

## **Biodiversity Conservation and Protected Areas in British Columbia**

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### ***Executive Summary***

In Fall 2002, the UBC Centre for Biodiversity Research assessed the effectiveness of BC's Protected Areas Strategy in protecting rare and endangered species in British Columbia.

Distribution data were assembled for species listed at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), provincial 'Red-listed' species, endemic species, and potentially rare and endangered invertebrates in British Columbia, together with similar data on all species of butterflies, Odonata (dragonflies and damselflies), small mammals and vascular plants. From these data rarity and richness hotspots in British Columbia were determined to identify areas with high numbers of species at risk and areas of high biological diversity. The coincidence of the top 5% of the rarity hotspots with the protected areas within the province was then computed.

Overall, there was found to be a marked lack of coincidence between the current protected areas and the occurrence of large numbers of the endemic species, federal COSEWIC-listed species, provincially Red-listed species, and potentially rare and endangered invertebrates in the province. In the top 5% of the rarity cells for the groups considered, there was on the whole, relatively little protected area coincidence. Based on the available data, it would appear that a significant number of BC's rare and endangered species are located outside BC's protected areas. The same would appear to be true for richness hotspots (areas of high biological diversity), although the precise numbers were not computed in this case. Further study is however needed on species rarity and richness within protected areas in the province.

Because of the general lack of coincidence between biodiversity rarity and richness hotspots with current protected areas, it is evident that the 12% of the land area currently designated as protected area in the province, does not provide adequate protection for the very rich and rare biodiversity in British Columbia.

Clearly, there needs to be more inventory of rare and endangered species undertaken in BC's protected areas and other areas with biodiversity conservation potential. It is noted that because the South Okanagan, south-east Vancouver Island and Lower Mainland are not only biodiversity rarity and richness hotspots, but also alien species hotspots with increasing threats from human impacts, these areas of the province should become the focus for increased and integrated biodiversity conservation planning in the province, preferably at the ecosystem level.

## ***Introduction***

The ongoing loss and endangerment of species has resulted in countries throughout the world embarking on various biodiversity conservation strategies, following ratification of the Convention on Biological Diversity (CBD). Although the CBD lacks targets and deadlines (ten Kate 2002), Canada has developed a Biodiversity Strategy, and both Canada and British Columbia have signed the 'National Accord for the Protection of Species at Risk in Canada' (Scudder 1999). Canada and British Columbia are now legally committed to Article 7 of the CBD which requires the identification, monitoring and conservation of ecosystems and habitats containing high diversity, and large numbers of endemic and threatened species. To accomplish this, one needs to determine these areas of high diversity, and areas with large numbers of endemic and threatened species. To date this has not been done in British Columbia (Scudder 1996).

British Columbia's biodiversity conservation strategy depends on a planning framework that accommodates two complementary components, namely the establishment of a network of protected areas, and the application of integrated resource management principles outside of these protected areas (Anon 1992). The protected areas strategy (PAS) aimed to protect 12% of the land area of the province by the year 2000 (British Columbia 1993). Although this 12% target has now been achieved, the major ecological regions in BC lack proportional representation under the PAS.

Given the 12% target, it may thus be expected that some of the goals of the PAS might have been achieved. In particular, the protection of areas with large numbers of endemic, rare or endangered species.

To date, there has been no assessment of the success of the PAS in this regard. Hence, the aim of this research was to correct this deficiency, by undertaking such an assessment, that entailed plotting the occurrence of endemic, and rare and endangered species against the recorded network of protected areas in the province.

Hotspot analysis is one of a set of tools now available to help set priorities for conservation planning (Reid 1998), and can be employed in the current assessment. It allows for the identification of areas of high biological diversity, and areas with large numbers of endemic species or species at risk.

Although the term 'biodiversity hotspot' was originally coined to indicate areas with a large number of endemic species, it is now most commonly used with reference to regions of high species richness (Reid 1998). It is so used in this research. Thus an endemic species hotspot, is an area with a large number of endemic species. Likewise, a rarity hotspot is an area with a large number of rare species, while a richness hotspot is an area with high species richness.

## ***Materials and Methods***

Georeferenced databases were obtained from various sources, predominately from the BC Conservation Data Centre and G.G.E. Scudder (see Table 1). Mapping and analyses for

determining the biodiversity hotspots were completed using custom modified and copyrighted versions of WORLDMAP (v. 4.20.16), made available by Dr. Paul Williams (Natural History Museum, London). Customizations to WORLDMAP were made based on the BC government's 1:20 000 mapsheet grid, representing a total of 7030 grid cells. Mapsheet grid data were provided by K. Karr, Business Services & Innovation Branch, Ministry of Water, Land and Air Protection, Victoria, B.C. The government office previously known as the B.C. Ministry of Environment, Lands and Parks provided electronic basemap and parks coverages.

ESRI's ArcView (v. 3.2) was used to prepare map images showing location of species and the top 5% rarity hotspots, and to calculate the total area of each hotspot that overlapped with provincial and national parks. Provincial parks were mapped by BC Parks and Crown Lands (last modified Dec. 2001), and are reasonably accurate when compared with the provincial boundary, which was mapped by the Surveyor General Branch (last modified Feb. 2000). However, the boundaries of national parks, also mapped by the Surveyor General Branch (last modification Jan. 1998), are less detailed than either of the provincial map coverages and do not correspond with adjacent provincial parks or the provincial boundary. In these circumstances, the boundary of the national park was altered to match those of the more accurate provincial boundary. Since national park boundaries have been altered in some circumstances and the disclaimer associated with the original park maps stated that the mapped boundaries may not be legal boundaries, the area calculations for provincial and national parks should be considered as approximate values.

Grid cells (i.e. 1:20,000 mapsheets) varied from 124.52 km<sup>2</sup> in the northeast to 165.16 km<sup>2</sup> in the southwest, with some grid cells extending outside the provincial border. In these circumstances, the terrestrial area within BC was used as the total area for calculations of hotspot area within a grid cell. The ocean-marine portion of each hotspot was calculated separately from the terrestrial portion because it was not possible to accurately identify the total area of ocean-marine within British Columbia's jurisdiction. Therefore, the calculations of percentage of total hotspot area protected only refer to the terrestrial area. The percent protected of the first three hotspots selected by WORLDMAP was also calculated. This measure was calculated as the total area protected by both terrestrial and marine parks within the selected grid cell divided by the total area of the grid cell.

## **Results**

Table 1 summarizes the data used in the current analysis, and details the sources for these data, and the number of taxa involved. The number of records in the database is also reported.

The maps showing the databased locality records for endemic species (Fig. 14), species listed at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Fig. 15), provincially Red-listed species (endangered and threatened categories)(Fig. 16), and potentially rare and endangered invertebrates (Fig. 17), indicate that relatively few of the records occur in the mapped protected areas in the province. However, some quantification of this situation is necessary to confirm this.

Biodiversity hotspot maps were thus prepared for each of these groups and some of their component taxa. From these, the top 5% of the rarity hotspots were computed and mapped (Figs.

1-8). Tables 2-9 record these top 5% of the rarity hotspots in order of species richness, and detail the precise grid-cell location, plus other relevant data.

The coincidence of these top 5% of grid-cell located hotspots, with recorded protected areas was then computed. The last column in Table 10 reports the percentage of the top 5% of the hotspots listed that fall within protected areas.

The greatest area protected in the top 5% of rarity hotspot grid cells was 17.91% for the rare Odonata (dragonflies and damselflies). COSEWIC-listed species and provincially Red-listed species showed about 12% protected area overlap, but endemic species only 6.87%. Rare butterflies at 3.4%, showed least protected area overlap. Because of the problem with some grid cells including both ocean-marine and land areas hotspot overlap with protected ocean-marine areas had to be computed separately, and results are presented in Table 11.

Table 12 presents the percentage of the area protected in the top three of the 5% of the rarity hotspot grid-cells. The highest percentage in the first choice was only 18.77%, and was the same grid cell 082E.003 for rare butterflies, rare Odonata, rare vascular plants, rare vertebrates, provincially Red-listed species, and potentially rare and endangered invertebrates. This grid cell involving the South Okanagan, shows a marked coincidence of top rarity hotspots in these taxa and groupings. It was also the second most important hotspot for the COSEWIC-listed species. The highest protected area percentage obtained was for the second highest hotspot grid cell for the rare Odonata (38.63%), with the rare vertebrates close behind at 31.12%.

The sample richness hotspot maps shown for the butterflies (Fig. 10), Odonata (Fig. 11), small mammals (Fig. 12) and vascular plants (Fig. 13) show a striking coincidence between the richness and rarity hotspots in these taxa. As a result, one can expect similar protected area percentages, although these were not computed for the top 5% of such richness hotspots, owing to the large number of hotspots involved (Table 1).

## **Discussion**

Overall, there is a marked lack of coincidence between recorded protected areas and the occurrence of large numbers of endemic species, COSEWIC-listed species, provincially Red-listed species, and potentially rare and endangered invertebrates. In the top 5% of the rarity hotspot cells for the groups considered, there was on the whole, relatively little protected area coincidence. The same would appear to be true for richness hotspots, although the precise numbers were not computed in this case. Even where there is protected area overlap, there is no assurance that these protected areas provide the needed ecosystems and habitat for the species involved.

A lack of high coincidence between the hotspots and protected areas is perhaps not too surprising, because until now, the relevant rarity and richness hotspot data have not been available (Scudder 1996). Furthermore, it should be noted that the strategies in the past governing federal and provincial park selection and designation were not focussed on biodiversity conservation. In the 1930s and 1940s, parks were set aside primarily to encourage tourism. By the 1970s and 1980s park creation began to focus on the protection of unique natural environments (SOE 1998). Only in the 1990s, did representation of British Columbia's biological

and cultural diversity, recreation resources, and habitat protection become the primary objectives of BC Parks (SOE 1998).

Although the primary goal of the more recent PAS in the province was to protect viable representation of natural diversity (British Columbia 1993), for the purpose of the PAS, the measure of diversity was limited to an assessment of an areas richness as it applies to natural, cultural heritage, and recreational values. In other words, diversity in this context is not the same as biological diversity (Scudder 1992).

Despite the fact that additional protected areas have been added very recently in the form of parks set aside in local Land and Resource Management Plans (LRMP), these have been designated usually as a result of consensus decision making by regionally-based, multi-stakeholder round tables where biodiversity conservation principles are only one of a series of values to be considered.

It should also be noted that the recorded and digitally mapped protected areas in the province, include only national parks, ecological reserves, class A and B provincial parks, recreation areas, and other areas that fall under the Environment and Land Use Act (SOE 1998). They do not include wildlife reserves, migratory bird sanctuaries, and regional parks (SOE 1998), although these have some biodiversity conservation value (Scudder 2000). Wildlife Habitat Areas recently established under the Forest Practices Code and Wildlife Management Areas established under the Wildlife Act are also not included. There are in addition, many other areas of biological conservation value that need to be added, including areas set aside by the federal government, the Nature Trust of British Columbia, the Land Conservancy, and other agencies. However, most of these have not been digitally mapped. Until this required digital mapping is undertaken and completed, these lands cannot be included in analyses such as the present.

It is also evident that there needs to be more inventory of rare and endangered species undertaken in protected areas and other areas with biodiversity conservation potential in the province. Despite the limitations with occurrence data for these areas, the results from the available data clearly show a general lack of coincidence between rarity and richness hotspots with protected areas in BC.

Because of the general lack of coincidence between rarity and richness hotspots with the current protected areas, it is evident that the 12% of the land area currently designated as protected area is not well suited to provide adequate protection for the very rich and rare biodiversity in British Columbia. Much more area is needed for sustained biodiversity conservation, either through additional protected areas or through the second component of BC's biodiversity conservation strategy, namely the application of integrated resource management principles outside of protected areas. Available studies suggest that the land area needed to represent and protect most elements of biodiversity, including wide-ranging animal species is about 50% (Soulé and Sanjayan 1998) Such areas need not be "off limits" for resource extraction or development, but must be managed in a sustainable manner. Even using complementarity principles, which are used to conserve the most species in the least amount of area, close to 40%

of the land area is needed in the South Okanagan to maintain rare biodiversity, without including buffer zones and corridors for connectivity (Warman 2001).

Research currently being undertaken by the UBC Centre for Biodiversity Research on the location of alien or “non-native” species in BC shows a marked coincidence with the rarity and richness hotspots identified in this report. Because the South Okanagan, south-east Vancouver Island and Lower Mainland are not only biodiversity rarity and richness hotspots, but are also alien species hotspots, with increasing threats from human impacts, it is recommended that these areas of the province should become the focus for increased and integrated biodiversity conservation planning in the province, preferably at the ecosystem level.

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<b>Table 1: Data Imported into WORLDMAP - 1:20 000 mapsheet grid</b>				
<b>Data</b>	<b>Number of records</b>	<b>Number of taxa</b>	<b>Number of hotspots representing top 5%</b>	<b>Data provided by</b>
<b>Rarity hotspots mapped</b>				
CDC Red-listed species (provincial)	1,571	382	29 (5.0%)	Conservation Data Centre (CDC)
COSEWIC-listed species (federal)	315	46	7 (5.5%)	Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (listing provided by D. Fraser)
Endemic species	582*	196**	14 (5.2%)	Compilation (Revised Sept. 26, 2002)
Rare Invertebrates	9,198	855	34 (5.0%)	Scudder (Terrestrial and Freshwater invertebrate species from Occasional Paper 2)
Rare Butterflies	1,883	56	12 (5.2%)	Compilation (CDC <i>Butterflies of BC</i> , CDC Red-listed, Scudder's Occasional Paper 2)
Rare Odonata	884	17	11 (5.4%)	Compilation (Scudder/RBCM/CDC Red-listed)
Rare Vascular Plants	3067	218	23 (5.1%)	Compilation (CDC Red-listed, Douglas data)
Rare Vertebrates	516	76	15 (5.0%)	Compilation
<b>Samples of richness hotspots mapped</b>				
Butterflies	12,293	267	64 (5.0%)	CDC ( <i>Butterflies of BC</i> )
Odonata	27,291	105	48 (5.0%)	Scudder/RBCM
Small Mammals	9,757	88	66 (5.0%)	D. Nagorsen
Vascular Plants	101,985	2,823	284 (5.0%)	CDC/ Douglas data (Revised Aug. 26, 2002)

\*Single species/locality occurrence.

\*\*Endemic Species/Number of taxa: We currently list 198 endemic species. Only 196 reported here as Coleoptera *Hypera publicollis* and Heteroptera *Phytocoris dentatus* are listed but we have no georeferenced data for either species.



**Tables 2-9**  
**WORLDMAP version 4.20.16 results**  
**Priority Areas Analysis: Top 5% rarity hotspots**  
**mapped on 1:20 000 Mapsheet Grid**

**Table 2**

<b>CDC Red-listed: Top 5.0% (29 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species Richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
1	082E.003	49	49	49	13.14	13.14
2	092B.044	33	33	82	8.85	21.98
3	092C.085	21	19	101	5.09	27.08
4	092B.043	20	7	108	1.88	28.95
5	082E.002	17	7	115	1.88	30.83
6	092B.033	17	6	121	1.61	32.44
7	092B.072	15	4	125	1.07	33.51
8	082E.023	11	0	125	0.00	33.51
9	092B.053	11	3	128	0.80	34.32
10	082E.033	11	1	129	0.27	34.58
11	082E.032	10	2	131	0.54	35.12
12	092B.075	10	2	133	0.54	35.66
13	082E.013	8	0	133	0.00	35.66
14	092H.020	7	2	135	0.54	36.19
15	092B.074	7	2	137	0.54	36.73
16	082E.012	7	1	138	0.27	37.00
17	092F.030	7	2	140	0.54	37.53
18	092B.083	7	1	141	0.27	37.80
19	082E.021	7	0	141	0.00	37.80
20	092H.001	7	5	146	1.34	39.14
21	082L.024	6	1	147	0.27	39.41
22	082L.034	6	1	148	0.27	39.68
23	092I.044	6	3	151	0.80	40.48
24	094A.020	6	6	157	1.61	42.09
25	092B.034	6	1	158	0.27	42.36
26	092G.011	6	2	160	0.54	42.90
27	092B.084	6	1	161	0.27	43.16
28	092B.054	6	1	162	0.27	43.43
29	092I.078	6	3	165	0.80	44.24

**Table 3**

<b>COSEWIC-listed: Top 5.5% Hotspots (7 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species Richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
1	092B.044	9	9	9	19.57	19.57
2	082E.003	8	8	17	17.39	36.96
3	092B.072	7	2	19	4.35	41.30
4	092B.033	5	1	20	2.17	43.48
5	092H.001	5	5	25	10.87	54.35
6	082E.023	4	1	26	2.17	56.52
7	082E.013	4	1	27	2.17	58.70

**Table 4**

<b>Endemic Species: Top 5.2% Hotspots (14 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
1	082F.018	12	12	12	6.09	6.09
2	092G.025	11	11	23	5.58	11.68
3	092B.044	10	9	32	4.57	16.24
4	092B.043	9	4	36	2.03	18.27
5	092I.069	7	6	42	3.05	21.32
6	103C.080	7	7	49	3.55	24.87
7	103F.056	7	4	53	2.03	26.90
8	103C.100	7	1	54	0.51	27.41
9	092B.062	6	5	59	2.54	29.95
10	103F.028	6	1	60	0.51	30.46
11	092B.054	5	1	61	0.51	30.96
12	103F.018	5	0	61	0.00	30.96
13	103C.070	5	0	61	0.00	30.96
14	082E.003	5	5	66	2.54	33.50

**Table 5**

<b>Potentially Rare &amp; Endangered Invertebrate Species: Top 5.0% Hotspots (34 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
1	082E.003	163	163	163	19.06	19.06
2	082E.013	114	46	209	5.38	24.44
3	092B.043	74	65	274	7.60	32.05
4	092B.044	72	32	306	3.74	35.79
5	082E.023	63	13	319	1.52	37.31
6	082E.062	62	16	335	1.87	39.18
7	082E.012	61	25	360	2.92	42.11
8	082E.053	60	17	377	1.99	44.09
9	082E.002	49	7	384	0.82	44.91
10	082L.024	46	13	397	1.52	46.43
11	092F.030	39	17	414	1.99	48.42
12	082E.032	34	2	416	0.23	48.65
13	082F.018	31	27	443	3.16	51.81
14	082E.021	31	3	446	0.35	52.16
15	092G.025	31	18	464	2.11	54.27
16	092B.072	30	6	470	0.70	54.97
17	082E.033	27	3	473	0.35	55.32
18	092B.054	26	5	478	0.58	55.91
19	092B.063	26	10	488	1.17	57.08
20	092B.053	23	4	492	0.47	57.54
21	082E.042	23	2	494	0.23	57.78
22	092I.069	21	9	503	1.05	58.83
23	082E.043	21	0	503	0.00	58.83
24	092H.040	20	3	506	0.35	59.18
25	092G.011	20	4	510	0.47	59.65
26	092G.021	19	1	511	0.12	59.77
27	092B.062	19	9	520	1.05	60.82
28	082E.004	17	1	521	0.12	60.94
29	092I.061	17	5	526	0.58	61.52
30	082E.031	16	5	531	0.58	62.11

<b>Potentially Rare &amp; Endangered Invertebrate Species: Top 5.0% Hotspots (34 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
31	082E.009	16	2	533	0.23	62.34
32	092H.016	16	12	545	1.40	63.74
33	092H.001	16	14	559	1.64	65.38
34	092B.093	16	2	561	0.23	65.61

Table 6

<b>Rare Butterflies: Top 5.2% rarity hotspots (12 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
1	082E.003	16	16	16	28.57	28.57
2	092B.043	14	11	27	19.64	48.21
3	082E.053	10	2	29	3.57	51.79
4	092B.072	10	0	29	0.00	51.79
5	092B.053	10	0	29	0.00	51.79
6	092B.044	10	0	29	0.00	51.79
7	082L.024	9	1	30	1.79	53.57
8	082E.021	9	2	32	3.57	57.14
9	092B.082	9	0	32	0.00	57.14
10	092F.030	9	0	32	0.00	57.14
11	092B.062	7	1	33	1.79	58.93
12	092B.054	7	0	33	0.00	58.93

Table 7

<b>Rare Odonata: Top 5.4% rarity hotspots (11 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
1	082E.003	4	4	4	23.53	23.53
2	093C.052	4	4	8	23.53	47.06
3	092H.001	4	3	11	17.65	64.71
4	093G.042	3	2	13	11.76	76.47
5	082E.033	3	0	13	0.00	76.47
6	093H.029	3	0	13	0.00	76.47
7	093N.080	3	0	13	0.00	76.47
8	094D.077	2	0	13	0.00	76.47
9	082N.028	2	0	13	0.00	76.47
10	082E.034	2	0	13	0.00	76.47
11	082N.009	2	0	13	0.00	76.47

Table 8

<b>Rare Vascular Plants: Top 5.1% rarity hotspots (23 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
1	082E.003	47	47	47	21.56	21.56
2	092B.044	38	37	84	16.97	38.53
3	092B.043	23	5	89	2.29	40.83
4	092B.053	17	0	89	0.00	40.83

<b>Rare Vascular Plants: Top 5.1% rarity hotspots (23 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
5	092B.033	16	2	91	0.92	41.74
6	082E.002	14	2	93	0.92	42.66
7	092B.072	14	2	95	0.92	43.58
8	092I.044	13	4	99	1.83	45.41
9	082E.012	13	4	103	1.83	47.25
10	082E.021	13	0	103	0.00	47.25
11	092I.069	12	4	107	1.83	49.08
12	092B.063	12	0	107	0.00	49.08
13	082E.004	11	3	110	1.38	50.46
14	092I.078	11	2	112	0.92	51.38
15	092B.054	10	1	113	0.46	51.83
16	092H.058	10	5	118	2.29	54.13
17	082E.005	9	2	120	0.92	55.05
18	092B.075	9	1	121	0.46	55.50
19	092G.011	9	1	122	0.46	55.96
20	082G.061	9	3	125	1.38	57.34
21	082E.013	9	0	125	0.00	57.34
22	082E.053	9	0	125	0.00	57.34
23	094A.020	8	6	131	2.75	60.09

Table 9

<b>Rare Vertebrates Top 5.0% rarity hotspots (15 grid cells)</b>						
<b>Choice</b>	<b>Grid cell name</b>	<b>Species richness</b>	<b>Increment</b>	<b>Cumulative</b>	<b>Inc %</b>	<b>Cum%</b>
1	082E.003	9	9	9	11.84	11.84
2	082E.002	7	3	12	3.95	15.79
3	082E.023	6	0	12	0.00	15.79
4	082E.032	6	1	13	1.32	17.11
5	082E.013	5	0	13	0.00	17.11
6	102I.085	5	5	18	6.58	23.68
7	082E.033	5	1	19	1.32	25.00
8	082F.027	5	5	24	6.58	31.58
9	092G.009	4	4	28	5.26	36.84
10	092F.078	4	4	32	5.26	42.11
11	082E.042	4	0	32	0.00	42.11
12	092H.001	4	3	35	3.95	46.05
13	092G.008	3	1	36	1.32	47.37
14	102I.086	3	1	37	1.32	48.68
15	082L.034	3	1	38	1.32	50.00

**Table 10**  
**Areas and overall percentage of the top 5% hotspots located in terrestrial portions of provincial and national protected areas in BC.**

<b>Species Group</b>	Provincial Park Area (km <sup>2</sup> )	National Park Area (km <sup>2</sup> )	Total Area Protected (km <sup>2</sup> )	Total Area (km <sup>2</sup> )	Area Protected (%)
<i>Individual Taxonomic Groups</i>					
Rare Butterflies	54.58	0.00	54.58	1603.42	3.40
Rare Odonata	144.86	156.60	301.46	1682.82	17.91
Rare Vascular Plants	244.64	0.00	244.64	3105.63	7.88
Rare Vertebrates	182.10	0.00	182.10	2019.04	9.02
<i>Composite Data Sets of Taxa</i>					
Potentially Rare/Endangered Invertebrates	421.66	0.00	421.66	4795.70	8.79
Endemic Species	87.41	21.04	108.45	1578.42	6.87
CDC Red Listed Species	432.52	2.96	435.48	3534.92	12.32
COSEWIC Species	112.35	0.00	112.35	931.05	12.07

**Table 11**  
**Areas of the top 5% hotspots located in marine portions<sup>1</sup> of provincial and national protected areas in BC.**

<b>Species Group</b>	Provincial Park Area (km <sup>2</sup> )	National Park Area (km <sup>2</sup> )	Total Area Protected (km <sup>2</sup> )
<i>Individual Taxonomic Groups</i>			
Rare Butterflies	5.38	0.00	5.38 <sup>2</sup>
Rare Odonata	0.00	0.00	0.00
Rare Vascular Plants	8.17	0.00	8.17 <sup>2</sup>
Rare Vertebrates	19.13	0.00	19.13
<i>Composite Data Sets of Taxa</i>			
Potentially Rare/Endangered Invertebrates	8.75	0.00	8.75
Endemic Species	8.85	0.00	8.85
CDC Red Listed Species	10.04	1.02	11.06
COSEWIC Species	2.56	0.00	2.56

<sup>1</sup> Some grid cells identified as hotspots include protected areas that extend into the ocean. The area of marine protected areas within the hotspot has been calculated, even though the taxonomic group may not occur in ocean environments.

<sup>2</sup> These species are not found in ocean environments, however their hotspots coincided with marine protected areas.

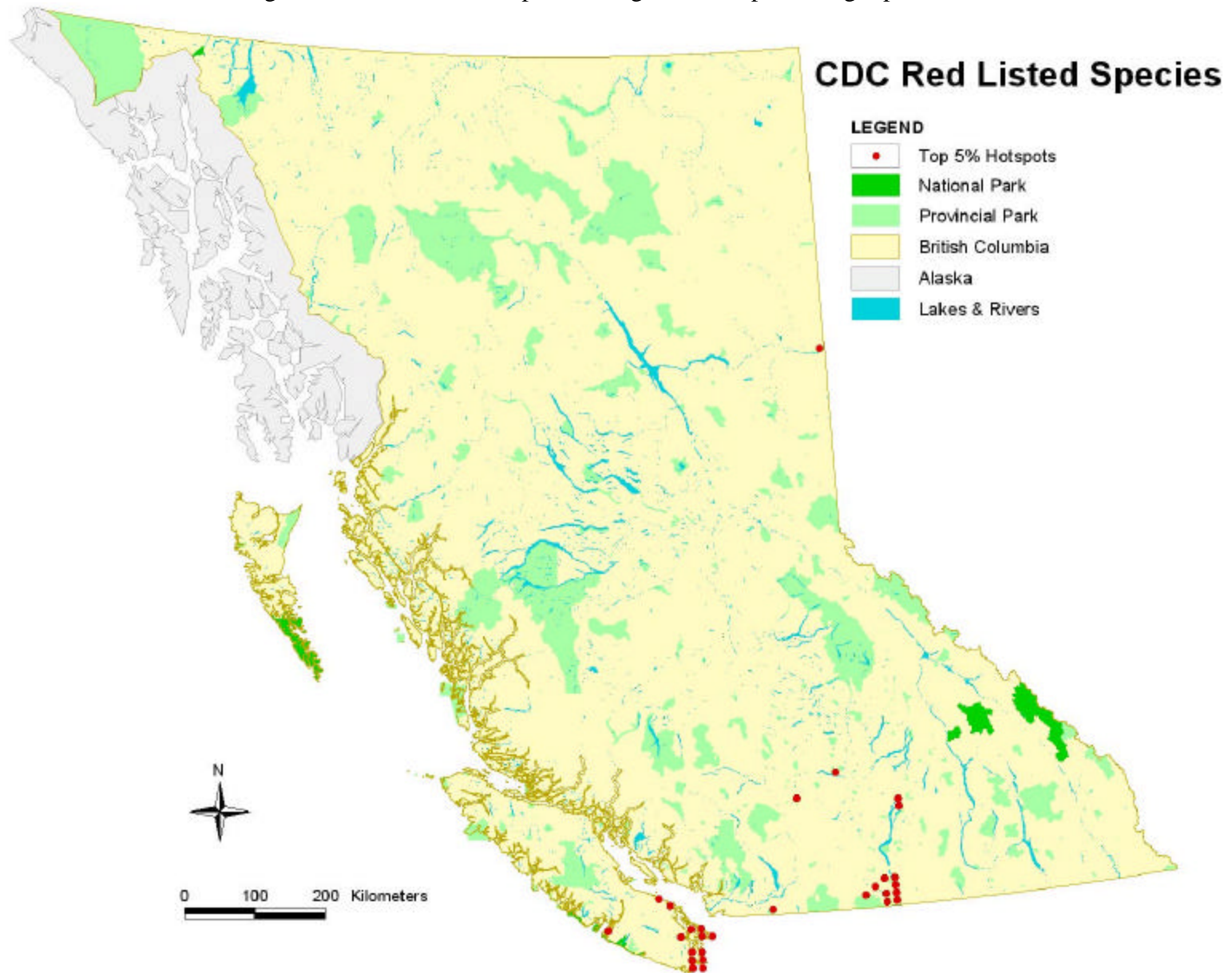
**Table 12**  
**Percentage of each of the first three sequentially selected hotspots located in provincial and national protected areas in BC (includes both terrestrial and marine areas).**

<b>Species Group</b>	First Choice (%)	Second Choice (%)	Third Choice (%)
<i>Individual Taxonomic Groups</i>			
Rare Butterflies	18.77	1.91	0.00
Rare Odonata	18.77	38.63	26.95
Rare Vascular Plants	18.77	1.62	1.91
Rare Vertebrates	18.77	31.12	21.71
<i>Composite Data Sets of Taxa</i>			
Potentially Rare/Endangered Invertebrates	18.77	1.06	1.91
Endemic Species	0.00	0.00	1.62
CDC Red Listed Species	18.77	1.62	2.44
COSEWIC Species	1.62	18.77	0.33

Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

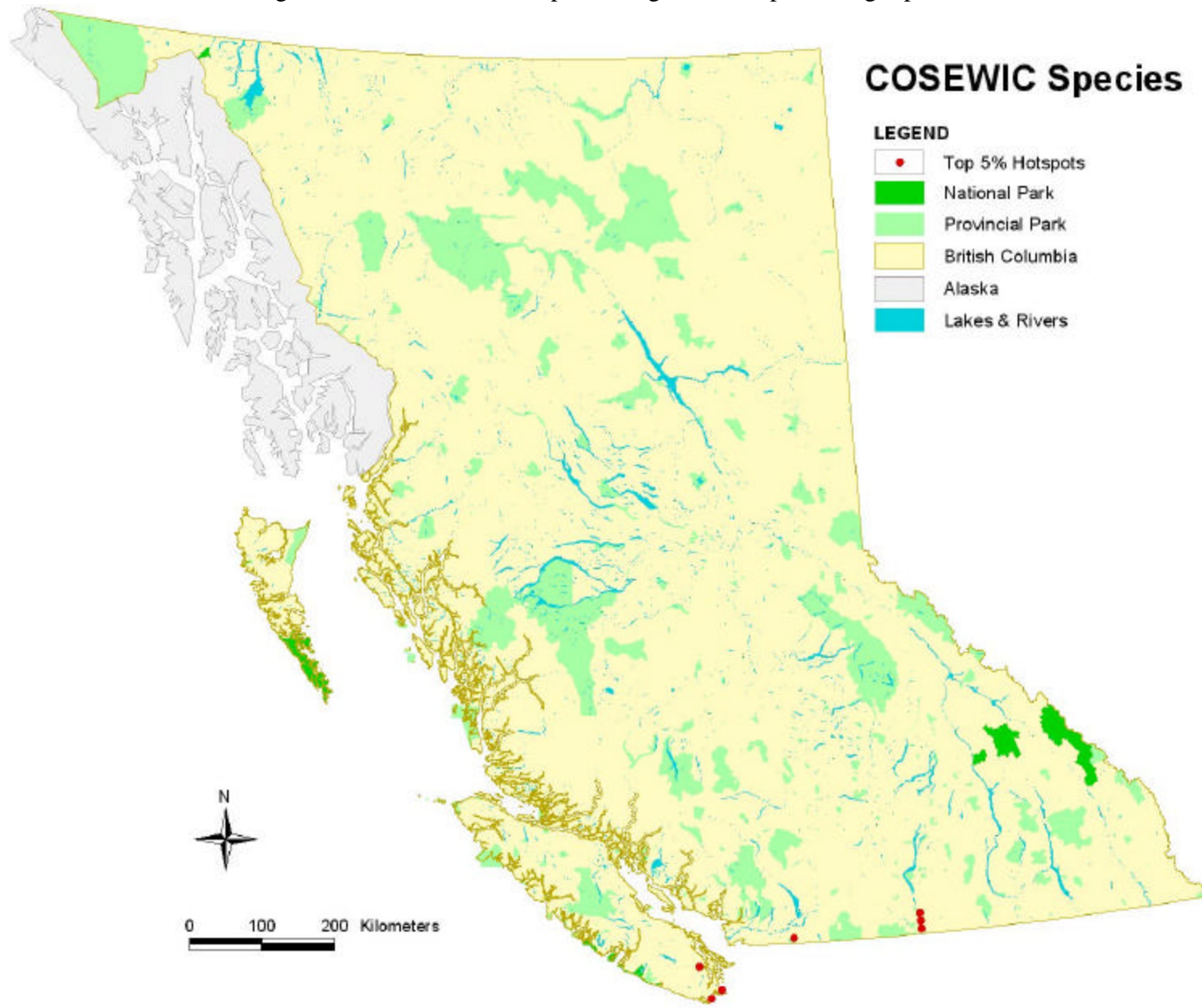
**Figures 1-8. Top 5% Species Rarity Hotspots**

Figure 1. CDC Red-listed species: 29 grid cells representing top 5.0%



Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

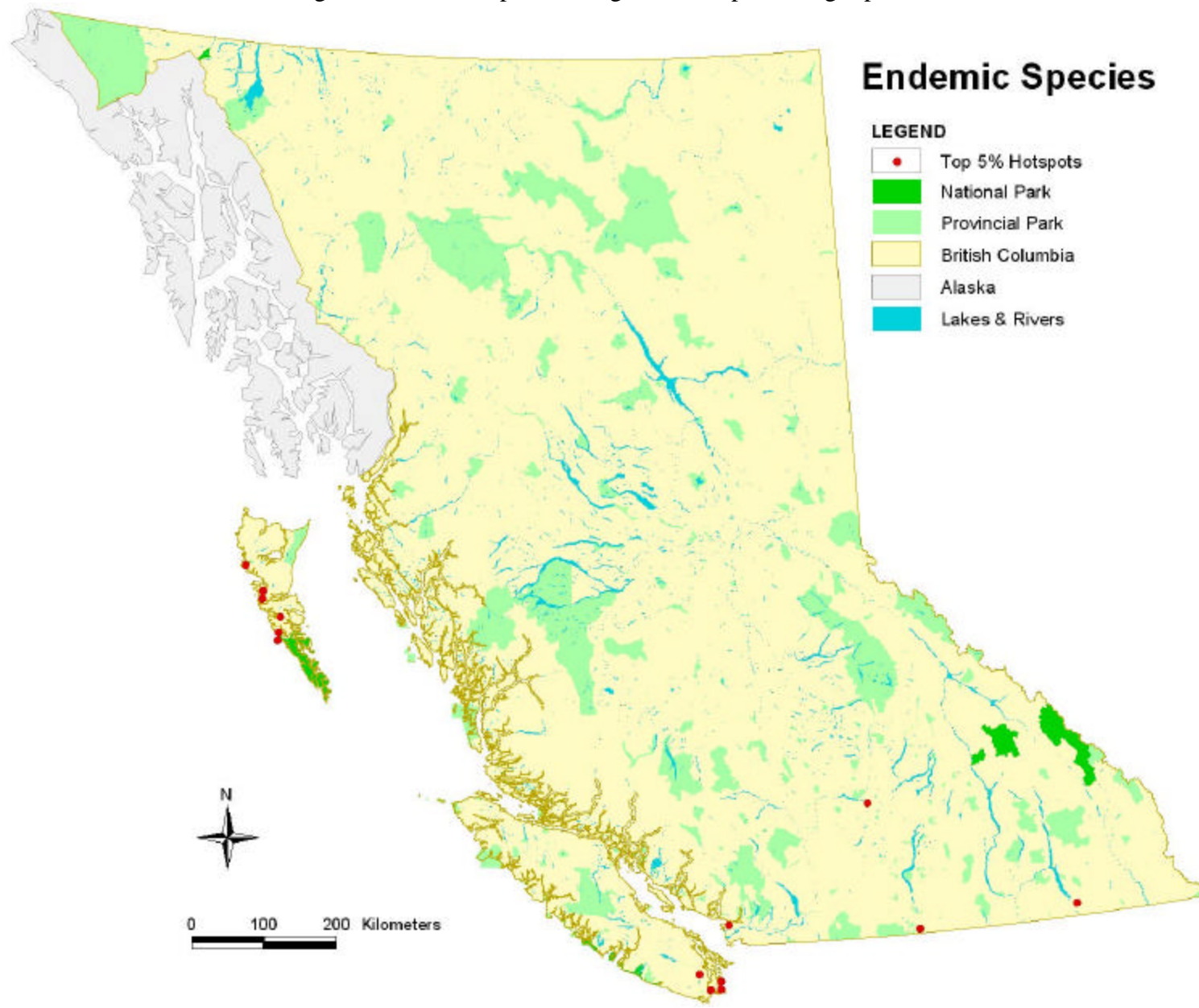
Figure 2. COSEWIC-listed species: 7 grid cells representing top 5.5%





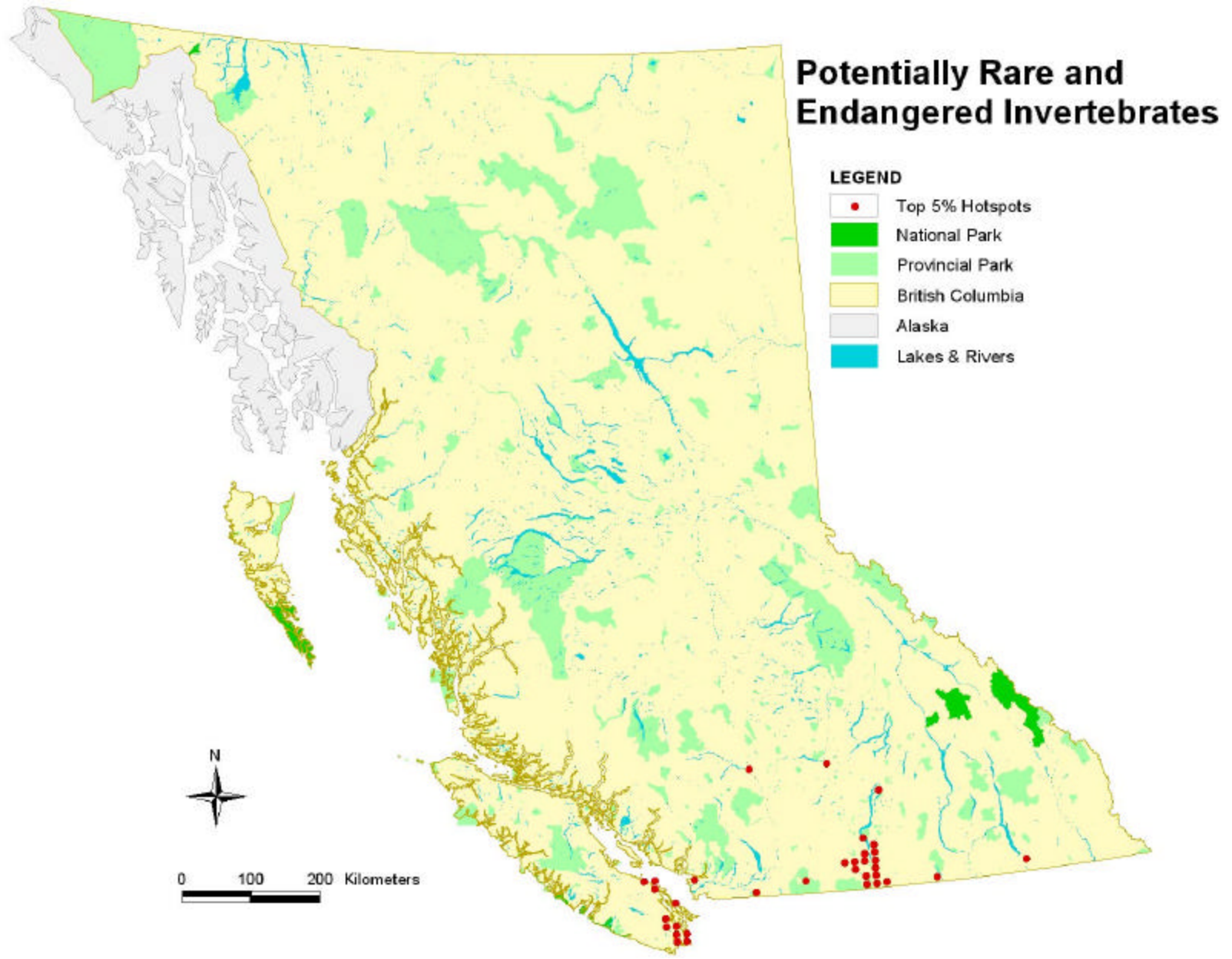
Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

Figure 3. Endemic species: 14 grid cells representing top 5.2%



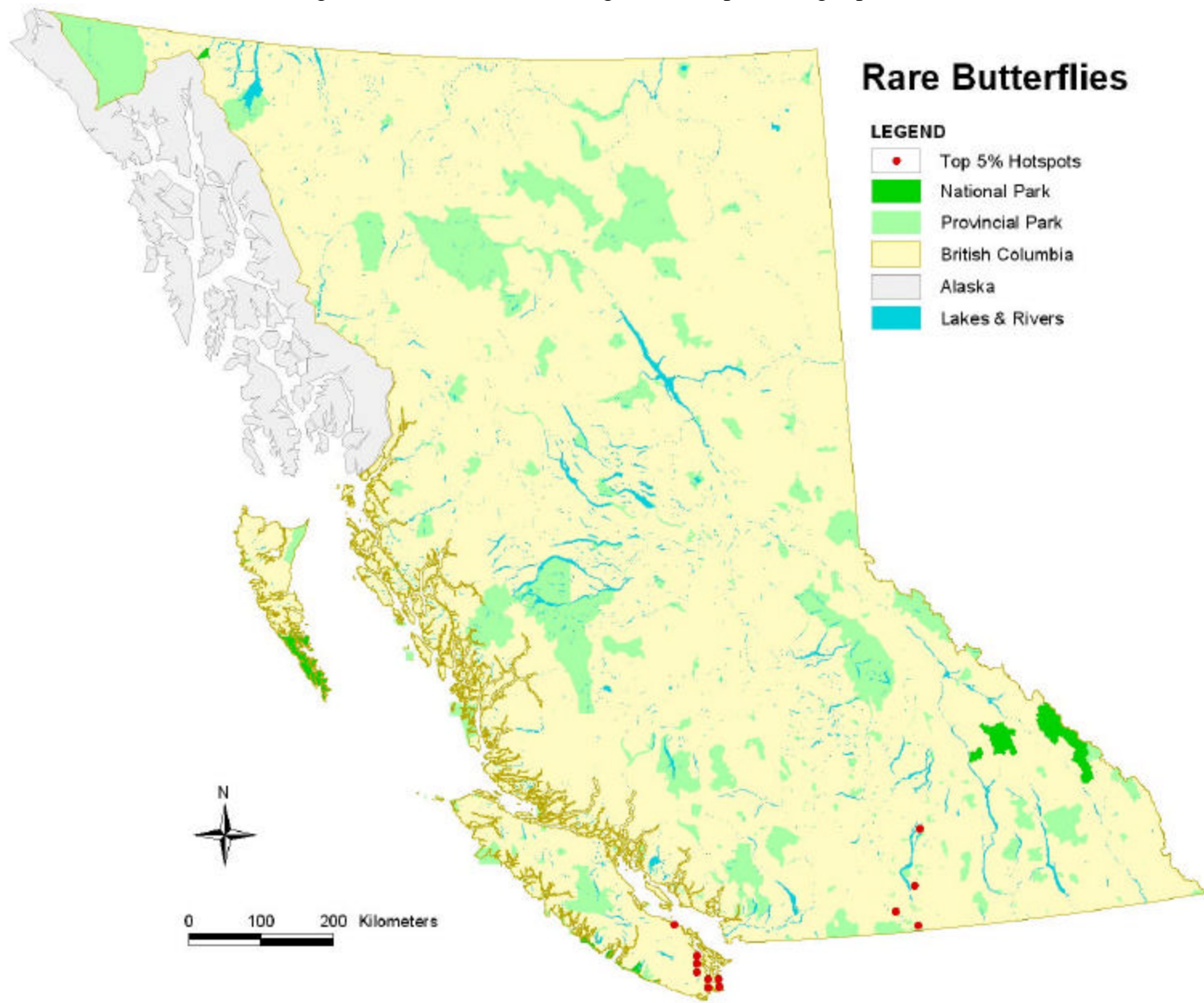
Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

Figure 4. Potentially Rare and Endangered Invertebrate species: 34 grid cells representing top 5.0%



Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

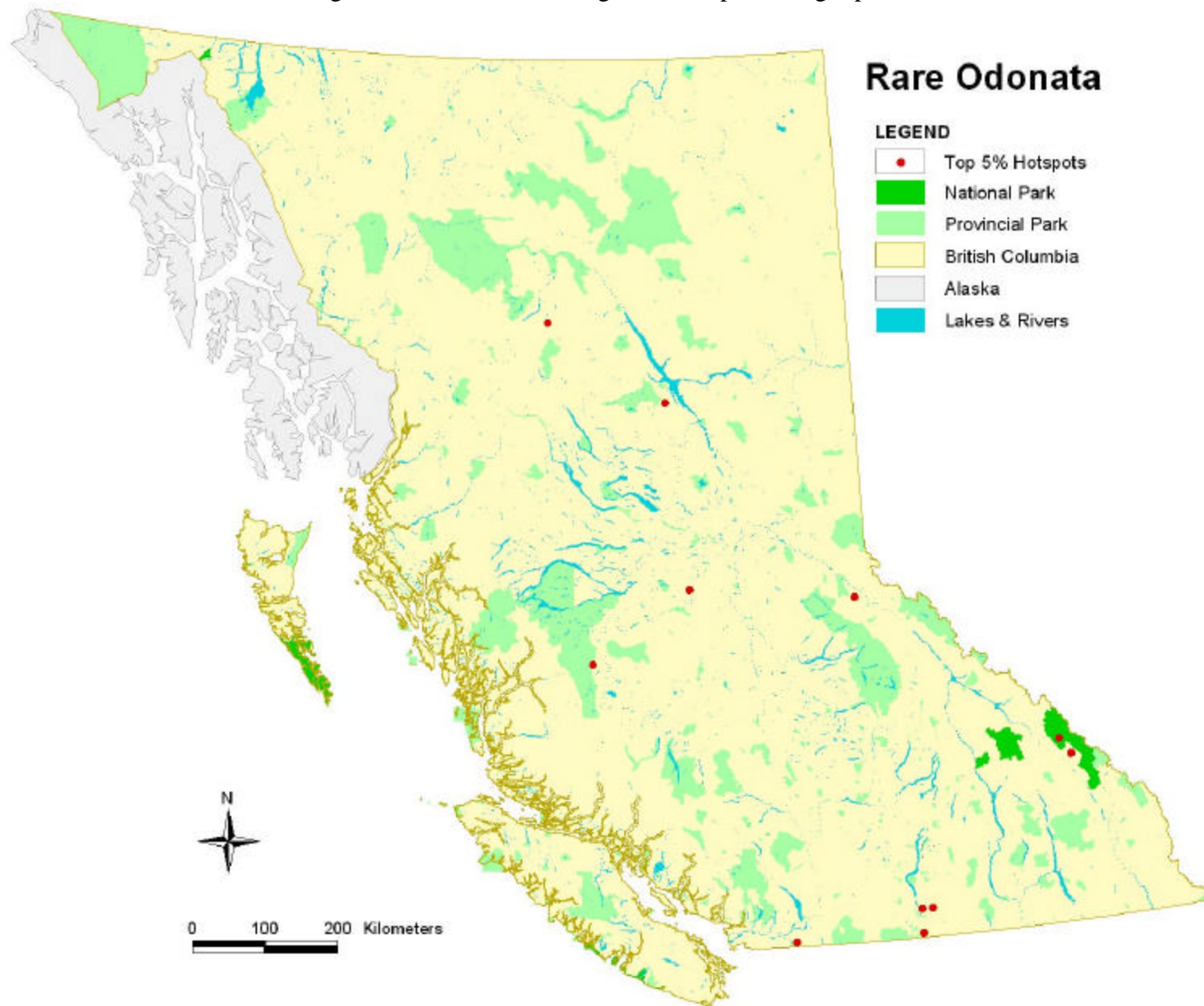
Figure 5. Rare Butterflies: 12 grid cells representing top 5.2%





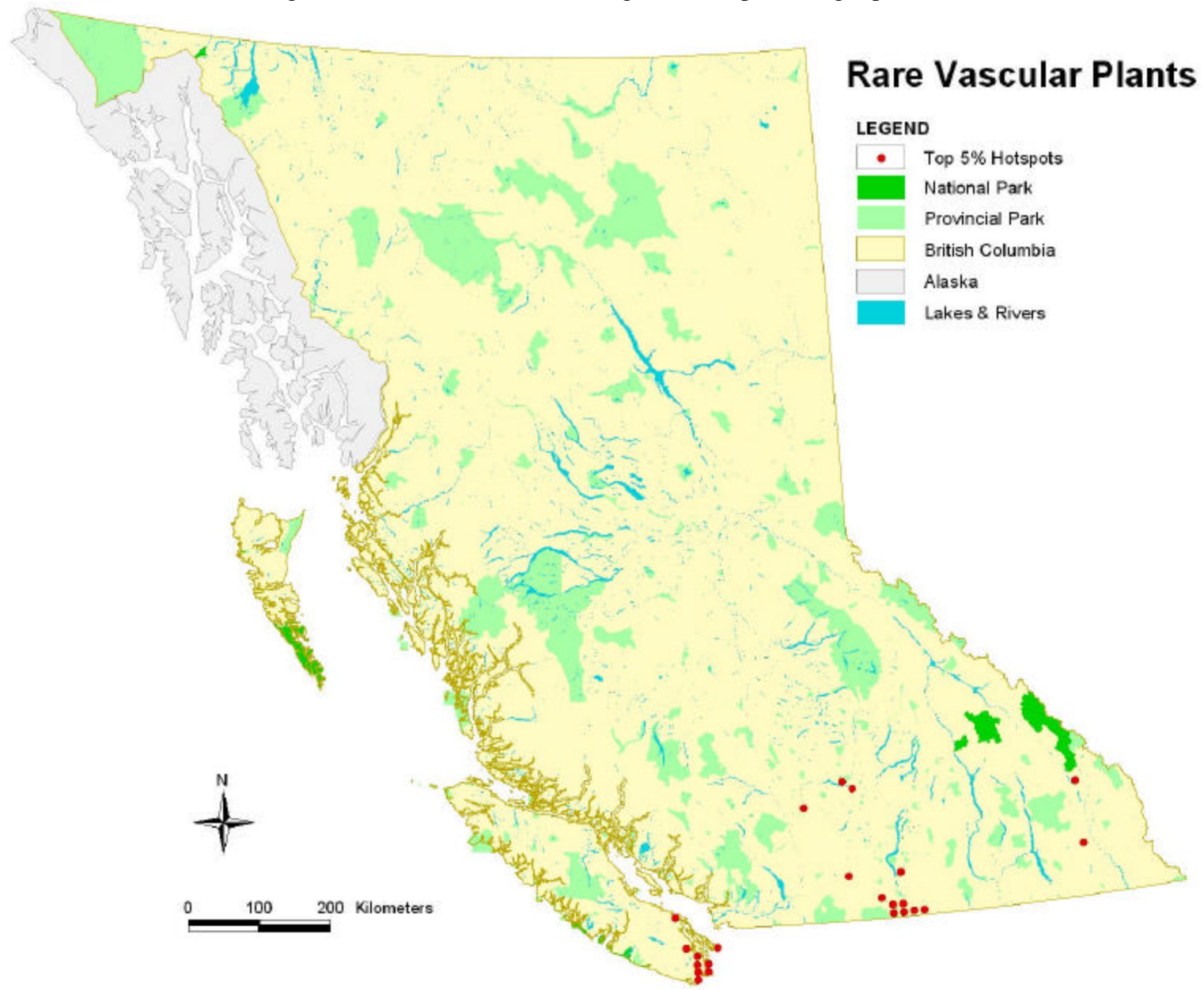
Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

Figure 6. Rare Odonata: 11 grid cells representing top 5.4%



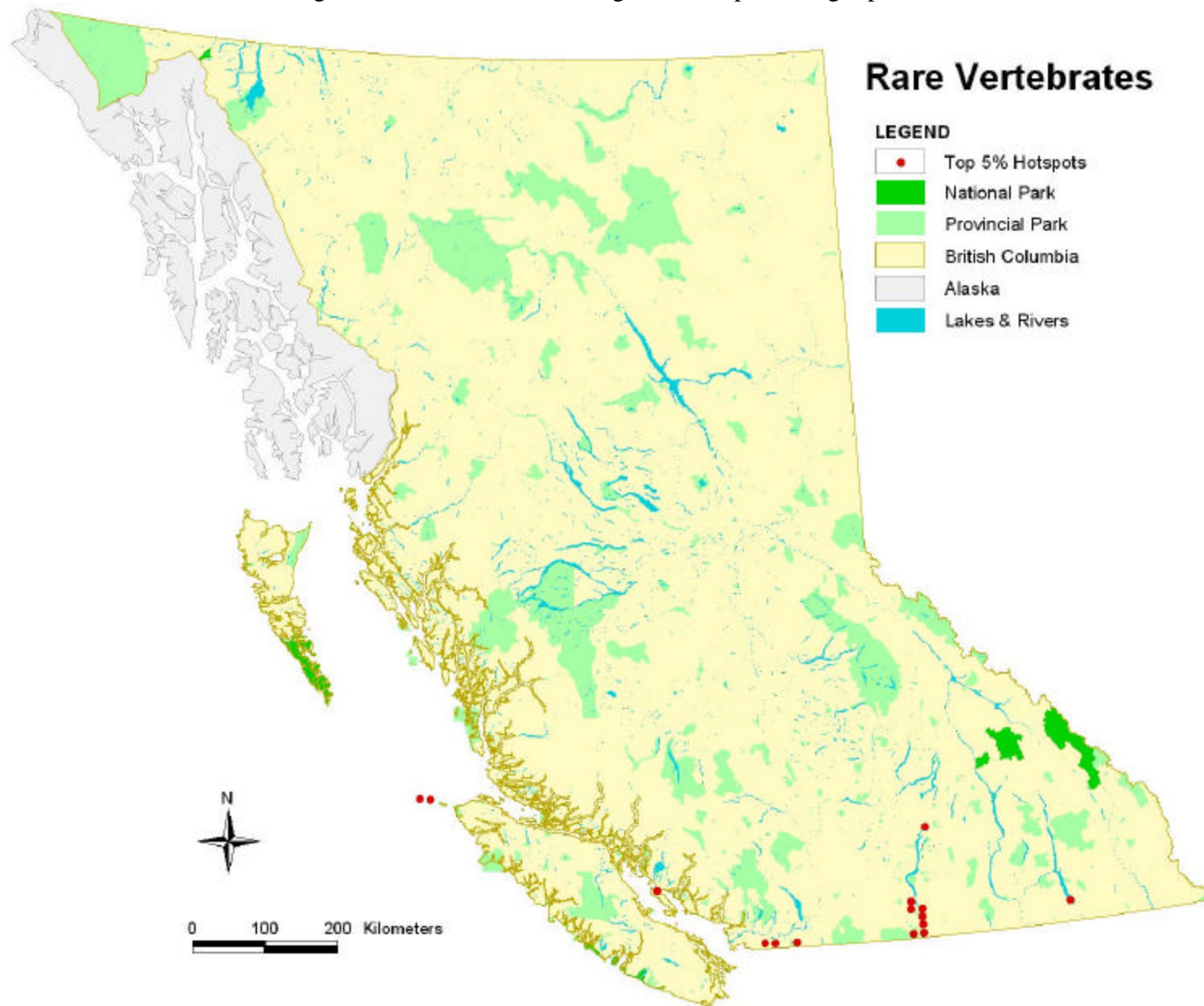
Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

Figure 7. Rare Vascular Plants: 23 grid cells representing top 5.1%



Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

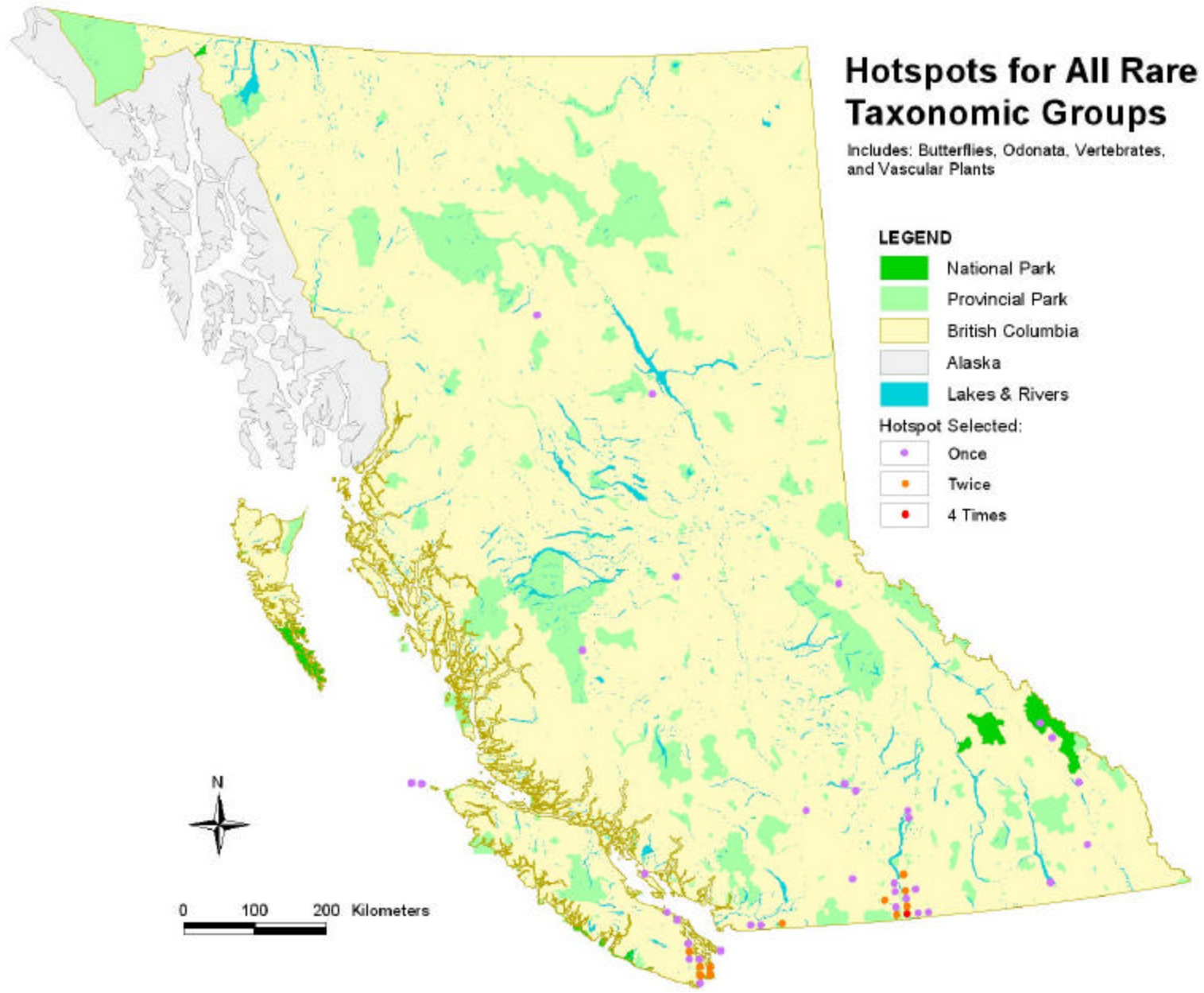
Figure 8. Rare Vertebrates: 15 grid cells representing top 5.0%





Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

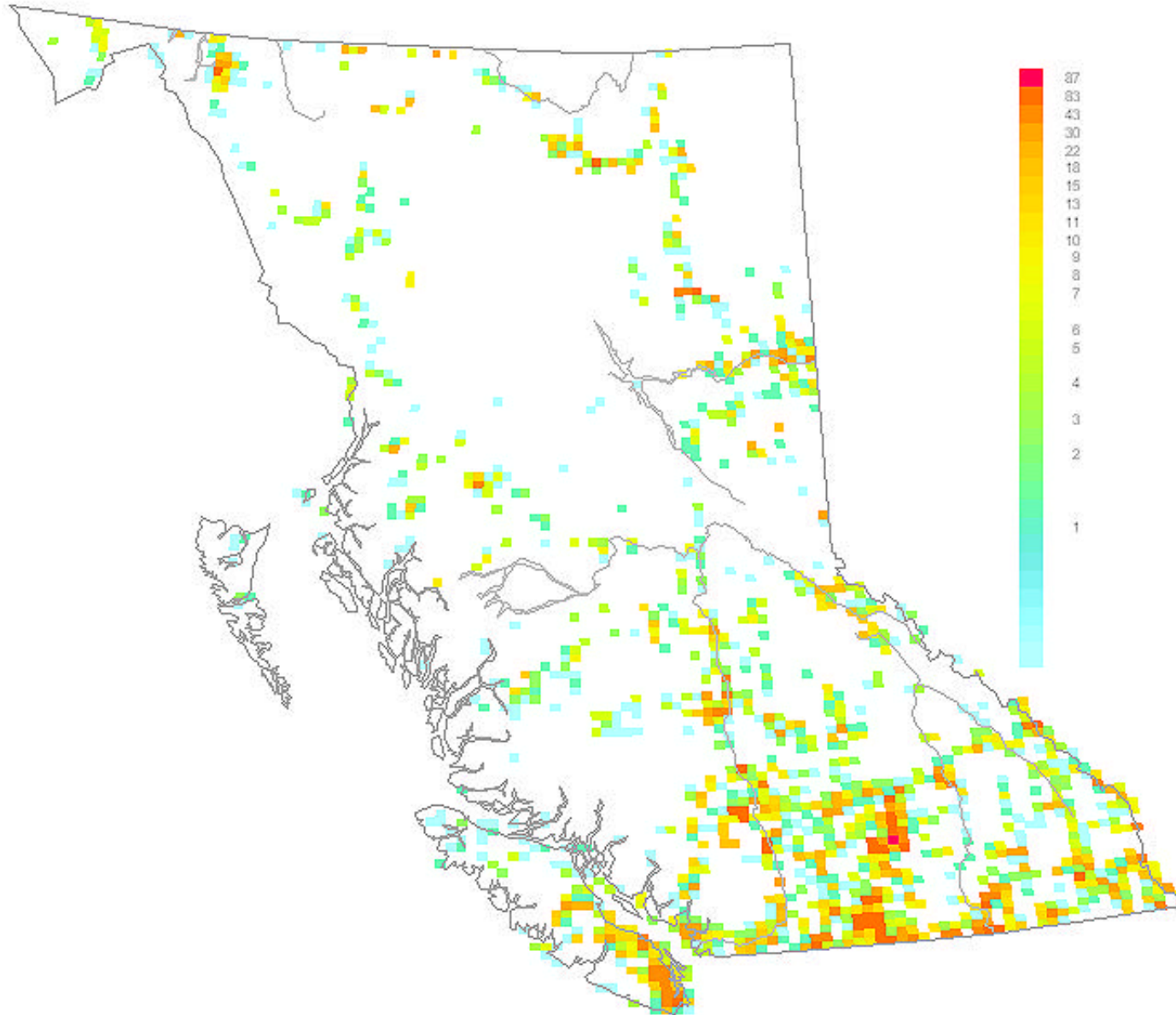
Figure 9. Rare Taxonomic Groups Combined (Butterflies, Odonata, Vertebrates, and Vascular Plants): representing top 5%



Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

**Figures 10-13. Samples of Species Richness Hotspots plotted in WORLDMAP**

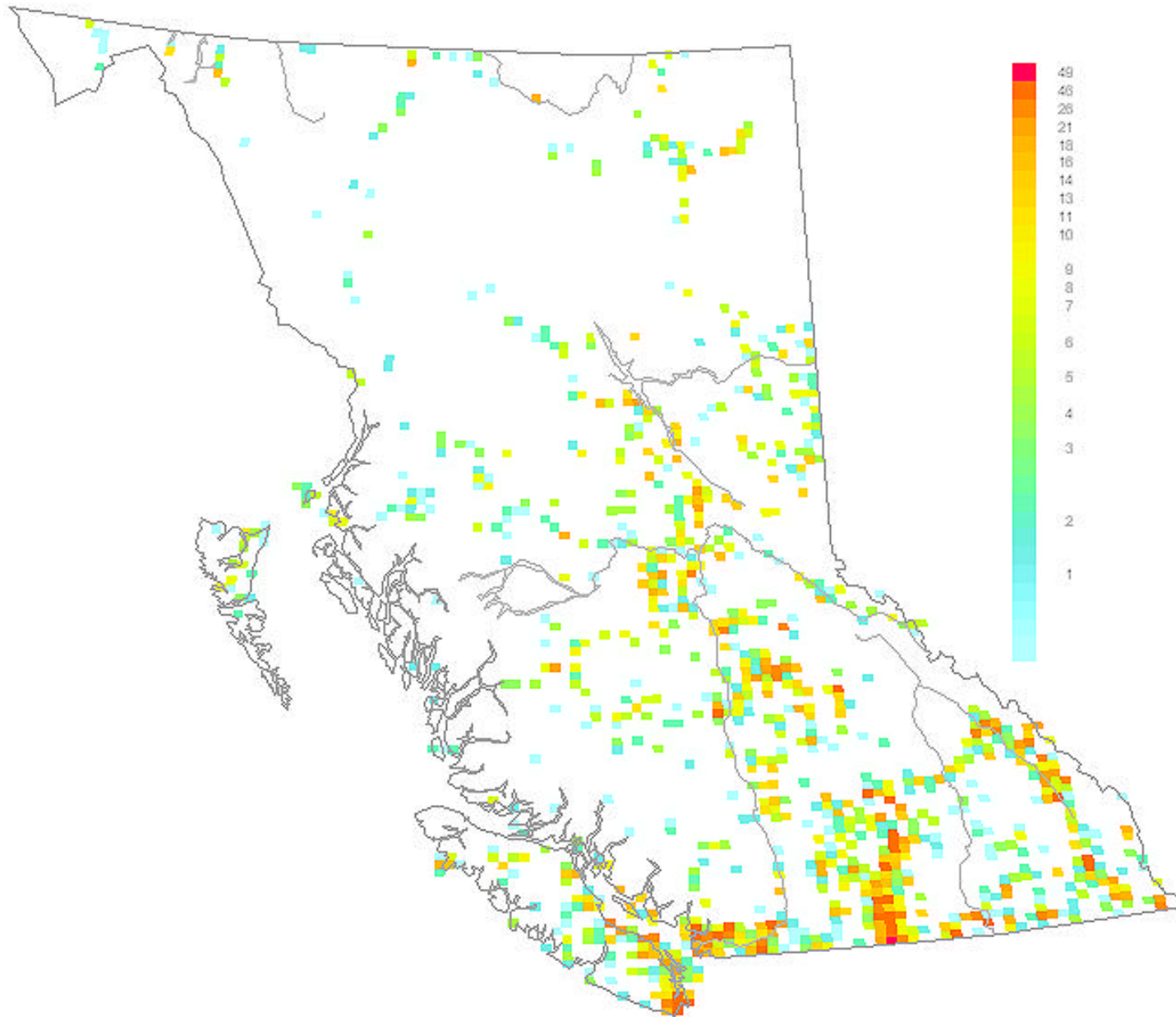
Figure 10. Butterfly Richness (12,293 records/267 taxa plotted in 1,268 grid cells)





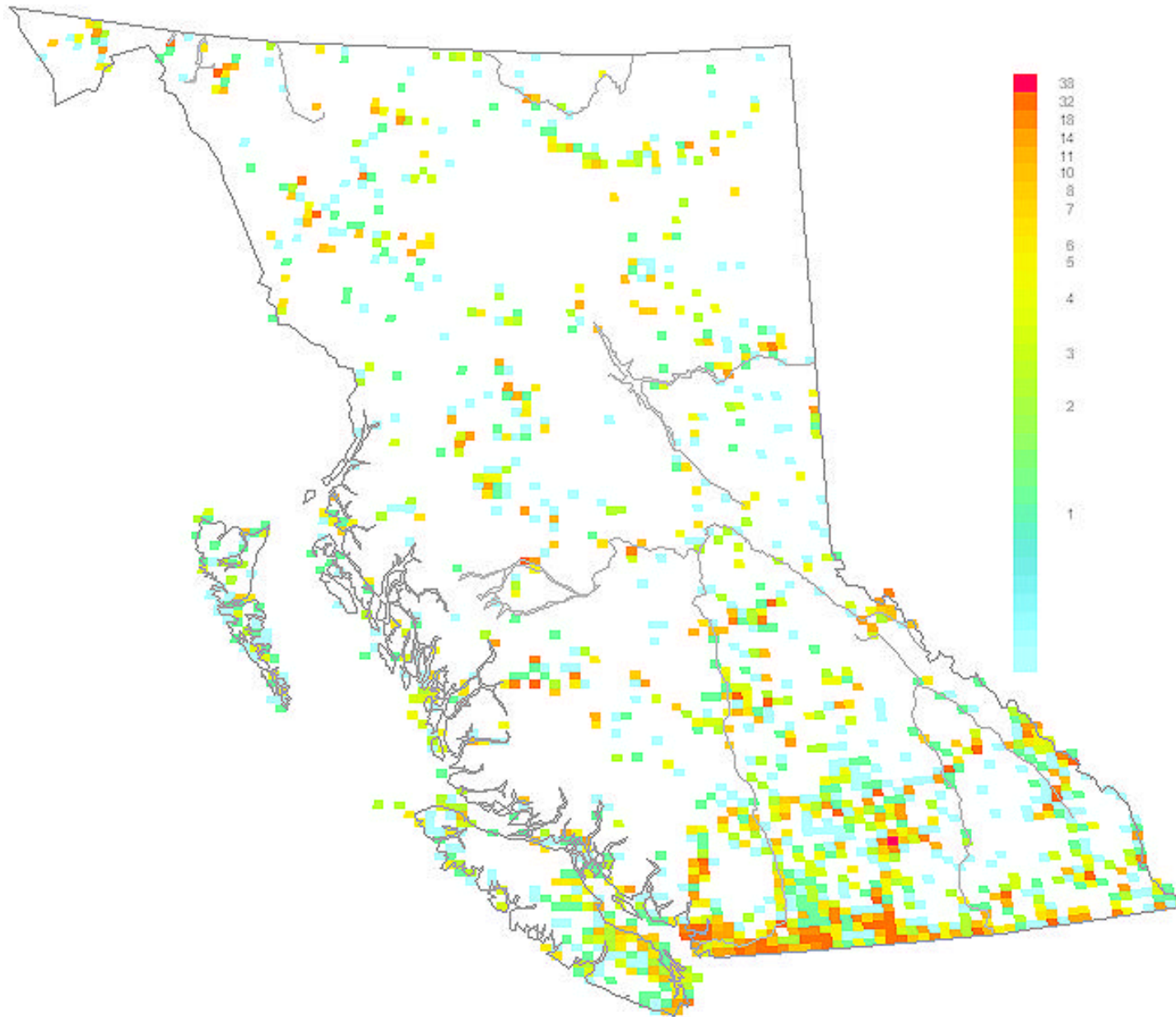
Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

Figure 11. Odonata Richness (27,291 records/105 taxa plotted in 959 grid cells)



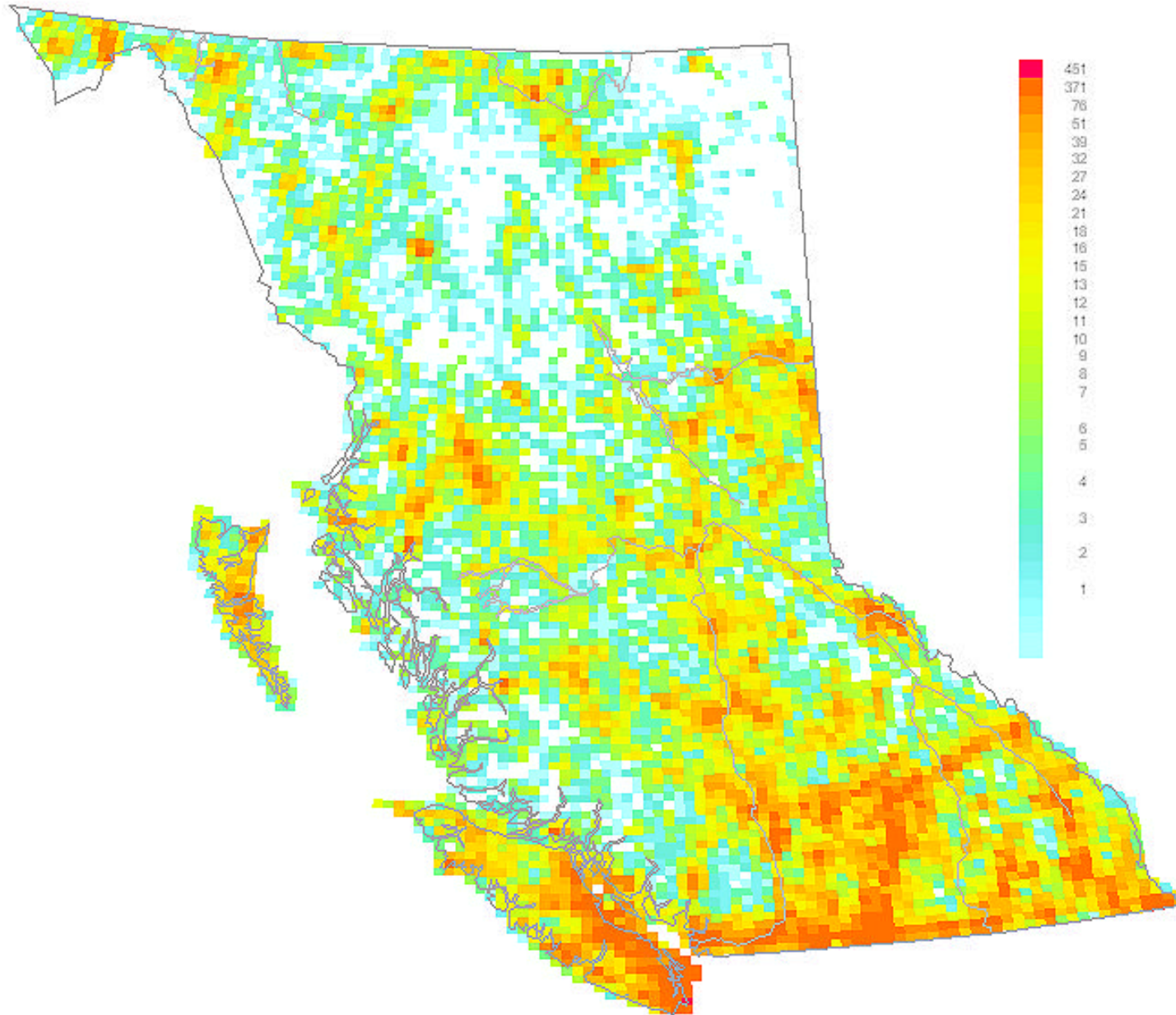
Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

Figure 12. Small Mammals Richness (9,757 records/88 taxa plotted in 1,322 grid cells)



Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

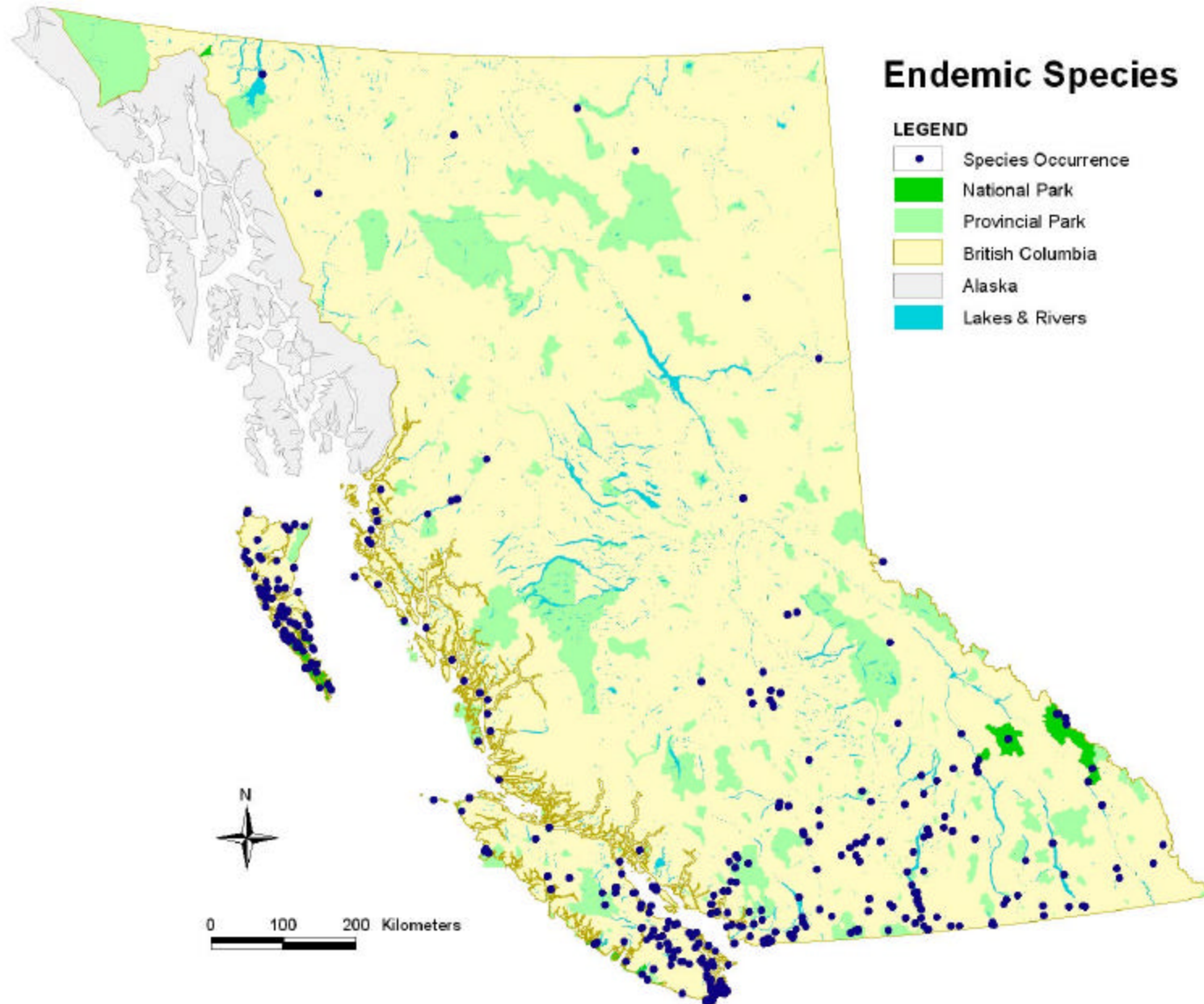
Figure 13. Vascular Plants Richness (101,985 records/2,823 taxa plotted in 5,642 grid cells)





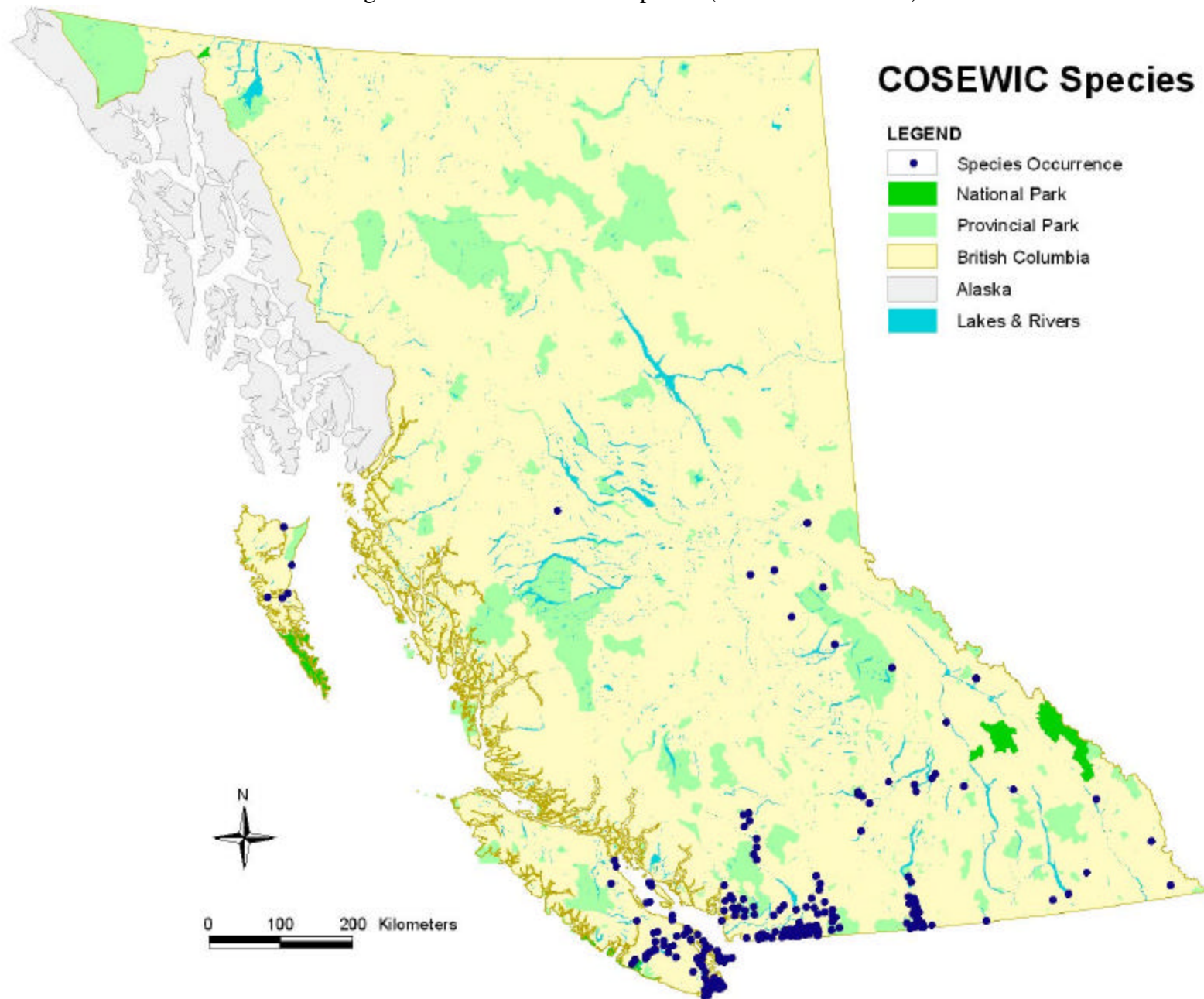
**Figures 14-17. Rarity Mapping**

Figure 14. Endemic species (582 records/196 taxa)



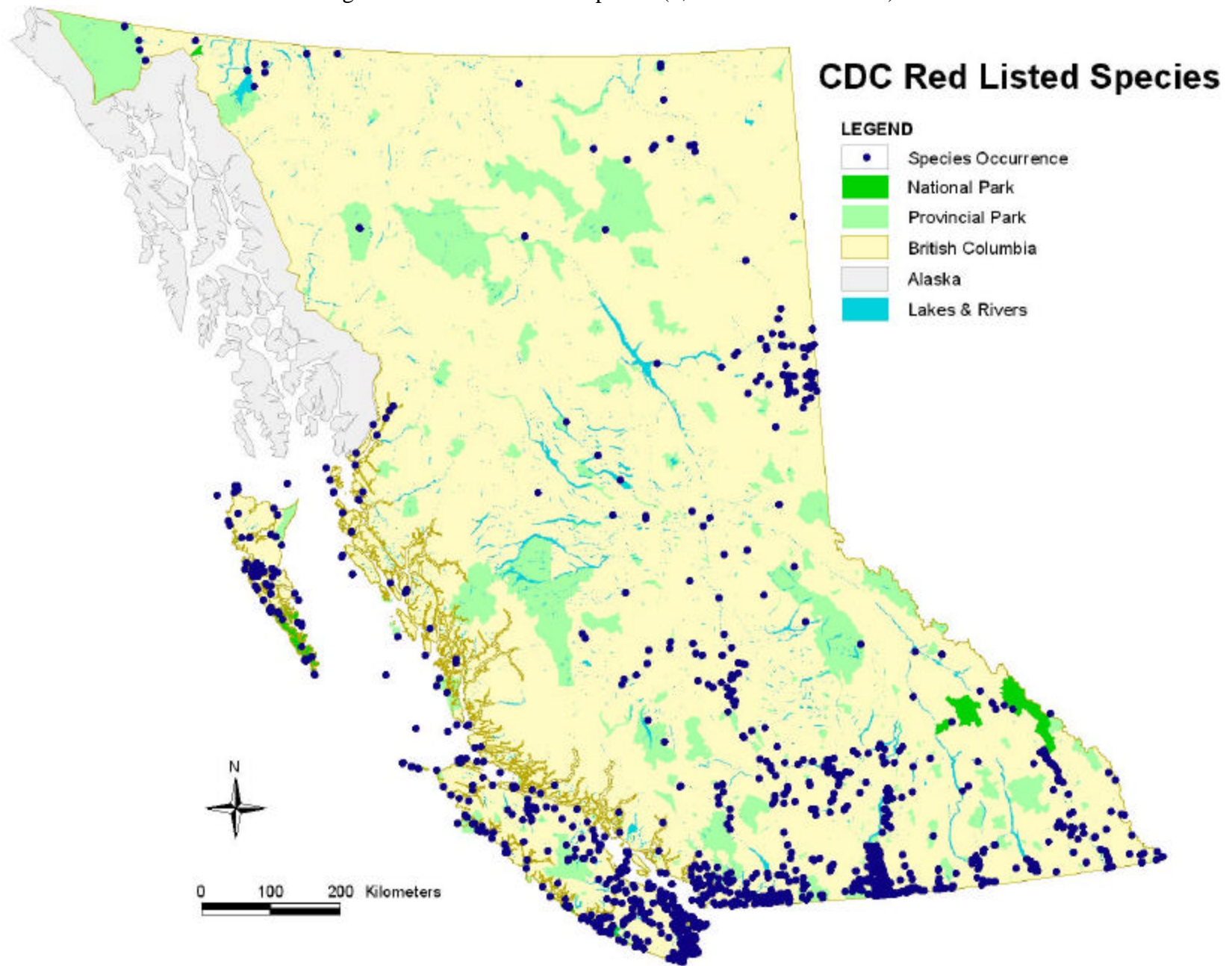
Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

Figure 15. COSEWIC-listed species (315 records/46 taxa)



Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

Figure 16. CDC Red-listed species (1,571 records/382 taxa)





Top 5% Rarity Hotspots in BC and samples of Richness hotspots, based on 1:20 000 mapsheet grid

Figure 17. Potentially rare and endangered invertebrates (9,198 records/855 taxa)

