



**TECHNICAL SUBCOMMITTEE
COMPONENT REPORT**

APPLYING THE CONCEPT OF STEWARDSHIP RESPONSIBILITY IN BRITISH COLUMBIA

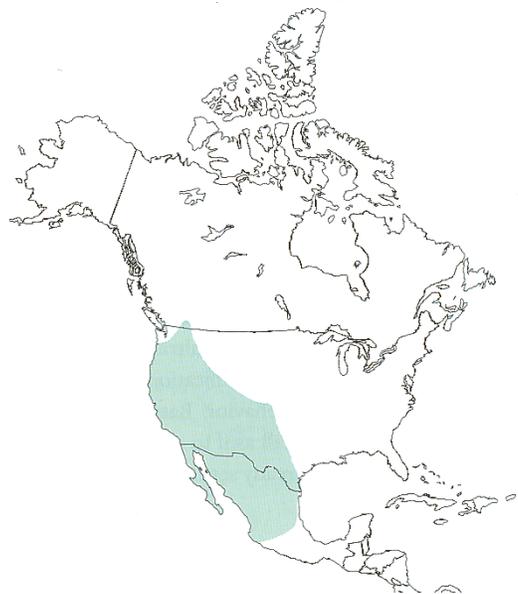
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Applying the Concept of Stewardship Responsibility to Species in British Columbia



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Summary

Lists of species at risk are designed primarily to provide an easily understood estimate of risk and extinction. The lists have become linked to decision-making processes, often in unhelpful ways. Unhelpful guidance can be reduced through the concept of responsibility. The broad concept of stewardship responsibility is simple: within a jurisdiction we should allocate greater effort to conserve species for which we have a greater proportion of the global population or range (responsibility). That is, *other things being equal*, a species having 70% of its population or range within British Columbia should receive greater conservation effort than a species having 2% of its range within the province. The concept is widely applied in international conservation efforts and can be adapted readily to a particular jurisdiction.

For most species, responsibility is estimated from the proportion of occupied range occurring within British Columbia. The task is simple but tedious because a variety of sources are required for the vast majority of species. Estimating responsibility for ecosystems confronts a major challenge: there is far less agreement on what is the same ecosystem than on what is the same species. Moreover, we should not expect close agreement, because ecosystems are aggregations of species whose boundaries we determine more arbitrarily than we assign species designations. Estimating responsibility for uncommon constellations of species is likewise difficult: requiring overlays of individual species maps and arbitrary judgments about the degree of overlap.

Stewardship responsibility is described by seven classes ranging from 1 (endemic; 100% of global range or population within the province) to 7 (low and localized, <10% global responsibility and occurring over <30% of the province). For some taxa a further class can be used as a subset of 7 (<2% of global responsibility within the province). Additional measures provide context for interpretation of the class include: global threat, seasonality, isolation (disjunct or not), and size of the global range.

The concept of responsibility, using the 7 classes, was applied to 13 groups of organisms within the province: amphibians, birds, mosses, freshwater fish, mammals, reptiles and turtles, butterflies, dragonflies and damselflies, non-marine molluscs, ferns and fern allies, monocotyledonous plants, dicotyledonous plants, conifers, and mosses. We estimated responsibility for 3,843 species (Table 1). Responsibility for taxa below species level (i.e., taxa lacking formal species names, population and varieties) were not included in this report. These include species tracked by the B.C. Conservation Centre as well as some species not on lists provided by CDC but for which there is evidence of their occurrence in British Columbia. There is uncertainty around many of these species, whether listed by CDC or not. Taxonomic issues are present throughout but are more evident within some groups. These and other issues specific to a group of organisms are discussed separately for each group (Section 4.1). Generally, the pattern of responsibility follows what is expected from log-normal distributions of community structure, with the vast majority of species (2,963, 78%) having less than 10% of their range within the province (Tables 1). The province appears to host 15 endemic species.

The utility of applying the concept of stewardship responsibility has been documented for several nations and smaller jurisdictions. However, there cannot be an arbitrary cut-off for conservation actions based solely on stewardship responsibility (reasons summarized in Section 5). We recognize three ways in which stewardship responsibility can make conservation actions more cost effective and successful: 1) Conservation effort is focused where it is most likely to be effective (i.e., the species is most abundant); 2) Proactive responses, that are more likely to produce success, are encouraged by examining closely species that are not yet rare but are declining or under imminent threat; 3) A more equitable allocation of resources for conservation across jurisdictions is encouraged.

Simplistic application of some arbitrary stewardship cut-off can easily lead to misapplication of the concept and outcomes contrary to the goal of conservation. We note six considerations that make simplistic application of the concept invalid (Section 5). That is, stewardship responsibility alone is far too simplistic and potentially misleading; it must be interpreted within the context of other factors. It does not, for example, provide more than the broadest indication of risk, and that is risk within the jurisdiction.

Barriers to implementing the concept include effort, accuracy, taxonomy and level of discrimination. We note ways in which each of these can be reduced, and no barrier outweighs the advantages that can be gained.

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1. The Concept of Responsibility

Lists of species at risk are designed primarily to provide an easily understood estimate of risk and extinction. Although the estimates of risk may be accurate, focusing on species at greatest risk can be unhelpful. Possingham et al. (2002) put it this way:

“It is inappropriate to use threatened species lists for resource allocation. Resources for conservation are limited. Spending the most money on species with the highest extinction possibilities is not the most efficient way of promoting recovery or minimizing global extinction rates, because some of the most highly ranked species require huge recovery efforts with a small chance of success, whereas other less threatened taxa might be secured for relatively little cost.”

The potential for unhelpful guidance for lists of species at risk is greatest within a particular jurisdiction when risk is considered only from the perspective of the jurisdiction and not placed into global context (e.g., Avery et al. 1995; Bunnell et al. 2004; Eaton et al. 2005). Dunn et al. (1999) divided the issues guiding our conservation actions into two broad classes: concern (factors influencing risk) and responsibility (sometimes termed stewardship; referring to stewardship responsibility). The broad concept of stewardship responsibility is simple: within a jurisdiction we should allocate greater effort to conserve species for which we have greater responsibility (where responsibility is considered proportion of population or range). That is, *other things being equal*, a species having 70% of its population or range within British Columbia should receive greater conservation effort than a species having 2% of its range within the province. The issue is not simply one of equitable sharing of resources. The more compelling reason for applying responsibility is that the likelihood of successful outcomes is greatly enhanced where populations are larger and more concentrated (Abbitt and Scott 2001; Clark et al. 2002; Elphick et al. 2001). The concept thus serves as a planning and priority-setting tool, guiding effort to areas of greatest responsibility or where the likelihood of success and impact of effort is highest. For several reasons, including those summarized in Section 5, stewardship classes cannot provide a simple cut-off for conservation actions. They can, however, serve to focus review of important features determining risk and the likelihood of success prior to enacting conservation effort.

The concept of responsibility appears to have been invoked first for birds to describe critical areas serving as potential ‘migratory bottlenecks’. In this way, stewardship responsibility is an important guiding principle of the RAMSAR Convention, Western Hemisphere Shorebird Reserve Network, and the Important Bird Areas Program. In these instances, the concept has served to guide conservation efforts to areas where their impact is likely highest. More generally, we can index stewardship responsibility by the proportion of global abundance or range for species occurring within the jurisdiction for which stewardship is being assessed (e.g., British Columbia or Canada). A high proportion reflects high stewardship responsibility. In this broader sense, the concept has been championed in North America primarily by the Partners in Flight system in Canada, Mexico, and the United States (Carter et al. 2000; Dunn et al. 1999; Panjabi et al. 2005). By focusing conservation effort where the species is best represented, successful outcomes are more likely.

Where a consistent taxonomy is available, the concept has been applied to ecosystems as well. The Biogeoclimatic Ecosystem Classification (BEC) system provides such a taxonomy within British Columbia. Using the BEC system, ecosystem representation has been applied to a number of large planning units within the province (e.g., Bunnell et al. 2003: Chapter 2; Wells et al. 2003, 2004). In these latter instances the concept of responsibility focused attention on ecosystems within the planning unit, whose representation was most strongly expressed within the unit relative to the rest of the province.

2. Methodology

Population based: For organisms, stewardship responsibility ideally would be based on proportions of the population within a particular jurisdiction. This can be approximated only within three broad groups of species: 1) birds that show strong seasonal aggregations, 2) some marine mammals that congregate, and 3) game species that are surveyed by government agencies throughout their range. Of these three groups the first two appear best documented. The ability to assess seasonal concentrations of bird species that naturally aggregate is increasing, as is the quality of reporting (Morrison et al. 2000a,b). The ability to assess populations and period of occupancy within a jurisdiction for some marine mammals also has increased, and is particularly sound for species that 'haul out' and can be counted (e.g., northern elephant seal). As the concern for all of biodiversity has grown, funding to survey game species has declined, and estimates for game species are becoming increasingly less rigorous, other than for species of most conservation concern (e.g., some caribou populations).

Population-based assessments of stewardship responsibility should:

- Indicate that the assessment is population based.
- Indicate sources when a single monograph or few sources have contributed strongly to the estimate. Documenting sources when a compilation of population estimates has been used is helpful, but is likely to be ever-changing so worthwhile only for species for which stewardship may influence conservation actions.
- Note whether or not the estimate is based on seasonal aggregations or resident populations. The former may be temporary, but still critical.

Range or area based: Responsibility estimates for ecosystems or communities are necessarily area based. Those for most species also are necessarily area based, because the only data consistently available are presence:absence or range.

For species, range maps are employed and differences in approach are primarily in detail or precision; they are invariably tedious. For example, Anonymous (2006) in Ontario limited their analysis to reptiles occurring in Ontario. For each species they acquired the most current available range maps throughout their range, entered coordinates of each range into GIS, and calculated the portion of the range occurring in Ontario. Such a detailed approach has the desirable attributes of accuracy (to the degree that range maps are accurate) and precision, particularly among assessors. Unfortunately, it is costly in time and funding so can be applied to only a few species. An approach that can be applied to many more species is necessarily more coarse, and includes the following steps:

- 1) From NatureServe obtain the North American jurisdictions in which the species occurs. Note not all groups are well documented within NatureServe.
- 2) Evaluate whether the species occurs outside North America. Note: NatureServe is not consistently clear on this point.
- 3) For each jurisdiction (including other countries where appropriate) obtain the most current range map. Jurisdictional range maps (e.g., provinces or states) are almost always more detailed than maps covering larger areas. Note: during this stage it sometimes becomes clear that a jurisdiction has been omitted by NatureServe.
- 4) Knowing the area of the jurisdiction and the apparent proportion of the area occupied by the species, estimate the total area occupied within the jurisdiction.
- 5) Sum estimated areas occupied in all jurisdictions and determine the proportion of that total occurring within British Columbia, or stewardship for the province. This estimate almost always is crude, but can be divided into classes.

Note: We found that single large range maps are almost always unhelpful because they typically outline the entire range, ignoring the unoccupied areas within the boundary. Others dealing with large ranges have encountered the same problem (e.g., Laliberte and Ripple 2004, Lomlino and Channel 1995). Despite the tedium, it is significantly more accurate to unearth more detailed fine-scaled maps.

Whatever approach is taken to assess stewardship, the value can then be viewed in the context of other features such as trend or threat.

For constellations of species (e.g., intact predator-prey systems; groups of regional rare species that may approximate rare ecosystem types), the difficulty is identical to that for ecosystems – no unequivocal identity exists that can be used across jurisdictions. The methodology must exploit overlays of species' ranges. Some of these species are highly mobile (sometimes migratory) and others may range widely. Other than the fact that arbitrary judgments need to be made concerning the degree of overlap, the approach is the same as that for species' ranges described above. The approach requires GIS support, not budgeted within this project. Instead, we have described potential constellations that merit a closer examination. The utility has been documented for the simple case of large carnivores and ungulates by Laliberte and Ripple (2004).

3. Describing and Classifying Global Responsibility

Accuracy and precision differ across estimates whether based on proportion of population or total range occupied. For this reason, it is disingenuous to attempt to discriminate beyond classes when using the more practical or general approaches to assessment. In the large majority of cases the estimate of 'global responsibility' was based on the portion of the global range occurring in British Columbia. We found the following classes useful (the class numbers used in excel tables are noted; Table 1):

- 1 **Endemic**, 100% of the range, area or population is within the province. Endemics merit their own designation because the province has 100% of global responsibility. Within British Columbia, endemism generally occurs at the subspecific level. Freshwater fish are an exception. Some populations appear to represent incipient endemism.
- 2 **Very high**, 75 to 99% global stewardship responsibility.
- 3 **High**, 51 to 74% global stewardship responsibility.
- 4 **Moderately high**, 30 to 50% global stewardship responsibility.
- 5 **Intermediate**, 11 to 29% global stewardship responsibility.
- 6 **Low and wide spread**, <10% global stewardship responsibility but occurs over >30% of the province.
- 7 **Low and localized**, <10% global stewardship responsibility and is localized, occurring over <30% of the province.
- 8 **Very low**, <2%, always a subset of class 7.

The last class (8) could not be consistently applied because ranges are not consistently well documented. It was applied only where available data permitted. It reflects an attempt to further subdivide class 7: up to 2% and 3 to 10%. We undertook this subdivision when we found that provincial stewardship responsibility for more than 25 SARA-listed species was no more than 2%, and that many of these species were designated G5 by Nature Serve ('demonstrably widespread, abundant, and secure'). All summary statements include '8' in class 7. Where our best estimates left classes uncertain – e.g., class 3-4 – the summaries tally that taxon in the highest class.

There are important modifiers to this basic scheme that usually are applied to classes 6 and 7. For example, a responsibility of 30% has different implications for a species that occurs in only 4 jurisdictions than for a species occurring in 20 or more. Likewise, a global responsibility of 10% has different implications for a species with a large global range than for a species with a small global range. There are species that are sufficiently widespread (e.g., fisher) that every jurisdiction contains less than 10% of the global range. These should be flagged, because every jurisdiction has some responsibility for their well being. The summaries for responsibility of taxonomic groups include a column 'Global Range' (Table 2). This arbitrary classification of global range is provided to create context for the rating of responsibility. The classes of global range are 'statistical' rather than absolute, and acknowledge the 10% boundary of the lower responsibility classes; typically: Small (S) occurs in 10 or fewer jurisdictions (in which

case 30% responsibility can be significant). Medium (M) occurs in 11 to 19 jurisdictions, and L (Large) occurs in 20 or more jurisdictions (in which case 10% responsibility may be significant). Exceptions occur when the species occurs on more than one continent or extends south into Mexico. When that occurs the species' global range is arbitrarily designated 'Large'.

Because the fundamental scientific rationale for maintaining biological diversity is the maintenance of genetic variability (e.g., Bunnell 1998; Namkoong 1998), it is helpful to designate disjunct populations separately. These may be species in the making. Almost all disjunct populations are class 7 (58%), a few are class 3; in either case the province has <10% global responsibility. We found the following additional designations for disjunct populations practical and insightful (Table 2):

D1 Disjunct and limited to British Columbia.

D2 Disjunct and not limited to British Columbia (typically BC and Alberta).

Defining disjunct is not straightforward because distances and other features conferring isolation vary among groups. Because we examined so many disparate groups or organisms we chose an arbitrary distance of isolation within the appendices – distance from the more continuous population was arbitrarily established across groups as 200 km; smaller where isolation was apparent as through confined water bodies or different phonological characteristics. The purpose was to flag species that merited further attention on either a species or species-group basis. Provided disjunct populations are flagged, their potential genetic contribution can be evaluated using the basic principles summarized by Bunnell et al. (2004).

Major sources used in estimating responsibility are listed for each organism group below. Experts consulted were:

Lichens:	Trevor Goward
Mosses:	Karen Golinski, Patrick Williston
Monocot and dicot plants:	Curtis Björk
Non-marine molluscs:	Unchecked by experts
Odonata:	Rob Cannings
Butterflies:	Crispin Guppy
Freshwater fish:	Ted Down, Sue Pollard
Amphibians:	R. Wayne Campbell
Reptiles:	R. Wayne Campbell
Birds:	R. Wayne Campbell
Mammals:	David Nargorsen

4. Applying the Concept of Responsibility in British Columbia

It is important to appreciate that simplistic application of some arbitrary stewardship cut-off can easily lead to misapplication of the concept and outcomes contrary to the goal of conservation. We note six considerations that make simplistic application of the concept invalid (Section 5). That is, stewardship responsibility alone is far too simplistic and

potentially misleading; it must be interpreted within the context of other factors. It does not, for example, provide more than the broadest indication of risk, and that is risk within the jurisdiction. Here we summarize only the global stewardship classes. These do *not* translate directly into priorities for action.

4.1 Species

Global responsibility was estimated for 3,841 species in 13 major groups of organisms occurring in B.C. (Table 1). A full species list with global responsibility rankings is available at www.biodiversitybc.org (see Bunnell et al. 2007; Appendices for Global Responsibility Status for BC Species_November 2007.xls). While responsibility was estimated for taxa below the species level (i.e., taxa lacking formal species names, subspecies, populations and varieties) in a previous version of this report, this report focuses only on the species level. A summary of responsibility estimates for those taxa below species listed on CDC Species and Ecosystems Explorer <http://www.env.gov.bc.ca/atrisk/toolintro.html>, is available at www.biodiversitybc.org in association with report: The Status of Genetic Diversity in British Columbia.

Generally, we did not estimate responsibility for exotic or introduced species except in a few instances where they clearly are well-established parts of the fauna. Nor did we estimate responsibility for 'accidentals'. Neither are included in the summary tables.

In some cases, we added species not on lists provided by CDC but for which there is evidence of their occurrence in British Columbia. These are highlighted in red in the electronic files (Bunnell et al. 2007). There is uncertainty around many of these species, whether or not they are listed by CDC. For example, Cook et al. (2005) argued that the western pond turtle (*Actinemys marmorata*) is not native to the province. We followed CDC's designation of 'extinct'.

Taxonomic issues are present throughout but are more evident within some groups. Problems in estimating stewardship are sometimes specific to particular groups of organisms. Those and broad patterns within groups of organisms are summarized below. To describe stewardship we used the classes described in Section 3, including the modifiers.

Table 1. Global responsibility rankings for 13 major groups of species occurring in British Columbia.

SPECIES GROUP	Total Number of Species Assessed	Global Responsibility Ranking								Total Number of Species of Important Global Responsibility (1-3)	Species of Important Global Responsibility (Percent of total species assessed)
		Endemic 1	Very High 2	High 3	Moderately High 4	Intermediate 5	Peripheral Low and widespread 6	Peripheral Low and localized 7	Unknown		
VERTEBRATES	562	2	10	11	41	57	244	196	1	23	4%
Amphibians	20	0	0	1	7	1	1	10	0	1	5%
Birds	352*	0	7	5	13	25	183	119	0	12	3%
Freshwater Fishes	67	1	0	4	14	10	14	23	1	5	7%
Mammals	109	1	3	1	6	19	44	35	0	5	5%
Reptiles and Turtles	14	0	0	0	1	2	2	9	0	0	0%
INVERTEBRATES	423	2	2	5	15	49	186	158	6	9	2%
Butterflies and Skippers	180	0	0	1	5	18	70	86	0	1	1%
Dragonflies and Damselflies	86	0	0	0	1	9	54	22	0	0	0%
Non-marine Molluscs	157	2	2	4	9	22	62	50	6	8	5%
VASCULAR PLANTS	2,096	6	3	34	103	314	520	1106	10	43	2%
Ferns and Fern Allies	111	1	0	4	5	24	28	49	0	5	5%
Conifers	26	0	0	3	10	4	3	6	0	3	12%
Monocotyledons	556	0	0	2	16	69	178	288	3	2	<1%
Dicotyledons	1,403	5	3	25	72	217	311	763	7	33	2%
NON-VASCULAR PLANTS	760	5	0	19	30	77	299	254	76	24	3%
Mosses	760	5	0	19	30	77	299	254	76	24	3%
TOTAL	3,841	15	15	69	189	497	1,249	1,714	93	99	3%
Percent of Total Species		<1%	<1%	2%	5%	13%	33%	45%	2%	3%	

*Does not include extinct species,
For complete species lists see www.biodiversitybc.org

Vertebrates

Amphibians: British Columbia is not a convivial place for amphibians, which attain much higher richness in warmer climates. Of the 20 species present, 11 (55%) are peripheral (Table 1). There is a small group of amphibians adapted to cooler climates, and these are well represented within the province with 8 species (40%) falling into stewardship classes 3 and 4 – 30% to 74%. Only two exotic species are reported for the province. But, as for the introduced fish, the nature of their habitat and feeding increases their impact. The bullfrog (*Rana catesbeiana*) has had serious impacts on the native amphibian fauna, and merits tracking by CDC. Provincial distributions were checked against data of the Biodiversity Centre for Wildlife Studies, then interpreted within a wide variety of sources.

Birds: Birds have the largest proportion of migratory species – some of which merely migrate through, some of which only breed within the province, and some of which are resident. The nature of their responsibility rating is qualified by a suffix: [b] breeding, [m] migration, [r] resident year round, v [vagrant] and [w] winter. For provincial distributions we utilized Campbell et al. (1990a,b,1997,2001). For the wider context we chose one major source: the American Ornithological Union as commented on by authors in Birds of North America Online [BNAO]; distributions are primarily from the Birds of North America Online with local refinement from data of the Biodiversity Centre for Wildlife Studies.

Many bird species have a large global distribution (e.g. Clark's grebe, pied-billed grebe, mallard) (Table 2, Appendix A in Bunnell et al. 2007). In these cases size of the global breeding range and stewardship responsibility are estimated, but description of the distribution often includes the portion outside North America. Supportive databases are large for birds, so we often have estimated the provincial portion of national responsibility at the species level. Disjunct populations can be found only among resident taxa.

At least 16 exotic bird species have been reported for the province; most appear relatively innocuous. Because birds are so mobile, an additional 131 species erratically enter the province (e.g., black-throated sparrow, rustic bunting). We followed CDC and considered these species 'accidental'. Responsibility cannot be estimated for these species other than to note that it is very low.

Table 2. Global range classes for B.C. native species assessed.					
SPECIES GROUP	Number of Species in Range Class				
	S: Small (10 or fewer jurisdictions)	M: Medium (11-19 jurisdictions)	L: Large (20 or more jurisdictions)	Large (on more than one continent)	Blank (no range described)
VERTEBRATES					
Amphibians	14	2	3	0	1
Birds	55	70	224	0	3
Freshwater Fishes	36	7	23	0	1
Mammals	33	28	47	0	1
Reptiles and Turtles	7	3	4	0	0
INVERTEBRATES					
Butterflies and Skippers	46	64	70	0	0
Dragonflies and Damselflies	8	24	54	0	0
Non-marine Molluscs	80	1	44	0	32
VASCULAR PLANTS					
Ferns and Fern Allies	39	10	61	0	1
Conifers	12	7	7	0	0
Monocotyledons	114	89	312	40	1
Dicotyledons	530	279	507	80	7
NON-VASCULAR PLANTS					
Mosses	6	2	67	0	685
TOTAL	980	586	1423	120	732

Freshwater fish: Given the province's glacial history and the constraining nature of water bodies, the proportion of disjunct populations within species is high, >10%. Although fish taxonomy is unclear, even at the species level, it appears better to consider it unsettled than as dubious. Many taxa have yet to be formally named. Of the species present in provincial waters, 14 are exotic. Although this value is not nearly so high as that for dicotyledonous and monocotyledonous plants, the impacts have been significant, including the extinction and near extirpation of several aquatic species. The restrictive nature of water bodies and voracious nature of some of these exotics focuses and strengthens their impact. We believe that one species within the CDC list has been reported only from oceanic waters, and not from freshwater, the green sturgeon (*Acipenser medirostris*). Primary sources for estimated responsibility of freshwater fishes were: Fish Wizard, Cannings and Ptolemy 1998, Page and Burr 1991; Scott and Crossman 1998).

Mammals: Marine mammals present particular difficulties. (Note, solely marine mammals such as cetaceans and sea otter were included in this assessment). It is more problematic to associate these species with jurisdictions. The decision regarding global range was arbitrary: if found in one or two adjacent oceans (e.g., Pacific Ocean and Bering Sea; or Atlantic and Caribbean) it was designated S or small; if found broadly in North American or temperate waters it was designated M or Medium; if found worldwide, the global range was designated L or Large. Data on the proportion of a species migrating through provincial waters is less clear than for bird species migrating through the province and resident or migratory status was not specified (e.g., Killer Whale populations). It is likely that the responsibility rating assigned certain species is lower than the highest seasonal concentration; examples include northern fur seal, California

sea lion, and northern elephant seal. The problem of assessment is similar among the whales.

Impacts of the 11 exotic species in the province can be severe, but are generally localized. Of the 109 mammal species assessed within the province, most are small and 72% (79) are peripheral. There is only one endemic species (responsibility class 1), the Vancouver Island marmot (*Marmota vancouverensis*) (Table 1; Appendix E in Bunnell et al. 2007), and its status as a full species is dubious; divergence levels from the hoary marmot (*Marmota caligata*) in mtDNA are well below the species level (e.g., Nagorsen 2005). Most of the provincial distributions were derived from sources specific to British Columbia – Nagorsen (1996, 2005), Nagorsen and Brigham (1993), Shackleton (1999). The other primary source, useful in providing broader context, was the Mammalian Species Accounts of the American Society of Mammalogists.

Reptiles: As for amphibians, the province is not a convivial place for reptiles. Of the 14 species present, 11(79%) are peripheral. The species for which the province has the highest responsibility is the northwestern garter snake (*Thamnophis ordinoides*), for which the province has somewhat over 30% of the global range (Appendix B in Bunnell et al. 2007). There are only two recorded introduced species, and only one – the red-eared slider (*Trachemys scripta elegans*) – is a serious threat to the native fauna (Bunnell 2005). Provincial distributions were checked against data of the Biodiversity Centre for Wildlife Studies, then interpreted within a wide variety of sources.

Invertebrates

Butterflies: A major issue with the butterflies is taxonomy and the issue merits attention. Among the groups treated, butterflies also appear to be one of the least extensively sampled groups within the province. One result is that there is lack of certainty about whether ranges that appear disjunct are truly disjunct, or simply lacking intervening samples (Table 3). The relatively high incidence of disjunct populations found among butterflies (6%) may reflect mobile species' responses to scattered habitat or incomplete sampling. Only two exotic butterflies appear present. At the full species level, only one species occurs in responsibility class 3 or higher, Vidler's alpine (*Erebia vidleri*). A full 87% (156 of 180) of the species assessed are peripheral (Table 1). Guppy and Shepard (2001) was the primary source for provincial distributions, interpreted within a wide variety of additional sources.

Table 3. Incidence of disjunct ranges for B.C. species.			
SPECIES GROUP	Disjunct and Limited to B.C. D1	Disjunct and Not Limited to B.C. D2	Total
VERTEBRATES			
Amphibians	3	1	4
Birds		1	1
Freshwater Fishes	8	1	9
Mammals			0
Reptiles and Turtles	2		2
INVERTEBRATES			
Butterflies and Skippers	3	8	11
Dragonflies and Damselflies			0
Non-marine Molluscs	3	2	5
VASCULAR PLANTS			
Ferns and Fern Allies		2	2
Conifers			0
Monocotyledons	9		9
Dicotyledons	15		15
NON-VASCULAR PLANTS			
Mosses	53	87	140
TOTAL	96	102	198

Odonata: We found no evidence of exotic dragonflies or damselflies occurring within the province. The species present tend to have large global ranges (55 of 86 or 64% of the species present) (Table 2). As a result 88% of the species present within the province are peripheral – 10% or less of their global range occurs in British Columbia (Responsibility classes 6 and 7) (Table 1). The single species for which the province has potentially significant responsibility is the black petaltail (*Tanypteryx hageni*), class 4 (30 to 50% responsibility) (Appendix B in Bunnell et al. 2007). Cannings (2002) was the primary source for provincial distributions, augmented by a variety of sources to obtain estimates of global distribution.

Non-marine molluscs: Freshwater molluscs are considered to be the most endangered taxonomic group in North America (71 mussel species appear on the US Endangered Species list). Although most non-marine molluscs do not disperse well, adults and eggs can be moved passively over long distances by wind, water, birds and mammals. Because they are small they also are dispersed readily in soil around imported plants. Given their limited active dispersal, the proportion of exotics is thus relatively high ($31/98 = 16\%$), most of which are native to Europe and Asia. All but two exotics are terrestrial, indicating the restrictions to movement imposed by aquatic environments. The greatest agricultural pests are among exotics, the *Arion* species and *Deroceras reticulatum*. Some species like *Oxychilus draparnaudi* and *Aegopinella nitidula* may become important predators on native terrestrial molluscs.

Responsibility classes for this group as a whole are somewhat suspect simply because they are not well sampled. Estimates are as good as available data allowed, but we acknowledge that data for this group were spotty. The lack of good documentation of

species' distributions also means that our ability to assess disjunct populations also is limited. We suspect the number of disjunct populations is higher than that summarized in Appendix D (Bunnell et al. 2007). A total of 112 of the 157 species for which we estimated responsibility are peripheral (89%); 8 species appear to be stewardship class 5 or higher (>50%) (Table 1). Provincial distributions of slugs and snails were largely derived from Forsyth (2004); for other taxa a wide variety of sources was used.

Vascular Plants

Ferns and fern allies: *Ferns and fern allies were not completed for this report.*

Conifers: *Conifers were not completed for this report.*

Monocotyledonous plants: The province does not contain large areas of lower elevation where monocots tend to do better – grasslands and wetlands. In part, because favourable habitat is scattered and not abundant, about 84% of the species apparently native to British Columbia (369/448) are 'peripheral' having less than 10% of their range within the province (Table 1; Appendix C). Issues of inconsistent taxonomy were especially evident among more diverse groups, such as *Carex* and its close allies. No species fall into class 1 or 2, with 75% or more of their range within the province. While Douglas et al. (1998-2002: volumes 6,7, and 8) was the primary source for provincial distributions, responsibility was based on a wide variety of sources including visits to herbaria in adjacent states.

Dicotyledonous plants: Exotics comprise almost 40% ($543/1,403 = 39\%$) of the taxa recognized for the province. In most instances their non-native status is clear. CDC does not have the funding to track exotics within the province, but given that 39% of the taxa are exotic there undoubtedly are effects that currently are not quantified. Provincial responsibility is 75% or greater for <1% of species and 30% or greater for only 10% (Table 1). Species with only 10% or less of their range within the province comprise 71% of the dicot flora. Douglas et al. (1998-2002) again was the primary source for provincial distributions (volumes 1 through 5, and 8), while responsibility was based on a wide variety of sources including visits to herbaria in adjacent states.

Non-vascular Plants

Mosses: A major stumbling block was the lack of a definitive list of "The Mosses of BC". The list used by CDC, which is currently under review, is incomplete and uses taxonomy that is generally out of date. The list recently compiled by Dr. Wilf Schofield and Olivia Lee specifically for the province is the most complete, but differs somewhat from the online *Bryophyte Flora of North America*, which is intended to be the current taxonomic standard. The lack of an agreed-upon list is partially the result of shifting and occasionally contentious taxonomy. Although progress was made on a more complete listing, for simplicity, we finally chose to focus on the list currently maintained by CDC with a small number of additions and deletions. In total, we estimated responsibility for 760 moss species.

The relatively small portion of exotics within the moss flora (7/760 or 0.9%) may reflect the antiquity of the global moss flora; most 'weedy' mosses have had millions of years to

disperse widely and show a global distribution. Conversely, other moss species demonstrate extreme habitat specificity and some show very limited dispersal capability. Both features lead to isolation and speciation. Of the 760 moss taxa evaluated we found five endemic to the province (Tables 1; Appendix E in Bunnell et al. 2007), but a considerable number of regional endemics are restricted to the Pacific Northwest (e.g., *Sphagnum schofieldii*, *Sphagnum sjorsii*, *Crumia latifolia*, *Dicranella pacifica*). Mosses show a high incidence of disjunct ranges (Table 3). Estimates of responsibility for mosses necessarily were derived from a wide variety of sources, many noted in the electronic file (Bunnell et al. 2007).

4.2 Constellations of Species

As noted under methodologies, constellations of species are more complex to deal with than species or ecosystems. A significant challenge is the requirement of digital range maps for individual species. First, however, potential candidate groups must be selected. These are intended to represent conservation opportunities that exist within the province and either do not exist, or exist to a much lesser extent, elsewhere. We note 5 potential areas or groups that merit further study.

1) Large predator-prey systems: The high richness of British Columbia's ungulate and large carnivore fauna has been known for decades (Bunnell and Williams 1980). Laliberte and Ripple (2004) have documented range contraction of 17 species within these two groups in North America. Both groups show a marked contraction of their ranges towards and into British Columbia. In fact, British Columbia currently appears to be the only north temperate region where historical large predator-prey systems are still intact. Some taxa (e.g., Stone's sheep) show an increase in their range within the province (Laliberte and Ripple 2004), which now hosts about 70% of the global population (Shackleton 1999). Obvious concentrations of large carnivores and ungulates occur in the east Kootenay and the Muskwa Kechika. Data provided by Laliberte and Ripple (2004) make a compelling argument for the impact of human density and conversion of ecosystems as the primary factor driving range contraction (see also Ceballos and Ehrlich 2002). Both the east Kootenay and Muskwa Kechika merit attention in terms of the opportunity for preserving large predator-prey ecosystems. Given the role played by human development, success is more likely in the Muskwa Kechika.

We did not have the time or resources to implement the approach of Laliberte and Ripple (2004), but we can summarize their data to reveal broad ecosystems that appear to be most heavily impacted (Table 3). The pattern of range contraction is what would be expected from patterns of human habitation and ecosystem conversion. Contraction has been greatest in the drier grassland and shrubland ecosystems where human habitation can be dense and alteration through agriculture is intensive. The boreal forest shows the least loss of range among large carnivores and ungulates.

Table 4. Mean percent of historic range lost in major ecosystems for large carnivores (9 species) and ungulates (5 species) occurring within British Columbia (derived from data in Laliberte and Ripple 2004)

	Forests		
	Temperate Conifer	Boreal	Grasslands & Shrublands
Carnivores	32.9%	14.8%	78.3%
Ungulates	42%	15.7%	90%

The lack of any widely applicable taxonomy of broad ecosystem types prohibits relating these patterns unequivocally to particular BEC zones. It is apparent, however, that the drier warmer ecosystems show the most impact. That also is obvious among smaller organisms at risk within the province (e.g., vascular plants, reptiles, birds, small mammals). Given that success in conservation is so dependent on an early start, it suggests that conservation funding will be most cost-efficient and effective when allocated to boreal regions.

2) Caribou Chilcotin wetlands and Columbia Wetlands: Both areas host not only a high richness of breeding birds, but also serve as important staging areas for migrating bird species that nest elsewhere in the province or farther north. That is, their contribution to sustaining biological diversity extends well beyond the resident species. Preliminary examination reveals that this richness is not restricted to birds among vertebrates and extends beyond vertebrates. In both cases, it is possible that appropriate action taken soon could either forestall or significantly reduce the harmful effects of climate change. The conservation issue is made more pressing because wetlands farther south are under even greater threat. Richness for the vertebrates within the two areas could be documented by the Biodiversity Centre for Wildlife Studies using NTS grid cells. Natural history data could then be used to indicate those specifically dependent on the wetland environment. The same source could be used to identify more specifically contributions made by existing conservation efforts (e.g., Bummers Flat). Combined these activities could focus conservation efforts to maintain a site critical to many species within the province.

3) Pacific Flyway: The Pacific Flyway remains the most intact of all of North America's flyways. Part of the reason is that feeding and staging routes along the Alaskan and British Columbian coast have received less impact than elsewhere along the flyway. Large proportions of the global population of numerous species use the feeding and staging areas. Although their use is temporally limited, and some do not breed within the province, the use is vital to their sustained breeding. Within the province, most conservation effort to date has focused on southwestern British Columbia (e.g., Boundary Bay), where impacts are growing – particularly within the backshore. Effort there is merited because of growing impacts, but the flyway should be treated as an integrated whole. That could be done for British Columbia, because of the long series of data hosted by the Biodiversity Centre for Wildlife Studies. The most significant staging areas and their relative use could be identified. While it is apparent that areas in the extreme southwest, such as Boundary Bay, are critical, it is likewise apparent that other

areas along the coast merit attention if the integrity of the flyway is to be sustained within the province.

4) 'Fishless' water bodies, particularly lakes and ponds: We appreciated this conservation opportunity late, when we were working on threats for the Species at Risk Coordination Office. One of the major threats to a number of amphibians (frogs and at least one salamander), plus native fish, has been the introduction of game fish into water bodies otherwise free of game fish. Within the province this has led to extinction of two stickleback species, as well as local extirpation of a variety of amphibian species. Game fish introductions also impact species that are primarily terrestrial. British Columbia, for example, hosts the large majority of the world's population of Barrow's goldeneye. Barrow's goldeneye feeds primarily in aquatic invertebrates that are consumed by game fish; so does the northern waterthrush (the province hosts over 50% of Canada's population and one subspecies appears restricted to the province).

Because we were late in appreciating this, our assessment is necessarily preliminary. It is clear, however, that British Columbia has not experienced the introduction of game fish to near the same degree as has happened elsewhere, particularly in the United States. Given the significance these water bodies have and the well-documented impacts of not protecting them from introductions, their distribution within the province and practices impacting them merit attention.

Two other groups that are not locally concentrated merit consideration because preliminary examination suggests that significant contributions could be made with relatively little effort or cost.

5) Regional endemic mosses: A partial list of mosses occurring in British Columbia and endemic to the Pacific Northwest includes:

<i>Andreaeobryum macrosporum</i>	<i>Fissidens pauperculus</i>
<i>Atrichum selwynii</i>	<i>Fissidens ventricosus</i>
<i>Barbula convoluta</i> var. <i>gallinula</i>	<i>Grimmia attenuata</i>
<i>Brachydontium olympicum</i>	<i>Meiotrichum lyallii</i>
<i>Buxbaumia piperi</i>	<i>Pogonatum contortum</i>
<i>Coscinodon calyptratus</i>	<i>Polytrichastrum alpinum</i> var. <i>sylvaticum</i>
<i>Coscinodon yukonensis</i>	<i>Scouleria marginata</i>
<i>Crumia latifolia</i>	<i>Seligeria careyana</i>
<i>Dicranella pacifica</i>	<i>Sphagnum alaskense</i>
<i>Dicranum howellii</i>	<i>Sphagnum inexpectatum</i>
<i>Dicranum pallidisetum</i>	<i>Sphagnum mendocinum</i>
<i>Didymodon vinealis</i> var. <i>rubiginosus</i>	<i>Sphagnum pacificum</i>
<i>Ditrichum montanum</i>	<i>Sphagnum schofieldii</i>
<i>Ditrichum schimperi</i>	<i>Sphagnum sjorsii</i>
<i>Fissidens aphelotaxifolius</i>	<i>Sphagnum wilfii</i>

Other regional endemics within the bryophytes include: *Blespharostoma arachnoideum*, *Dendrobazzania griffithiana*, *Cololejeunea macounii* and *Chandonanthus hirtellus* among the liverworts. The hornwort *Phaeceros hallii* is endemic to PNW, and occurs at about

four locations in south-coastal British Columbia (Victoria and Gulf Islands; Ryan 1996). Almost a third of all occurrences of rare bryophytes within the province occur in the Coastal Western Hemlock Zone (Ryan 1996). Areas particularly rich in bryophytes include the Queen Charlotte Islands, Brooks Peninsula on Vancouver Island, and the lower mainland. Over half of the rare species found in this zone are not found in other BEC zones, including 12 liverworts and 27 mosses. Unfortunately, one of these species, *Bryhnia hultenii*, is known only from a single locality (Inver Creek near Prince Rupert), which has since been logged, and it is doubtful that this species is extant in British Columbia.

First steps in evaluating conservation opportunities for these are: 1) complete the list, 2) evaluate the degree to which the flora is shared with other jurisdictions in the Pacific Northwest, 3) assess which species occur in protected areas, 4) determine habitat affinity for the species, 5) compare apparent requirements with those of regional endemic lichens. Step 2 provides an estimate of provincial responsibility for a group of species having limited ranges. Step 3 assesses the degree of protection already afforded these species. Step 4 refines estimates of conservation opportunities and tactics. For example, some species are wetland associates while others live on trees or dead wood and could be addressed by appropriate forest practices. Step 5 is intended to evaluate whether the number of organisms suitable for similar conservation tactics is larger than for bryophytes alone.

6) Regional endemic lichens: There appear to be more regional endemic lichens than mosses (Brodo and Ley 1998; Goward et al. 1998; McCune and Geiser 1997) Selected species include:

<i>Alectoria imshaugii</i>	<i>Lobaria silvae-veteris</i>
<i>Bryoria carlottae</i>	<i>Massalongia microphylliza</i>
<i>Bryoria cervinula</i>	<i>Neofuscelia subhosseana</i>
<i>Cladonia schofieldia</i>	<i>Nephroma occultum</i>
<i>Fuscopannaria pacifica</i>	<i>Physcia tribacia</i>
<i>Fuscopannaria alaskana</i>	<i>Pseudocyphellaria mallota</i>
<i>Hypogymnia heterophylla</i>	<i>Pseudocyphellaria perpetua</i>
<i>Leptogium polycarpum</i>	<i>Pseudocyphellaria rainierensis</i>
<i>Leptogium tacomae</i>	

Steps in assessing the current status of these and other regional endemic species, and the protection currently offered them are the same as for the bryophytes. Step 1, a complete list, could be completed readily. Much of the information already has been collated (Brodo and Ley 1998; Goward et al. 1998; McCune and Geiser 1997). Step 2 is relatively easy, because Trevor Goward has completed most of the maps on a regional basis; that is, there are species maps for endemics of the Pacific Northwest, but these are not digital. With maps in hand, step 3 can be accomplished, even with paper maps. Step 4 is partially complete. Many of the regional endemic lichens are epiphytic or occur on down wood. As a general rule, the endemic species are restricted to standing wood; the closer to the ground the lichen's niche, the more likely it is to be circumboreal. Spribille et al. (2006) have treated species on dead wood; Goward and Ahti (1992) have addressed the epiphytes. Regional endemics are present among several epiphytic genera, including: *Ahtiana*, *Hypogymnia*, *Parmelia*, *Platismatia*, *Tuckermanopsis* and

Vulpicida. Given the expected similar habitat affinities for many species step 5 should be conducted jointly for bryophytes and lichens.

5. Utility of Stewardship Responsibility in Guiding Conservation Actions

It is important to acknowledge that jurisdictional responsibility is completely unrelated to the risk status of a species or ecosystem at the global scale (other than for endemics). Responsibility provides some insight into risk at the jurisdictional level, simply because species that have only a small portion of their range within BC are necessarily relatively rare and vulnerable to chance events within the province.

The utility of stewardship responsibility lies in the guidance it can give to the allocation of resources to conservation actions within the jurisdiction. Even at this scale, responsibility cannot be interpreted outside a broader context. That is, there cannot be an arbitrary cut-off for conservation actions based solely on stewardship responsibility. There are several reasons why an arbitrary cut-off is inapplicable and can achieve undesirable results:

- 1) A species may be declining throughout its range and the proportion within a jurisdiction, even though small, may represent an opportunity for effective conservation action.
- 2) There are many widespread species for which no jurisdiction has >10% global responsibility. Conservation actions for widespread species at risk should be shared equally among jurisdictions (Mehlman et al. 2004). In British Columbia these are almost always peripheral (i.e., <10% of their global range within the province). Responsibility must be treated differently for widespread species for which many jurisdictions host less than 10% of the global population. In the Appendices, the large global range of these species is noted; whether they merit conservation action is a function of their global T ranks.
- 3) Some peripheral disjunct populations merit separate scrutiny for their potential contribution to genetic variability. These may be species in the making. Bunnell et al. (2004) review criteria that can be used to assess that potential. Disjunct populations are indicated in the Appendices. As noted, the criterion for designating a population as disjunct within the Appendices is arbitrary and evaluation of the criteria suggesting contribution to genetic variability must be species specific. Moreover, a species distribution could be disjunct from areas of greater threat – which is a quite different, but important concept; see 4)
- 4) Peripheral disjunct populations also merit a higher responsibility score when the taxon is declining elsewhere in its range, but is stable or increasing in the jurisdiction (e.g., Lomolino and Channell 1995).
- 5) Some peripheral populations can be maintained with very little expense (e.g., purple martin). That small effort may be significant in maintaining the species.
- 6) The proportion of migratory populations within the province varies seasonally. For migratory birds we have indicated seasons separately and reported the season of highest aggregation or highest responsibility.

The preceding caveats apply to the use of an *arbitrary* cutoff that ignores other important features. An arbitrary level can still be of significant help in focusing where effort should be spent evaluating additional features. The primary utility of stewardship responsibility will remain as a index to focus such effort and as a planning tool to make conservation efforts more effective. It achieves the latter in three broad ways:

- a) Conservation effort is focused where it is most likely to be effective. The most compelling reason for applying stewardship responsibility is that the likelihood of successful outcomes is greatly enhanced where populations are larger and more concentrated (Abbitt & Scott 2001; Clark et al. 2002; Elphick et al. 2001).
- b) Proactive responses, that are more likely to produce success, are encouraged by closely examining species that are not yet rare but are declining or under imminent threat. Considering stewardship responsibility helps ensure that species currently too abundant to appear on 'at risk' are not overlooked when declines are small but continuous.
- c) A more equitable allocation of resources for conservation across jurisdictions is encouraged.

The approach is proven and the utility of employing stewardship responsibility for ranking jurisdictional conservation concerns for species has been reported for individual states (e.g., Atwood 1994) and nations (e.g., Avery et al. 1995; Bunnell et al. 2004; Eaton et al. 2005; Keller and Bollman 2004; Keller et al. 2005).

6. Barriers to Assessing Stewardship Responsibility

Implementation of stewardship responsibility has been advocated by many (e.g., Avery et al. 1995; Bunnell et al. 2004; Dunn et al. 1999; Eaton et al. 2005; Keller and Bollman 2004; Keller et al. 2005; Panjabi et al. 2005), and is one of the principles within IUCN guidelines. When following these guidelines, the apparent failures of agencies to guide conservation efforts effectively appears to result from following 'at risk' lists and an overly optimistic application of the 'rescue effect' from adjacent jurisdictions (Avery et al. 1995; Eaton et al. 2005; Gärdenfors et al. 2001; Keller and Bollman 2004). Conceptually, the concept of stewardship responsibility appears sound. The difficulty appears during assessment of such responsibility. Most workers advocating the application of stewardship have avoided the tedium of estimating proportions or ranges or populations; Partners in Flight is an exception and provides useful estimates for landbirds. Major barriers in assessing stewardship (no rank implied) are:

- 1) **Effort.** There very rarely is a single source from which the estimate can be derived (see steps for range above). For British Columbia, a large portion of this effort has been completed within Forest Science Program grants to F. Bunnell, and refined within this project. That reduces the necessary effort substantially, and subsequent updating or stewardship assessments could be assigned to species for which assessment is believed most likely to influence actions within the province.
- 2) **Accuracy.** The scale or context (e.g., accurate global range) changes at an unknown but surely variable speed. This is a barrier only if expectations of accuracy and precision are high. Using classes, as described above, is a more realistic and practical approach. Note that it is primarily the extremes of the scale (e.g., classes 1, 2, 6 and 7) that are of most interest. Estimation at

these extremes is the most likely to be accurate (Regan et al. 2005). The more troubling issue is how global warming is expected to cause rapid changes in range in British Columbia and globally (Bunnell et al. 2005).

- 3) **Taxonomy.** A consistent taxonomy is necessary to assess responsibility efficiently, because many sources must be employed. Consistent taxonomies are variably expressed across organism groups. Troublesome areas were summarized in Section 4.1 above. This is not a large barrier provided broad classes of responsibility are used. For ecosystems, identity and subsequent cross-walking across jurisdictions to determine area will remain a vexing challenge. The challenge can be accommodated somewhat by adopting more coarse discrimination, but that tends to omit ecosystems of particular interest. There never will be a taxonomy for constellations of species.
- 4) **Degree of discrimination.** We were advised to consider only the species level. Ignoring subspecies and populations would bypass the vexing issues of the Northern Spotted Owl (*Strix occidentalis caurina*) and caribou. However, provided the taxonomy is sound, it also bypasses the fundamental rationale for conserving biodiversity – the maintenance of genetic variation. We elected to consider subspecies, varieties and populations although that increased the effort substantially. It is clear, however, that finer levels of discrimination are much better supported in some groups (e.g., large mammals), than in others (e.g., small mammals, butterflies). These problems were recorded in Section 4.1. Fine discrimination likely will prove still more problematic for ecosystems, and presently only Zones of the BEC classification appear reasonably robust for any effort estimating responsibility. Conversely, the designation of disjunct populations could be refined beyond that in the Appendices, by recognizing more explicitly mobility of different groups.

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