Gap Analysis for Ecosystems and Species at Risk Using Terrestrial Ecosystem Mapping

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ABSTRACT

Terrestrial Ecosystem Mapping (TEM) is the standard methodology used in British Columbia to map terrestrial ecosystems. TEM uses a 3-level classification hierarchy: ecoregion units and biogeoclimatic units at broader levels, and site units with vegetation development stages at the detailed level. Accompanying databases consist of a core set of data attributes, which can be used to develop interpretive products for a variety of purposes, including management interpretations for species and ecosystems at risk. This paper provides a summary of TEM projects completed or ongoing in British Columbia as of August 1998. TEM coverage was analyzed, and its usefulness to the management of species and ecosystems at risk was assessed, using both the ecoregion and biogeoclimatic classifications and the British Columbia Conservation Data Centre (CDC) rare element occurrence database. It was determined that the majority of TEM completed to date did not include areas of high rarity value. Recommendations for future TEM in the province based on distribution of ecosystems and species at risk are discussed.

Key words: biogeoclimatic zone, ecosection, ecoprovince, gap analysis, mapping methodology, terrestrial ecosystem mapping.

The Standard for Terrestrial Ecosystem Mapping (TEM; RIC 1998) is a methodology designed for mapping at scales of from 1:5,000 to 1:50,000. It builds upon existing methodologies and classifications (Fig. 1) developed by the British Columbia Ministry of Forests (MOF; Mitchell et al. 1989) and the British Columbia Ministry of Environment, Lands and Parks (MELP; Demarchi et al. 1990). The flexibility of TEM allows for a wide variety of interpretations, which provide management information for species and habitats at risk. Since TEM's introduction in 1995, nearly 100 TEM projects have been initiated provincially.

The objective of this paper is to initiate a strategic plan for future TEM in British Columbia via a gap analysis of current TEM. Existing TEM is compared to distribution of rare species (birds, animals, and plants) and rare ecosystems, as defined by the British Columbia Conservation Data Centre (CDC)[1] (B.C. CDC 1999). This analysis uses 2 levels of classification in the TEM methodology: ecoregion classification (Demarchi 1996), and biogeoclimatic classification (Meidinger and Pojar 1991).

[1] For a description of the Conservation Data Centre, visit their home page at http://www.env.gov.bc.ca/wld/cdc.

TEM STANDARDS AND INTERPRETATIONS

TEM guidelines, combined with a core set of data attributes required for each TEM project, regardless of project objectives, provide a powerful provincial planning tool. By having a standard dataset, data warehouse, and format for data presentation, information can be readily accessed and shared by a wide variety of users. In the common inventory and mapping language that TEM provides, we can further build on our provincial knowledge base to develop a better understanding

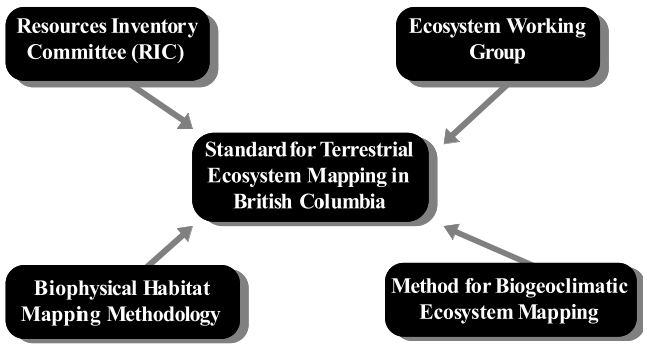

Figure 1. Development of Terrestrial Ecosystem Mapping Standards.

L. M. Darling, editor. 2000. Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C., 15 - 19 Feb.,1999. Volume One. B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops, B.C. 490pp.

of the scope and breadth of ecological diversity that exists provincially. TEM data can be used across jurisdictions, regions, client groups, and projects. The provincial data warehouse will serve to provide baseline information for future management and planning strategies. The analysis presented in this paper illustrates the ability we now have to assess gaps in inventory and mapping of provincially rare species habitat and ecosystems.

Some interpretive products from TEM focus specifically on species or ecosystems at risk (e.g., grizzly bear or marten habitat capability and suitability), while others focus on resource management (e.g., forest harvesting, silviculture treatments, urban planning exercises, conservation of natural areas, or planning of pipeline corridors). While many management practices are not aimed specifically at species at risk, they affect the plant and animal species that utilize the ecosystem as habitat, and the ecosystem itself. Regardless of the form of resource management, whether it be for mining, urban development, or forest management, there are implications for the biology and management of species and ecosystems at risk.

STATUS OF TEM

Along with the first draft of TEM in 1995, a significant number of TEM projects at scales of 1:50,000 and 1:20,000 were also initiated (Fig. 2). Of the approximately 95 million hectares of land in British Columbia, approximately 9.3% has been mapped using TEM. Approximately 5% has been mapped at 1:50,000, and 4.3% has been mapped at 1:20,000. The number of TEM projects has continued to grow, totalling 99 projects province-wide as of 31 August 1998. These initial TEM projects have depended largely on the interests of specific clients (Fig. 3) and regional access to Forest Renewal British Columbia (FRBC) funding.

While initial TEM projects may have addressed species or ecosystems at risk, initiation of these projects was not based on a provincial mapping strategy or priority list. As funding sources and the understanding of the potential interpretative uses of TEM evolved, so have client groups of TEM. For example, the Columbia Basin Fish and Wildlife Compensation Program in the Kootenays has completed a significant amount of TEM in order to assess wildlife values within its management areas. Increasingly, TEM projects are being initiated by local governments, First Nations, the British Columbia Ministry of Energy and Mines, and British Columbia Parks, illustrating a shift in applications of TEM.

METHODS

The analysis of TEM coverage in British Columbia demonstrates that almost 10% of the province is mapped at 1:20,000 or 1:50,000. A detailed TEM project tracking system maintained by MELP (B.C. MELP 1998) includes a map of all TEM projects currently underway (Fig. 2). Biogeoclimatic maps and ecoregion maps were used in conjunction with the TEM base map to arrive at area summaries for all biogeoclimatic and ecoregion units with TEM coverage.[2] It is important to note that other mapping methodologies, such as Biophysical Habitat Mapping (Demarchi et al. 1990) and Sensitive

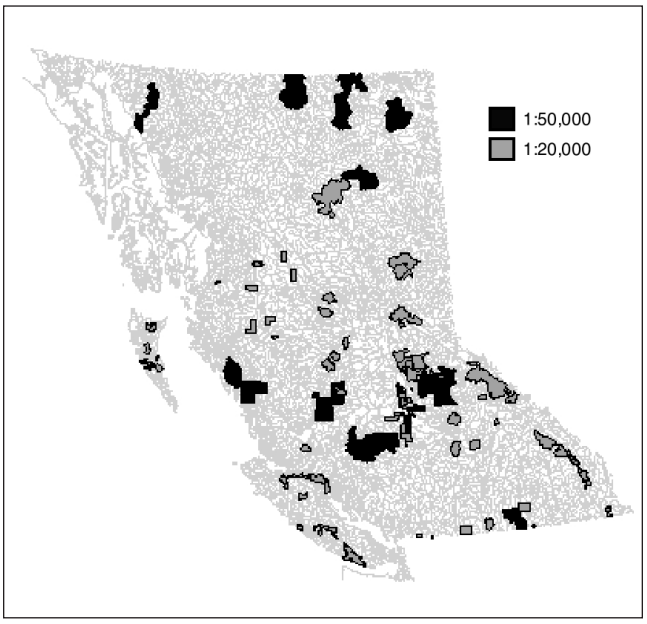

Figure 2. Distribution of TEM mapping in British Columbia.

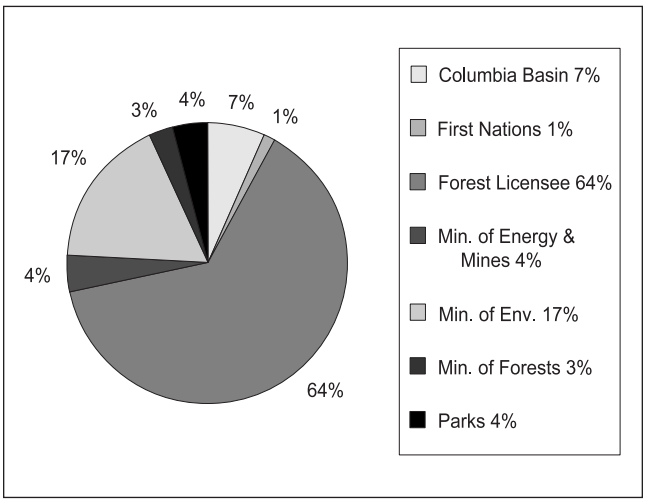

Figure 3. TEM projects by client type.

[2] Area summaries are approximate, reflecting differences in map scale and generalizations in TEM project boundaries.

Ecosystem Inventory (Ward et al. 1999), provide inventory and mapping for significant portions of ecoregions and biogeoclimatic units. For the purposes of this analysis these other methodologies are not considered. In some cases, such as the Southern Interior ecoprovince, the existence of other mapping may have played a factor in the lack of TEM, and/or could be revised to TEM standards and incorporated into the provincial coverage of TEM. TEM coverage was compared to areas of high rarity value to determine how effective the current TEM is in providing tools to develop management plans for species and ecosystems at risk.

The analysis uses high rarity value to rank ecoregion and biogeoclimatic units for mapping priorities. The criteria for determining areas of high rarity value are based on the CDC rare element database and tracking lists (B.C. CDC 1999). A rare element occurrence (EOR) is the actual location of a threatened or endangered plant, animal, or plant association[3] as identified by the CDC. An ecosection with high rarity value is one with >75 EORs or more than one-third of its ecosystems listed as rare by the CDC. A biogeoclimatic unit with high rarity value is one with >50 EORs or more than one-third of its ecosystems listed as rare by the CDC tracking list. A comparison of the area of TEM within each identified ecoregion and biogeoclimatic unit indicated gaps in inventory data relevant to the occurrence of rare elements in British Columbia. The number of EORs and rare ecosystems within the ecoregion and biogeoclimatic units, in conjunction with TEM coverage, determined the ranking priority for future TEM.

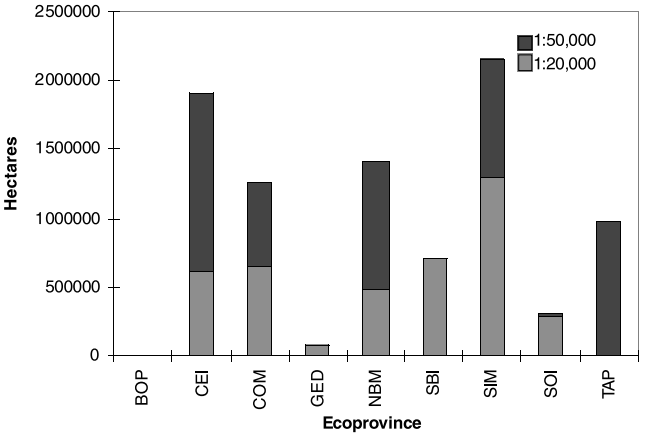

Figure 4. TEM mapping by ecoprovince (see Table 1 for codes).

[3] The ecosystem is a member of a specific plant association and, for this paper, the term "ecosystem" is treated as equivalent to the rare plant association.

RESULTS

TEM Gap Analysis at the Ecoregion Level

TEM has been conducted in all 9 of the terrestrial ecoprovinces, although in the Boreal Plains ecoprovince there is so little TEM coverage that it comprises <0.5% (Fig. 4). The majority of the mapping, 95% (Fig. 5), occurs in 6 ecoprovinces: Southern Interior Mountains; Central Interior; Northern Boreal Mountains; Coast and Mountains; Taiga Plains; and Sub-Boreal Interior. Only 5% of the mapping occurs in the remaining 3 ecoprovinces: Georgia Depression; Southern Interior; and Boreal Plains. These 3 are the smallest ecoprovinces (Table 1), and while one would expect areas of mapping to reflect that size difference, the contrast in total area mapped between the 2 groups is significant.

The analysis highlights 18 ecosections that fall within the criteria of high rarity value (Table 2). The results are even more significant than expected: 12 of the 18 ecosections occur within the 3 ecoprovinces with the least amount of TEM (Georgia Depression, Southern Interior, and Boreal Plains). Eleven of these ecosections occur within the Georgia Depression and the Southern Interior. The ecoprovinces with the highest amount of TEM (Southern Interior Mountains and Central Interior), each include only 1 ecosection with high rarity value.

The Coast and Mountains is a wide-ranging ecoprovince, which includes the Queen Charlotte Islands, and most of Vancouver Island and the coastal mainland. Of the 25 ecosections within this ecoprovince, 4 (Eastern Pacific Ranges, Windward Island Mountains, Skidegate Plateau, and Windward Queen Charlotte Mountains) are rated high in rarity value. These ecosections range from having almost no mapping to moderate amounts of TEM (Table 2).

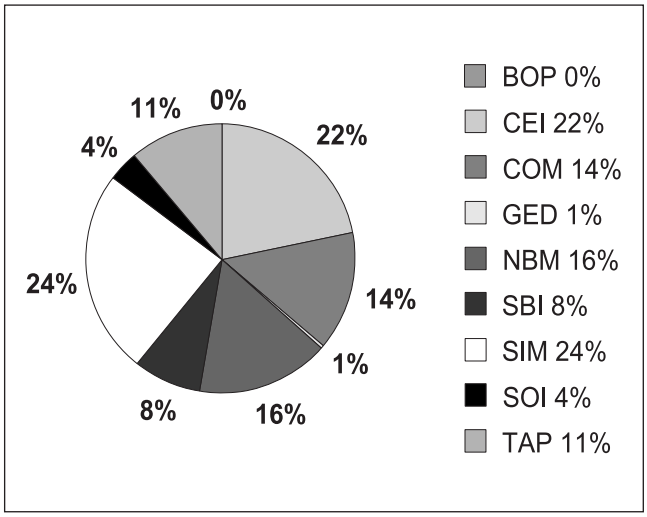

Figure 5. Total distribution of TEM by ecoprovince (see Table 1 for codes).

Table 1. Percentage of TEM coverage by terrestrial ecoprovince.

Ecoprovince	Code	Total area (ha)	% mapped
Coast and Mountains	COM	18,841,854	3
Georgia Depression	GED	1,833,924	4
Central Interior	CEI	10,489,177	6
Sub-Boreal Interior	SBI	14,200,964	5
Southern Interior Mountains	SIM	13,675,827	9
Southern Interior	SOI	5,832,390	5
Boreal Plains	BOP	3,952,454	0
Taiga Plains	TAP	5,971,567	14
Northern Boreal Mountains	NBM	18,982,157	3

The Georgia Depression includes 7 ecosections, 6 of which are rated high for rarity values (Fig. 6). The seventh ecosection, Juan de Fuca Strait, is a marine ecosection. The Georgia Lowland ecosection is low in rare element occurrences, but high in ecosystem rarity and, as such, is particularly vulnerable to increasing population pressures.

The Southern Interior ecoprovince is another area high in rarity value. Of the 12 ecosections, 5 (Southern Thompson Upland, Thompson Basin, Northern Okanagan Highland, Okanagan Range, and Southern Okanogan Basin) are rated high for the numbers of rare element occurrences and rare ecosystems. All except the Southern Okanogan Basin have little or no TEM coverage.

The Boreal Plains is a smaller ecoprovince located in the northeast portion of the province and is an extension of the much more wide-ranging central plains of Canada. One of its 4 ecosections, the Peace Lowland, has high rarities in the CDC element database and rare grassland ecosystems.

Of the 12 ecosections within the Central Interior ecoprovince, the Fraser River Basin is the only one rated high for rarity value. This ecosection has TEM coverage of 65% of the area.

The Southern Interior Mountains ecoprovince includes 19 ecosections, 1 of which was rated high for rarity value. The East Kootenay Trench has moderate TEM coverage at 24% of the area.

The Northern Boreal Mountains, the Sub-Boreal Interior, and the Taiga Plains included no ecosections rated high for rarity value.

TEM Gap Analysis at the Biogeoclimatic Level

All of the 14 biogeoclimatic zones within British Columbia have some degree of TEM (Fig. 7). The distribution of total TEM by zone is shown in Figure 8. A total of 71% of TEM

Table 2. Priority ranking for ecosections rated as having high rarity values. (EOR = rare element occurrence.)

Ecosection	Code	No. of EORs	No. of rare ecosystems	% mapped	Priority ranking
Eastern Pacific Ranges	EPR	101	18	0	1
Windward Queen Charlotte Mountains	WQC	192	22	6	1
Fraser Lowland	FRL	197	42	1	1
Leeward Island Mountains	LIM	174	27	6	1
Nanaimo Lowland	NAL	638	56	0	1
Southern Gulf Islands	SGI	193	43	0	1
Strait Of Georgia	SOG	135	43	0	1
Northern Okanagan Highland	NOH	118	14	6	1
Southern Thompson Upland	STU	124	32	0	1
Thompson Basin	THB	86	16	4	1
Georgia Lowland	GEL	29	40	0	2
Peace Lowland	PEL	101	2	0	2
Skidegate Plateau	SKP	134	10	17	3
Windward Island Mountains	WIM	327	23	11	3
East Kootenay Trench	EKT	147	10	24	3
Okanagan Range	OKR	178	26	25	3
Fraser River Basin	FRB	115	22	65	4
Southern Okanogan Basin	SOB	364	25	14	4

Table 3. Percentage of TEM coverage by biogeoclimatic (BGC) zone.

BGC zone	Total area (ha)	% mapped	BGC zone	Total area (ha)	% mapped
Alpine Tundra and Parkland	17,757,600	7	Interior Douglas-fir	4,372,100	13
Bunchgrass	319,100	16	Mountain Hemlock	4,027,500	3
Boreal White and Black Spruce	14,831,400	10	Montane Spruce	2,642,900	18
Coastal Douglas-fir	205,900	0	Ponderosa Pine	340,400	4
Coastal Western Hemlock	10,607,600	9	Sub-Boreal Pine–Spruce	2,374,100	9
Engelmann Spruce–Subalpine Fir	13,156,100	12	Sub-Boreal Spruce	10,080,700	9
Interior Cedar–Hemlock	5,238,800	11	Spruce–Willow–Birch	8,270,300	5

occurs in the following 5 zones: Alpine Tundra and Parkland (AT&P)[4]; Boreal White and Black Spruce (BWBS); Coastal Western Hemlock (CWH); Engelmann Spruce–Subalpine Fir (ESSF); and Sub-Boreal Spruce (SBS). However, the distribution of mapping relative to total area of a biogeoclimatic zone varies widely (Table 3). Zones that have a very small total area can have a significant amount of TEM. For example, TEM covers 16% of the Bunchgrass (BG) zone's total area, while there is <0.01% TEM coverage in the Coastal Douglas-fir (CDF) zone. Zones covering large areas of the province also have variable TEM coverage. For example, 12% of the ESSF has TEM coverage, compared to 7% of the AT&P.

Assessing TEM coverage by biogeoclimatic zone provides an overview of where mapping occurs in the province. A finer level of detail, the biogeoclimatic subzone/variant level, is required to assess gaps in mapping for rare element occurrences (EORs) and rare ecosystems.

There are 133 biogeoclimatic subzone/variants currently described within British Columbia. Analysis of TEM by subzone/variant identifies 46 that meet the criteria for high rarity (Table 4). The distribution of the 46 units shows 4 zones as having the most significant number of EORs and rare ecosystems (Table 5). The BG, CWH, Ponderosa Pine (PP), and Interior Douglas-fir (IDF) zones have the highest percentages of units with high numbers of rarities. The CDF has only 1 subzone unit described; it is rated high in rarity values.

The Alpine Tundra and Parkland zone is not further discussed in this document. This zone is widely distributed at high elevations throughout British Columbia, but its plant communities are poorly described and correlated, making it difficult to determine gaps in TEM and their relation to rare species and ecosystems.

The BG, located in the dry southern Interior of the province, has 5 biogeoclimatic units, all of which are considered to have high rarity values. While the BG is limited in its distribution, 16% of the total area has been mapped. However, the bulk of the mapping has focused on the BGxw2 and BGxh3 subzone/variants (Table 6). While both of these biogeoclimatic units have significant numbers of EORs and rare ecosystems, the remaining 3 units (BGxh1, BGxh2, and BGxw1), have very little to no TEM and the highest numbers of rarities. Biophysical habitat mapping in the South Okanagan (Lea et al. 1991) focused on the BGxh1 subzone and could be updated and incorporated into the scope of TEM coverage.

The CDF is limited to the southeast portions of Vancouver Island, the Gulf Islands, and the Sunshine Coast. Much of the

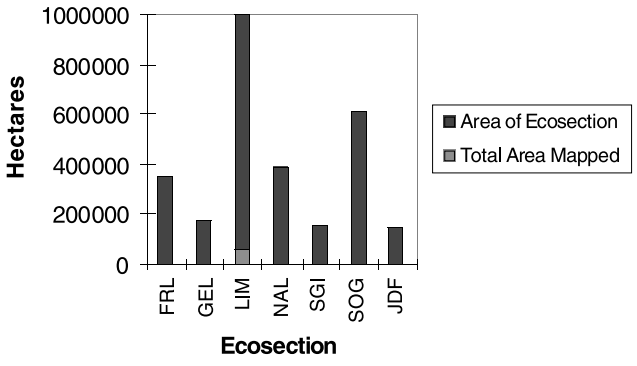

Figure 6. TEM by ecosections of the Georgia Depression ecoprovince (see Table 2 for codes).

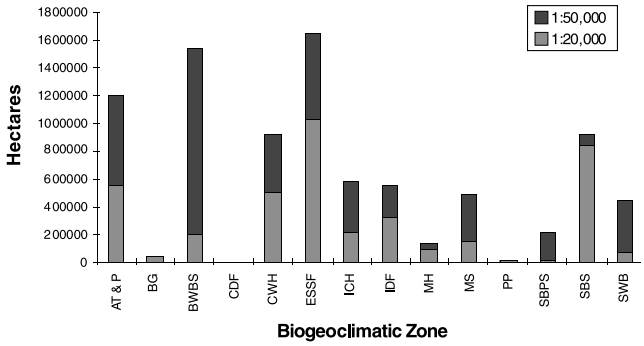

Figure 7. TEM by biogeoclimatic zone (see Table 5 for codes).

[4] At regional and provincial mapping scales, biogeoclimatic mapping combines parkland with the Alpine Tundra (AT) zone, rather than mapping the parkland with the adjacent forested subzone. This paper follows this convention for area calculations.

Table 4. Codes and names of biogeoclimatic (BGC) units (subzones/variants; B.C. MOF and B.C. MELP 1998) that meet the criteria for high rarity.

BGC unit code	BGC unit name
BGxh1	Okanagan - Very Dry Hot - Bunchgrass
BGxh2	Thompson - Very Dry Hot - Bunchgrass
BGxh3	Fraser - Very Dry Hot - Bunchgrass
BGxw1	Nicola - Very Dry Warm - Bunchgrass
BGxw2	Alkali - Very Dry Warm - Bunchgrass
BWBSmw1	Peace - Moist Warm - Boreal White and Black Spruce
CDFmm	Moist Maritime - Coastal Douglas-fir
CWHdm	Dry Maritime - Coastal Western Hemlock
CWHds1	Central - Dry Submaritime - Coastal Western Hemlock
CWHds2	Southern - Dry Submaritime - Coastal Western Hemlock
CWHmm1	Submontane - Moist Maritime -Coastal Western Hemlock
CWHmm2	Montane - Moist Maritime - Coastal Western Hemlock
CWHms1	Southern - Moist Submaritime - Coastal Western Hemlock
CWHms2	Central - Moist Submaritime - Coastal Western Hemlock
CWHvh1	Southern - Very Wet Hypermaritime - Coastal Western Hemlock
CWHvh2	Central - Very Wet Hypermaritime - Coastal Western Hemlock
CWHvm1	Submontane - Very Wet Maritime - Coastal Western Hemlock
CWHvm2	Montane - Very Wet Maritime - Coastal Western Hemlock
CWHwh1	Submontane - Wet Hypermaritime - Coastal Western Hemlock
CWHwm	Wet Maritime - Coastal Western Hemlock
CWHws1	Submontane - Wet Submaritime - Coastal Western Hemlock
CWHws2	Montane - Wet Submaritime - Coastal Western Hemlock
CWHxm1	Eastern - Very Dry Maritime - Coastal Western Hemlock
CWHxm2	Western - Very Dry Maritime - Coastal Western Hemlock
ESSFdk	Dry Cool - Engelmann Spruce–Subalpine Fir
ICHdw	Dry Warm - Interior Cedar–Hemlock
ICHmk3	Horsefly - Moist Cool - Interior Cedar–Hemlock
ICHmm	Moist Mild - Interior Cedar–Hemlock
IDFdk1	Thompson - Dry Cool - Interior Douglas-fir
IDFdk3	Fraser - Dry Cool - Interior Douglas-fir
IDFdk4	Chilcotin - Dry Cool - Interior Douglas-fir
IDFdm1	Kettle - Dry Mild - Interior Douglas-fir
IDFdm2	Kootenay - Dry Mild - Interior Douglas-fir
IDFww	Wet Warm - Interior Douglas-fir
IDFxh1	Okanagan - Very Dry Hot - Interior Douglas-fir
IDFxh2	Thompson - Very Dry Hot - Interior Douglas-fir
IDFxm	Very Dry Warm - Interior Douglas-fir
IDFxw	Very Dry Warm - Interior Douglas-fir
MHmm1	Windward - Moist Maritime - Mountain Hemlock
PPdh1	Kettle - Dry Hot - Ponderosa Pine
PPdh2	Kootenay - Dry Hot - Ponderosa Pine
PPxh1	Okanagan - Very Dry Hot - Ponderosa Pine
PPxh2	Thompson Very Dry Hot - Ponderosa Pine
SBSdh	Dry Hot - Sub-Boreal Spruce
SBSdk	Dry Cool - Sub-Boreal Spruce
SBSmh	Moist Hot - Sub-Boreal Spruce

Table 5. Number of biogeoclimatic (BGC) units (subzones/variants; B.C. MOF and B.C. MELP 1998) with high rarity values.

BGC zone	BGC code	Total no. of units	No. of units with high rarity values	% of units with high rarity values
Alpine Tundra and Parkland	AT&P	N/A	N/A	N/A
Bunchgrass	BG	5	5	100
Coastal Douglas-fir	CDF	1	1	100
Coastal Western Hemlock	CWH	19	17	89
Ponderosa Pine	PP	4	4	100
Interior Douglas-fir	IDF	15	10	67
Sub-Boreal Spruce	SBS	17	3	18
Interior Cedar–Hemlock	ICH	20	3	15
Boreal White and Black Spruce	BWBS	8	1	12
Montane Spruce	MS	8	0	0
Engelmann Spruce–Subalpine Fir	ESSF	25	1	.04
Mountain Hemlock	MH	4	1	25
Sub-Boreal Pine–Spruce	SBPS	4	0	0
Spruce–Willow–Birch	SWB	3	0	0
Total		133	46	

CDF has been altered through urban and resource development. The remaining natural areas play a critical role in providing habitat for species and representation of ecosystems at risk. There are only a few very small TEM projects completed in the CDFmm (<0.01% of the zone).

The wide-ranging Coastal Western Hemlock zone stretches along the coast and coast mountains from the Canada–United States border to northern British Columbia. This zone has 19 biogeoclimatic units described, of which 17 are considered to have high rarity values (Table 6). The amount of TEM in each varies significantly, from 0% in the CWHds2 to >20% in the CWHmm1. This zone is the single most significant zone in terms of mapping recommendations, even though 9% of its total area has been mapped.

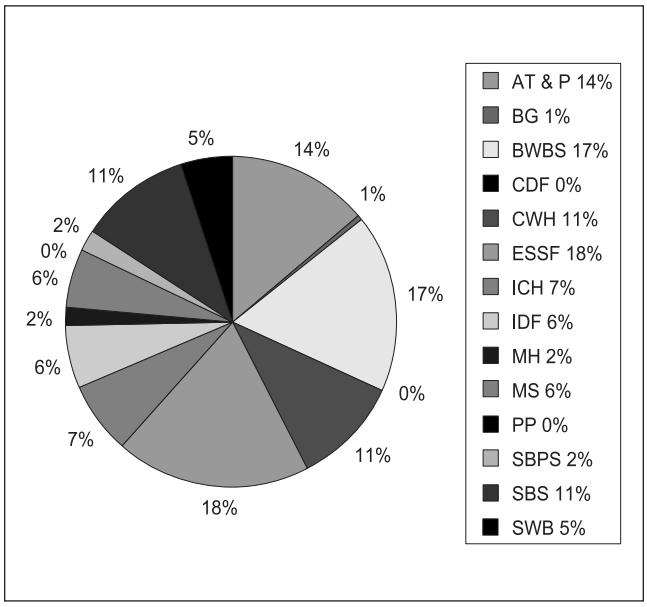

Figure 8. Total distribution of TEM by biogeoclimatic zone (see Table 5 for codes).

The Ponderosa Pine zone is the smallest biogeoclimatic zone. Its distribution is limited to the lower valleys of the Fraser, Thompson, Okanagan, and Nicola rivers, and the southern portion of the Rocky Mountain Trench. Only 4% of its total area has been mapped. There are 4 biogeoclimatic units in the zone, all of which are considered high priority (Table 6). One subzone, the PPxh1, has also been mapped in the South Okanagan (Lea et al. 1991).

The Interior Douglas-fir zone, occurring throughout the southern Interior and East Kootenays, has 15 biogeoclimatic units. Of these, 10 have high rarity values. While 13% of the IDF's total area has been mapped, mapping within areas of high priority varies significantly (Table 6).

The remaining 9 biogeoclimatic units with high rarity values occur within the Sub-Boreal Spruce, the Interior Cedar–Hemlock (ICH), the Boreal White and Black Spruce, the Engelmann Spruce–Subalpine Fir, and the Mountain Hemlock (MH) zones (Table 6). The Sub-Boreal Pine–Spruce (SBPS), the Montane Spruce (MS), and the Spruce–Willow–Birch (SWB) zones have no units with high rarities.

DISCUSSION

An inventory strategy for the protection of rare wildlife, plants, and ecosystems in British Columbia can be developed from this TEM Gap Analysis. Recommendations for future TEM are based on the amount of existing TEM coverage and the rarity values of each biogeoclimatic or ecoregion unit.

Determining Priorities for Ecoregion Units

The analysis identifies 18 ecosections with high numbers of EORs or rare ecosystems. Of these 18 ecosections, 6 have significant (>10%) amounts of TEM. These ecosections are assigned lower priority than those ecosections with <10% TEM. Table 2 ranks the 18 ecoregions as Priority 1–4 according to the following criteria:

- Priority 1: high numbers of EORs and rare ecosystems, and <10% TEM coverage.
- Priority 2: high numbers of EORs or high numbers of rare ecosystems, <10% TEM coverage, and >10 rare ecosystems.
- Priority 3: high numbers of EORs and/or high numbers of rare ecosystems, and >10% TEM coverage.
- Priority 4: high numbers of EORs and/or high numbers of rare ecosystems, and >50% TEM coverage. It also includes the areas with mapping easily converted to TEM.

TEM is highly recommended for 2 ecosections within the Coast and Mountains ecoprovince. The Eastern Pacific Ranges ecosection on the mainland occurs in the area of transition between the coastal and interior climates, resulting in ecosystems particularly high in species diversity. For example, dry Ponderosa Pine forest and moist Cedar-Hemlock forest are located within a few kilometres of each other within the Skagit Valley. The Windward Queen Charlotte Mountains ecosection is also high in priority. Many endemic plant species, known only from glacial refugia, occur in this area. Two other ecosections are recommended for future TEM but are third in priority. These are the Skidegate Plateau, also on the Queen Charlotte Islands, and the Windward Island Mountains on the west side of Vancouver Island, an area known for its coastal temperate rain forests.

The 6 terrestrial ecosections of the Georgia Depression are recommended for future TEM (Table 2). In addition to the natural causes of rarity in this ecoprovince, intense population and development pressures have resulted in extensive depletion of the native species and ecosystems that once occurred more commonly throughout the area. In some selected areas, local governments and British Columbia Parks are initiating TEM at larger scales (1:10,000 and 1:5,000) for planning and conservation management. It is important to note that the Sensitive Ecosystem Inventory (Ward et al. 1999) provides partial mapping of the Nanaimo Lowland, the Southern Gulf Islands, and a portion of the Strait of Georgia, identifying generalized rare ecosystem units. Such partnerships amongst agencies, both governmental and non-governmental, are recommended to complete the work in this biologically diverse area.

Within the Southern Interior ecoprovince, 4 ecosections are recommended for further TEM. This area, also high in natural forms of rarity, has experienced loss of species and ecosystems in the past from agricultural and forestry land

Table 6. Priority ranking for biogeoclimatic (BGC) units rated as having high rarity values. See Table 4 for codes. (EOR = rare element occurrence.)

BGC unit	No. of EORs	No. of rare ecosystems	% mapped	Priority ranking
BGxh1	315	11	0.1	1
BGxh2	42	6	0.2	3
BGxh3	23	2	66.9	4
BGxw1	40	5	0.0	3
BGxw2	57	3	52.7	4
BWBSmw1	156	0	1.6	2
CDFmm	759	18	0.0	1
CWHdm	144	13	3.7	1
CWHds1	30	9	0.1	3
CWHds2	2	10	0.0	3
CWHmm1	6	7	20.3	4
CWHmm2	12	6	3.9	3
CWHms1	46	7	6.0	3
CWHms2	2	7	0.0	3
CWHvh1	280	12	2.1	1
CWHvh2	150	11	13.4	1
CWHvm1	132	7	4.8	1
CWHvm2	35	4	2.7	3
CWHwh1	92	8	14.5	1
CWHwm	4	7	10.1	3
CWHws1	3	5	0.5	3
CWHws2	0	6	2.6	3
CWHxm1	177	16	1.7	1
CWHxm2	104	14	10.8	1
ESSFdk	54	0	7.5	2
ICHdw	62	0	11.0	2
ICHmk3	0	4	6.7	3
ICHmm	0	3	43.4	4
IDFdk1	35	4	0.9	3
IDFdk3	36	7	21.3	4
IDFdk4	13	8	3.6	3
IDFdm1	21	3	12.8	3
IDFdm2	71	5	15.1	1
IDFww	14	4	0.1	3
IDFxh1	159	10	4.8	1
IDFxh2	38	7	2.5	3
IDFxm	55	6	58.6	4
IDFxw	4	6	0.0	3
MHmm1	53	0	3.7	2
PPdh1	25	5	12.4	3
PPdh2	38	5	3.3	3
PPxh1	118	9	4.1	1
PPxh2	24	6	3.4	3
SBSdh	7	4	39.1	4
SBSdk	16	4	2.5	3
SBSmh	7	7	1.4	3

Table 7. Overlap of ecosections and biogeoclimatic (BGC) units with high rarity values. See Tables 2 and 4 for codes.

Ecosection	BGC unit(s)
EPR	CWHds1, CWHms1, IDFww
SKP	CWHvh2, CWHwh1
WQC	CWHvh2, CWHwh1
WIM	CWHmm1, CWHvh1, CWHvm1, CWHvm2, CWHxm2, MHmm1
GEL	CWHdm, CWHmm1, CWHvm1, CWHvm2, CWHxm1
NAL	CDFmm, CWHmm1, CWHmm2, CWHxm1, CWHxm2
FRL	CDFmm, CWHdm, CWHds1, CWHvm2, CWHxm1
SGI	CDFmm, CWHxm1, CWHxm2
SOG	CDFmm, CWHmm1, CWHxm1, CWHxm2,
LIM	CWHmm1, CWHmm2, CWHvm2, CWHxm1, CWHxm2, MHmm1
FRB	BGxh1, BGxh3, BGxw2, IDFdk4, IDFxm
EKT	ESSFdk, IDFdm2, PPdh1, PPdh2
SOB	BGxh1, IDFxh1, PPxh1
NOH	IDFdm1, IDFxh1, PPdh1, PPdh2
STU	BGxh2, IDFdk1, IDFdm2, IDFxh2, PPxh2
THB	BGxh2, BGxw1, IDFdk1, IDFxh1, IDFxh2, IDFxw, PPxh2
OKR	BGxh1, IDFdk1, IDFdm2, IDFxh1, PPxh1
PEL	BWBSmw1

use, and now from increasing population pressures. The Southern Thompson Upland, the Thompson Basin, and the Northern Okanagan Highland should be the first priority for future TEM. The Okanagan Ranges and the South Okanogan Basin are third and fourth, respectively, in priority, as each has >10% TEM coverage. There has been considerable detailed mapping using the Biophysical Inventory Methodology (Demarchi et al. 1990) for the South Okanogan Basin ecosection (Lea et al. 1991). With some adaptation of attribute codes, this project could be used in the TEM coverage. Therefore, the priority for the Okanogan Basin ecosection, rather than mapping, would be to convert the existing biophysical mapping to the standard TEM methodology for inclusion in the provincial data warehouse.

The Peace Lowland, within the Boreal Plains ecoprovince, is ranked high in rarity value because of its high number of EORs. It is ranked priority 2 for future TEM. The East Kootenay Trench includes both high numbers of EORs and rare ecosystems, but because of its relatively high amount of TEM, is ranked third in mapping priority. The Fraser River Basin, while high in both EORs and rare ecosystems, has TEM coverage for more than half of its area. Therefore it is ranked fourth in mapping priority and is not recommended for future mapping.

Determining Priorities for Biogeoclimatic Units

The analysis identifies 46 biogeoclimatic units as high in EORs and/or rare ecosystems. Of these 46 units, 7 have significant amounts of TEM (i.e., >20% of the total subzone mapped). Those subzones that are considered to have significant amounts of TEM are assigned lower priority than those with very little TEM. The remaining subzones have the following breakdown of rarities: 12 have high numbers of both EORs and rare ecosystems; 4 have high numbers of EORs only; and 23 have high numbers of rare ecosystems only. Table 6 ranks the 46 subzones as Priority 1–4 according to the following criteria:

- Priority 1: high numbers of EORs and rare ecosystems, and <20% TEM coverage.
- Priority 2: high numbers of EORs only, and <20% TEM coverage.
- Priority 3: high numbers of rare ecosystems only, and <20% TEM coverage.
- Priority 4: high numbers of EORs and/or rare ecosystems, and >20% TEM coverage.

The 5 zones with the most significant numbers of units with high rarities and limited mapping are the CWH, CDF, PP, IDF, and BG.

SUMMARY

The analysis indicates a high degree of overlap between the 18 ecosections in British Columbia that have been identified as having high rarity values and the 46 biogeoclimatic units with high rarity values (Table 7). Each of the listed ecosections includes at least 1 biogeoclimatic unit that is high either in rare element occurrences or in rare ecosystems. We recommend 16 of these ecosections for future Terrestrial Ecosystem Mapping with wildlife and rare ecosystem interpretations. The Fraser River Basin and the South Okanogan Basin ecosections are not recommended for further mapping at this time. The biogeoclimatic units that occur within these ecosections (BGxh3, BGxw2, IDFdk4, and IDFxm), have high TEM coverage or are mapped (Lea et al. 1991), and are therefore not considered in the following discussion of biogeoclimatic units.

Of the 133 biogeoclimatic units in British Columbia, 46 are rated high in rarity values. The overlap of ecosection and biogeoclimatic units indicates that 34 of the biogeoclimatic units will be represented by mapping within the high priority ecosections.

Twelve biogeoclimatic units are not represented in the ecosection overlap. Of these 12 biogeoclimatic units, the ICHmm, IDFdk3, and SBSdh are ranked fourth in priority because of significant existing TEM coverage, and are therefore not further recommended for mapping. This leaves 9 biogeoclimatic units recommended for further mapping. They are: CWHds2, CWHms2, CWHwm, CWHws1, CWHws2,

ICHdw, ICHmk3, SBSdk, and SBSmh.

Terrestrial Ecosystem Mapping of project areas within the 16 above-listed ecosections and 9 biogeoclimatic units will provide considerable inventory data for a significant proportion of the species and ecosystems at risk in British Columbia. Information on the location of rare species' habitats and rare ecosystems can be used to prepare management plans that will, in future, protect the rare elements of biodiversity in British Columbia.

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