classification, may span numerous biogeoclimatic units and encompass from one to many site series. Site associations represent an organization of ecologically equivalent sites that are expressed by a certain climax vegetation within a specific range of climate, soil moisture, and nutrient regime. Site series are simply a climatically uniform portion of a site association (Banner *et al.* 1990). Analyses of site association data for the region have not been undertaken, but a preliminary examination reveals a similar pattern to that in the site series, with far more in the CWH zone (46) than in other zones (BWBS, 26; ESSF, 19; ICH, 24; MH, 14; SBPS, 7; and SBS, 22). Details of site identification are presented in Banner *et al.* 1993.

Pojar *et al*. (1990) report that interior forests in general have greater ecosystem and landscape diversity than coastal forests, and perhaps more azonal habitats that have not been described. Comparison of habitat mapping between two CWH versus two SBS forested landscapes revealed smaller polygon sizes — and thus apparently greater landscape diversity — in the SBS areas. It has been suggested that vegetation expression of minor site differences in moisture, and therefore in vegetation diversity, are greater in moderate climates (as in the SBS), while extremes of moisture (as in the CWH) mask the expression of site differences (B. Fuhr, pers. comm., B.C. Ministry of Environment, Lands and Parks).

Apparent differences in ecosystem diversity may reflect different levels of effort, including a greater mapping and research effort in the coastal ecosystems than in other parts of the region. Consequently, there may be more seral stages in the interior that have not been described, as well as more azonal habitats. Sampling intensity is likely to have been lower in zones with limited access, such as the ESSF and MH zones. Individual mapping preferences also influence the apparent diversity (i.e., with ‘‘lumpers’’ vs. ‘‘splitters’’).

3.2 Subzone Descriptions

3.2.1 The Boreal White and Black Spruce dry cool subzone (BWBSdk)

Within the Prince Rupert Forest Region, the BWBSdk (formerly BWBSe, BWBSa2) occupies valleys in the Cassiar Mountains and large portions of the Stikine, Yukon, and Dease plateaus and the Liard Plain. Outside the region, it occupies the Fort Nelson Lowlands and the Rocky Mountain Trench and major side valleys south to the vicinity of Williston Reservoir. The principal BWBSdk areas in the Prince Rupert Forest Region include the Dease River drainage; the lower Blue and Little Rancheria rivers; the lower Kechika and Rabbit rivers; Coal River; the main Liard Valley; parts of the Stikine, Taku, Teslin, and Atlin drainages; much of the Kechika system in the Rocky Mountain Trench; and the upper Tatshenshini River (Trowbridge *et al*. 1983).

Two variants are described for the BWBSdk in the Prince Rupert Forest Region. The BWBSdk1 (formerly BWBSe) is found in the Cordilleran portions of the range given above, while the BWBSdk2 (formerly BWBSa2) occurs on the northern plateaus and plains. The BWBSdk1 experiences such peculiarities of mountain climate as temperature inversions, chinook winds, local rainshadows, and pronounced aspect differences. The BWBSdk2 has a more continental climate, with colder winters and colder soil temperatures but a warmer, moister growing season with more growing degree days (Trowbridge *et al*. 1983). Zonal sites are dominated by white spruce and varying amounts of trembling aspen, black spruce, and lodgepole pine. The shrub layer includes *Rosa acicularis, Shepherdia canadensis, Viburnum edule*, and sometimes *Ledum groenlandicum*. The herb layer is dominated by *Linnaea borealis, Epilobium angustifolium*, and *Vaccinium vitis-idaea*. The mosses *Hylocomium splendens*, *Pleurozium schreberi*, and *Ptilium crista-castrensis* are present in both variants, but often do not form a thick carpet-like layer (Trowbridge *et al*. 1983).

Wetlands are common but not extensive. Bogs, fens, and swamps are each represented as site series. Grassland communities are included in a grassland/shrub site series.

Fourteen and 11 site units have been described in the BWBSdk1 and dk2, respectively. Most forested series represent the Boreal White Spruce–Lodgepole Pine Habitat Class (see Fuhr and Edie 1989).

3.2.2 The Boreal White and Black Spruce very wet cool subzone (BWBSvk)

The BWBSvk is an unusual boreal subzone that occurs in British Columbia only in the western part (Alsek Ranges) of the Tatshenshini-Alsek area, also known as the Haines Triangle (Banner *et al*. 1993). This far northwestern corner of the province lies between the Coast Mountains to the east and the higher, wetter, more heavily glaciated Icefield and Fairweather ranges to the west. The valley of the lower Alsek River provides the only low-elevation breach in the windward front of the massive St. Elias Mountains, so weather spawned in the North Pacific is funnelled up the Alsek and Tatshenshini rivers.

The climate of the BWBSvk appears to be a dominantly interior but transitional type, with strong gradients. It is drier than that of the coastal belt (which occurs further west in Alaska), but wetter and considerably snowier than that of the BWBSdk in the Tatshenshini Basin to the east. Heavy snowpacks and strong winds are key environmental features.

Reconnaissance-level sampling indicates that zonal forests in the BWBSvk are a mixedwood type, with white spruce, black cottonwood, and paper birch the most abundant tree species. The open stands have a well-developed understorey of shrubs (willows, Sitka alder, mountain alder, soopolallie, highbush-cranberry, and red swamp currant) and herbs. Soils are Brunisols developed in loess (aeolian deposits); interestingly, soils do not show evidence of fire. Trembling aspen is uncommon; lodgepole pine and subalpine fir are absent, as are western hemlock, Sitka spruce, and red alder. Notable is the abundance of black cottonwood. It forms extensive stands (with very minor white spruce) with an alder understorey on many of the recent fluvial landforms. Very recent sandy gravelly river deposits develop a characteristic cover dominated by yellow mountain-avens, rock mosses, and coral lichens. Newly exposed glacial till tends to be covered by thickets of Sitka alder and willows, rather than by trees. Wetlands are uncommon, and are mostly riparian backswamps and marshes.

3.2.3 The Coastal Western Hemlock very wet hypermaritime subzone (CWHvh)

The CWHvh (formerly CCPH, CWHhm) occurs along the western shores of the Queen Charlotte Islands and the offshore islands and edges of the mainland coast. Although sometimes occurring 70 km inland along inlets and channels, it is never more than 25 km from the ocean. It extends north to the lower end of Observatory Inlet and as far south as northern Vancouver Island. The CWHvh occurs from 0 to 600 m in elevation, occupying the Hecate Lowland, Milbanke Strandflat, the outer Queen Charlotte Ranges, and Skidegate Plateau. Inland, it is restricted to the westernmost Kitimat Ranges and southwestern Boundary Ranges (Banner and Pojar 1987).

Within the Prince Rupert Forest Region, the CWHvh is represented by just one variant, the CWHvh2 or central variant. The northern part occurs in southeast Alaska (Banner and Pojar 1987). Zonal vegetation is dominated by red- and yellow-cedar and western hemlock; shore pine is often abundant. Large snags and dead-topped trees are characteristic of these sites. Shrub layers are dominated by *Gaultheria shallon, Vaccinium* spp., and *Menziesia ferruginea*. *Blechnum spicant, Cornus unalaschkensis*, and *Maianthemum dilatatum* are frequent in the herb layer. *Rhytidiadelphus loreus* and *Hylocomium splendens* dominate the moss layer.

A unique feature of the CWHvh is the extensive area covered by depressional, flat and sloping bogs. Marshes and fens also occur but are more localized along lake margins and flowing water (Banner *et al*. 1986, 1988).

There are 22 site units described for this subzone, including 4 bog, 1 swamp, and 1 fen/marsh wetland types. The Coastal Western Hemlock–Western Redcedar and Western Hemlock–Sitka Spruce Habitat Classes dominate, with a large variety of other habitat types as well.

3.2.4 The Coastal Western Hemlock very wet maritime subzone (CWHvm)

The CWHvm (formerly CWHi) is characterized by a wet, humid, mild, oceanic climate. It occupies the inner portions of coastal islands and the mainland of the Coastal Mountains, extending as far north as Portland Canal and south through the Vancouver Forest Region. To the west, it is bordered by the CWHvh (formerly CCPH). Eastern limits of the subzone are more diffuse; it occupies most of the low- to middle-elevation coastal valleys on the mainland, including the Kwinamass, lower Khutzeymateen, Gitnadoix, Kitimat, Kildala, Kemano, Kowesas, Kitlope, and Tezwa drainages. Zonal forests are dominated by western hemlock and usually amabilis fir. *Vaccinium* spp. are common in the shrub layer; *Blechnum spicant* tends to dominate the herb layer; *Hylocomium splendens* and *Rhytidiadelphus* spp. dominate the moss layer (Yole *et al*. 1982; Clement [1]).

[1] Clement, C. 1990. Ecosystem units of the Khutzeymateen and Kateen drainages. B.C. Min. For., For. Sci. Section, Smithers, B.C. Unpubl. manuscript.

Two variants have been described for the CWHvm. The submontane variant, CWHvm1, occupies an extensive area at elevations below 400 m. The CWHvm2 covers a similar geographic area and occurs above the CWHvm1 (400–800 m) and below the Mountain Hemlock zone. Steep-sided valleys with granite slopes have resulted in common occurrences of rockfalls, avalanche tracks, and coarse, rubbly colluvial deposits in the valley bottoms. The subzones are floristically similar except that yellow-cedar and mountain hemlock occur more frequently in the CWHvm2; and *Rhytidiopsis robusta* and *Mnium* spp. replace *Hylocomium splendens* as dominants (Yole *et al*. 1982).

The CWHvm3 and CWHvm4 were described by Clement[2] for the south half of TFL 41, but Banner *et al*. (1993) have added these proposed variants to the CWHvm1 and vm2, respectively. The area Clement studied occurs entirely within the Coast Mountains and is dissected by Gardner Canal. It includes the southernmost river drainages listed above — the Kemano, Kowesas, Kitlope, and Tezwa. These variants are distinguished floristically by the absence of *Blechnum spicant*. A Gardner Canal phase is recognized around Kemano and south along Gardner Canal to the lower Kitlope Valley; it is characterized by the occurrence of Douglas-fir on xeric to submesic sites. The presence of subalpine fir and dominance of *Oplopanax horridus* and *Rubus spectabilis* characterize the Tezwa River phase of the CWHvm2, which occurs only along the upper reaches of the Kitlope and Tezwa drainages.[3]

The CWHvm1 includes 14 defined site units; the CWHvm2, 11. Each variant also includes several non-forested site units (wetlands, estuaries, avalanche tracks). Forested sites usually represent the Amabilis Fir–Western Redcedar Habitat Class.

3.2.5 The Coastal Western Hemlock wet maritime subzone (CWHwm)

The CWHwm (formerly CWHj) extends along the lower Unuk, Iskut, and Stikine river drainages as far north as the Alaska border. It occurs along Portland Canal and Observatory Inlet, extending up the Kincolith and Iknouk rivers. The CWHwm is also reported further inland, along the middle and upper Khutzeymateen and the Kateen drainages (areas currently mapped as undifferentiated CWHvm). The subzone is bordered by the CWHvh (formerly CCPH) to the southwest and by the ICHvc (formerly ICHg) to the north. It occurs along valley bottoms and slopes to 600 m. The Mountain Hemlock Zone occurs above the CWHwm throughout its geographic extent.[4,5]

The CWHwm probably has two or three variants (submontane, montane, northern), but they have not been formally described because of insufficient sampling. The CWHwm1, the submontane variant, occurs below 400 m, extending along the Portland Canal as far north as Stewart, and along the middle and upper Khutzeymateen River, Carm Creek, and Kateen River. Sitka spruce and western hemlock dominate mesic forests; western redcedar is infrequent, and amabilis fir is absent. Blueberry, devil's club, Cordilleran bunchberry, five-leaved bramble, and spiny wood fern are characteristic of the understorey. Mosses are represented by *Rhytidiadelphus loreus*, *Hylocomium splendens*, and *Mnium* spp.

The CWHwm2, the montane variant, has a cooler, moister climate than the CWHwm1, occurring between 400 and 600 m elevation, within the same geographic range as the CWHwm1. Floristic composition is much the same as in the CWHwm1, except for a higher occurrence of yellow-cedar, mountain hemlock, fern-leaved goldthread, and deer fern.

The CWHwm3, the northern variant, is characterized by deeper snowfall and colder temperatures, absence of western redcedar, and greater presence of mountain hemlock. It occurs along the northern part of Observatory Inlet and Portland Canal, and along the Unuk, Iskut, and Stikine river

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[2] Clement, C. 1988. Biogeoclimatic units and ecosystem associations of Tree Farm Licence 41, south half. B.C. Min. For., For. Sci. Section, Smithers, B.C. Unpubl. manuscript.
[3] Ibid.
[4] Clement. C., D. Yole, A. Banner, and J. Pojar. 1990. A field guide for identification of the Wet Maritime Coastal Western Hemlock subzone (CWHwm) in the Prince Rupert Forest Region. B.C. Min. For., For. Sci. Section, Smithers, B.C. Unpubl. manuscript.
[5] Clement, 1990.

drainages,[6,7] as well as the lower Taku River and several small drainages in the Haines Triangle (J. Pojar, pers. comm., B.C. Ministry of Forests).

Thirteen site units have been described in the CWHwm, including avalanche track and bog units. Fens and marshes are grouped together. Most forested sites fall into the Western Hemlock–Sitka Spruce Habitat Class.

3.2.6 The Coastal Western Hemlock wet submaritime subzone (CWHws)

The CWHws (formerly CWHf) encompasses valley bottoms and eastern slopes of the Coast Mountains, Kitimat Ranges, and adjacent slopes of the Hazelton Mountains, with elevations ranging from 10 to 1000 m. It occurs within the Nass and Skeena drainages to the north, south to the Zymoetz, Kitsumkalum, and upper Kitimat, and as a narrow band around Morice, Nanika, and Tahtsa lakes. It also occurs around the western half of Whitesail and Eutsuk lakes and continues along the upper Kimsquit drainage as far south as Dean Channel. To the west, it borders the CWHvm (formerly CWHi) and the ICHmc (formerly ICHg) to the east. At higher elevations, eastern edges abut transitional Mountain Hemlock and Engelmann Spruce–Subalpine Fir zones. Although predominantly coastal, the climate is significantly influenced by continental weather patterns. Winter cold spells and summer droughts do occur, but not to the extent experienced by the interior regions. These climatic conditions are reflected floristically; both coastal and interior species occur here. Mesic climax forests are dominated by western hemlock, with amabilis fir, western redcedar, and spruce. *Vaccinium* spp. dominate the shrub layer; *Rubus pedatus*, *Cornus canadensis*, and *Clintonia uniflora* are frequent in the herb layer; and mosses are dominated by *Hylocomium splendens* (Haeussler *et al*. 1984).

The CWHws has been separated into two variants: the low-elevation, primarily western, CWHws1, and the high-elevation variant CWHws2 (formerly CWHf2 and i3),[8] which generally occupies the eastern and southern portions of the subzone. Valley bottoms and slopes to 600 m are represented by the CWHws1, including the Skeena Valley, Kitsumkalum and upper Kitimat river valleys, the lower Zymoetz, and along that portion of the Nass River occurring between the Tseax lava beds and the Ishkheenickh River.

The CWHws2 occurs above the CWHws1 (600–1000 m) along these same rivers and south throughout the Kimsquit River drainage at lower and middle elevations, and further inland in the Hazelton Mountains, where it generally lies between the ICH and MH or ESSF zones. It is cooler and wetter than the CWHws1 and is distinguished floristically by the frequent occurrence of *Streptopus streptopoides* and the presence of *Vaccinium membranaceum* instead of *V. parvifolium*.

Thirteen site units have been described for the CWHws1 and 14 for the CWHws2, including an avalanche track unit. Most forested units represent the Western Hemlock–Sitka Spruce Habitat Class. There are also several units representing the Sitka Spruce–Black Cottonwood Riparian Habitat Class.

3.2.7 The Engelmann Spruce–Subalpine Fir moist cold subzone (ESSFmc)

The ESSFmc (formerly the ESSFk) occupies the highest portions of the Nechako Plateau and is also found in the Telkwa Range and along the eastern side of the Skeena Mountains, including the Babine Range. It occurs directly above the SBSmc subzone at elevations between 1200 and 1800 m in the south, and from 950 to 1500 m in the north. Of the three ESSF subzones in the Prince Rupert Forest Region, the ESSFmc has the most continental climate, with colder winter temperatures, lower annual precipitation, and lighter snowpack than the others. Zonal sites are dominated by subalpine fir, with hybrid spruce and lodgepole pine as well in seral stands. Lodgepole pine and sometimes whitebark pine occur on the driest sites. The typical understorey vegetation of the subzone includes *Cornus canadensis, Arnica cordifolia, Orthilia secunda, Pleurozium schreberi, Barbilophozia lycopodioides,* and *Peltigera aphthosa* (Yole *et al*. 1989).

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[6] Clement *et al*., 1990.
[7] Clement, 1990.
[8] Clement, 1988.

Twelve site units have been described, most representing the Engelmann Spruce–Subalpine Fir Wet Forested Habitat Class, but also including the Avalanche Track Habitat Class.

3.2.8 The Engelmann Spruce–Subalpine Fir moist cool subzone (ESSFmk)

The ESSFmk (formerly the ESSFl) occurs as a 30 km wide band along the leeward (eastern) flanks of the Coast Mountains. It also occupies much of the subalpine elevations of the Tahtsa Ranges and portions of the Bulkley Ranges to the south of Telkwa Pass in the Burnie River valley. Winter snowpacks are relatively high, probably often greater than 2 m, but the Coast Mountains create a rainshadow, so summer rainfall is low. Snowy winters with minimal ground freezing apparently allow for the growth of mountain hemlock and amabilis fir. Subalpine fir dominates zonal sites, while whitebark pine is common on dry, rocky sites. Understorey vegetation on zonal sites includes *Vaccinium membranaceum*, *V. ovalifolium*, *Rubus pedatus*, *Dicranum fuscescens*, and *Barbilophozia floerkei*. Species diversity is relatively low in the herb and moss layers of this subzone (Yole *et al*. 1989).

Nine site units have been described in the ESSFmk, most representing the Engelmann Spruce–Subalpine Fir Wet Forested Habitat Class.

3.2.9 The Engelmann Spruce–Subalpine Fir wet very cold subzone (ESSFwv)

The ESSFwv (formerly the ESSFi) is found above the ICHmc and ICHvc subzones in the northernmost sections of the ESSF zone. It ranges from 900 to 1500 m in elevation in the southwestern portion of the Skeena Mountains to around Hazelton, the central section of the Hazelton Mountains, the highest parts of the Nass Basin, and along the eastern flank of the Coast Mountains north of the Nass River.

This subzone has a snowy winter and a moister growing season than the other two ESSF subzones in the region. Climax zonal sites are dominated by subalpine fir, with mountain hemlock, hybrid spruce, and western hemlock also present. Understorey species include *Vaccinium membranaceum, Menziesia ferruginea, Cornus canadensis, Rubus pedatus, Pleurozium schreberi*, and *Barbilophozia lycopodioides*. Lodgepole pine is rare in this subzone. The shrub and herb strata are floristically more diverse than in the ESSFmc and ESSFmk (Yole *et al*. 1989).

Eleven site units have been defined in the ESSFwv, most representing the Engelmann Spruce–Subalpine Fir Wet Forested Habitat Class.

3.2.10 The Engelmann Spruce–Subalpine Fir parkland subzones (ESSFmcp, ESSFmkp, and ESSFwvp)

Several ESSF parkland subzones lie above each of the three forested ESSF subzones, extending up to the timberline and separating the forested subzones from the Alpine Tundra zone (Yole *et al.* 1989) (the names of the parkland subzones correspond to the names of the forested subzones below them). The harsh climate and heavy snowpack of the parkland subzones do not permit the growth of continuous, productive forests suitable for timber harvesting (Yole *et al*. 1989), but recreation and wildlife values are relatively high.

Three main physiognomic vegetation classes — tree clump, treeless meadow, and treeless heath — occur in all three parkland subzones. Each of these classes has a range of associated moisture and nutrient regimes, with clumps of stunted subalpine fir predominating in the mesic treed ecosystems. Mountain hemlock, common in the tree clumps of the ESSFmkp and ESSFwvp, is virtually absent from the ESSFmcp. Common species include alpines such as *Artemisia arctica, Cassiope mertensiana, Lupinus arcticus, Castilleja parviflora*, and *Phleum alpinum*, as well as species of the ESSF forested subzones (Yole *et al*. 1989).

Site units have not been described for the ESSF parkland subzones, but ESSF Wet Parkland, Avalanche Track, and Subalpine Meadow Habitat Classes are represented.

3.2.11 The Interior Cedar–Hemlock moist cold subzone (ICHmc)

The ICHmc (formerly the ICHg1, ICHg2, and ICHg3) covers the Nass Basin upstream from below the junction with the Tseax River, the Tseax Valley and Lava Lake valley, the Cranberry Creek valley, the valley floor of the Skeena River above Legate Creek, the valleys of the major tributaries of the Skeena including the Bulkley below Trout Creek, the Kispiox River below Sweetin River, and the Kitwanga, Kitseguecla, and Suskwa river valleys. Elevations range from as low as 300 m in the Nass Basin to as high as 1100 m in some parts of the Nass Basin and in the Rocher de Boule and Kispiox ranges (Houseknecht *et al.* 1987).

Two variants, the ICHmc1 and ICHmc2, have been described. Generally the ICHmc2 covers the valley floors in the more southerly and easterly portions of the range outlined above; the ICHmc1 covers the upper Nass and Skeena drainages as well as valley slopes above the ICHmc2. The ICHmc1 is cooler and moister than the ICHmc2 and has a shorter growing season. Western redcedar is absent in the ICHmc1 but frequent in the ICHmc2. Western hemlock and subalpine fir dominate zonal climax stands in the ICHmc1; western hemlock and western redcedar dominate the ICHmc2. Shrub and herb layers are generally poorly developed on zonal sites, though there is usually a well-developed moss layer containing *Hylocomium splendens, Pleurozium schreberi*, and *Ptilium crista-castrensis* (Houseknecht *et al.* 1987).

Portions of the ICHmc1 are characterized by the presence of amabilis fir and are designated the ICHmc1a, or Amabilis Fir Phase. This phase consists of old-growth stands showing no signs of past fire for many generations. These forests resemble higher-elevation areas of the Coastal Western Hemlock zone (Houseknecht *et al.* 1987). Seral stands are common in the ICHmc2 and adjacent portions of the ICHmc1. The portion of the ICHmc2 formerly designated the ICHg3 is strongly influenced by frequent natural fires and widespread human disturbance. In these seral areas trembling aspen and paper birch dominate, with *Corylus cornuta* typically dominating the shrub layer. Lodgepole pine, spruce, and subalpine fir are the main conifers of seral stands (Houseknecht *et al.* 1987).

Seven site units are recognized in the ICHmc1, three in the ICHmc1a, and 14 in the ICHmc2, including 3 representing seral associations. The Western Hemlock–Subalpine Fir Habitat Class is typical for the ICHmc1; the ICHmc2 has mostly the Western Hemlock–Western Redcedar Habitat Class. The Lodgepole Pine Habitat Class occurs on dry sites in both variants.

3.2.12 The Interior Cedar–Hemlock very wet cold subzone (ICHvc)

The ICHvc (formerly ICHg4) occupies low to medium elevations most of the length of the Bell-Irving River (north to Ningunsaw Pass) and its major tributaries as far south as Irving Creek and the White River. Elevation range is considerable. In the main Bell-Irving valley the ICHvc extends to 800 m, but on sheltered north-facing slopes it attains 1000 m. Cold air drainage in narrow side valleys forces it down below 700 m. In the south, the minimum elevation is as low as 240 m near Meziadin Lake (Houseknecht *et al.* 1987).

Snowfall in the ICHvc is high, with normal snowpack maximums estimated at 2.5–5 m in depth. Zonal sites are characterized by western hemlock, subalpine fir, *Oplopanax horridus, Vaccinium* spp., *Gymnocarpium dryopteris*, and mosses. Fire has had little impact. Black cottonwood is the only typical seral species, occurring infrequently on upland sites and pioneering on sandbars. All side valleys are strongly affected by avalanching; the typical vegetation of avalanche slopes is represented by a defined site unit in the ecosystem classification.

There are nine site units described for the ICHvc, the forested units mostly representing the Western Hemlock–Subalpine Fir Habitat Class. Avalanche tracks are described in a moist thicket site series. Very diverse wetland types are included in one site unit.

3.2.13 The Interior Cedar–Hemlock wet cold subzone (ICHwc)

The ICHwc (formerly ICHg5) occurs in the central parts of the Iskut and Stikine valleys, at elevations ranging from 150 m to 900 m. Snowpacks are moist and moderately heavy, but not as heavy as in

the Meziadin–Bell-Irving area. Zonal sites are characterized by climax forests of western hemlock, with minor subalpine fir and Roche spruce. Lodgepole pine, aspen, and paper birch are scattered, forming seral forests in burned-over areas, especially in the vicinity of Bob Quinn Lake.

The ICHwc has 12 described site units, including two non-forested wetland types.

3.2.14 The Mountain Hemlock moist maritime subzone (MHmm)

Within the Prince Rupert Forest Region, the MHmm (formerly the MHa, MHb, MHd, and MHe) occurs at subalpine elevations in maritime to submaritime climate areas of the Kitimat, Nass, and Boundary ranges. Below it lies the Coastal Western Hemlock zone and above it the MHmmp (parkland) subzone. Elevations range from 765 to 855 m in northern areas (Ketcheson 1990) and, in the south, from about 760 to 1200 m in the Kimsquit drainage (Clement 1984) and from about 700 to 1100 m in the Kitlope drainage.[9] The elevational range of the subzone can be much lower (450–750 m) in areas subject to cold air drainage.[10] Two variants are currently accepted: the MHmm1 in the more western and windward portions of the range, and the MHmm2 in the eastern, more leeward areas.

Zonal sites are occupied by the Western hemlock–Amabilis fir–Blueberry association and are dominated by western hemlock, associated with yellow-cedar in the windward variant or amabilis fir in the leeward. A cold air variant has been described that has subalpine fir dominant on forested sites. Understorey vegetation includes *Vaccinium alaskaense, V. ovalifolium, Rubus pedatus, Rhytidiopsis robusta, Rhytidiadelphus loreus*, and *Dicranum* spp.

Eleven site units are currently defined for each variant, though others have been described in available references. Forested units generally represent the Mountain Hemlock Forested or Mountain Hemlock–Amabilis Fir Habitat Classes; the Subalpine Meadow and Avalanche Track Habitat Classes are also present.

3.2.15 The Mountain Hemlock wet hypermaritime subzone (MHwh)

The MHwh (formerly the MHc) occurs at subalpine elevations in the hypermaritime outer coast portion of the Prince Rupert Forest Region and in the adjacent portions of the Vancouver Forest Region, including the Queen Charlotte Islands. It is divided into the MHwh1 (Windward MHwh) and MHwh2 (Leeward MHwh) variants. Ten site units have been defined for the windward variant. Climax zonal sites are occupied by the Western hemlock–Sitka spruce–Blueberry association. Forested units probably represent the MH, with inclusions of the Subalpine Meadow Habitat Class.

3.2.16 The Mountain Hemlock parkland subzones (MHmmp, MHwhp)

These subzones overlie correspondingly named forested Mountain Hemlock subzones and grade into the Alpine Tundra zone above. There has been little study of these subzones and detailed information on the variants and their site units is not available. Elevations range from 855 to 1375 m in the northern part of the Prince Rupert Forest Region (Ketcheson 1990), up to about 1500 m in the central part, and as high as about 1700 m in the south around Bella Coola (outside the region) (Pojar and Nuszdorfer 1988).

Zonal vegetation generally consists of a diverse mosaic of tree islands, shrub patches, moist herb openings, wetlands, and rock outcrops. Two variants of the MHmmp subzone have been described. Mountain hemlock and amabilis fir dominate the MHmmp1 zonal sites, in association with ericaceous shrubs including mountain-heathers and lichens such as *Cladina* (Clement 1984). Yellow-cedar can be present as well.[11] The MHmmp2 has mountain hemlock and subalpine fir (Pojar *et al.* 1982; Clement 1984). The MHwhp has not been described. Site units have been sketchily outlined in various reports. There appear to be at least three each in the MHmmp1 and MHmmp2, but there is no definitive publication. The habitats represented fall into the Mountain Hemlock Parkland Habitat Class.

[9] Clement, 1988.
[10] Ibid.
[11] Clement, 1990.

3.2.17 The Sub-Boreal Pine–Spruce moist cold subzone (SBPSmc)

Within the Prince Rupert Forest Region, the SBPSmc (formerly the SBSa2) occupies only a very small area south and east of Tetachuck Lake on the Nechako Plateau. The elevation range is from below 900 m to about 1200 m (Pojar and Nuszdorfer 1988). Nine site units have been defined. The zonal association, representing the Sub-Boreal White Spruce–Lodgepole Pine Habitat Class, is dominated by lodgepole pine and white spruce with an understorey of *Shepherdia canadensis* and *Cornus canadensis*. *Pleurozium schreberi* and *Peltigera aphthosa* dominate the moss layer. Other habitats represented include the Lodgepole Pine Habitat Class on dry sites, the Black Spruce–Lodgepole Pine Habitat Class, and the Black Spruce Bog Habitat Class.

3.2.18 The Sub-Boreal Spruce dry cool subzone (SBSdk)

The SBSdk (formerly the SBSd) occupies lowlands in the Fraser Plateau and Fraser Basin. Its extent includes the Bulkley River valley upstream from just above Moricetown; the valleys of the Buck and lower Morice rivers; the plains extending south and west from the Decker Lake, Burns Lake, and upper Endako River areas across François and Ootsa lakes to Tetachuck Lake; and the valley of lower Babine Lake and the Sutherland River (Pojar and Nuszdorfer 1988). Climax communities on zonal sites are dominated by hybrid spruce with an understorey including *Rosa acicularis, Arctostaphylos uva-ursi, Lathyrus nevadensis, Pleurozium schreberi*, and *Ptilium crista-castrensis*.

Fourteen site units have been defined (Lewis *et al*. 1986b; Banner *et al*. 1993), including representation for swamps, bogs, grasslands, and a deciduous scrub ecosystem. Numerous habitat classes occur, with the Subboreal White Spruce–Lodgepole Pine Habitat Class on climax zonal sites.

3.2.19 The Sub-Boreal Spruce moist cold subzone (SBSmc)

The SBSmc (formerly the SBSe) is represented in the Prince Rupert Forest Region primarily by a single variant, the SBSmc2. It is found on higher ground than the SBSdk, mainly on the Nechako Plateau and in the Babine Upland, and also in higher areas within the Bulkley Basin and Nazko Upland. Generally it occurs above the SBSdk and below the ESSFmc (Pojar and Nuszdorfer 1988). Zonal climax communities are dominated by subalpine fir, hybrid spruce, and lodgepole pine, with an understorey of *Vaccinium membranaceum, Cornus canadensis, Pleurozium schreberi*, and *Ptilium crista-castrensis*.

Thirteen site units have been defined (Lewis *et al*. 1986b; Banner *et al*. 1993), three of which (04, 08, and 11) occur in the Prince George and Cariboo forest regions but not in the Prince Rupert Forest Region. One unit represents both fens and marshes. Most ecosystems, including the zonal, represent the Sub-Boreal White Spruce–Lodgepole Pine Habitat Class.

3.2.20 The undifferentiated Sub-Boreal Spruce zone (undifferentiated SBS)

Areas of undifferentiated SBS occur in the Prince Rupert Forest Region along the Stikine and Taku drainages at the boundary between the Coast Mountains and the Stikine and Yukon plateaus, at elevations ranging from 50 to 900 m (Pojar *et al*. 1982). Detailed descriptions are lacking. Zonal sites are dominated by hybrid (Roche) spruce, subalpine fir, and mosses — *Pleurozium schreberi, Hylocomium splendens*, and *Ptilium crista-castrensis* (Pojar *et al*. 1982). These communities probably represent the White Spruce–Subalpine Fir Habitat Class. No site units have been defined, though there are descriptions of at least four distinct associations, including (in addition to the zonal) a dry forested ecosystem (Fuhr and Edie 1989), a scrub ecosystem on steep slopes, and a grassland ecosystem (Pojar 1982).

3.2.21 The Spruce-Willow-Birch zone (SWB)

The SWB is a boreal subalpine zone, which in the Prince Rupert Forest Region occurs on the Stikine and Yukon plateaus and in the Cassiar Mountains, primarily above the BWBS, at elevations ranging from 900 to 1600 m (Pojar *et al*. 1982). The mean annual precipitation at Cassiar is 700 mm; the mean

annual snowfall, 409 cm. The climatic climax tree species are subalpine fir and white spruce; edaphic climax or seral species are lodgepole pine, trembling aspen, black spruce, and balsam poplar (Pojar *et al.* 1982).

Several subzones of the SWB have been tentatively identified (Banner *et al.* 1993), but none of these has yet been mapped or described sufficiently for inclusion in this report. However, the Tatshenshini-Alsek area has a distinctive SWB element, which we can tentatively call the SWBvk or very wet cool subzone. This very snowy subzone is primarily non-forested, although it has scattered open stands of white spruce and black cottonwood, both of which (but more commonly cottonwood) form timberline. The dominant vegetation is dense shrubby thickets of medium to tall shrubs, especially Sitka alder and willows (variable, Barclay's and Alaska willows). There is very little scrub birch, in contrast to the rest of the SWB. Moist, lush meadows are common and widespread, including a distinctive Fireweed–Red raspberry–Cow-parsnip association that appears to persist without fire.

Site units have not been defined for the SWB. The most detailed description of the zone is found in Pojar (1985), in which 20 community types are described for the SWB of the Gladys Lake Ecological Reserve. A description of an additional (bog) unit is found in Pojar *et al.* (1982). The communities described include coniferous and deciduous forests, a pygmy forest, and numerous scrub, steppe, and wetland types. The zonal ecosystem represents the Subalpine Fir–Scrub Birch Forested Habitat Class. The numerous community types represent a broad range of habitats.

4 RARE, THREATENED, AND ENDANGERED VASCULAR PLANTS

In the following discussion, the plants mentioned refer to vascular plants only.

4.1 Information Sources

Information on rare and threatened vascular plants is presented in Appendix 3. The information was provided initially by George Douglas, and has subsequently been updated by information from the Conservation Data Centre (CDC) (George Douglas, pers. comm.). Information on species, existing status, locations in forest districts, and habitats are provided. Appendix 3i should be consulted for explanations of the status rankings used in this discussion: Global (G), National (N), and Subnational (S), 1 through 5.

Douglas[12] lists 589 rare species for British Columbia; 134 of these have been recorded in the Prince Rupert Forest Region (Appendix 3ii). The CDC listing (as of June 8, 1992) lists 112 rare species for the region, out of approximately 600 for the province. A number of species listed for the region in Appendix 3ii are absent from the latest CDC listing because they are no longer considered provincially rare. These include: *Boschniakia rossica, Draba longipes, D. macounii, Carex glacialis, C. microglochin, C. scopulorum*, and *Woodsia alpina*. Although these species are now considered infrequent in the province (rather than rare) and are given an S3 status, they have been retained in Appendix 3ii.

4.2 Representation of Rare Plants in the Region

The Prince Rupert Forest Region, which accounts for a little over 25% of the provincial land base, harbours approximately 20% of the total known rare plants in the province. It would appear that rare plants are under-represented in the region, compared to other parts of the province. This may simply reflect the relatively low sampling intensity in the north (see Section 11.3), or it may reflect the smaller flora in the northern part of the province. It should be noted that this forest region lacks the ''fringe'' ecosystems that just penetrate the province from the south and east, injecting relatively large numbers of rare species.

Genera in which rare species are particularly well represented are *Draba* and *Oxytropis.* The vast majority of rare species in these genera for British Columbia occur within this region, which has 13 of the province's 15 rare *Draba* species and at least 5 of 10 *Oxytropis* species. As might be expected, these northerly species are most typically associated with alpine and subalpine habitats.

[12] Douglas, G.W. 1991. Rare, endangered and threatened native vascular plants of British Columbia. B.C. Min. For., Res. Br., Victoria, B.C. Unpubl. rep.

4.3 Significance

All species listed in Appendix 3i are significant at least at a provincial level, and in many cases nationally and internationally. Of particular interest are those species so far recorded in the province only in the Prince Rupert Region. These are boldfaced in the following text. There are 34 species apparently exclusive to the region; all except two of them have been recorded only in the Cassiar District. The overwhelming majority have a circumpolar or arctic/alpine distribution and reach the southern limits of their ranges within the region. All of these species occur also in the Yukon, Alaska, and often in the Northwest Territories. Some extend through Quebec, to Greenland, or to east Asia. Many of these species may be more frequent outside the province, but the majority have not yet had a global or national status assigned to them by the CDC. However, those Beringian species confined to Canada are presumably of some significance at a global level. None of the rare species recorded for the region is listed by the Committee on the Status of Endangered Wildlife in Canada.

There are a great many other species that may be regionally rare, but are not considered rare provincially. It is beyond the scope of this study to document all the regionally or locally rare species.

Species known to be significant at a national or global level include (species in bold have been recorded in British Columbia only within this Forest Region):

G1 - *Salix raupii*

G2 - ***Androsace alaskana**, Draba ruaxes, **D. stenopetala**, D. ventosa*, ***Montia bostockii**,* and ***Phacelia mollis***

G3 - ***Douglasia gormanii**, Juncus arcticus* ssp. *alaskanus*, ***Oxytropis huddelsonii,** Polystichum setigerum,* and *Thelypteris quelpaertensis*

Additional species considered significant, at least at a national level, include:

N1 - ***Papaver alboroseum*** (possibly significant at a global level), *Primula cuneifolia* var. *saxifragifolia, Sparganium glomeratum*, and ***Woodsia alpina***

N2 - *Carex gmelinii, Draba densifolia, Lilaea scilloides,* and *Rumex pauciflorus*

N3 - *Gentianella tenella* ssp. *tenella*, *Poa abbreviata* ssp. *jordalii*

In addition to species mentioned above, those species considered rare in the province (S1) and unique to this region are: ***Arctophila fulva, Artemisia alaskana, Carex krausei, C. supina* ssp. *spaniocarpa, Castilleja hyperborea, Diapensia lapponica, Draba corymbosa, D. palanderiana, Erigeron uniflorus, Erysimum pallasii, Geum rossii, Ledum palustre* ssp. *decumbens, Leucanthemum arcticum, Lupinus kuschei, Luzula groenlandica, Oxytropis jordalii* ssp. *jordalii, Parrya nudicaulis, Polemonium caeruleum* ssp. *amygdalinum, Potamogeton perfoliatus*, *Primula sibirica*** and ***P. stricta, Saxifraga reflexa, Saxifraga serpyllifolia, Saussurea angustifolia* var. *angustifolia*, *Senecio congestus, S. ogotorukensis***, and ***Silene taimyrensis.***

4.4 Rare Plant Habitats

An overwhelming majority of the rare plants in the region occurs in non-forested habitats, such as moist-wet meadows or dry rocky slopes, and most are in the alpine and subalpine zones. As such, most are in habitats unlikely to be threatened by forestry or most other developments. Unlike in much of the province, rare plants in the Prince Rupert Forest Region are relatively secure. This is partly reflected in the very small number on the CDC ‘‘tracking’’ list. The CDC produces a tracking list[13] of about 130 of the most threatened species in the province. On the most recent list (1993), no threatened or endangered species are recorded for the Prince Rupert Region. ***Androsace alaskana, Draba stenopetala, Phacelia mollis***, and ***Salix raupii*** are considered globally rare but not threatened or endangered.

Species in non-forested wetland habitats within forested areas (e.g., within Black Spruce Bogs) could conceivably be affected by forest development in surrounding areas, primarily through hydrologic and possibly microclimatic effects. This would apply to fen, marsh, and bog species within the montane zone (e.g., *Ledum palustre* ssp. *decumbens, Montia chamissoi, Senecio congestus*, and *Salix raupii).*

[13] British Columbia Conservation Data Centre. 1993. Native vascular plant tracking lists. Victoria, B.C. Unpubl. doc.

Very few rare species occur in forested habitats. *Malaxis monophyllos* var. *brachypoda* is one which occurs in moist forests in the montane zone. Several other species are mentioned as occurring in forest openings in the montane zone, including *Oxytropis huddelsonii*, *O. jordalii*, *Anemone canadensis,* and *Castilleja hyperborea*. Some of these species, however, also occur in other habitats. *Boschniakia rossica* is associated with deciduous species such as Alnus and Betula; it also occurs in balsam poplar floodplain forest along the Tatshenshini River. It is now no longer considered provincially rare (and does not therefore appear in Appendix 3i). *Halimolobos mollis* occurs on dry slopes and in open forests in montane zones.

5 FUNGI

5.1 Extent of Knowledge

With a few exceptions, little is known of the taxonomy or distribution of the fungi of the Prince Rupert Forest Region, for two reasons. First, northwestern British Columbia has not been well sampled, so there is a lack of data. Second, collections are seldom coded in a manner that would allow records for a particular forest region to be pulled out, though this information may be readily available for particular collecting locations or for the province as a whole.

About 340 species of gilled fungi have been identified in British Columbia under 410 names; the total number of species may be around 2000. Hypogeous fungi such as truffles are almost unreported, but there are probably many species. Fungi of all kinds may number over 10 000 species in the province. In addition, lichens, treated in this report as fungi, number in excess of 1000 species. The latest inventory of lichens and allied fungi lists 1013 species in 205 genera (Goward 1990).

Fungal tree pathogens occurring in the Prince Rupert Forest Region include a variety of rot-causing organisms, rusts, and stem canker fungi. Mycorrhizal species are present, but it is unknown which are important. Approximately half of the mushroom species are believed to be mycorrhizal.

Fungal diversity is considered to be higher in the western, coastal portions of the region. However, there has been no ecological inventory of fungi *per se.* Lack of data makes it generally impossible to assess the status of different species adequately. They are frequently dependent on undisturbed forest ecosystems.

Pine mushrooms are a locally significant resource. The Ministry of Forests has undertaken a review of the pine mushroom industry in British Columbia,[14] as has the Centre for Land and Biological Resources Research.[15]

Numerous popular guides and technical references to the mushrooms of British Columbia, Canada, and North America have been published, and a checklist of the lichens has been published by the Canadian Museum of Nature (formerly the National Museum of Natural Sciences).

5.2 Collections and Databases

The Pacific Forestry Centre in Victoria maintains the Forest Insect and Disease Survey for British Columbia. This is part of a national database consisting of collection records going back to the 19th century. The province's records (more than 600 000) account for about 45% of the total. The data include over 6000 insects and about 3300 diseases. Decay fungi, mycorrhizal fungi, and mushrooms are included, as are beneficial insects, pest insects, and predators. The data are coded by host species, location, and date, and are retrievable by UTM grid (10 km cell size) or by drainage divisions. One could therefore retrieve records for pest A on host B in years C and, by compiling drainage divisions, could obtain information for a forest region. The database incorporates the biogeoclimatic zone map.

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[14] F.B.M. Consulting Ent. 1989. The harvesting of edible wild mushrooms in British Columbia. B.C. Min. For., Integrated Resources Br., Victoria, B.C. Unpubl. rep.

[15] Redhead, S. 1991. Pine mushrooms. Cent. Land and Biol. Resources Res., Agric. Can., Ottawa, Ont. Unpubl. rep.

The National Mycological Herbarium of the Centre for Land and Biological Resources Research holds about 275 000 fungal specimens, including about 10 000 living culture strains. It is not known how much of this material is from British Columbia as only a small portion of this collection is in a database. There is little information on wood rot fungi in the Prince Rupert Forest Region. The Inventory Branch of the Ministry of Forests maintains a large database of decay and breakage plots, including hundreds of plots in the Prince Rupert Region. Generally, however, the pathogens are not identified, so this resource is of limited use as a source of knowledge of fungi in the region.

The best collection of lichens is probably the one in the University of British Columbia Herbarium, which is computerized and indexed by genus and species. Specimens are filed by geographical area, which for British Columbia specimens is the whole province. To find out which specimens have been collected in the Prince Rupert Forest Region, every collection record would have to be checked, which would be impractical. Records could, however, be pulled out by specific collecting locations within the region. The area around Prince Rupert, including Rainbow Lake, and along the major highways has been sampled (T. Goward, pers. comm., Clearwater, B.C.).

The Royal British Columbia Museum has a small lichen collection consisting mostly of duplicates of specimens contained in the University of British Columbia Herbarium. There is also a small collection of fungi and lichens at the University of Victoria, which is probably not significant for the purposes of this survey.

6 INVERTEBRATES

6.1 Extent of Knowledge

As with fungi, little is known of the taxonomy or distributions of invertebrates in the Prince Rupert Forest Region. The reasons are lack of basic data for most and difficulty in accessing what does exist for a particular region.

Some insect groups and arachnids are fairly well known, including dragonflies, mosquitoes, deer flies, horseflies, pest species of beetles, and spiders. Butterflies (160-odd species) are well known from along the main highways, but are poorly sampled elsewhere. Even for the better-known groups, however, knowledge is so fragmentary that it is often impossible to assess their true status (Cannings 1990). With the exception of forest pests, moths are virtually unknown.

There is no good estimate of the number of insect species in British Columbia. Cannings (1990) suggests that 35 000 for the province as a whole is a good guess, though fewer than half (15 000) have been found so far. In the south, for example, a survey of the Brooks Peninsula, Vancouver Island, revealed 519 terrestrial invertebrates in 190 families, of which 31 were undescribed species and 34 were previously unknown in Canada (Cannings 1990). The same author reports that 90 of 100 gall midges collected in Sooke, Vancouver Island, were also new to science.

Soil invertebrates in the Prince Rupert Forest Region are also extremely poorly known. Within British Columbia, the numbers of known genera of soil invertebrate groups are as follows:[16]

Group	No. of genera	Group	No. of genera
Protozoa	100	Tardigrada	5
Rotifera	4	Myriapoda	7
Nematoda	11	Crustacea	4
Annelida	8	Arachnida	113
Gastropoda	5	Hexapoda	50

[16] Marshall, V. 1991. Data from a Biodiversity Symp. presentation, Victoria, B.C.

Taxa and distributions of dragonflies and mosquitoes have been described in publications of the B.C. Provincial Museum (now the Royal British Columbia Museum).[17] The Centre for Land and Biological Resources Research has published a selection of handbooks on insects, including distribution maps.[18] A series of annotated checklists of some insect groups and water mites of British Columbia has also been published in the journal *Syesis*.[19] As well, the National Museum of Natural Sciences (now the Canadian Museum of Nature) publishes a multi-volume generic list, reference list, and set of species synopses of aquatic (freshwater and marine) invertebrates of Canada.[20]

6.2 Collections and Databases

The principal insect collections are at: the National Insect Collection at the Centre for Land and Biological Resources Research in Ottawa; the Spencer Entomological Museum of the Department of Zoology at the University of British Columbia; the collection of the Royal British Columbia Museum in Victoria; and the collection of the Pacific Forestry Centre (Natural Resources Canada) in Victoria. In addition, the Canadian Museum of Nature in Ottawa has started an insect collection. These collections are mostly not computerized and all are organized by species, so it is tedious to determine which specimens are from a particular geographical region.

The National Insect Collection has about 15 million insect specimens, including a significant amount of material from northwestern British Columbia. The collection also includes spiders and mites, including some from northwestern British Columbia. The collections are well maintained and organized by species, but not by geographical area. No catalogue exists.

The Spencer Entomological Museum has about 600 000 insect specimens, mostly from southern British Columbia, but including some from the Yukon as well. The collection has very few specimens from northwestern British Columbia, though there are some beetles from the Terrace area. Phytophagous and parasitic tree-living insects are represented, but not soil and litter insects. Habitat information is generally lacking. There is no feasible way to pull out the specimens by geographical region. The collection is not yet computerized, although data management software has been purchased.

The Pacific Forestry Centre insect collection was started in 1949, and now includes 65 000–70 000 specimens representing about 6500–7000 species. The emphasis is on forest insects: there are many defoliators, bark beetles, parasitic wasps, and flies. The collection also includes a few spiders. As well, the Centre has a Soil Zoology Collection with about 4000 specimens of mites, spiders, pseudoscorpions, crustaceans, collembola, and other hexapods, molluscs, and annelids, but most of these are from southern British Columbia. It is difficult to pull out information by forest region, as the records are tracked by species.

The Canadian Museum of Nature insect collection is only about 3 years old. The collection has a research focus and has been acquired mostly by donation. British Columbia is not as well represented as other regions of Canada and the rest of the world. There is a rather small amount of material from northwestern British Columbia, including leaf beetles and wood-boring beetles from along the Stewart-Cassiar highway. The collection is about 99% beetles, especially phytophagous beetles. There is no catalogue.

As well, the Canadian Museum of Nature has collections of other major invertebrate taxa, most notably of crustaceans, molluscs, and annelids. The crustacean collection includes material from northwestern Canada and Alaska; some terrestrial crustaceans (isopods) from British Columbia are not catalogued. The mollusc collection includes freshwater and terrestrial molluscs, but there is little or no material from northwestern British Columbia.

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[17] Handbooks No. 35 and 41, respectively. B.C. Provincial Museum (Royal British Columbia Museum), Victoria, B.C.

[18] Centre for Land and Biological Resources Research. 1977–1992. Insects and arachnids of Canada and Alaska. Parts 1–16. Vol. 1–20. Ottawa, Ont.

[19] Conroy and Scudder (1976), Ricker and Scudder (1976), Scudder (1976), Scudder (1977), Scudder *et al.* (1977), Nimmo and Scudder (1979), Nimmo and Scudder (1984).

[20] National Museum of Natural Sciences. 1983–1988. Bibliographia Invertebratorum Aquaticorum Canadensium. Vol. 1–8. National Museums of Canada, Ottawa, Ont.

The annelid collection includes a few unidentified earthworm specimens from northwestern British Columbia, as well as at least five identified leeches and one identified aquatic oligochaete. All of the leeches in the collection, but only some of the aquatic oligochaetes and a small portion of the earthworms, are included in a computer database. There is not much terrestrial material from northwestern British Columbia generally, and probably little freshwater material outside the above taxa. Marine material is better represented.

The Canadian Museum of Nature is currently entering its collection records into a database. A new computer cataloguing system is being installed, which will allow data to be accessed by geographical references.

The Royal British Columbia Museum has a collection of mostly marine invertebrates. Terrestrial specimens in the collection include some isopods (pill bugs) and gastropods; there are also some freshwater species. The material is organized by collecting location. Existing paper records are being entered into a database.

The Canadian Heritage Information Network (CHIN) is a national database of collections from museums across Canada, including about 25 in the natural sciences field. Its Natural Sciences Database currently holds over 800 000 records, indexed by over 600 fields. The data belong to the participating museums. Data can be obtained by means of a CHIN data request form, or from a member institution such as the Royal British Columbia Museum who can be asked to do a search through CHIN. CHIN is currently setting up an on-line database of collections from the Canadian Society of Zoologists.

7 TERRESTRIAL VERTEBRATES: DIVERSITY AND DISTRIBUTION

In the following discussions, species diversity refers simply to the number of vertebrate species. No estimates of abundance, either absolute or relative, are incorporated into the analyses.

7.1 Terrestrial Vertebrate Occurrence in the Region

7.1.1 Full species list

Appendix 4i provides a full species list for the region, giving scientific and common names and the standardized code for each species. This list includes species not confirmed for the region. A total of 359 terrestrial vertebrate species, comprising 7 amphibians, 2 reptiles, 288 birds (including accidentals and pelagics), and 62 terrestrial mammals has been identified for the region, along with an additional confirmed 3 subspecies and 45 unconfirmed species. The latter comprise 2 amphibians, 2 reptiles, 31 birds, and 7 mammals, which are considered as either probable or possible for the region, but no confirmed records were located. A further 3 species have been suggested at some time for the region, but are considered unlikely on the basis of their ranges and habitats.

7.1.2 Pelagic, accidental, and casual species

Of the regional totals, 8 species of birds confirmed for the region are considered pelagic (the albatrosses, shearwaters, and, to a lesser degree, the jaegers), and another 20 are considered accidental to the region. Although these appear in the full species list, they are not considered in any subsequent analyses and are not incorporated into management assemblages.

At least 34 bird species may be considered casual to the region, having only 2–6 confirmed records each for the region. In reality, however, many of these ‘‘casual’’ species may be regular visitors or even low-density residents in the region. The lack of sightings may in part reflect lack of observers. Some species listed as casual may in fact be widespread. Species with only a few records, but with at least one breeding record for the region, were considered either resident or migrant breeders and were not included in the casual category.

The bobcat, although it has been recorded at the southeastern margins of the region, might be considered incidental in the region, and has not been considered further in this report. The raccoon, although included on the mammal list, is not confirmed. Occurrence is based on a report by Hay,[21] reporting raccoon tracks in the Kitimat area. Raccoons also apparently occur in the Skeena River Ecological Reserve (B.C. Ministry of Environment and Parks 1987). Otherwise the raccoon is not known to occur in the region, although it is well established in the Queen Charlottes where it was introduced. The Sitka mouse, also included in the region list, occurs on offshore islands around the Queen Charlottes. There is some confusion over the taxonomy of some of the *Peromyscus* species, and it may or may not occur in the region (see Appendix 4ii for details). Similarly the Columbian mouse could also occur, although it seems unlikely on the basis of information in Nagorsen (1990).

7.1.3 Non-breeding species

It is uncertain how many of the bird species recorded in the region are breeding. In addition to the 8 pelagic, 20 accidental, and at least 34 casual species in the region for which there are no breeding records, there are also some non-breeding residents and regular migrants. Altogether, breeding records exist for only 166 of the 288 confirmed species for the region. However, it is likely that many of the species not yet recorded as breeding do breed. In fact, the total number of breeding bird species likely exceeds 200 of the 288 species recorded for the region, perhaps by a considerable number.

Many of the non-breeding species, although identified and included in the subzone analyses (Section 7.3), are not generally considered further in determining habitat affinities and management groups. As noted above, breeding for some of these species is likely but is unrecorded, due to a relatively low number of human observers, secretive habits, and remote nesting habitats.

Several species for which there are no breeding records have been retained in the analyses here, because we thought that they very likely do breed in the region, and/or are generally of interest in forest management. Examples are Cooper's Hawk, Northern Pygmy Owl, Short-eared Owl, and Vaux's Swift.

Some of the non-breeding birds use the region for staging and resting on migration, or for wintering (all along the Pacific coast from Alaska to Chile). Most of these species are Arctic and Siberian breeding species such as the Greater White-fronted Goose, Snow Goose, Black-bellied Plover, Ruddy and Black Turnstone, Surfbird, Red Knot, many other sandpipers, Snowy Owl, Tundra Swan, and Rough-legged Hawk. These species largely use non-forested wetland areas or high elevation tundra habitats, and are of little relevance in forest management. Many of them are of management concern for a variety of reasons, but their populations are strongly influenced by external factors (e.g., management practices in their breeding grounds). Consequently, beyond identifying their recorded occurrence by subzone, we have not examined these species in further detail.

Other non-breeding species are at the northerly and westerly limits of their ranges, and sightings may be mostly of dispersing juveniles. Examples include Wood Duck, Virginia Rail, and Long-eared Owl. Some of the species at the edge of their breeding ranges may be added to the regional breeding bird list in the future, as reporting improves or range expansion occurs. Gradual range expansions and shrinkages are in part natural, but may also be accelerated or decelerated by artificially induced environmental changes, including climate changes and forest cover changes. However, these non-breeding species are, at the present time, of marginal concern to forest managers in the region.

7.1.4 Introduced species

Non-native introduced species to the region are the European Starling, Rock Dove, House Sparrow, house mouse, black rat, and Norway rat. These are largely considered pest species. One game bird, the Ring-necked Pheasant, is also introduced.

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[21] Hay, R.B. 1976. An environmental study on the Kitimat Region with special reference to the Kitimat River Estuary. Environ. Can. Can. Wildl. Serv. Pac. and Yukon Region. Unpubl. rep.

Local introductions and transplanting of native species have also occurred. Fisher, for example, have been introduced into the Khutzeymateen in an effort to control porcupine damage (Sullivan and Cheng 1989).

7.1.5 Hypothetical species

Several additional species could conceivably occur. No systematic attempt to identify all hypothetical species has been made here. These are considered possible or probable based on their occurrence elsewhere, in particular in the Queen Charlotte Islands. There are no confirmed records as yet for species in the Prince Rupert Forest Region. Many of the Queen Charlotte species, however, would not find Hecate Strait a significant barrier, and they can be expected in the region on occasion. These include the Laysan Albatross, Buller's Shearwater, Red-faced Cormorant, Magnificent Frigatebird, Great Egret, Emperor Goose, Eurasian Wigeon, Snowy Plover, Curlew Sandpiper, and Thick-billed Murre.

7.2 Species Diversity in a Regional, Provincial, and National Context

7.2.1 National and provincial context

The overall diversity of terrestrial vertebrates is largely a consequence of the diverse terrain, climatic regimes, and consequent vegetation communities, coupled with natural and artificially induced disturbance regimes. For a northern temperate nation, Canada contains a great diversity of wildlife and a unique representation of larger forms. Within Canada, most of that diversity is present in British Columbia.[22] Of the country's total native fauna, the province has about 70% of the breeding birds, 72% of the terrestrial mammals, 49% of the amphibians, and 41% of the reptiles.[23]

More than 600 terrestrial vertebrate wildlife species occur in British Columbia (Bunnell 1990). Almost one-quarter (28) of the mammal species in Canada occur only in this province (Bunnell and Williams 1980). British Columbia has more breeding birds and more mammals than any other province or territory, has many unique species, and has an even greater proportion of unique subspecies (see section 7.2.6).

Although less rich in species than the warmer, southern latitudes of the province (see Section 7.3 below), the Prince Rupert Region supports a considerable range of species unique to Canada or British Columbia, and supports breeding populations of world significance for a number of species. It is noteworthy that most of the species in the province are forest-dwelling, and about 72% of the provincial mammalian fauna is dependent to some degree on forest cover (Bunnell 1990).

The relative proportions of the provincial fauna represented within the region are illustrated in Figure 3. Provincial totals represent minimums, as taken from Cannings and Harcombe (1990).

7.2.2 Threatened/endangered species (provincially and nationally)

Species considered at risk at a national level are listed by the Committee on the Status of Endangered Wildlife in Canada. Regional species or subspecies currently listed by the Committee are the Anatum Peregrine Falcon (endangered), the Marbled Murrelet (threatened), and the Caspian Tern, Cooper's Hawk, Great Gray Owl, Peale's Peregrine Falcon, Trumpeter Swan, Keen's long-eared myotis, and western woodland caribou (vulnerable) (Munro 1990).

A total of 112 species confirmed for the region is listed on the latest provincial status lists (B.C. Ministry of Environment 1991b). Two species, the Keen's long-eared myotis and the Marbled Murrelet, and one subspecies, the Anatum Peregrine Falcon, are red-listed as provincially endangered species.

[22] Bunnell, F.L. [no date]. Biodiversity: what, where, why, and how. Univ. of B.C., Vancouver, B.C. Unpubl. draft.
[23] Ibid.

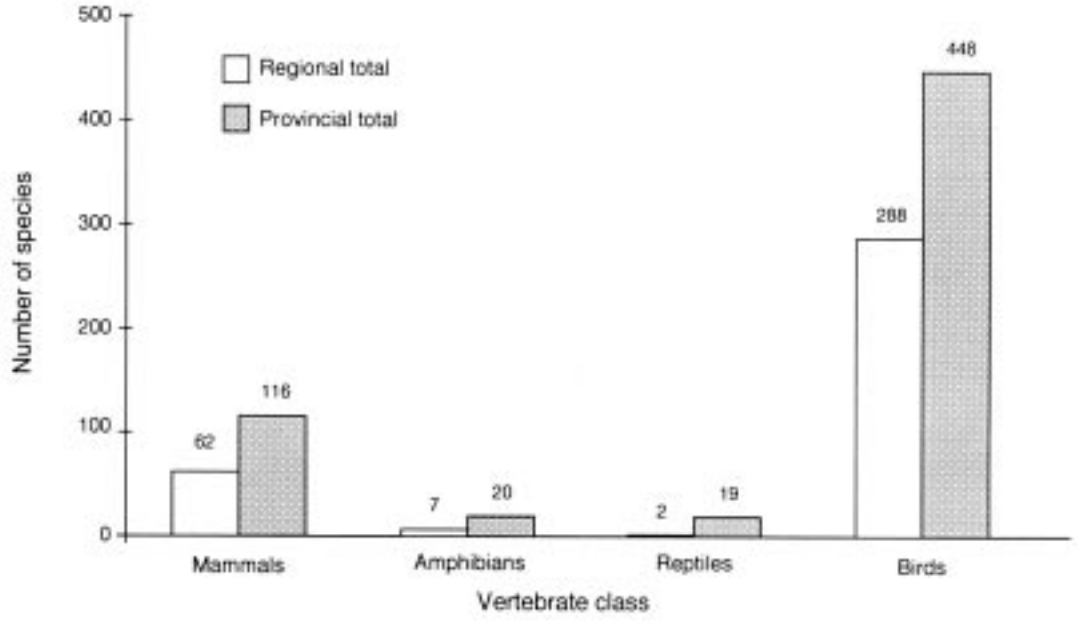

FIGURE 3. Vertebrate species: regional and provincial totals.

A further 37 species (1 amphibian, 31 birds, and 5 mammals) are on the blue list. That is, they are considered to be threatened species within the province (three of these — the Long-billed Curlew, Horned Puffin, and Lewis' Woodpecker — are accidental to the region). The tailed frog is the only blue-listed amphibian. The birds include a number of ducks, seabirds, and shorebirds, several raptors (Bald Eagle, Peale's Peregrine Falcon, and Gyrfalcon), and several typically northern passerines (Gray-cheeked Thrush, Northern Shrike, Brewer's Sparrow, Arctic Longspur, and Snow Bunting). Mammals on the blue list are the tundra shrew, fisher, grizzly bear, Dall's thinhorn sheep, and caribou.

Seventy-two of the confirmed regional species appear on the provincial yellow list. Criteria for inclusion on this list include social and economic factors rather than strictly biological ones. The species included are generally of management concern because they are managed as big game, furbearers, or game birds, or they are of high public interest for some other reason.

7.2.3 Reptiles and amphibians

Of the seven amphibians recorded for the region, four are represented in Canada only within British Columbia. These are the spotted and tailed frogs, northwestern salamander, and rough-skinned newt. The two reptiles recorded — western and common garter snake — both reach their northerly limits within the region.

7.2.4 Mammals

Mammals of particular significance, in terms of biodiversity, include the many Beringian species reaching the southern limits of their distribution within the region. This includes such species as Dall's and Stone's sheep, arctic ground squirrel, tundra shrew, tundra vole, and collared pika. Other typical northern species are the northern red-backed vole, brown lemming, and northern bog lemming. Several of these species, including the collared pika, Dall's sheep, tundra shrew, and tundra vole, are unique to this region. Others (e.g., Stone's sheep) are shared with the Prince George Forest Region. In general, these species occupy alpine and tundra habitats and are of relatively minor concern in forest management.

Small mammal communities are particularly diverse in the north. Krebs and Wingate (1976), working in Kluane National Park in the Yukon, recorded 19 small mammal species, and found the study areas to have the highest diversity of microtine rodents in North America. It is likely that small mammal communities in the SWB and BWBS zones, in the north of the region, are similar in composition.

The province has a majority of the world's population of mountain goat, which is best represented within the Prince Rupert Forest Region. Grizzly bear and caribou are also nationally (and internationally) significant resources.

Mammals reaching their northerly limits within the region include the southern red-backed vole and several of the bats, such as Keen's long-eared myotis (which is largely confined to British Columbia) and the silver-haired bat. The latter two species are confined to coastal areas.

Species that occur through much of the region, reaching their northerly limits within the Yukon, include the deer mouse, heather vole, least chipmunk,and long-tailed vole (Krebs and Wingate 1976). Species typically found throughout the region include moose, marten, red squirrel, snowshoe hare, beaver, porcupine, short-tailed weasel, gray wolf, and grizzly and black bear. The least weasel may occur through much of the region, but is probably at very low densities.

7.2.5 Birds

The north is also important for the production of many waterfowl species, particularly Northern Pintail, scaup, and Green-winged Teal. Estimates for the Kawdy Plateau alone are 3, 3, and 4% respectively, of total British Columbia breeding populations for these species (Hawkings and Majiski 1991).

The Prince Rupert Forest Region is the only known nesting area in the province for Oldsquaw (there is only one confirmed record; the known regular breeding range is some distance away), and one of only two known areas for breeding Red-breasted Mergansers. The latter species breeds only on the Teslin Plateau, and in Masset Inlet in the Queen Charlotte Islands. The region is also an important nesting area for the Pacific Loon, which breeds on the Teslin Plateau and throughout the Liard Basin (including sites north of the Prince George Forest Region); and a breeding area for Barrow's Goldeneye. The province is the major breeding and wintering area in the world for this species.

Several shorebird species appear to breed in British Columbia only within this region, breeding in subalpine and alpine habitats in the Chilkat Pass area of the St. Elias Mountains. These species appear to be at the southern edge of their breeding ranges in this area. They include the Wandering Tattler, Hudsonian Godwit, and Red-necked Phalarope (see Campbell *et al.* 1990). These species may also breed elsewhere in the Northern Mountains and Plateaus ecoregion.

The Lesser Golden Plover has only one confirmed breeding record for British Columbia, on the Spatsizi Plateau (six pairs; see Campbell *et al.* 1990). There are also a number of species that breed only in the Prince Rupert Region and one or two other localities (generally the Queen Charlotte Islands). The Semipalmated Plover breeds mainly in the Northern Mountains and Plateaus, the Chilkat Pass area, and the Queen Charlotte Islands (there are also two other disjunct localities). The Short-billed Dowitcher also breeds in the extreme northwest, and there is one record from the Queen Charlotte Islands. The Least Sandpiper breeds in the Chilkat Pass area, the Spatsizi Plateau, and the Queen Charlotte Islands. It is also thought to breed throughout the Northern Mountains and Plateaus where suitable habitat occurs (Campbell *et al.* 1990).

Of the gulls and terns, the Arctic Tern breeds in British Columbia only in the northwest, from the Tatshenshini River east to Atlin and south to Spatsizi.

Amongst the raptors, the Gyrfalcon appears to breed only within this region, where it breeds throughout the Northern Mountains and Plateaus from the St. Elias Mountains southeast to Spatsizi. Breeding populations of Bald Eagles and both Peale's and Anatum Peregrine Falcons occur, although the coastal subspecies is more abundant around the Queen Charlottes. At least two pairs of tree-

nesting Peregrine Falcons have been recorded on Byers Island, in Ecological Reserve #103 (B.C. Ministry of Environment and Parks 1987). Provincially significant numbers of Osprey also breed in the region.

Other typical northern breeding species, unique in British Columbia to this region, are the Northern Shrike, Gray-cheeked Thrush, Common Redpoll, American Tree Sparrow, Snow Bunting, and Smith's Longspur. Alpine and northern breeding species shared with other regions include the Rock Ptarmigan, Willow Ptarmigan, Pine Grosbeak, and White-winged Crossbill, as well as three owl species—the Boreal Owl, Great Gray Owl, and Northern Hawk Owl.

As in other parts of the coast, Marbled Murrelets are common in some inlets, such as Gardner Canal and Khutzeymateen Inlet, and likely are breeding. Significant colonies of some of the seabirds, including Ancient Murrelets, Rhinoceros Auklets, Cassin's Auklet, and Leach's and Fork-tailed Storm Petrels, also occur on the outer coast, although they are more abundant around the Queen Charlottes. Tufted Puffins breed in these Ecological Reserves as well. The Pigeon Guillemot breeds in the southern coastal portion of the region, where it appears to reach the northern edges of its breeding range. Information on the colonies that occur in Ecological Reserves in the region is provided in Table 4.

TABLE 4. Seabird colonies in Ecological Reserves of the Prince Rupert Forest Region (compiled from information in B.C. Ministry of Environment and Parks 1987)

Species	Ecological Reserve		
	23	25	103
Ancient Murrelet	X		
Rhinoceros Auklet	X		X
Cassin's Auklet	X	X	X
Tufted Puffin	X		X
Leach's Storm Petrel	X		X
Fork-tailed Storm Petrel	X		X
Marbled Murrelet	P		
Pigeon Guillemot	X		
Glaucous-winged Gull	X		X
Black Oystercatcher	P		X

X indicates a breeding colony is present within the reserve.
P indicates probable breeding.

Ecological Reserves:
#23 - Moore, McKenney, and Whitmore islands
#25 - Dewdney and Glide islands
#103 - Byers, Conroy, Harvey, and Sinnett islands

7.2.6 Subspecies diversity

It is also worth noting that at the subspecies level, British Columbia has an even greater proportion of the representation of national vertebrate diversity. Of at least 547 mammal subspecies, 286 occur in the province. Of these, 163 are exclusive in Canada to British Columbia (Bunnell and Williams 1980).

7.3 Species Diversity by Subzone/Variant

7.3.1 Species/subzone matrix

Terrestrial vertebrate occurrence was identified for the region by subzone, and variant where appropriate, and according to season for birds. The data are summarized in Figure 4, and the full species/subzone matrix is provided in Appendix 5. Some of the variants were amalgamated because there was insufficient information to distinguish between them in terms of wildlife occurrence and habitat use. For example, the ESSF mc and mk were amalgamated, as were the CWH ws1 and ws2. The MH undifferentiated was not separated out in the tables, since no specific information exists.

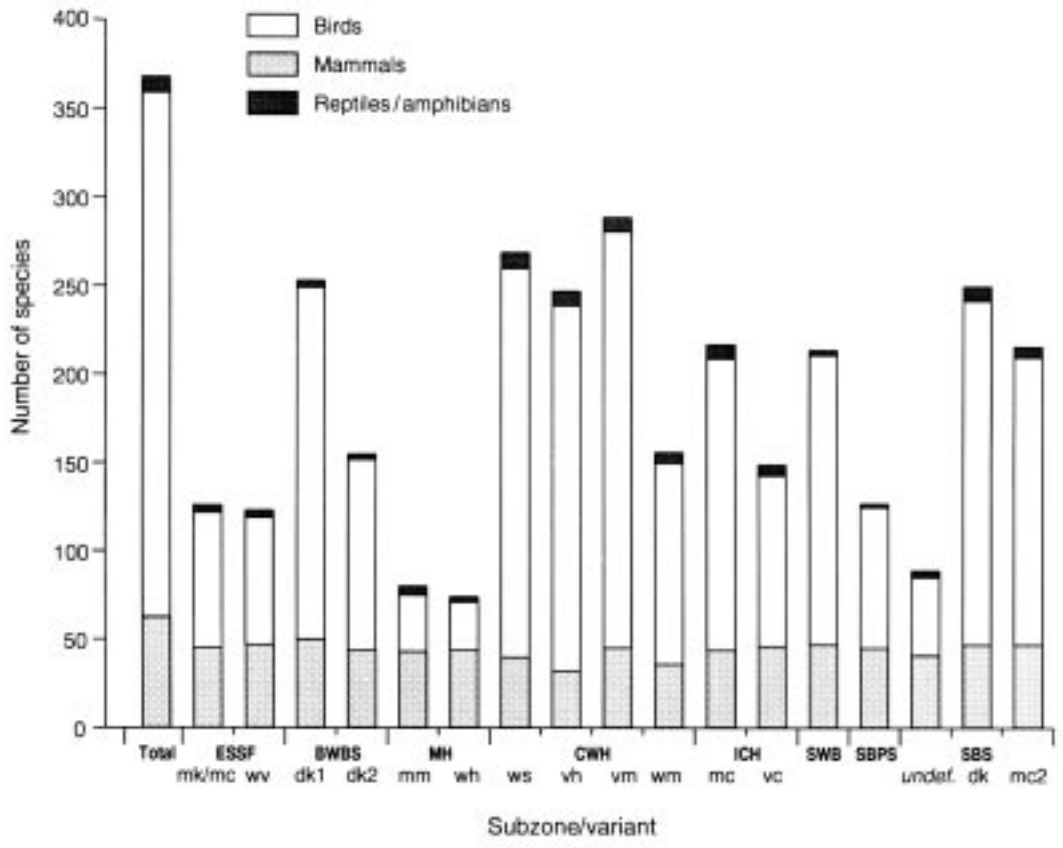

FIGURE 4. Terrestrial vertebrate species by subzone/variant.

For reptiles, amphibians, and mammals, occurrence is reported on a presence/absence basis only. This is on the assumption that, for the most part, these species will be present year-round within the subzones/variants, and will breed within them. There are of course exceptions, primarily with the large, migratory ungulates that use different subzones seasonally, and the bats, many of which will be absent in winter as they migrate south. Also, winter-dormant or hibernating species such as bears and ground squirrels may be essentially absent from some subzones/variants in the winter months (e.g., grizzly bears are likely to be present in the ESSF subzones in winter months, although not active, and to be absent from some of the low-elevation subzone/variants).

For birds, information on seasonal use is essential. The Royal British Columbia Museum has distribution maps at 1:2 000 000, with occurrence and breeding records of each species plotted. It is thus usually possible to determine, from location records, the subzones and variants where species were recorded, and when. For birds, seasonal occurrence is provided in the tables. Information sources used in determining distributions are given in Appendix 4ii. Highly pelagic species were not identified by subzones.

No detailed analyses of community composition in the different subzones have been undertaken. However, overall, we might expect fewer differences among communities of birds across the region than for mammals, reptiles, and amphibians, due to birds' greater mobility. The following discussion looks briefly at general trends. Typical species for each subzone/variant are not discussed but can be surmised from the tables, together with information in the individual subzone chapters in Meidinger and Pojar (1991).

7.3.2 The North — SWB, BWBSdk1 and BWBSdk2, BWBSvk, and SBS undifferentiated

Species diversity in the region is strongly affected by the harsh northern and interior climates that predominate over much of the area. This is a major limitation for the distribution of many vertebrate species. Only those physiologically or behaviourally adapted to survive the long, cold winters (e.g., through hibernation or migration) can occur. Consequently, these northern interior portions of the region are likely to be significantly less diverse than the more southerly latitudes.

This is borne out to some extent by existing data. For example, reptiles are entirely absent from these northerly subzones, and amphibians are restricted to four species. The most widespread are the western toad, spotted frog, and wood frog. The wood frog would seem to be the best adapted of the amphibians for cold climates. It is believed to have survived in Beringia and to have subsequently dispersed southwards (Environment Canada 1985). Environment Canada (1985) notes that the distribution of various amphibians in the north appears dependent on length of the summer frost-free period, rather than on winter severity. Approximately 100 days seems to be the minimum time for maturation to the adult stage.

Waterfowl populations in the extreme north (mainly in SWB and alpine habitats) exhibited far fewer species present than occurred in parklands of central British Columbia, and also far fewer breeding species (8 vs. 23) (Hawkings and Majiski 1991). Nevertheless, overall species diversity still appears to be considerable, particularly at the lower elevations. A total of 256 terrestrial vertebrates is reported for the BWBSdk1, lower only than CWH subzones. In particular, small mammal communities in the north area are surprisingly diverse (see Section 7.2.4).

Although growing season is short and annual productivity relatively low in the northern BWBS and SWB subzones/variants, these areas are nevertheless significant in terms of wildlife production. Hawkings and Majiski (1991) suggest the quality of wetlands on the Kawdy Plateau (largely SWB) is similar to that in lower-elevation wetlands (mainly BWBS) in terms of waterfowl productivity. This is also likely true for many of the shorebirds.

In the Canadian Wildlife Service studies, the higher-elevation communities (SWB) were found to be dominated by a small number of species (mainly scaup, Northern Pintail, and Green-winged Teal) present in high abundance, compared to lower-elevation wetlands in the Teslin Plateau and Liard Plain (BWBS dk1 and dk2). These latter had many more species, such as Bufflehead, Barrow's Goldeneye, Mallard, and American Wigeon (Hawkings and Majiski 1991). Consequently, these BWBS variants have high significance for biodiversity, in spite of their relatively low annual productivity and presumed low diversity in terms of year-round residents.

Many species of interest such as Smith's Longspur and American Tree Sparrow breed in these northern areas (see Section 7.2.5). Most of the birds are migratory, wintering further south, but they find excellent breeding habitat in these northern areas.

The higher diversity of the BWBSdk1 over the BWBSdk2 and BWBSvk is probably at least partly an artifact of recording effort. Several studies and collections have been made in the Atlin area and the Haines Triangle area.

7.3.3 The Interior — SBSdk and SBSmc2, SBPS, and ICH subzones and variants

As in the north, the harsh cold winters in the interior limit species distribution. Because the SBPS in particular represents such a small part of the region, there are very few records from within the region for this subzone. Many species are not on the lists, though they probably occur and breed in the SBPS, such as Mallard, Northern Pintail, Blue-winged Teal, and possibly Cinnamon Teal. Records from the Cariboo Forest Region would likely provide better information on vertebrate use of both the SBPS and the SBS subzones. For the SBPS, only one amphibian and no reptiles have been recorded, but several probably occur. Their diversity would, however, be limited by the cold winters and relatively short cool summers.

There are also several species that may occur in these subzones (particularly in the SBS and SBPS) that do not occur widely in the rest of the region. Examples are the Marsh Wren and Gray Catbird. These are primarily species nearing the western and/or northern edges of their breeding ranges. Typical interior species such as the Boreal Owl and Great Gray Owl occur here as well as further north.

The ICH subzones also may actually harbour considerably more diversity of species than is apparent from the tables. In this region, the ICH is transitional between coastal and interior ecosystems, and might be expected to have a number of typically coastal species, as well as typically interior species.

7.3.4 The Coast — all CWH subzones

The CWH zone, and in particular the vh and wm subzones, is the most diverse zone in the region. This zone incorporates many unique habitats, including offshore islands (in the vh), rocky shorelines, estuaries, and marine cliffs, and consequently has a source of diversity absent from all other zones. This is particularly significant for breeding seabirds such as the Rhinoceros Auklet, Cassin's Auklet, and Leach's and Fork-tailed Storm-Petrels, and for several non-breeding birds such as cormorants and Black Oystercatchers. Breeding Sandhill Cranes also occur in this zone.

Even without this additional source of diversity, the CWH might be expected to be relatively rich in species, since coastal climates are milder than interior and northern climates, productivity is higher, and structural diversity in coastal old-growth forests is higher than in interior old growth (Pojar *et al.* 1990). The relatively mild winters enable a greater diversity of wintering species to occur than elsewhere in the region. Important wintering habitat occurs for species such as the Trumpeter Swan (in estuaries and lakes), Barrow's Goldeneye, Harlequin Duck, and Western Grebe (inshore waters), and many of the forest-dwelling species, including many raptors, woodpeckers, game birds, and passerines, are resident all year.

Although the richest regional zone for vertebrate species, the CWH zone within this region is less diverse than the CWH further south. Provincial totals for the CWH are 285 species for hypermaritime, 396 for maritime (these figures have been adjusted to exclude marine mammals), and 305 for submaritime subzones.[24] Regional totals in comparison are 254 (89%) for the CWHvh, 298 (75%) for the CWHvm, and 274 (90%) for the CWHws (note that these totals are based on both confirmed records and the speculated distributional data incorporated in tables in Appendix 5). The most northerly subzone, the CWHwm, is apparently less diverse still, with only 156 species recorded. This may be partially due to lack of recording, although there are likely some real differences. (Note that these totals exclude species considered accidental or highly pelagic.)

The moist, mild climate permits a number of amphibians, largely absent elsewhere in the region, to inhabit the zone. However, of 20 amphibians listed for the province and 12 for the CWH zone,[25] only 6 generally occur in the Prince Rupert Forest Region. Major zoogeographic barriers have probably restricted movements of many of the southerly amphibian species up the coast. In closed-canopy Douglas-fir forests in Oregon, small mammal and amphibian distributions were affected much more by zoogeographic barriers to dispersal than by longitude or elevation, and small, localized distributions of many species — especially amphibians — occurred (Aubry 1989). The rough-skinned newt, northwestern salamander, and tailed frog have only been found in the CWH zone, while the wood frog is largely absent from this zone.

Mammals largely absent from this part of the coast include the Beringian species (see Section 7.2.4) and the western long-eared myotis, meadow vole, woodchuck, chipmunks, long-tailed and least weasels, and mule deer. Caribou are also generally absent (although there are records, such as from the Gamsby River drainage). Species such as the lynx and snowshoe hare are also more interior

[24] Stevens, V. 1990. Wildlife ecosystem relationships in the Coastal Western Hemlock. B.C. Min. For., B.C. Min. Environ. and Parks, Victoria, B.C. Unpubl. draft.
[25] Ibid.

species, and are generally uncommon in the CWH and absent from the hypermaritime. Moose have been gradually expanding west and are now in many of the coastal watersheds, although probably not in the hypermaritime.

Mammals largely confined to the coast include the Sitka black-tailed deer (subspecies of mule deer) and some of the bats. These probably occur in the adjacent MH subzone as well.

It is likely that the CWH, with the many small offshore islands and many zoogeographic barriers, harbours a high degree of intraspecific diversity, compared to the interior. This would particularly be the case for mammals. Overall, it seems likely that much of the diversity on the coast is at a microscale — that is, a result of the wide range of unique microhabitats of high value for wildlife.

7.3.5 ESSF and MH subzones

These subzones are likely to receive use by many of the vertebrates in adjacent, lower-elevation subzones (i.e., many of the CWH species will occur in the MH, and many SBS and ICH species in the ESSF). However, a reduction in species diversity with increase in elevation seems probable, on the basis of climatic and productivity changes with elevation. Many of the species in the adjacent lower zones may not get up into the higher elevations, and many of those that do (such as the red squirrel) are likely present at lower densities, and often for restricted seasons.

Nevertheless, a number of species are characteristic of the higher-elevation forests, including birds such as Clark's Nutcracker, Golden-crowned Sparrow, Hermit Thrush, and Willow Ptarmigan. Mammals such as the collared pika, wolverine, mountain goat, and many small rodents often find optimal habitats in higher-elevation forests and parklands. Some excellent seasonal grizzly bear and caribou habitats also occur, particularly in the ESSF. Many raptors find excellent hunting opportunities in these forests and adjacent parklands, and some use associated cliffs and talus slopes for nesting habitat.

Overall, however, it does appear from the tables that both the ESSF, and more particularly the MH, are relatively impoverished in vertebrate diversity. Again, it is difficult to know how much of this is due to lack of sampling. Because people do not generally live or work in these subzones and access is often limited, the occurrences are poorly recorded. On the other hand, a lot of recreational activity occurs at the higher elevations, particularly in the parklands. We might expect the ESSF to have received more attention than the MH, as the latter is often relatively inaccessible and often commercially inoperable. This may partly account for the apparent low diversity in the MH. On the other hand, the MH is rugged, cold, wet, and immensely snowy, and vertebrate diversity is almost certainly significantly lower in this zone than in the others.

8 HABITAT AFFINITIES: RED-, BLUE-, AND YELLOW-LISTED SPECIES

Habitat affinities for species on the provincial red, blue, and yellow lists — except two considered accidental (Horned Puffin and Long-billed Curlew) — are shown in the tables provided in Appendix 6. Individual species notes are incorporated in Appendix 4ii. Status was based on a listing produced by the B.C. Ministry of Environment in February 1991 (B.C. Ministry of Environment 1991b). Note that the provincial list is regularly revised, and readers requiring the most up-to-date information should contact the B.C. Ministry of Environment, Lands and Parks, Wildlife Branch.

9 MANAGEMENT INDICATOR SPECIES

9.1 Uses of Management Indicator Species

Management Indicator Species (MIS), simply defined, are any vertebrate or invertebrate species whose population changes are believed to indicate the effects of land management activities. Indicator species are being used increasingly in North America for what is assumed to be a cost-effective way of monitoring the effects of management on wildlife populations and habitats.

In the United States, models are developed for each MIS and these are applied to forest planning. The MIS populations are monitored to evaluate the applicability of the MIS, and to assess whether project objectives are being met. Research and management efforts consequently are focussed on a relatively small number of species, collectively intended to represent the complex of habitats, species, and associated management concerns (Sidle and Suring 1986).

9.2 Criticisms of MIS

The use of MIS has been critically reviewed by a number of authors, including Block *et al.* (1987), Patton (1987), Landres *et al.* (1988), and Harcombe *et al.* (1989). All of these authors express serious reservations about using particular vertebrate species to indicate population trends and habitat suitability for other species. In wildlife management, MIS are generally used to:

- assess population trends for other species (essentially the guild indicator concept, also discussed below in Section 10); and
- determine habitat quality for other species, communities, or ecosystems (Harcombe *et al.* 1989).

The main criticisms of these two approaches are summarized below.

- Using an indicator species to assess population trends in other species (guild indicator species) appears to be inherently flawed. Through evolutionary processes and niche differentiation, no two species are exactly alike in their ecological requirements, and are thus unlikely to exhibit parallel trends or responses to changes in their environment. To work, the indicator species must be ecologically as close as possible to the other species it is indicating. Yet the closer they are, the more these species will be competing for the same resources. Thus, for example, a downturn in the indicator species population in response to management may free up limited resources for ecologically similar species, and the effects of this may override any direct effects of management. In addition, the species are likely to differ in other aspects of their biology, such as susceptibility to disease or predation, which introduces added error into the assumptions. Furthermore, indicators are based on guilds, yet the composition of any particular guild is likely to vary, both spatially and temporally.
- Implicit in using MIS to indicate habitat quality for other species is the assumption that the population density of the indicator is an index of quality for that species, and that quality for other species can be directly extrapolated from habitat suitability of the indicator. Difficulties with these assumptions are discussed in some detail in Harcombe *et al.* (1989). They are:
    - Density is a tenuous index of habitat quality.
    - Managing for the ecological indicator will overlook other species' needs.
    - Lack of long-term research at present negates the possibility of assessing efficiency.

In addition to the above, the notion of cost-effectiveness in using MIS, even with a conspicuous, easily recognized species, has been largely dispelled by Verner (1984).

It is clear that MIS are not a panacea for resolving the complexities of managing our forests (or other habitats) to maintain biodiversity. However, as Wilcove (1989) points out, MIS are useful tools for managing

multiple-use lands, as they give a direction and focus to efforts to protect biodiversity. Consequently, MIS for the region have been selected within the categories listed below. It must be stressed, however, that MIS should be selected from these lists only in keeping with specific assessment objectives, should be applied with extreme caution, and should be used only if no applicable alternative exists. Direct measurements, for example of habitat components, are often possible and preferable, and more cost-effective.

9.3 MIS Selection Process

Species were selected, through a process of elimination, within the following five categories:

1. threatened or endangered species
2. species of commercial value
3. species of special interest (e.g., for wildlife viewing)
4. species believed sensitive to forestry management practices
5. ecological indicator species

Because we did not review all species in the region, a crude first cut was made in which species thought to belong to one of the above categories, and species used as indicators in Alaska, were initially identified. This limited selection was then discussed at a workshop held in Smithers in February 1991. Participants (Appendix 8) also raised some additional species for discussion during the course of the day.

The process used to select MIS was adapted from that established in the United States, as reported in Sidle and Suring (1986). This involved:

1. identification of species within the categories of potential MIS.
2. consideration of whether the species represent a significant diversity or productivity issue at local, regional, or provincial levels. Species felt to be of little significance were rejected.
3. consideration of factors affecting population abundance. Species with irruptive occurrence (many finches) were rejected; those with regular cycles were retained if the reasons for population fluctuations were well understood; those subject to influences entirely beyond the control of the region or Forest Managers were rejected at this stage.
4. consideration of monitoring feasibility. The majority of species were given a subjective ranking of 1 (easy to monitor) to 3 (most difficult). An assessment of 3, however, did not automatically exclude a species from further consideration. A species difficult to monitor may still be a valuable indicator (depending on objectives), and the development of new techniques may render some of these species easier to monitor in future.

9.4 Elimination of Species

Species were rejected from further consideration for MIS if they:

- were too versatile or variable in their habits to make good indicators (e.g., Barred Owl, Osprey, Chestnut-backed Chickadee, Merlin, Olive-sided Flycatcher, Gray Jay, Hairy Woodpecker, Hermit Thrush, and river otter).
- had little relevance for forestry management (e.g., Red-throated Loon, Brewer's Sparrow, Willow Ptarmigan, Common Snipe, tundra shrew, tundra vole, muskrat, red fox, coyote, and striped skunk).
- could be better represented by other species for the same purpose (e.g., wilderness species may be better indicated by caribou and wolverine than by gray wolf, and the latter was therefore rejected).
- were strongly dependent on particular prey species. In such cases it was felt that the prey might be more suitable to monitor than the predators (e.g., gray wolf, lynx).
- were subject to too many variables outside regional control, or outside forest management control (e.g., irruptive species, such as the crossbills, Steller's Jay, and many migratory birds that winter to the south).

- were highly specialized species, which may make them important on a site-specific basis, though they are unlikely to be appropriate as more general habitat indicators (e.g., the Rhinoceros Auklet or Ancient Murrelet).
- had very localized distributions (e.g., Wood Duck).

Species were not specifically rejected because they are at the edges of their range within the region. Scudder (1989, cited in Cannings 1990) suggests that marginal populations have a high adaptive significance to the species, which emphasizes the value of marginal habitat conservation. Weber (1980) also included peripheral species in a list of rare and endangered breeding bird species for the province, and suggested that they should be monitored.

9.5 Results

Overall, 115 species and 1 additional subspecies (69 birds, 44 mammals, and 3 amphibians) were briefly reviewed for their suitability as MIS. In some cases, species were discussed as groups rather than individually. This resulted in a first cut of 53 species tentatively accepted, with 63 species rejected (see Table 5).

TABLE 5. Management Indicator Species: accepted and rejected

Species accepted at first cut (N = 53)			
Bald Eagle	Common Merganser	Mountain Goat	Rough-skinned Newt
Barrow's Goldeneye	Common Pika	Mule Deer	Sandhill Crane
Beaver	Golden-crowned Kinglet	Northern Flying Squirrel	Sharp-shinned Hawk
Big Brown Bat	Great Blue Heron	Northern Goshawk	Silver-haired Bat
Black Bear	Grizzly Bear	Northern Red-backed Vole	Snowshoe Hare
Black-tailed Deer	Harlequin Duck	Northern Saw-whet Owl	Solitary Vireo
Boreal Owl	Keen's Long-eared Myotis	Northern Waterthrush	Southern Red-backed Vole
Brown Creeper	Least Flycatcher	Northwestern Salamander	Three-toad Woodpecker
Bufflehead	Little Brown Myotis	Pileated Woodpecker	Vaux's Swift
California Myotis	Long-legged Myotis	Porcupine	Warbling Vireo
Caribou	Marbled Murrelet	Red Squirrel	Water Shrew
Clark's Nutcracker	Marten	Red-breasted Sapsucker	Western Long-eared Myotis
Collared Pika	Moose	Red-eyed Vireo	Wolverine
			Yuma Myotis

Species rejected at first cut (N = 63)			
Ancient Murrelet	Gray-cheeked Thrush	Pacific Loon	Townsend's Warbler
Arctic Tern	Great Gray Owl	Peregrine Falcon - Peale's	Tree Swallow
Barred Owl	Great Horned Owl	Peregrine Falcon - Anatum	Tundra Shrew
Black-backed Woodpecker	Greater Yellowlegs	Purple Finch	Tundra Vole
Blue Grouse	Hairy Woodpecker	Pygmy Shrew	Varied Thrush
Bonaparte's Gull	Heather Vole	Red Crossbill	White-tailed Deer
Brewer's Sparrow	Hermit Thrush	Red Fox	White-tailed Ptarmigan
Chestnut-backed Chickadee	Hooded Merganser	Red-breasted Nuthatch	White-winged Crossbill
Common Goldeneye	Leach's Storm-Petrel	Red-throated Loon	Willow Ptarmigan
Common Snipe	Least Chipmunk	Rhinoceros Auklet	Wilson's Warbler
Cougar	Lynx	River Otter	Wood Duck
Dusky Shrew	MacGillivray's Warbler	Rosy Finch	Woodchuck
Earred Grebe	Merlin	Ruffed Grouse	
Fisher	Mountain Bluebird	Sitka Mouse	
Fork-tailed Storm-Petrel	Muskrat	Spruce Grouse	
Gray Jay	Olive-sided Flycatcher	Striped Skunk	
Gray Wolf	Osprey	Tailed Frog	

A full list of accepted species by category, together with broad geographic areas for which the species are applicable, are given in Appendix 7i. The general areas are given as coastal, interior, northern, and high elevation, grouped as in Sections 7.3.2–7.3.5. Species have not been categorized specifically by subzone

and variant at this stage, since there is poor distributional information, with few records for many of the species and subzones. A list of species not considered during the workshop is provided in Appendix 7ii.

These species cannot presently be recommended as MIS without much more rigorous assessment. If a species is to be used as an indicator, a detailed knowledge of its life history and ecology must be available. Detailed reviews of the species provisionally accepted should be undertaken, and the provisional list should be further refined, before specific MIS recommendations can be made.

Some of the species not considered in the assessments should also be considered for MIS status as more information becomes available; the passerines in particular were under-represented in this process due to lack of information. Similarly, some of the initially rejected species should be re-considered if new information suggests a reappraisal is needed.

9.6 Indicator Species Characteristics

Species likely to make the best indicators are those that:

- are easy to identify
- are noisy or leave conspicuous sign
- are capable of being monitored by direct correlation of sign (pellets, browse, tracks, etc.) sightings, and trapping data, by established techniques
- are sensitive to environmental change
- are users of readily identifiable forest structures
- have a relatively well-known life history (essential)
- have home ranges or nesting territories that are clearly defined and can be monitored

Species with naturally low densities and cyclic species may be particularly difficult to monitor, but should not be excluded on this basis. Year-round residents and breeding species should generally be selected.

Szaro and Balda (1982) suggest that ideal indicators should be conspicuous by sight and sound, and should operate during hours when people are active. These authors focus their attention on birds. However, there appears to be no reason why an indicator species should be diurnal, if it can be effectively monitored by methods not involving direct observation. Small nocturnal mammals or amphibians that can be sampled by pitfall traps, or species adequately enumerated on the basis of scat counts, for example, are equally valid.

The amphibians, with their limited dispersal capabilities and apparent associations with moist, mature forests, may be more valuable monitors on the coast than species with high dispersal capabilities. Aubry (1989) points out that they are much less mobile and far more sensitive to adverse environmental conditions than either birds or mammals, and that this has resulted in disjunct distributions and small, localized populations for many terrestrial and aquatic species.

9.7 Application of MIS

9.7.1 Objectives of using MIS

If our overall aim is to maintain the full range of diversity within our forested areas, we need to combine multiple species management objectives into appropriate and practical management strategies. The idea of using MIS is that the species selected would collectively represent all of the habitats and species, and the management concerns, in the area. Species — or better, groups of indicator species — can be used to establish a ‘‘coarse filter’’ for conserving biodiversity. In such an approach, species associated with both upslope and riparian habitats need to be selected. Some species for which we have no knowledge and that have very specific requirements may well get missed.

Nevertheless, it could be that by managing for a small number of indicator species, we may arrive at the closest approximation to managing for diversity that current knowledge will permit.

9.7.2 MIS at different planning scales

A broad scale of planning and prioritizing of different resource emphases, on the basis of land suitability, is prerequisite. Within this context, MIS selection can be tailored to various scales and different geographic areas. The spatial scale of the landscape is useful for integrating concerns from multiple levels (Noss 1989). At this level (multiple watersheds), species such as grizzly bear, caribou, and mule deer may be appropriate for monitoring how well we are doing in maintaining wildlife values and habitat contiguity over large areas.

Habitat fragmentation is an increasing concern, particularly in the light of mounting public pressure for smaller clearcuts and alternative harvesting techniques. However, considerably more research is needed concerning species associated with large areas of mature forests before specific indicators can be selected. Birds such as the Northern Goshawk may be appropriate as early warnings of fragmentation problems, but we have little understanding of their requirements and no inventory at the present time. In Oregon, Northern Goshawk nests were generally found on north-facing slopes near ephemeral streams (Reynolds 1983). Such habitats are likely to be overlooked when we emphasize south-facing slopes, as is often the case in traditional wildlife management.

Within a small watershed, species such as marten, Boreal Owl, or beaver may be more appropriate MIS, while the red-backed vole or an amphibian may be better at a stand level of monitoring, depending on objectives. Different indicator species lists need to be developed for different planning scales. A two-tier system may suffice, one for broad landscape planning (single large, or multiple watersheds), and a second list for smaller watersheds of, say, 15 000–20 000 ha or less.

9.7.3 MIS and different resource emphases

Within watersheds, species must be selected according to specific management objectives. For example, if timber production is the primary objective, and wildlife secondary, then managing to enhance species that do well in fragmented landscapes with plenty of edges, maintaining only small habitat areas and minimal populations for other species and allowing for temporary local extirpations of certain species, may be appropriate. Different monitoring species may be required for this situation than in one in which wildlife and perhaps tourism values are a primary focus, and timber production a secondary objective.

In a coastal watershed being managed for biodiversity and timber production, a combination of grizzly bear, black-tailed deer, Bald Eagle, an upland cavity nester, and northwestern salamander (or tailed frog, if present) may be the kind of species grouping we can focus our management efforts and monitoring on, in the hope that the coarse filter established by maintaining values for these species will retain most other wildlife values.

9.7.4 MIS: current applicability

We emphasize that none of the species or species groupings mentioned above is specifically recommended at this point in time. We have serious reservations about the widespread applicability of using MIS. Much more work is needed to evaluate different management indicator species and to determine the most appropriate combinations of species to achieve the best approach within any given biogeoclimatic unit and ecosection or ecoregion.

Until we have more information about species and species groupings for meeting different management objectives, it may be more appropriate to continue to manage for specific habitat components (such as varying degrees of canopy closure, specified densities of snags, coarse woody debris, and green tree retention) on a watershed-specific basis.

10 MANAGEMENT GUILDS

10.1 Uses of Guilds

Guilds are groups of species that use environmental resources in a similar way. Consequently, it is believed that the members within a particular guild all respond in a similar way to changes in their environment. Groupings of species into guilds are generally used for management purposes in one of two ways:

1. as the basis for selecting ''guild indicator species,'' with the assumption made that the responses of the selected indicator reflects the effects of management practices on all other guild members. This approach has a number of serious flaws, discussed more fully in Verner (1984), Block *et al*. (1987), Landres *et al*. (1988), and Harcombe *et al*. (1989). Grouping species into guilds ignores the keystone functioning of some species (e.g., beaver, moose, red-backed voles), and unique species-specific responses to environmental change.

2. as the basis for monitoring the whole group, as proposed by Verner (1984). This approach ignores individual species fluctuations and, instead, monitors trends in the entire guild. While this may have some useful management applications, the danger in terms of maintaining biodiversity is that one or more species in the guild may be permanently lost from the management area, and warning signs for a particular species may go undetected.

10.2 Selecting Guilds

There is no standardized method for grouping species into guilds (Block *et al*. 1987). Groupings undertaken by various workers seem to be essentially investigator-defined, and have generally been based on several species characteristics: foraging, both for habits (e.g., gleaners, hawkers, probers, as in Holmes *et al*. [1979]) and for habitats; nesting; or both foraging and nesting. Methods have been both quantitative and, most frequently, qualitative. Consequently, even allowing for geographic variations, guild memberships vary greatly between studies; and, within a given guild, species responses to management have often been found to be inconsistent (see, for example, Verner 1984).

Block *et al*. (1987) tested the concept with ground-foraging birds and concluded that the applicability of indicator species depends strongly on the guild definition, selection criteria, and geographic ranges where they are applied.

Few attempts have been made to group species into guilds in British Columbia. Birds grouped by ''lifeforms'' in Morgan *et al*. (1985), along the lines of lifeforms defined by Thomas (1979), produced groups in which such disparate species as Turkey Vulture, Rhinoceros Auklet, Belted Kingfisher, American Dipper, and Common Raven are grouped together. Northern Goshawk is in the same group as Marbled Murrelet and Steller's Jay, and Cooper's Hawk is in with Rufous Hummingbird. Yet it is hard to imagine any two of these species responding in a similar fashion to environmental perturbations. These same species fall into different groupings in Sadoway (1988), who compiled considerable information on the breeding birds of Vancouver Island, and grouped them into 11 ''lifeforms.''

Guilds can be defined by objective methods, such as cluster analysis. However the results are only as good as the information put in. Because our knowledge of basic ecological requirements is lacking for many species, in practice we are not likely to have any more consistency than if a group of wildlife specialists were to sit down and arbitrarily assign species to guilds on the basis of their knowledge. Also, composition of any given guild will vary from place to place, and individual species strategies may also vary geographically (i.e., a species may belong to different guilds depending on where it occurs). All this makes guild determination, and the value of these groupings, of questionable value.

10.3 Management Assemblages

10.3.1 Rationale

For management purposes, grouping species on the basis of their dependence on and use of particular habitats or habitat components may be of value. Species that, on the basis of their life history and ecology, are determined to be the most demanding of a given habitat type or attribute can then be the focus of research to determine appropriate management strategies to maintain that particular type/attribute. For example, amongst coarse woody debris (CWD) users, research and monitoring of those species likely to be the most exacting in their requirements would help us determine appropriate management strategies for CWD management. Similarly, some key species may help us focus on requirements for large trees, snags, trees with thick bark, shrub layer, coniferous canopy, and so on. At a landscape level, monitoring a species associated with wilderness (e.g., caribou or wolverine) may help us retain the values necessary for populations of other species associated with wilderness.

10.3.2 Approach

To group species on the basis of their dependency or use of particular habitats or habitat components, habitat affinity tables were established along the same lines as those for the red-, blue-, and yellow-listed species. The tables are provided in Appendix 7iii. As limited information was available for many species, forest seral stages were amalgamated into three groups: early (seral stages 1 and 2), mid (stages 3 and 4), and mature/old growth (stages 5 and 6). Some additional species, not included in Appendix 7iii, considered suitable were added to the list. The information in the tables is clearly very generalized, and should be regarded as hypotheses only, to be verified and added to as more information becomes available. The tables are intended as a starting point only.

Based on these tables (set up as a spreadsheet/database), species were then grouped into ‘‘assemblages’’ (the term ‘‘guild’’ is avoided here because of the specific biological implications attached) on the basis of their use (for foraging and/or breeding) of different habitats and habitat components. Some examples of assemblages generated from the database are provided in Appendix 7iv. The categories given as examples are neither comprehensive, nor are they mutually exclusive. They are intended only as examples. Preliminary groupings could be further subdivided and refined by combining a variety of different categories (e.g., riparian forest cavity nesters for which deciduous trees are important, but that readily adapt to artificially made nest structures). Lists can be produced from the database depending on user requirements, on a project-specific basis.

10.3.3 Weaknesses

In addition to the many uncertainties inherent in the raw data (see, for example, Section 11), a couple of significant omissions from the database should be noted. Ideally, successional stages should be defined in the database for all major forest types. Information on use of different vertical strata (e.g., below ground, litter layer or ground surface, shrub layer, tree bole, canopy, air space) and on canopy closure (e.g., canopy $>$60% closure) also needs to be incorporated. This would permit sorting for groupings such as: forest species that primarily forage on the ground in mature/old-growth forests (e.g., Dark-eyed Juncos, Winter Wren, thrushes); species that forage mainly along trunks and branches (woodpeckers, nuthatches); and canopy feeders in mixed forests.

Additional wildlife information required in making management decisions, and that should also be incorporated into the database, is a quantified assessment of reproductive capability, dispersal ability, and versatility for each species. All of these will strongly affect a species response to management, including its ability to recover from impacts and to recolonize areas.

11 RELIABILITY OF INFORMATION

11.1 Areal Estimates

For subzones/variants, a number of inconsistencies were apparent in the information that was originally digitized. Estimates are consequently fairly crude and should not be used at a fine scale (e.g., for research purposes). Because the interior/edge ratio is low for the subzone/variants measured by digital planimeter, the inaccuracies in estimating area are likely to be relatively high. Note that the discrepancy between total area by zone and total area by ecoregion (see below) is approximately 2%. This reflects an average margin of error. However, errors in estimates for fragmented, linear subzones/variants are likely greater than this.

No areal adjustments have been made for the CWHvm3 and CWHvm4, the CWHwm variants are not separated, the ICHvc variants are not separated, and the various ESSF and MH parklands are not separately distinguished. The subzone boundary changes in Ketcheson (1990) have not yet been incorporated in the estimates.

Errors in estimates for some of the larger units, including ecoregions and ecosections, are probably lower than 2%, as these units are more geographically discrete and interior/edge ratios are relatively high. These estimates are likely to be considerably more accurate than for the more dispersed subzones and variants. The majority of the digital readings for ecosection estimates varied by less than 1% (average deviation from the mean); the highest deviation was 3.6% (for Nazko Upland Ecosection).

11.2 Ecosystem Synopses

Biodiversity in the Prince Rupert Forest Region is highly complex, and its representation in existing user-oriented ecosystem and habitat classification schemes is incomplete. The Biogeoclimatic Ecosystem Classification (BEC) system summarizes vegetational and abiotic components of ecosystem diversity in considerable detail, but wildlife aspects are not accounted for. The wildlife habitat classification scheme is much more generalized in its treatment of vegetation types than is the BEC, although there is some correspondence between the two. Non-wildlife, non-green plant components of biodiversity are essentially ignored in both systems.

The degree of precision and completeness of the BEC descriptions are presumably related to management priorities. Thus the system in its present form tends to be incomplete or imprecise in describing ecosystems of relatively low commercial value.

In particular, the Spruce-Willow-Birch zone and the Mountain Hemlock zone (as well as the Alpine Tundra zone, which is outside the scope of this report) have yet to be described in Land Management Report or Field Guide format, although plant associations are described in reports on specific areas. The parkland subzones of the Engelmann Spruce–Subalpine Fir zone have not been described to the level of ecosystem associations. Some areas of the Sub-Boreal Spruce zone remain ‘‘undifferentiated.’’ Far northwestern British Columbia (the so-called Haines Triangle) has some as yet undescribed subzones and ecosystems. In the lower Tatshenshini-Alsek drainage, it appears that these are distinct subzones of both the BWBS (not CWH as formerly mapped) and SWB (J. Pojar, pers. comm., B.C. Ministry of Forests).

Diverse fen wetland types of a given subzone or variant tend to be grouped in one site series, and fens may be lumped with marshes, swamps, or bogs. Moreover, non-forested vegetation types of presumably minor occurrence in a subzone or variant tend to be omitted from the classification (e.g., marshes and swamps generally, and subalpine meadows in the forested ESSF).

The representation of seral ecosystems in the BEC system is not yet consistent. Seral site series have been defined in the ICHmc2 but not elsewhere in the classification system. Avalanche tracks are treated as site series in the CWHvm and CWHwm, but not elsewhere.

11.3 Rare, Endangered, and Threatened Plants

There is little doubt that the region has received relatively poor coverage in collections and studies, and the apparent distribution of rarities partly reflects this limited fieldwork (see Roemer[26] and Straley[27]). Clusters of rare plants along the Alaska and Haines highways, for example, probably indicate accessibility more than any genuine concentrations of rare species. It is likely that many of the species will turn out to be more common than currently indicated, but these are generally located in rather inaccessible habitats. Conversely, as much of the area is largely unstudied, many of the remote and inaccessible habitats may harbour rarities as yet unrecorded for the region or for the province.

Straley[28] points out that because of the limited fieldwork, it is very difficult to assess how common or rare many of the plants in the northern parts of the province are. In addition, the Conservation Data Centre (CDC) has discovered many misidentifications in some of the existing plant collections on which our rare plant information is based. Misidentifications are particularly common among some of the more difficult groups, including the Poaceae, Cyperaceae, Brassicaceae, and Fabaceae (G. Douglas, pers. comm., Conservation Data Centre). Although these collections are systematically being examined by the CDC, at the present time some of the records in the existing literature must be regarded with caution. Of the collections cited in Appendix 3ii, those of Agriculture (DAO) and the National Museum (CAN) in particular may be of questionable reliability.

In summary, more collection and more accurate identification are required before a really meaningful picture of rare plant occurrence and distribution in the region can emerge.

11.4 Species Distributions and Habitat Affinities

Species distribution information is fragmentary, with inconsistent coverage across the different zones and across different taxa. Problems are discussed within Section 3 of this report. The information in the species/subzone matrix needs considerable input by local wildlife staff and naturalists before it can reflect an accurate picture. However, the many gaps in the tables may stimulate efforts to survey particular areas/taxa, and may also encourage individuals with well-documented vertebrate records to report them officially to the Royal British Columbia Museum.

Habitat affinities are based on a wide range of sources. Information for some of the better known species should be reliable. For many of the lesser-known species, however, information has been extrapolated from studies elsewhere, or has been largely surmised on the basis of anecdotal information in the literature. The information should be regarded as hypotheses only, and further review from people with local expertise is needed before they can be considered a reliable source. It should also be noted that species use of forested habitats is identified by seral stage (1 through 6, corresponding to the grass-forb, shrub-sapling, pole-seedling, young, mature, and old-growth stages). The value of these stages is ranked (subjectively) as low, medium, or high, and no distinction has been made between values for feeding and breeding. Inevitably, this results in a very generalized assessment because different forest types are not distinguished, although there are substantial differences between the seral stages of an interior SBS forest, for example, and of a CWH forest. Nevertheless, it does provide some general indication of the value of the different stages.

[26] Roemer, H. 1990. Ecological reserves in British Columbia. B.C. Native Plants Colloquium, May 1990. Univ. B.C., Vancouver, B.C.
[27] Straley, G. 1990. Rate and endangered plants of British Columbia. B.C. Native Plants Colloquium, May 1990. Univ. B.C., Vancouver, B.C.
[28] Ibid.