Species Conservation

Table of Contents

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BACKGROUND

British Columbia occupies 10% of Canada's land area but contains more than half of Canada's species of vertebrates and vascular plants and three-quarters of the country's bird and mammal species (BCMELP and EC 1993). The complex glacial history, extensive coastline, mountain chains, and grasslands make British Columbia one of the most biologically diverse provinces in Canada. The province's remaining old-growth coastal rainforests are exceptionally rich in biological diversity and represent approximately one-quarter of all remaining coastal temperate rainforests worldwide (BCMOF 2004). The southern interior grasslands contain a large proportion of B.C.'s endangered and threatened species, and the province's estuaries and wetlands support a wide variety of species, including more than 300 species of birds (BCMSRM 2004b; BCMOE 2006b).

Some species that were once widespread elsewhere still have a last refuge in the steep and inaccessible terrain in parts of the province. The province is one of the last places left with a complex of large predator–prey systems (Laliberte and Ripple 2004). It has some of the last freshwater ecosystems naturally without fish, which are important for conserving amphibian and invertebrate species.

British Columbia is home to 142 mammal, 488 bird, 468 fish, 22 amphibian, and 18 reptile species (BCMELP and BCMOE 1999). Invertebrate species are estimated to number 50,000 to 70,000, of which about 35,000 are insects. The province is also home to about 2,800 species of vascular plants, 1,000 species of mosses and liverworts, 1,600 species of lichens, 522 species of attached algae, and over 10,000 species of fungi. Many of these species are endemic (meaning locally unique and native) to the province. For example, 24 of B.C.'s mammals are found nowhere else in Canada, and 162 of B.C.'s bird species breed only in the province (BCMELP and BCMOF 1999).

As many as 44 species in B.C. are considered "imperilled" or "critically imperilled" on a global scale (terms used by the global organization *NatureServe* for species ranking) (CDC 2005). This means that the province bears a share of the global responsibility for conserving them. Examples include the Oregon spotted frog (*Rana pretiosa*), an aquatic native of the Fraser Valley; the Cowichan lake lamprey (*Lampetra macrostoma*), a fish found in only two lakes on Vancouver Island; the caribou rams-horn (*Planorbella columbiensis*), a mollusc recorded only in Lac La Hache in the central interior; Gillette's checkerspot (*Euphydryas gillettii*), a butterfly restricted to localized areas in the southeastern corner of B.C. along the Rocky Mountains; and Keen's long-eared myotis (*Myotis keenii*), a small bat that occurs in humid forests from Alaska to Washington.

TAXONOMIC NOTE

For all discussions in this paper, the term "species" includes the full scope of species, subspecies, and significant populations (i.e., taxa) that are the focus of conservation listing in British Columbia and Canada.

How Conservation Status is Ranked in B.C.

Several key organizations provide species conservation information in British Columbia. At the national level, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is an independent body of experts who use scientific, aboriginal, and community knowledge to categorize species according to conservation risk. Species at risk are those that have been extirpated (meaning extinct in a local area, province, or country) or are designated as endangered, threatened, or of special concern (see text box "Ranking Species At Risk in British Columbia"). As of June 2005, COSEWIC had assessed more than 500 plant and animal species as being at risk in Canada, meaning that their continued existence in this country is in danger. About 180 of those species occur in British Columbia. Seven that once occurred in B.C. are now extinct or extirpated in Canada: the Island marble butterfly (*Euchloe ausonide insulanus*), Puget Oregonian snail (*Cryptomastix devia*), Pacific gophersnake (*Pituophis catenifer catenifer*), Pacific pond turtle (*Actinemys marmorata*), pigmy short-horned lizard (*Phrynosoma douglasii*), a subspecies of the Greater Sage-grouse (*Centrocercus urophasianus phaios*), and a subspecies of caribou (*Rangifer tarandrus dawnsonii*).

Within British Columbia, ranking of the conservation status of species is based on a standard set of criteria developed over the past 25 years by the international organization *NatureServe*. This is an international organization of cooperating conservation data centres and natural heritage programs, all using the same methodology to gather and exchange information. With guidance from various experts in North America, *NatureServe* scientists assign each species a global rank and a national rank. A species is also assigned subnational ranks, or "S-ranks," based on the status of species within each province or state in its range. The British Columbia Conservation Data Centre (CDC), in the Ministry of Environment, is the government body responsible for assigning the provincial S-ranks.

The CDC also publishes annually the provincial Red, Blue, and Yellow lists of species that have been assessed by provincial biologists (see text box for definitions of lists). As of February 2007, the Red list (species most at risk) contained 490 organisms and the Blue list, 513 organisms. So far, assessed groups in B.C. include mammals, birds, amphibians, reptiles, freshwater fishes, freshwater molluscs, butterflies, dragonflies, vascular plants, and mosses. Species legally designated as Extirpated, Endangered, or Threatened under the B.C. *Wildlife Act* are included on the provincial lists. As of May 2007, the sea otter (*Enhydra lutris*) was legally designated as Threatened; American White Pelican (*Pelecanus erythrorhyncos*), Burrowing Owl (*Athene cunicularia*), and Vancouver Island marmot (*Marmota vancouverensis*) were designated as Endangered.

RANKING SPECIES AT RISK IN BRITISH COLUMBIA

Terminology used by different conservation classification systems can be confusing. This table shows equivalent designations for species considered "at risk" of extinction and those "not at risk" according to the classification systems referred to in this paper.

Risk Level	BC CDC S-ranks[1]		Provincial Lists[2]	COSEWIC Categories[3]
At risk	SX Extinct/extirpated		Red List	Extinct
	SH Historic			Extirpated
	S1 Critically imperilled			Endangered
	S2 Imperilled			Threatened
	S3 Special concern		Blue List	Special Concern
Not at risk	S4	Apparently secure	Yellow List	Not at risk
	S5	Secure		

[1] **BC Conservation Data Centre Subnational ranks (S-ranks).** S-ranks are based on many factors, including number and viability of existing occurrences, trends in population size and geographic distribution, and threats facing the species or its habitat.

[2] **Provincial lists:** The BC Conservation Data Centre uses S-ranks to assign species to one of three provincial lists:

- Red list: Extirpated or presumed extirpated (not reported for 20–40 years). Species legally designated as threatened or endangered under the provincial *Wildlife Act* and all candidates for such designation (the majority of Red-listed species). Includes compound S-ranks: S1S2 and S1S3.
- Blue list: Species not immediately threatened but of concern because of characteristics that make them particularly sensitive to human activities or natural events. Includes compound S-ranks: S2S3 and S3S4 (animals only).
- Yellow list: all species not on the Red or Blue lists, but tracked by the CDC; they are not considered to be at risk.

[3] **Committee on the Status of Endangered Wildlife in Canada.** Species assessed by COSEWIC are designated as:

- Extinct: No longer exists.
- Extirpated: No longer exists in the wild in Canada, but occurs elsewhere.
- Endangered: Facing imminent extirpation or extinction.
- Threatened: Expected to become endangered if limiting factors are not reversed.
- Special concern: May become threatened or endangered for a combination of reasons.
- Not at Risk: Evaluated and found to be not currently at risk of extinction.

Species for which there is inadequate information to make an assessment are designated as "Data deficient."

As a signatory to the national 1996 Accord for the Protection of Species at Risk, British Columbia committed to supporting the recovery of threatened and endangered species in the province. Until the federal *Species at Risk Act* (SARA) was proclaimed in June 2003, however, no legislation specifically protected Canadian species at risk. SARA has three goals: (i) to prevent Canadian indigenous species, subspecies, and distinct populations from becoming extinct or extirpated (locally extinct); (ii) to provide for the recovery of endangered or threatened species; and (iii) to encourage the management of other species to prevent them from becoming at risk. To list a species under SARA, COSEWIC recommends it to the Minister of Environment based on a status assessment. After a period of public consultation, the federal Cabinet considers the recommendation, taking into account social, political, and economic factors, and decides whether the species should be added to the legal list of species at risk (Environment Canada 2005). SARA requires that a recovery strategy and an action plan be prepared for any extirpated, endangered, or threatened species listed under the act. Management plans are necessary for species of special concern. The federal minister is required to report on the progress of implementing each strategy and plan.

This paper focuses on indicators related to the conservation status of species (including populations, subspecies, and species groups) in British Columbia. In so far as the indicators show trends in species richness and abundance, they are also indicators of some aspects of biodiversity in the province. Biodiversity (biological diversity) is the abundance, variety, and interdependence of living organisms on the planet, including their genetic variety and the complex of natural communities and ecosystems of which they are part. The status and health of ecosystems and natural habitat in the province, which are also indicators of biodiversity, are discussed in the "Ecosystems" paper of this report, "Environmental Trends in British Columbia: 2007."

INDICATORS

1. Key Indicator: Changes in the conservation status of fauna and flora in B.C.

This is a state or condition indicator. It addresses the question: What is the overall change in status of large groups of species?

Conservation status of species, usually summarized as the proportion of native species that are at risk, is widely used as the basis for tracking trends in biodiversity (e.g., Environment Canada 2003; IUCN 2003b). Despite widespread use, however, indicators that summarize conservation status have been criticized because changes in knowledge of a species or how its status is assessed can mask actual changes in the status of the species (Possingham et al. 2002; Keith and Burgman 2004).

The conservation status of a species may change as a result of changes in one or more of the following:

- Organism taxonomy (e.g., single species are "split" into multiple species, or multiple species are "lumped" into one);
- Methods for assessing risk or assigning risk categories (e.g., the procedure for assessing status is changed);
- Knowledge of a species' status (e.g., new information about a species may show that it is at greater or lesser risk than had been previously assumed);
- Actual species status (e.g., the real abundance or distribution of a species has changed).

It is commonly assumed that a change in conservation status reflects a real change in the species status. However, a recent study of threatened and endangered vertebrate species in B.C. showed that 65% of the changes in status reported over 10 years were a result of increased knowledge or changes in assessment methods or taxonomy (Quayle and Ramsay 2005). The same study also found that some of the province's threatened and endangered species are naturally rare and that even in a pristine landscape they would likely never be ranked "Secure" (see text box).

To address these shortcomings, the following indicator was developed to correct for changes in taxonomy, assessment, and knowledge. The indicator improves on previous indicators by listing only the genuine change in the status of a species. It does not yet represent all species groups in B.C., but reptiles, amphibians, and some groupings of plants and invertebrates will be included in future.

Methodology and Data

The British Columbia Conservation Data Centre (CDC) publishes the provincial lists of species considered by provincial biologists to be endangered or threatened (Red list), of conservation concern (Blue list), or secure (Yellow list). The CDC is a member of NatureServe, which is an international organization of cooperating conservation data centres. There are 8 Canadian and 50 American local member programs that make up the NatureServe network in North America (NatureServe 2006). These centres all use the same methodology to gather and exchange information on threatened species.

Since 1992, BC CDC has assigned "S-ranks" (subnational or provincial status ranks) to the province's species based on a standard set of criteria (Master 1991; Regan et al. 2004). The S-ranks represent the level of extinction risk for each species within the province (see text box "Ranking Species at Risk in British Columbia").

For this indicator, changes in provincial S-ranks were determined by a method described in Quayle et al. (2007), who adapted the methods used for a global analysis (see Butchart et al. 2004; 2007). S-ranks for species were retrospectively corrected to adjust ranks that had over- or underestimated actual changes. Using their current knowledge of species ranking, biologists who assigned past ranks were asked to review rankings for 1992, 1997, and 2001. They were asked to distinguish real changes in status from changes due to other factors, such as increased knowledge or changes in assessment methods or taxonomy. Reviewers also checked S-ranks for species where no change had been recorded between 1992 and 2001 to look for real change that may not have been detected at the time.

The analyses in this indicator focussed on S-rank data for species within their natural range and breeding regularly in British Columbia between 1992 and 2007. Species ranked as historic (not observed for 40 years) or extirpated before 1992 were removed from the data set. Nonbreeding species, such as transient birds, were generally excluded from the data to ensure that the indicator reflected only species that rely on the province for at least one significant stage in their life cycle.

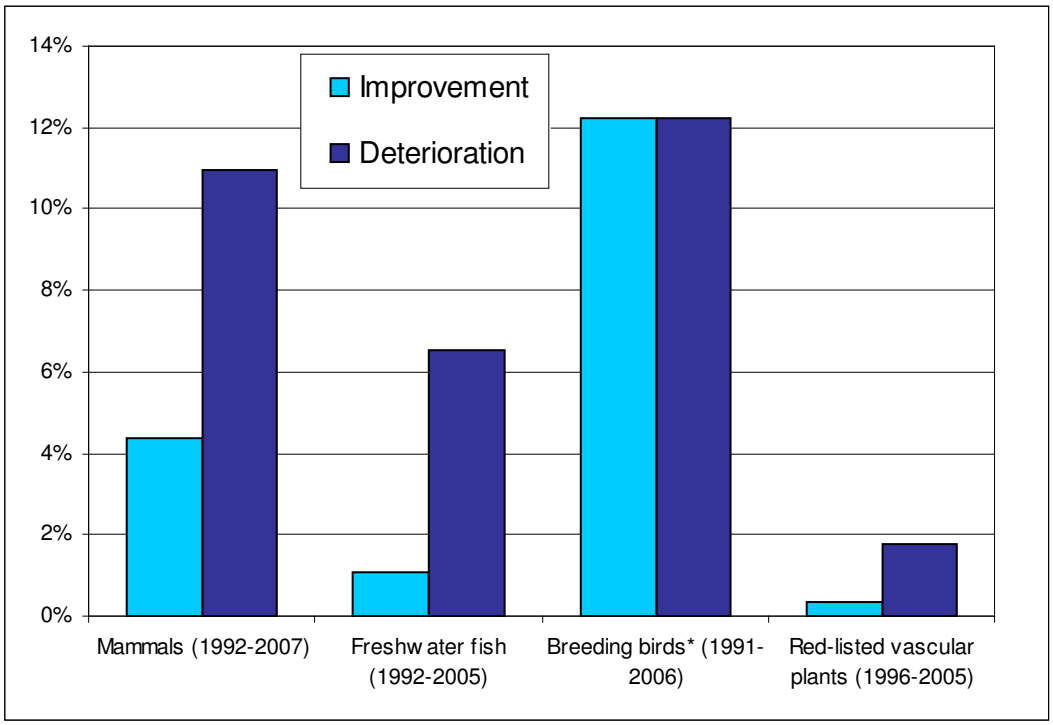
In cases of uncertainty, the NatureServe methodology used by the CDC allows a species to be assigned a compound rank (e.g., S1S2) to represent a range of possible S-ranks (NatureServe 2006). For such cases, the more precautionary of the two S-ranks was used in the analysis for the indicator. For species (mainly birds) that had different ranks assigned to the breeding and nonbreeding components of their life cycle, the rank of the breeding component was used in the analysis.

Although this indicator provides a more accurate picture of real change in species status than indicators based on simple proportions of species listed, there are two main limitations to this analysis.

1. It effectively sets an artificial, and relatively recent, baseline in 1992. This problem is most notable for three species extinct by 1992 that were not factored into the analysis: Dawson caribou (*Rangifer tarandus dawsoni*), Dragon Lake whitefish (*Coregonus* sp. 1), and Passenger Pigeon (*Ectopistes migratorius*). It also means that species on the "rebound" from decreased hunting, for example, can show as improving status. Such species could have had much larger populations before 1992. Improvement in the population status after 1992 may be small or negligible compared with the historic status. In future, of course, this baseline date will be less of a problem as species continue to tracked.

2. S-ranks are relatively crude measures of status. They allow for considerable change in population, distribution, and vulnerability before a species crosses the threshold that requires it to be assigned to a new status (c.f., killer whale ecotypes on the B.C. coast). For species already ranked at the lowest status (S1, Critically Imperilled), the next threshold they will cross if their numbers do not improve is to extirpation. A lack of change for S1 species may create the impression of stability in this indicator, whereas "Critically Imperilled" species are typically not characterized as stable. For example, the Spotted Owl (*Strix occidentalis*) has been ranked as S1 since its initial evaluation in 1992, which means that in the analysis it is categorized as Stable. Yet, over the period 1992–2007, the Spotted Owl population has been rapidly declining (CDC 2007).

Figure 1. Proportion of species in B.C., by species group, whose status improved or deteriorated enough to change the conservation status.



Sources: Breeding birds data from Quayle et al. 2007. Original data for other groups from BC Conservation Data Centre, accessed September 2005 (vascular plants), September 2006 (freshwater fishes), January 2007 (mammals). Data analyzed according to methods outlined in Quayle et al. 2007.

* Breeding birds include new immigrant species.

With the exception of breeding birds, over the period analyzed for each species group, more species were found to have deteriorated in conservation status than improved (Figure 1). More than 10% of mammal and breeding bird species deteriorated, whereas just over 6% of freshwater fish and nearly 2% of vascular plant species deteriorated. Breeding birds had the largest improvement at 12%. One-third of these improving bird species were new immigrants, having arrived in B.C. since 1947.

Details for each species group, including changes over time, are given below.

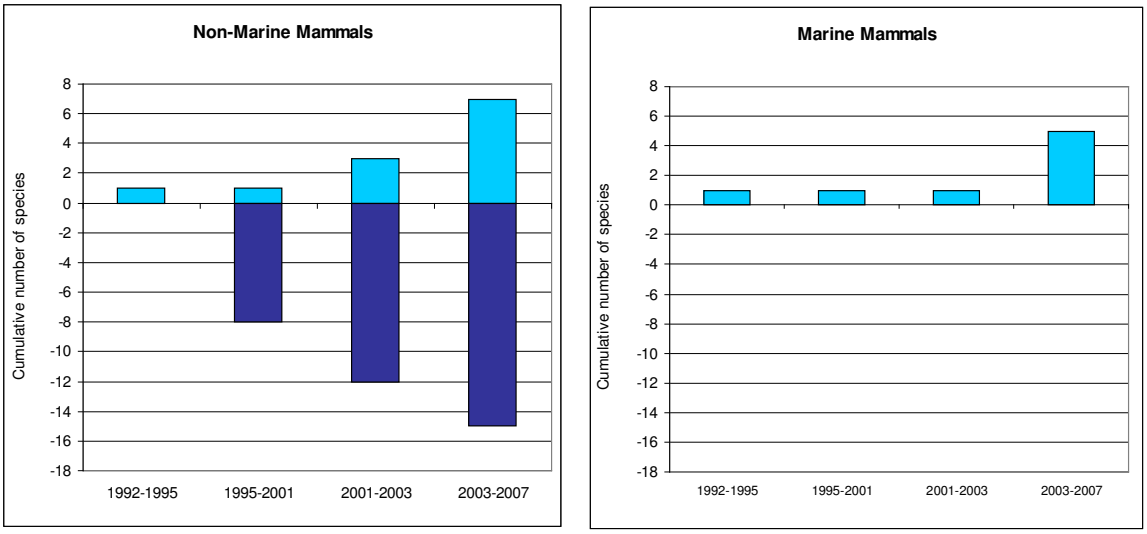
Figure 2 shows the cumulative number of mammal species that moved up or down at least one status category in specific time periods. Figure 3 shows the cumulative number of bird species that changed category. For the cumulative graphs, it is important to note that the species that changed status in one time period are then carried forward and added to the species for the next time period. For example, if three species improved in the first time period and two improved in the second period, the first bar shows three species and the second bar shows five species. Also, some species may have been counted more than once if they changed status in two or more of the time periods. For all time periods where the bars above the zero line are smaller than the bars below the line, the overall extinction risk is increasing. The design of the graphs was adapted from Baillie et al. (in press).

Mammals

Marine mammals included in the analysis were those for which S ranks were available. These species were known to breed in B.C. (e.g., northern sea lions, sea otters, harbour porpoises), or suspected to breed in B.C., such as sperm whales (c.f., Gregr and Trites 2001). Humpback and grey whales were also included, although they do not breed in B.C., because they forage with calves in tow in British Columbia waters and this is a critical part of their life cycle.

Of the 137 mammals analyzed, 78 species (57%) were considered Apparently Secure or Secure (S4, S4S5, or S5) for the entire period of analysis. However, the analysis shows an overall deterioration in the status of B.C.'s nonmarine mammal species (Figure 2). Although the S-ranks of some nonmarine species have improved, more have deteriorated. The status of all marine mammal species either remained unchanged or improved (Figure 2).

Figure 2. Cumulative number of nonmarine (left) and marine (right) mammal species that changed status by at least one category (S-rank) in B.C. since 1992 (*n* = 122 nonmarine species, *n* = 15 marine species). Light bar = improving (higher) S-rank; dark bar = deteriorating (lower) S-rank.



Source: Original data from BC CDC, accessed January 2007. Data analyzed according to methods outlined in Quayle et al. 2007.

The deteriorating status of many nonmarine mammal species results, at least in part, from the alteration and loss of their habitat. Mammals with large ranges are particularly vulnerable to changes that fragment their habitat because fragmentation reduces their ability to range widely for activities such as migration or escaping predators. Species with large home ranges and that have deteriorating status because of habitat alteration and loss include the Vancouver Island subspecies of wolverine (*Gulo gulo vancouverensis*) (COSEWIC 2003d) and three ecotypes of woodland caribou (*Rangifer tarandus caribou*) (COSEWIC 2002).

The improving status of marine mammals correlates with the impacts of policy decisions to protect several species: northern sea lions (*Eumetopias jubatus*), sea otters (*Enhydra lutris*), grey

whales (*Eschrichtius robustus*), humpback whales (*Physeter macrocephalus*), and sperm whales (*Megaptera novaeangliae*) (COSEWIC 2003a,b, 2004). Since 1970, sea lions have been protected by regulations under the federal *Fisheries Act*. The improved status of sea otters follows their reintroduction to the B.C. coast between 1969 and 1972 (more information in BCMOE 2006a). In 2007 COSEWIC moved the sea otter from Threatened to Special Concern. The improved status of large whales correlates with their recovery from low numbers after an international ban on whaling imposed in 1986 and a ban on driftnet fishing in 1992.

The fact that the S-ranks of marine mammals have not deteriorated since 1992 appears to conflict with recent designations of transient and southern resident killer whales (*Orcinus orca* ecotypes) as endangered species in both the US and Canada. However, this apparent contradiction is explained by the retrospective method used for this indicator, which allows past ranks to be corrected or assigned in light of current knowledge. Before 2001, only one killer whale ecotype had been ranked in British Columbia, but the analysis for this indicator provides the hindsight to suggest that the true status of some killer whale ecotypes had already deteriorated before then. Based on what is currently known about killer whale ecotypes in the Pacific Ocean, transient and southern resident killer whales were retrospectively ranked as S2 (Imperiled) back to 1992. Northern resident killer whales were assigned a rank of S3 (Special Concern) retrospectively to 1992. Therefore, over the period of this analysis (1992–2007), the declining status of these three killer whale ecotypes has remained within the range of their adjusted rank (see Quayle and Ramsay 2005 for a discussion of this as an issue when using Conservation status ranks as indicators).

Breeding Birds

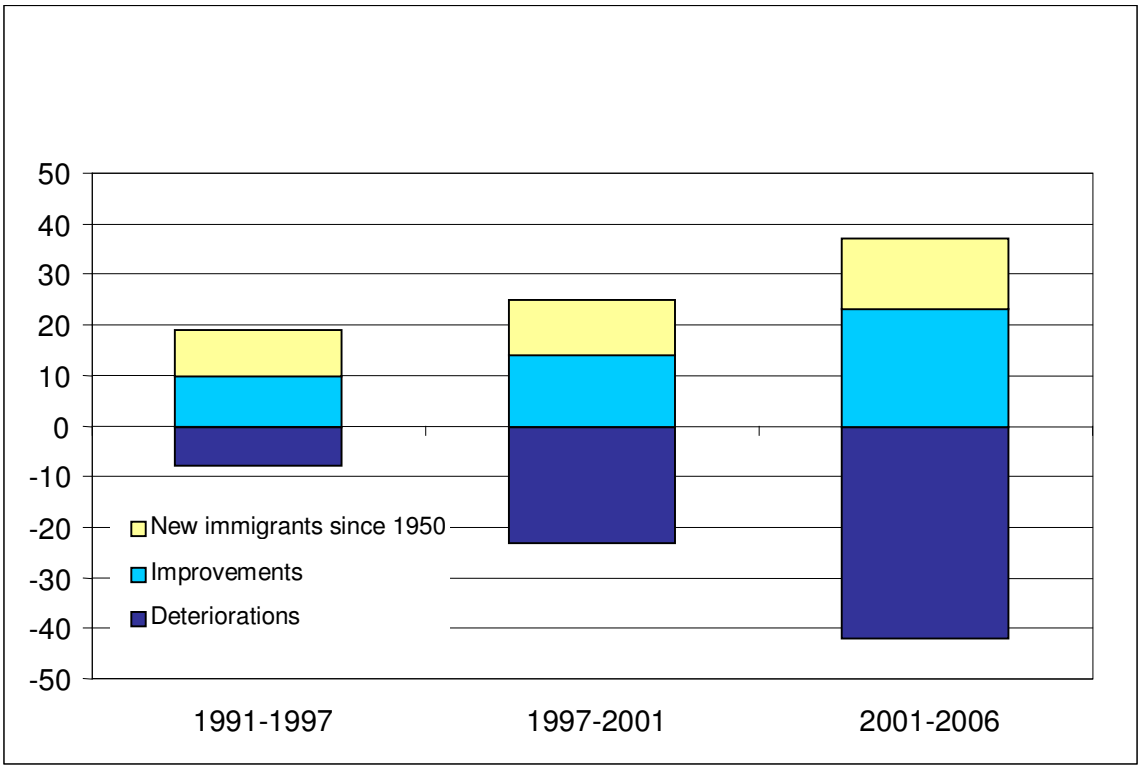
The 303 bird species known to breed in the province were included in the analysis. Species that regularly or sporadically occur in B.C., but for which there is no record of breeding in the province, were not included.

The analysis of bird data differed from the other groups because new immigrant breeding species were analyzed separately. New immigrants are species that have arrived in B.C. of their own accord and are believed to have become established in the province since 1947 when the first provincial bird species list was published (McTaggart-Cowan et al. 2001). Since 1947, 25 new immigrant species, including the Blue Jay (*Cyanocitta cristata*), Anna's Hummingbird (*Calypte anna*), and Ring-billed Gull (*Larus delawarensis*), have become established in British Columbia. They began by colonizing small areas of the province and their numbers and distribution then increased over time. Because the improving S-ranks for these species reflect this colonization, they were analyzed separately from other resident species.

Most breeding bird species (70–75% of species depending on the time period) were assigned S-ranks of Apparently Secure or Secure (S4, S4S5, or S5). The overall trend in bird conservation status shows deterioration (Figure 3), but the degree depends on whether new immigrant species (shown as the light coloured bars on Figure 3) are considered. If they are included, the number of species with deteriorating status exceeded the number with improving status only in the 2001–2006 period. If new immigrant species are not included, the number of species with deteriorating status was higher than the number improving in the two most recent time periods, 1997–2001 and 2001–2006.

Over the periods analyzed, one breeding bird became extirpated: a subspecies of Horned Lark (*Eremophila alpestris strigata*) was ranked as S1 (Critically Imperilled) in 1992 and eventually designated SX (Extirpated) in 2006.

Figure 3. Cumulative number of indigenous breeding bird species that changed status by at least one category (S-rank) in B.C. since 1992 (*n* = 303 species). Dark bars = deteriorating (lower) S-rank; middle bars (species present before 1947) and lightest bars (species immigrating since 1947) = improving (higher) S-rank.



Source: Quayle et al. 2007.

Freshwater Fishes

The freshwater fishes analyzed included those that spend their entire life cycle in freshwater (resident fish such as sculpins, dace, and bull trout), as well as those that spend only part of their life cycle in freshwater (anadromous fish such as salmonids and eulachon).

For freshwater fishes, 42 of 92 species (46%) were ranked as Apparently Secure or Secure (S4, S4S5, S5) for all three time periods analyzed. Between 1992 and 1998, six species deteriorated and only one improved. The analysis shows no net change since that period.

Only one species improved its status, the Lower Fraser population of white sturgeon (*Acipenser transmontanus*). Although they appear to be recovering, their numbers are still well below historic levels (Walters et al. 2005).

The six deteriorating species include the once-common eulachon (*Thaleichthys pacificus*). Since 1990, eulachon have declined coast-wide to the point that they are no longer available for traditional harvest in much of the historic range. Hay (1999) listed numerous threats contributing to the decline of eulachon, including over-harvesting and loss as by-catch in trawl fisheries; spawning failures due to disturbance; degraded water quality from urban land development and coastal forest practices; industrial activity and dredging; and increasing water temperatures.

Other deteriorating species are Pacific lamprey (*Lampetra tridentata*), coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*O. nerka*), and two now extinct species, the Hadley Lake limnetic and benthic sticklebacks (*Gasterosteus* sp. 12 and sp. 13).

Although the indicator shows that little has changed, it does not mean that the status of freshwater fish is stable. Freshwater fish are particularly vulnerable to change in their local environment because of their limited ability to disperse. Many freshwater fish species in B.C. have very restricted distributions (Cannings and Ptolemy 1998), which puts them at risk of extinction from local events. For example, two species of Hadley Lake sticklebacks became extinct when non-native catfish, which prey on stickleback eggs, were introduced to the only lake in which they occurred (on Lasqueti Island).

Red-listed Vascular Plants

The S-ranks of vascular plants were checked in the same way as for the vertebrates, except that only Red-listed plants were included in the analysis and only one time period (1996–2005) was used. Over this time, the S-rank changed for 82 Red-listed species, 46 of which were removed from the Red list. Much of this change was the result of new knowledge, improvements in plant taxonomy, and refinement in how the conservation status of plants is determined. Eighty-three new species were also added to the Red list during the 1996–2005 time period, for a net increase of 37 species of vascular plants.

After checking the reasons for the change in S-rank for each plant species, it was found that only seven species showed a genuine improvement or deterioration in status. A single species improved in status: the pink sand-verbena (*Abronia umbellata* ssp. *breviflora*) changed status from SX (Extirpated) to S1 (Critically Imperilled). The status of six other plant species deteriorated: deltoid balsamroot (*Balsamorhiza deltoidea*), dense spike-primrose (*Epilobium densiflorum*), brook spike-primrose (*Epilobium torreyi*), white meconella (*Meconella oregano*), coast microseris (*Microseris bigelovii*), and rosy owl-clover (*Orthocarpus bracteosus*).

Interpretation

This indicator shows that the S-rank of the majority of animal species analyzed did not change between 1992 and the mid-2000s (2005 for freshwater fish, 2006 for breeding birds, and 2007 for mammals). For those species that changed status in this time period, more species deteriorated than improved. The same was true of Red-listed vascular plants between 1996 and 2005.

The species with an improving rank tended to be one of the following:

- An immigrating species expanding its distribution in the province, as is the case for many birds.
- A rebounding species, such as marine mammals, with a population recovering from historically low numbers because conservation measures have been put in place to protect it.

The indicator does not appear to show a positive effect that could be attributed to the 1996 federal Accord for the Protection of Species at Risk. Population recovery is a slow process, particularly for the vertebrates that produce only a few young each year. In contrast to species that have rebounded relatively rapidly because they are now protected from being killed, it is likely that the period covered by this indicator is not long enough to show recovery of species that have declined because of impacts to their habitat. Changes made to the way habitats are altered by forestry practices and other human activities, for example, may take much longer to bring about improvements in the status of species that use those habitats

Long-term research shows that the total number of breeding bird species has been increasing in British Columbia since 1890 (McTaggart-Cowan et al. 2001). The establishment and spread of immigrant species raises a question of whether tracking overall changes in the status of species can be seen as a sign of an improvement in biodiversity. The BC CDC assigns S-ranks to species based exclusively on the status of populations for which British Columbia has responsibility, regardless of the status of the species in neighbouring jurisdictions. As a result, species on the edges of their range in the province can change rank over the study period as a result of natural movements in and out of the boundaries of the province. This is the case for many of the new immigrant bird species, which show an improvement in S-rank as they spill into British Columbia from neighbouring jurisdictions and as their population expands in the province. They may replace species with dwindling numbers, or possibly through competitive exclusion, may expand their range by taking over another species' ecological niche (e.g., Paine 1974). Many species expanding their range in the province are well adapted to human modified landscapes (e.g., House Finch, Bushtit, Blue Jay, Common Grackle, Anna's Hummingbird, several species of gulls).

Global climate change is also expected to lead to latitudinal shifts in species ranges (Thomas et al. 2004), a phenomenon already documented for birds in British Columbia (Bunnell and Squires 2005). If climate change leads to more immigration of southern species to British Columbia, this indicator could actually show further improvement in the status of bird fauna in the province, even though this "improvement" would be a result of the impact of climate changed by human activities. Plant species (discussed in Indicator 5), may also respond to a changing climate by expanding their ranges from outside British Columbia.

2. Secondary Indicator: Percentage of known species and ecological communities on the B.C. Red list

This is a state or condition indicator. It addresses the question: How many of B.C.'s known species and ecological communities are at greatest risk of extinction?

Threatened or endangered species and ecological communities are those that are at the greatest risk of declining and ultimately becoming extirpated (locally extinct) or extinct. These species

and ecological communities are included on B.C.'s Red list (for definition, see the text box "Ranking Species at Risk in BC"). The Red list includes extirpated species; to date no ecological communities have been recorded as extirpated.

The proportion of species at risk in B.C. is a measure of the current status of one aspect of biodiversity, consistent with other reporting in Canada and internationally (Environment Canada 2003; IUCN 2003b). As discussed in the introduction to Indicator 1, however, this measure has shortcomings as an indicator of trends in biodiversity. This is due to the large effect that changes in taxonomy, assessment methods and the state of knowledge of particular species have on status rankings (c.f., Quayle and Ramsay 2005).

Five species are extinct in B.C. and are not counted in this indicator. They are two stickleback species that were found in a single lake on Lasqueti Island (the Hadley Lake limnetic and benthic sticklebacks); Dragon Lake whitefish, also from a single lake; Passenger Pigeons; and Dawson caribou.

Methodology and Data

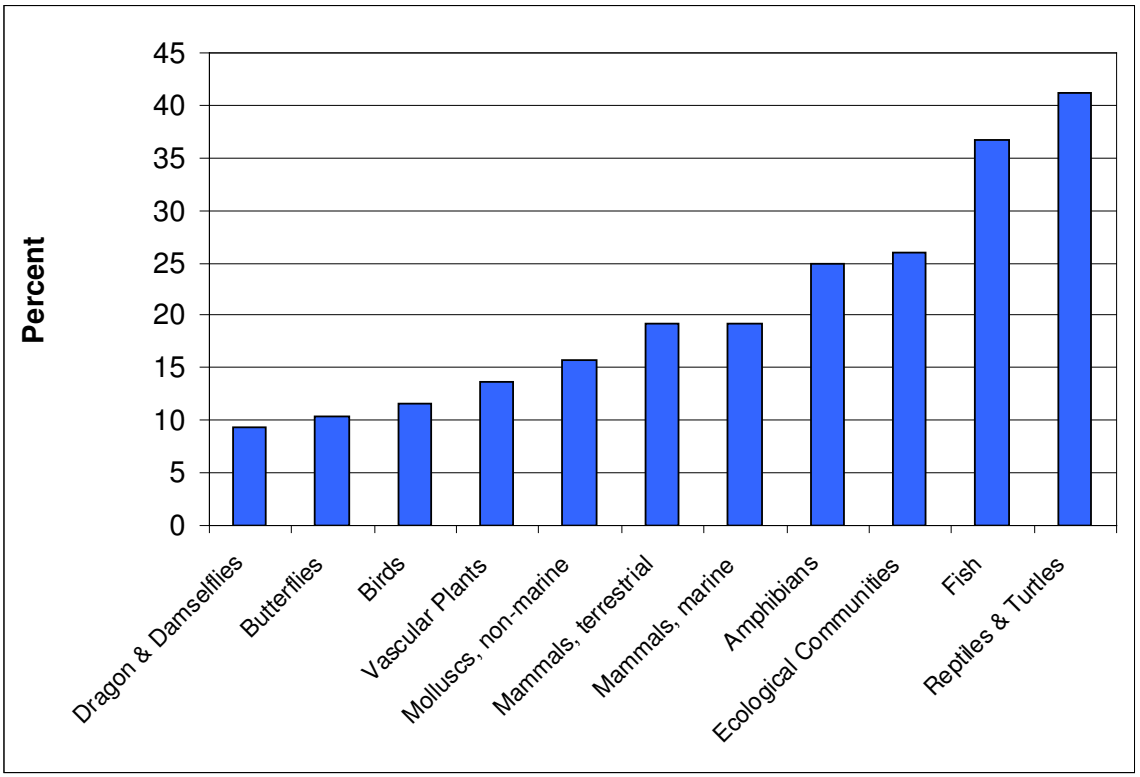
The BC Conservation Data Centre (CDC) determines and tracks rankings of species in the province with a colour-coded system. BC CDC uses a species tracking system developed by The Nature Conservancy (United States). This system is widely used in North America and enables comparisons among jurisdictions that use the same system (for an overview see *http://wlapwww.gov.bc.ca/wld/documents/ranking.pdf*).

This indicator presents the number of species and ecological communities included on the current provincial Red list. It does not include the five species extinct in B.C. Some subspecies or individual populations are listed separately by CDC. To be consistent with CDC listings, these listings were left as individual occurrences in the data set and were not combined as one occurrence under the species name. The total number of known species includes all species and populations on the Red, Blue, and Yellow lists. It does not include alien or extinct species.

Ecological communities are assemblages of plant species that can occur together and have the potential to interact with one another. They include natural plant communities and plant associations and the full range of ecosystems that occur in British Columbia (for more information, see *www.env.gov.bc.ca/cdc/ecology/index.html*). For details on how CDC determines whether an ecological community is endangered see: *www.env.gov.bc.ca/cdc/documents/ConsStatusAssessFactors.pdf*.

As of February 2007, the B.C. Red list contained 168 animals (15.5% of known animal species in B.C.), 322 vascular plants (13.7%), and 159 ecological communities (26.0%) (Figure 4, Table 1). The animals included vertebrates (amphibians, reptiles, and turtles, freshwater fish, marine and terrestrial mammals, and birds) and some invertebrates (butterflies, dragonflies, and nonmarine molluscs).

Figure 4. Red-listed species in B.C., by species group, as a percentage of the known number of native species in each group. Ecological communities are also included.



Source: BC Conservation Data Centre 2007.

Table 1. Red-listed species and ecological communities in B.C.

Group	Number Red listed	Total number known	% Red listed
Dragon- and damselflies	8	86	9.3
Butterflies	22	213	10.3
Birds	43	371	11.6
Molluscs, nonmarine	22	140	15.7
Mammals, terrestrial	23	120	19.2
Mammals, marine	5	26	19.2
Amphibians	5	20	25.0
Fish, freshwater	33	90	36.7
Reptiles and turtles	7	17	41.2
Total animals	168	1,083	15.5
Vascular plants	322	2,346	13.7
Ecological communities	159	611	26.0

Source: BC Conservation Data Centre 2007.

Note that some groups of species have not been fully assessed. For example, nonvascular plants, such as mosses, and invertebrates, including many of the insects, spiders, millipedes, and centipedes, have not been assessed across the range of known species. This indicator includes only a few groups of invertebrates and does not include nonvascular plants.

Interpretation

Although endangered and threatened species as a percentage of known species has been reported in previous Environmental Trends reports, it is not possible to compare previous and current data to establish a trend. As changes in the number of species included on the Red list (or Blue and Yellow lists) are often due to changes in taxonomy or assessment methods, these data simply provide a "snapshot" of the current status of endangered species and ecosystems in the province.

The proportion of a particular species group on B.C.'s Red list ranges from about 10% of known species in that group to just over 40%. The groups with the greatest number of Red-listed species are freshwater fish (37%) and reptiles and turtles (41%). For most animal groups included in this indicator, habitat modification and destruction is a major threat (Venter et al. 2006).

The Red-listed fish include six populations of white sturgeon, each of which is listed individually in CDC's database. In B.C., white sturgeon are found only in the Fraser and Columbia river systems. In the past they were threatened by overfishing and they continue to be threatened by habitat changes such as dams, altered river flow, channel dredging, and loss of wetland (COSEWIC 2003c). Four of the six white sturgeon populations listed by CDC can no longer be fished, and poaching remains a concern. The lower and middle Fraser populations still support catch-and-release fisheries. The Red-listed freshwater fish also include eight stickleback species, all of which have a distribution restricted to only one or a few lakes in B.C.

There are only 17 known reptile and turtle species in B.C.; of these, 7 are Red-listed: 3 turtles, 3 snakes, and 1 lizard (3 of these are extirpated).

The CDC recognizes 2,346 known vascular plant species in B.C.; 322 of these are on the Red list. Vascular plants include ferns and fern allies, coniferous trees, and flowering plants. Habitat loss and alien species are frequent reasons for vascular plant populations becoming endangered (e.g., BCMELP 1999a,b; CESCC 2006).

Ecological communities are associations of species that occur together and interact with each other in terrestrial, freshwater, and marine habitats. Many of the ecological communities recognized by CDC are terrestrial, and these are usually classified by the type of vegetation they contain (CDC 2004). Other communities may be classified using specific information about vegetation structure, site disturbance, or soil and terrain characteristics (CDC 2006). Of the 611 ecological communities that CDC includes in its database, over one-quarter (159) are Red-listed. Many ecological communities are on the Red list because they occupy only a small area in the province, and are therefore particularly vulnerable to threats such as climate change, habitat fragmentation and loss, poor grazing practices, invasion of alien plants, or recreational use (e.g., BCMSRM 2004a,b). Fire suppression over the last 150 years has also altered ecological communities by allowing other plant species to invade. For example, fire suppression in some areas where Garry oak once dominated has allowed Douglas-fir to take over (BCMELP 1993).

Many estuary and wetland ecosystems have been placed on the Red list because of activities such as dredging, draining and in-filling, water pollution, and invasion by alien plants (BCMOE 2006b).

Supplementary Information: How does the status of species at risk in B.C. compare with other provinces and territories?

The Canadian Endangered Species Conservation Council (CESCC) first assessed the status of a variety of species groups in 2000. These data were updated for 2005 and published in a report titled *Wild Species 2005: The General Status of Species in Canada*. The CESCC aims to determine what species are found in Canada, where they are found, and what their status is in Canada as a whole as well as in each province, territory, and ocean region. Four ocean regions—Pacific Ocean, Western Arctic Ocean, Eastern Arctic Ocean, and Atlantic Ocean—were included in their analysis because it is often difficult to associate whales and other marine species with a single province or territory.

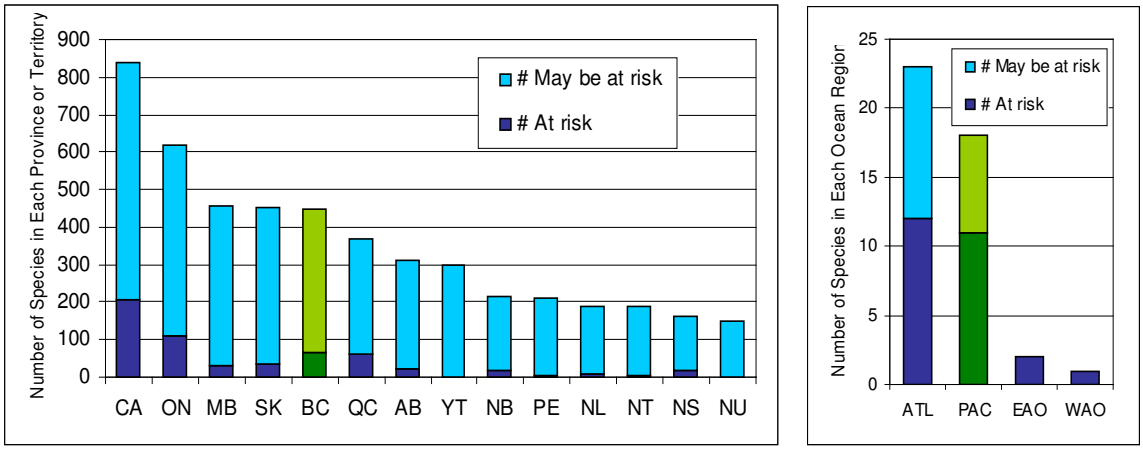
In total, 7,732 species are included in the 2005 data set. It includes all vertebrate species (amphibians, reptiles, freshwater and marine fishes, birds, mammals), all vascular plant species (ferns and fern allies, coniferous trees, flowering plants), and four groups of invertebrates (freshwater mussels, crayfish, dragon- and damselflies, tiger beetles). Based on the latest available information from provincial and territorial rankings, COSEWIC assessments, and species experts, each species was assigned to one of ten categories: Extinct, Extirpated, At Risk, May Be At Risk, Sensitive, Secure, Undetermined, Not Assessed, Exotic, or Accidental. Ranks were determined for each jurisdiction using a set of pre-defined criteria and then rolled up for the species in Canada as a whole. The group of species considered to be At Risk or May Be At Risk corresponds roughly to the BC CDC Red list of species, but without the subspecies or significant populations that are included on the B.C. lists. Also, the CESCC report distinguishes species At Risk from those that May Be At Risk based on whether a formal, detailed assessment of the species status has been completed.

Many species were not assessed in the Wild Species 2005 analysis. CESCC (2006) reports that Canada contains at least 70,000 recorded species and almost as many that have not been recorded (meaning that they are new to science or are known but not yet documented in Canada). Only 10% of recorded species were assessed and reported in Wild Species 2005, and possibly as few as 5% of all Canadian species. Species groups that were only partially assessed or not assessed at all include spiders, crustaceans, beetles, worms, mosses, fungi, algae, and the vast majority of invertebrates. For future reports, CESCC intends to expand the list of species groups assessed.

The number of species assessed was the total of species in all ten categories (therefore, it includes alien species). In the 2005 assessment, B.C. ranked fourth among the provinces and territories for the number of species considered At Risk or May Be At Risk (Figure 5). These data include 64 At Risk species and 382 May Be At Risk species, representing 1.8% and 10.5%, respectively, of all assessed species in B.C. (Table 2). For individual species groups, B.C.'s rank among provinces and territories changes: B.C. has the largest number of endangered amphibian, bird, fish, and mammal species. This result may be due in part to B.C.'s efforts to assess species status in the province, as well as to the large number of species that live in B.C. Nonetheless, the results indicate that B.C. has many species that are at risk of extirpation.

Of the four ocean regions, the Pacific Ocean ranks second with 11 species At Risk and 7 that May Be At Risk (Figure 5). Eight of the 18 marine mammals in these two categories are B.C. species, and all 8 are classified as being At Risk.

Figure 5. The number of species in Canada and in each province, territory, and ocean region that are classified as At Risk or May Be At Risk by the Canadian Endangered Species Conservation Council in 2005.



Source: Canadian Endangered Species Conservation Council (CESCC) 2006.

Note: Numbers for Canada are not a sum of the provinces and territories. Data for the ocean regions included only fishes, reptiles, and mammals. ATL = Atlantic, PAC = Pacific, EAO =Eastern Arctic Ocean, WEO = Western Arctic Ocean.

Table 2. Number of species (and proportion of total assessed) classified as At Risk or May Be At Risk by the Canadian Endangered Species Conservation Council in 2006.

	At Risk	May Be At Risk	Risk + May Be At Risk	Number of species assessed
Canada	206 (2.7%)	634 (8.2%)	840 (10.9%)	7,732
Ontario	109 (2.7%)	511 (12.6%)	620 (15.3%)	4,052
Manitoba	29 (1.2%)	426 (17.5%)	455 (18.7%)	2,440
Saskatchewan	34 (1.5%)	418 (18.1%)	452 (19.6%)	2,308
British Columbia	64 (1.8%)	382 (10.5%)	446 (12.3%)	3,628
Quebec	60 (1.8%)	308 (9.3%)	368 (11.1%)	3,328
Alberta	24 (1.0%)	286 (11.3%)	310 (12.2%)	2,535
Yukon	1 (0.1%)	296 (18.0%)	297 (18.0%)	1,649
New Brunswick	17 (0.7%)	200 (8.5%)	217 (9.2%)	2,362
Prince Edward Island	3 (0.2%)	208 (13.5%)	211 (13.7%)	1,537
Newfoundland	8 (0.4%)	181 (10.1%)	189 (10.5%)	1,799
Northwest Territories	4 (0.3%)	183 (11.9%)	187 (12.1%)	1,544
Nova Scotia	18 (0.8%)	143 (6.1%)	161 (6.8%)	2,362
Nunavut	2 (0.2%)	149 (14.6%)	151 (14.8%)	1,022
Atlantic Ocean	12 (1.4%)	11 (1.3%)	23 (2.6%)	871
Pacific Ocean	11 (2.4%)	7 (1.5%)	18 (3.9%)	457
Eastern Arctic Ocean	2 (1.2%)	0	2 (1.2%)	165
Western Arctic Ocean	1 (1.2%)	0	1 (1.2%)	81

Source: Canadian Endangered Species Conservation Council (CESCC 2006).

Note: Numbers for Canada are not a sum of the provinces and territories. Data for ocean regions include only fishes, reptiles, and mammals.

Supplementary information: Status and population trends for selected wildlife in B.C.

Mountain Caribou

The caribou of North America belong to a single species (*Rangifer tarandus*), with four living subspecies. Only one subspecies, the woodland caribou (*R. t. caribou*), currently lives within British Columbia. Woodland caribou are classified into three ecotypes: mountain (found primarily in the Cariboo, Selkirk, Purcell, and Monashee mountains of southeastern B.C.); northern (found from the Yukon border to the western Chilcotin and east to the foothills of the Rocky Mountains), and boreal (in the northeastern part of the province).

Only 1,900 mountain caribou remain in the province, down from the estimate of 2,300 animals in 2000. The population in B.C. represents almost the entire global population of this ecotype,

which has been placed on the provincial Red list by the CDC and has been assessed as Threatened by COSEWIC.

Eighteen herds make up the mountain caribou ecotype. Each herd occupies one or a few distinct ranges in southeastern B.C. (Figure 6). Although the herds are all the same species, they tend to remain isolated from each other (B.C. Mountain Caribou Science Team 2005). Most have been studied with aerial surveys since the early 1990s, and some radio telemetry tracking has also been done.

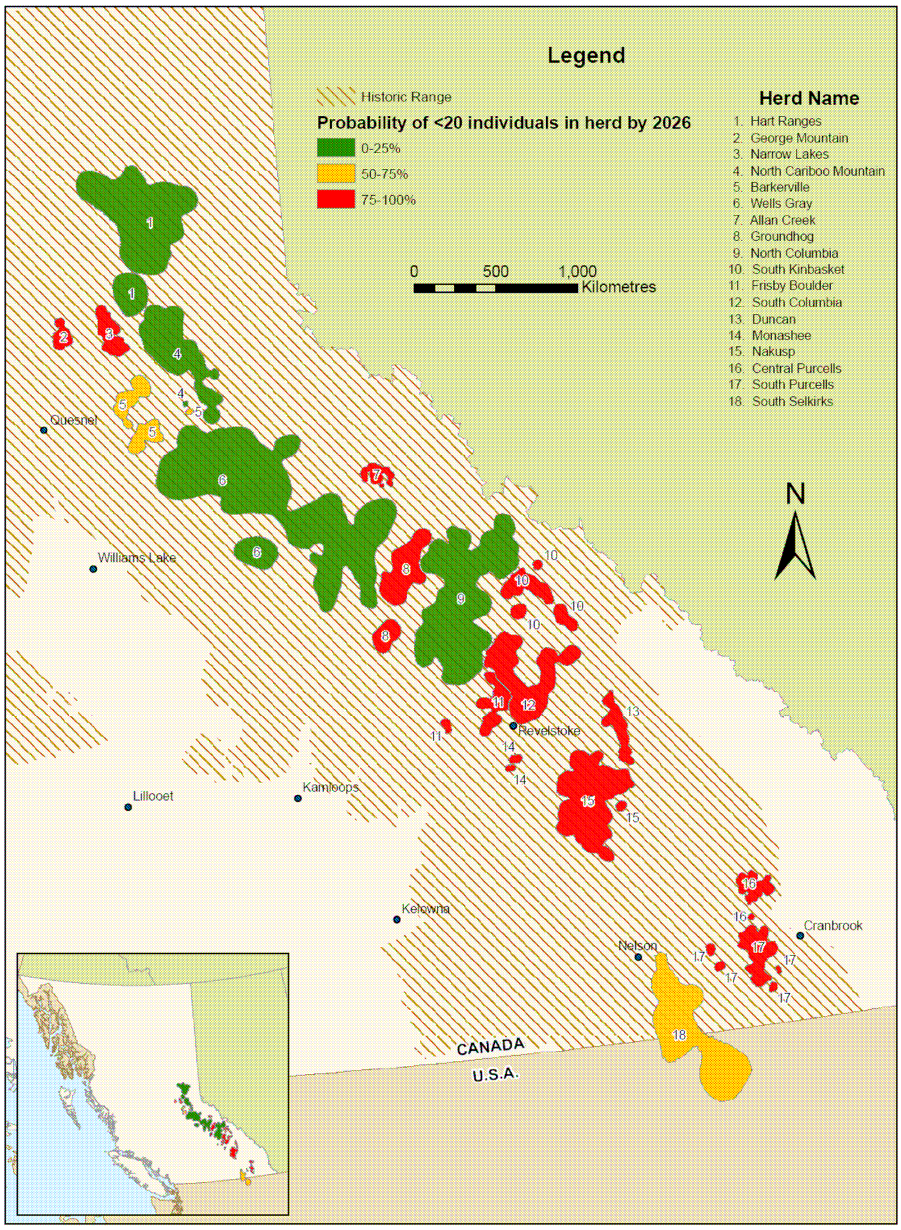
This analysis reports the extinction risk for 18 mountain caribou herds (Table 3). Population estimates from 10–15 years of surveys and tracking data were used to project the likelihood of each herd declining to fewer than 20 individuals within three generations (approximately 20 years, by 2026). When a herd dwindles to fewer than 20 individuals, it is unlikely to be able to rebound.

Two herds—George Mountain and Central Purcells—were already extinct in 2006. Six existing herds were found to be 100% likely to be extinct by 2026. Four herds had a more than 75% chance of becoming extinct by 2026 and two herds had a 50–75% chance of extinction by 2026. Only four herds had less than a 25% chance of becoming extinct. If these four herds are the only ones to persist and if they maintain their 2006 estimated population, the total population of the mountain caribou ecotype in 2026 would be about 1,500 animals. This is a loss of 20% of the current population.

Mountain caribou are threatened by several related factors: habitat change, disturbance, predation, and climate change (B.C. Mountain Caribou Science Team 2005). Habitat has been lost or fragmented by human activities such as logging, settlement, road building, and recreation, and by forest fires, natural and started by humans. This loss of habitat decreases the connectivity between large area of suitable habitat and makes populations more isolated (Thomas and Gray 2002). Loss of old-growth trees reduces the available habitat for lichens, which caribou eat in the winter (B.C. Mountain Caribou Science Team 2005). Disturbance by human activities, especially in the winter, can affect caribou behaviour and displace them from parts of their habitat. Predation continues to contribute to caribou loss. Climate change has several potential effects on caribou and their habitat, including changes in the amount and location of snowfall in winter, the frequency of wildfires, and the distribution of suitable habitat.

It is estimated that mountain caribou are now extirpated in 43% of their historic range (B.C. Mountain Caribou Technical Advisory Committee 2002). In October 2007, the province announced the Mountain Caribou Recovery Implementation Plan, which is a collaborative approach with conservation organizations, First Nations, the forest industry, and outdoor recreation groups aimed at restoring the mountain caribou population to pre-1995 levels throughout their existing range. The long-term survival, the persistence of mountain caribou will depend on a supply of large, contiguous areas of suitable summer and winter habitat with little or no human disturbance.

Figure 6. Current location and extinction risk of 18 mountain caribou herds in southeastern B.C.



Sources: Probability data from Ecosystems Branch, Ministry of Environment, 2006. Map distribution data from the provincial data warehouse (updated December 1, 2002).
Notes: The historic range shown on this map indicates the area of southeastern B.C. thought to have been occupied by woodland caribou. The historic range layer was created specifically for this map and does not correspond to extirpated range data that are housed in the provincial data warehouse.

Table 3. Population estimates for mountain caribou ecotype herds and risk of extinction (probability of <20 animals by 2026).

Map no.	Herd name	Population estimate, 2006	Risk of extinction (percent)
1	Hart Ranges	717	0
2	George Mountain	0	Extirpated
3	Narrow Lakes	40	92
4	North Cariboo Mountain	267	0
5	Barkerville	51	69
6	Wells Gray	422	0
7	Allan Creek	33	86
8	Groundhog	30	91
9	North Columbia	138	24
10	South Kinbasket	2	100
11	Frisby Boulder	19	100
12	South Columbia	29	100
13	Duncan	9	100
14	Monashee	8	100
15	Nakusp	85	83
16	Central Purcells	0	Extirpated
17	South Purcells	20	100
18	South Selkirks	37	54

Source: Ecosystems Branch, Ministry of Environment, 2006.

Note: Map numbers refers to Figure 6.

Killer Whales

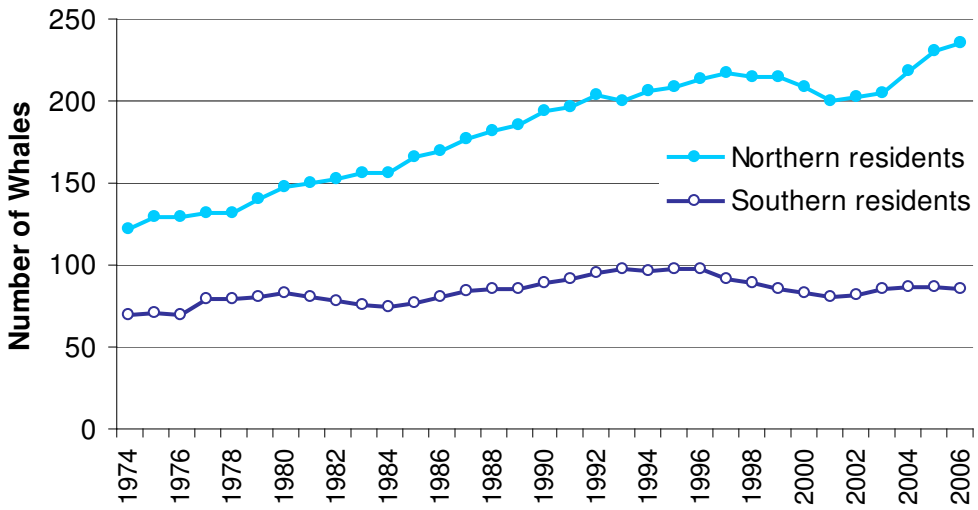
The status of killer whale populations is an indicator of the health of coastal ecosystems. They need clean water, healthy prey populations, and an environment that is large and quiet enough for them to maintain communication, locate and capture prey, and maintain other vital life functions (Killer Whale Recovery Team 2005).

Three distinct forms or ecotypes of killer whales live along the B.C. coast: transient, offshore, and resident. There are two different populations of the resident ecotype, designated southern residents and northern residents. The southern residents appear to be the most endangered, but all killer whale populations along the B.C. coast are considered to be at risk according to both federal and provincial criteria. A species recovery strategy has been drafted for the northern and southern resident populations.

Population counts of killer whales are made annually by the Center for Whale Research in Washington State for the southern residents and by the Cetacean Research Program, Fisheries and Oceans Canada, in Nanaimo for the northern residents. All whales in the southern population tend to be seen and counted during the year. In contrast, it is unusual to see all northern resident whales during the year because they travel widely along the B.C. coast. Counts are therefore generally less accurate for the northern residents.

Few data are available for killer whale populations before the early 1970s. It is known that 47 whales that were likely southern residents were captured and sent to aquariums in the late 1960s and early 1970s (Bigg et al. 1990). Live captures ended in 1973, and the population of southern residents increased to 83 whales by 1980 (Figure 7). After a surge in the number of breeding individuals, the population increased 34% over the next decade. The latest decline, which began in 1996, now appears to be reversing in some groups within the population, but not in others. In October 2006, three adult whales from the southern population died, causing concern for scientists (CWR 2007). Currently, the number of southern resident whales is still below the numbers estimated before the live captures occurred (Baird 1999).

Figure 7. Population trends for northern and southern resident killer whales of the B.C. coast, 1974–2006.



Sources: Center for Whale Research, Friday Harbor, Washington, USA, unpubl. data (southern population) Cetacean Research Program-DFO, Nanaimo, unpubl. Data (northern population).

At least 14 northern residents were captured between 1964 and 1973 (Bigg et al. 1990). Nonetheless, the northern population appears to have grown steadily from 1974 to 1991 (Figure 7). This may be because the northern population was larger to begin with, fewer individuals were captured, or they are generally exposed to less disturbance (Killer Whale Recovery Team 2005). After a slight decline in the late 1990s and early 2000s, the northern population now appears to be increasing again.

The small size of resident killer whale populations makes them particularly vulnerable to threats, such as reduced availability of prey, environmental contaminants (including oil spills),

disturbances, and noise pollution. Even under ideal conditions, killer whale populations tend to recover slowly because they mature slowly and mature females calve only every 5–6 years (Killer Whale Recovery Team 2005).

Recent research strongly links the population changes in both southern and northern resident killer whales to the abundance of Chinook salmon, which suggests that prey limitation may be an important factor in recent declines (Ford et al. 2005). In fall 2006 and spring 2007, some pods of the southern resident population were seen off the California coast where they may have travelled in search of food (CWR 2007).

The health of resident killer whales, including reproductive and neurological development and immune system function, is a concern because research has found high levels of chemical contaminants in their tissues (Ross 2006). Members of the southern population, in particular, have high contaminant levels, likely because of foraging in their usual summer range along the highly populated and industrialized southern B.C. and northern Washington coasts. Contaminants in marine mammals are discussed in the "Contaminants" paper of this report.

Managed Salmon Stocks

The status of commercially fished salmon stocks in B.C. was reported in the B.C. Coastal Environment report (BCMOE 2006a); the following analysis provides an update. It shows the outlook for managed salmon stocks, by species, relative to an assessment of the target abundance of fish for each stock. The unit used in this indicator is a "stock" or "stock group," as defined for fisheries management purposes. The outlook for each stock depends on the effect of environmental factors, as well as on the effects of fishing and fisheries management.

The 2006 outlooks for managed B.C. salmon stocks were obtained from Fisheries and Oceans Canada's website (DFO 2006). The Stock Assessment group of DFO assigns each stock group to a status category that reflects the available information on recent returns for each stock and the expert opinion of fisheries managers. Where stock targets have not been formally described, the targets are either historical levels of abundance or are based on expert opinion (DFO 2003).

Stock status outlook is rated on a scale of 1 to 4, according to where the stock is forecast to be for the coming year:
1 = Stocks are less than 25% of target abundance or declining rapidly.
2 = Stocks are well below target or below target and declining.
3 = Stocks are within 25% of target and stable or increasing.
4 = Stocks are well above target abundance.

A total of 92 stock groups were considered in 2006 and outlooks were provided for 88 of them. More than a third (34) of the stocks were assigned a range of outlook categories, reflecting the geographic variation in status within the stock group and uncertainties in outlook. For this analysis, all stocks were grouped with the primary outlook category, thus stocks rated as 1, 1/2, 1/3, or 1/4 were counted together, stocks rated as 2, 2/3, or 2/4 were counted together, and stocks rated as 3 or 3/4 were counted together. The 2006 outlooks for 88 managed stock groups (populations) of sockeye, chinook, chum, coho, and pink salmon are shown in Table 4.

Table 4. Number of managed salmon stocks in B.C. by outlook category (1 to 4).

Species	No. stocks assessed	Stock outlook category			
		1, 1/2, 1/3, 1/4	2, 2/3, 2/4	3, 3/4	4
Sockeye	29	8	7	5	9
Chinook	24	4	8	9	3
Coho	18	3	6	7	2
Pink	6	0	4	2	0
Chum	11	3	2	5	1
Total	88	18	27	28	15
Proportion of total		20.5%	30.7%	31.8%	17.0%

Source: DFO 2006 Salmon Stock Outlook.

Note: No data were available for one stock of coho and three stocks of pink salmon.

For 2006, 43 of the stock groups assessed were forecast to be in Categories 3 and 4, meaning they are stable, or at or above target abundance; 27 stocks were in Category 2 or had part of the stock group rated in that category. These are considered sensitive stocks that are well below target abundance or well below target and declining. Eighteen stocks, including 4 chinook, 3 coho, 3 chum, and 8 sockeye stocks, were rated in Category 1. These are stocks of most conservation concern because they are below 25% of target abundance or are declining rapidly.

Results differ slightly from the 2004 outlooks reported previously (BCMOE 2006a, see *www.env.gov.bc.ca/soe/bcce/*). Outlooks for most stocks were the same, with a few stocks lower and some higher in 2006 than in 2004. The time period is much too short to show trends because there are year-to-year variations in stock status as different year classes of salmon return.

Fall-run Cultus Lake sockeye are of particular concern because 2006 should have been a peak year, but fewer spawners were expected to return than the critical level identified in the recovery plan. Threats to this population include fishing, habitat alteration in Cultus Lake, environmental fluctuations, and impacts related to parasites (early migration) and predators (freshwater predation). DFO-led recovery activities include rearing captive brood stock, removing pike minnows (predators), and controlling milfoil in the lake. Sackinaw Lake sockeye have virtually disappeared, with no spawners expected to return in 2007. Both Cultus and Sakinaw Sockeye have been assessed by COSEWIC as endangered.

Lower Mainland Steelhead

Steelhead (*Oncorhynchus mykiss*) are highly valued by recreational anglers and are important in First Nations ceremonial, social, and food fisheries. The Steelhead Recovery Plan (Lill 2002) classifies wild steelhead stocks relative to the capacity of a watershed to produce and sustain steelhead. The classification includes four categories: Routine Management Zone (steelhead not threatened, able to withstand modest catch and release fisheries); Special Concern (mostly small stocks that may need conservation, but little information available); Conservation Concern

(steelhead estimated at 10–30% of habitat capacity); and Extreme Conservation Concern (steelhead at 10% or less of habitat capacity, risk of extinction).

The status of steelhead trout stocks over the whole province was reported in *Environmental Trends in British Columbia: 2002* (BCMWLAP 2002). About half of the stocks in B.C. assessed at that time were classified as healthy and about half were classified as Conservation Concern or Extreme Conservation Concern. Most of the latter were in the Lower Mainland and Vancouver Island.

In 2005, a study on the status of steelhead in the Fraser River watershed assessed stocks in 30 watersheds using methods similar to those used in 2002 (R. Ahrens, UBC Fisheries Centre, 2005, pers. comm.). Stocks in 10 of the 30 watersheds studied in 2002 were reassessed and 20 watersheds were assessed for the first time, for a total of 30 watersheds assessed in 2005 (Table 5). These assessments are part of the Steelhead Recovery Plan, which is completing stock assessments for all priority watersheds (*www.bccf.com/steelhead/about-steelhead.htm*). Methods and data were reported in detail in the B.C. Coastal Environment: 2006 report (BCMOE 2006a, see *www.env.gov.bc.ca/soe/bcce/*)

The 2005 study rated steelhead stocks in 3 watersheds as Conservation Concern and 27 as Extreme Conservation Concern. The status of stocks in 4 of the 10 watersheds assessed in 2002 had declined. Two moved from Conservation Concern to Extreme Conservation Concern and 2 watersheds that had been rated as healthy (Routine Management Zone) in 2002 declined to an Extreme Conservation Concern rating.

Table 5. Conservation status of steelhead for 30 Fraser River watersheds, 2005.

	Number of stocks assessed as	
Watershed	Extreme Conservation Concern	Conservation Concern
Lower Fraser	12	1
Mid Fraser summer	5	2
Fraser Canyon	4	–
Boundary Bay	3	–
Lower Fraser summer	3	–

Source: Data from R. Ahrens, Fisheries Centre UBC.

Declines in steelhead abundance are believed to have been caused by greatly reduced ocean survival combined with low productivity in freshwater habitats. Depending on the location of the stock, factors that may affect freshwater productivity include impacts from logging, urban development, agriculture, hydroelectric projects, and other changes to water flow (Lill 2002).

Steelhead populations elsewhere in the Pacific Northwest have also declined to the point of causing concern. For example, in May 2007, Puget Sound steelhead were listed as Threatened on the US endangered species list (NOAA 2007).

3. Secondary Indicator: Threats to species at risk in B.C.

This is a pressure indicator. It describes and ranks natural and human-caused threats to British Columbia species assessed as nationally at risk by COSEWIC.

A variety of threats, both naturally occurring and from human sources, can affect wildlife. Natural threats include interactions between native species, such a predation or competition for resources, and events such as storms and forest fires. Some species are threatened by innate characteristics such as being highly specialized or having a narrow ecological niche. Threats from human activity include habitat alteration and loss, pollution, over harvesting, and introduction of alien species. Climate change presents a long-term threat to species through physical impacts, such as more extreme weather or changes in river flow. Biological impacts of climate change include altered timing of development and reproduction or the expanded range of a competitor or predator.

Recovery strategies are being developed for species assessed by COSEWIC as extirpated, endangered, or threatened in Canada (see following indicator). To prepare these recovery strategies and determine the best use of conservation and recovery resources, we need to know which threats are most significant for these species.

Methodology and Data

The data used in this indicator were originally gathered for all species nationally at risk in Canada and published in Venter et al. (2006). For the B.C. analysis, the same database was used to extract the terrestrial, freshwater, and marine species that occur in B.C. Venter et al. (2006) compiled their database of species (which includes nationally extinct, extirpated, endangered, threatened, and special concern species) from COSEWIC information. Data sources were species status reports and executive summaries from COSEWIC and the Canadian Wildlife Service.

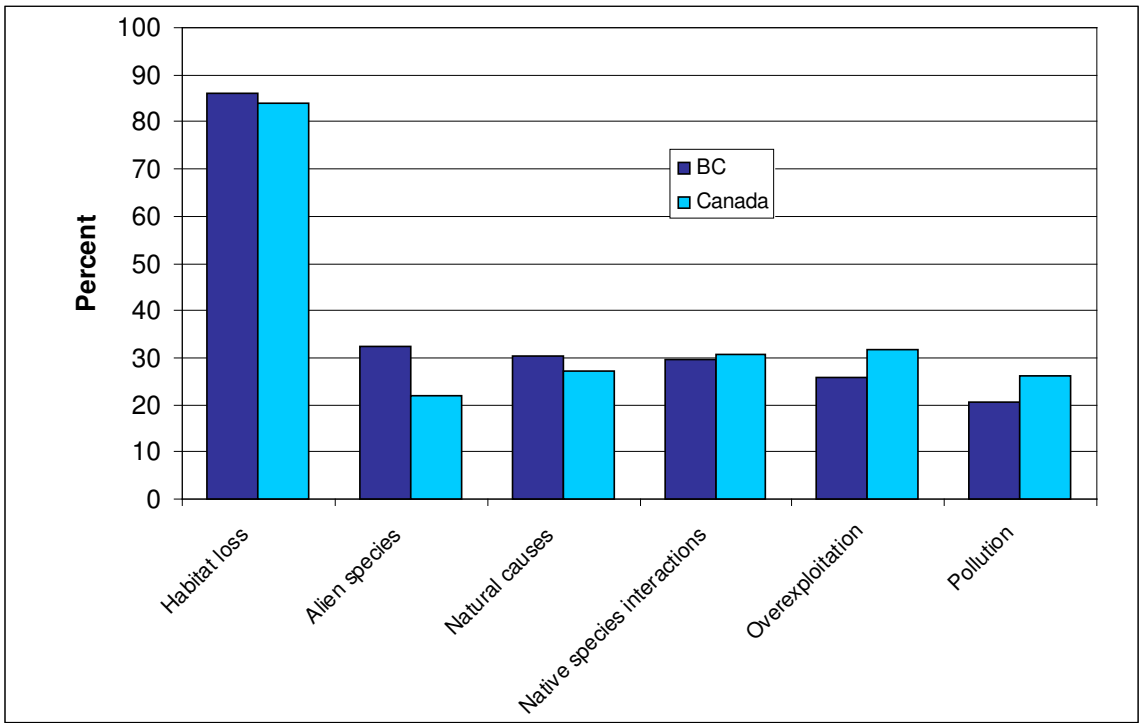
When Venter et al. (2006) compiled the data in June 2005, B.C. had 180 species in 12 species groups assessed to be nationally at risk by COSEWIC (36% of all such species at risk in Canada). Information was available on the threats facing 179 of the endangered species in B.C. One species, Haller's apple moss (*Bartramia halleriana*), had only potential or surmised threats listed and therefore was not included in the analysis.

Threats for the 179 species were grouped into six broad categories:

- Habitat loss: Reduction or degradation of required habitat through urbanization, agriculture, human disturbance, extraction, or infrastructure.
- Alien species: Competition, predation, hybridization, infection, or habitat modification by alien species. Cultivated species on farms and species native to Canada that had expanded or shifted their range naturally were not considered.
- Overexploitation: Intentional or unintentional harvest or persecution.
- Pollution: Chemical, thermal, or acoustic pollution, turbidity, and sedimentation.

- Native species interactions: An increase or decrease in a species' native competitors, predators, pathogens, prey, symbionts, or other organisms with which it interacts.
- Natural causes: Any random event (e.g., storm, drought, fire) or factor inherent to the species (e.g., limited dispersal, narrow niche).

Figure 8. Percentage of B.C.'s and Canada's species at risk* affected by six broad threat categories.



Source: Data for Canada from Venter et al. 2006. Original data for B.C. from COSEWIC database (2005) and analyzed according to methods outlined in Venter et al. 2006.

* Assessed as nationally at risk by COSEWIC.

Table 6. Number of Canada's and B.C.'s species at risk* that face six broad threat categories.

Species group	Habitat loss	Alien species	Natural causes	Native species interactions	Over-exploitation	Pollution
All Canadian species (n = 488)	409 84%	108 22%	133 27%	149 31%	154 32%	128 26%
All BC species (n = 179)	154 86%	58 32%	54 30%	53 30%	46 26%	37 21%
BC species only						
Vascular plants (n = 46)	40 87%	27 59%	15 33%	9 20%	2 4%	2 4%
Birds (n = 24)	22 92%	5 21%	3 13%	10 42%	7 29%	7 29%
Freshwater fish (n = 22)	18 82%	10 46%	4 18%	7 32%	4 18%	7 32%
Marine fish (n = 5)	4 80%	2 40%	3 60%	2 40%	5 100%	3 60%
Terrestrial mammals (n = 18)	16 89%	4 22%	3 17%	7 39%	7 39%	4 22%
Marine mammals (n = 13)	7 54%	0	1 8%	4 31%	10 77%	7 54%
Reptiles (n = 11)	11 100%	1 9%	7 64%	4 36%	7 64%	1 9%
Amphibians (n = 10)	9 90%	5 50%	7 70%	2 20%	1 10%	5 50%
Lepidoptera (n = 8)	8 100%	3 38%	0	1 13%	1 13%	0
Molluscs (n = 8)	7 88%	1 13%	4 50%	3 38%	2 25%	0
Mosses (n = 10)	9 90%	0	4 40%	1 10%	0	1 10%
Lichens (n = 4)	3 75%	0	3 75%	3 75%	0	0

Source: Data for Canada from Venter et al. 2006. Original data for B.C. from COSEWIC database (2005) and analyzed according to methods outlined in Venter et al. 2006.

Note: Categories do not sum to 100% for each species group because a species may appear in more than one threat category.

* Assessed as nationally at risk by COSEWIC.

Interpretation

Habitat loss was found to be the greatest threat to species at risk in B.C., affecting 86% of them (Figure 8, Table 6). Other threats listed were alien species (affecting 32% of species), native species interactions (30%), natural causes (30%), overexploitation (26%), and pollution (21%). Thirty percent were affected by only one threat, but most were affected by more than 2 of the 6 threats.

Comparison of the B.C. results to those for Canada showed similar threats. The main difference was that the second most important threat to B.C. species at risk was alien species, but nationally, this was the least common threat. The increased importance of alien species in B.C. may be due to the large proportion (31%) of B.C.'s at-risk species that are island species, found mainly on Vancouver Island, the Gulf Islands, and Haida Gwaii. Thirty-six of the 56 strictly island species in B.C., an astonishing 64%, were threatened by alien species compared to only 18% of B.C.'s mainland species (Venter et al. 2006).

Because many of the species groups contained only a small number of species, it is not possible to draw strong conclusions from the results. The analysis, however, did show that the relative importance of a threat type varied with the species (Table 6).

- Overexploitation was the most prevalent threat to marine mammals and marine fishes—more so than habitat loss. Reptiles were also vulnerable to overexploitation. However, it should be noted that if extirpated species had been included in the analysis, it would show that overexploitation or direct persecution has resulted in the loss of such species as Passenger Pigeon, wood and plains bison, and Sage Grouse from the province.
- Although habitat loss was important for all species, it threatened marine mammals less than other species.
- After habitat loss, alien species was the second greatest threat for butterflies and moths (Lepidoptera), freshwater fishes, and vascular plants. Half of amphibian species at risk were also threatened by alien species.
- Native species interactions were second to habitat loss for birds and terrestrial mammals, as were natural causes for reptiles, amphibians, molluscs, and mosses.
- Pollution threatened marine mammals, marine fishes, and amphibians, in particular.

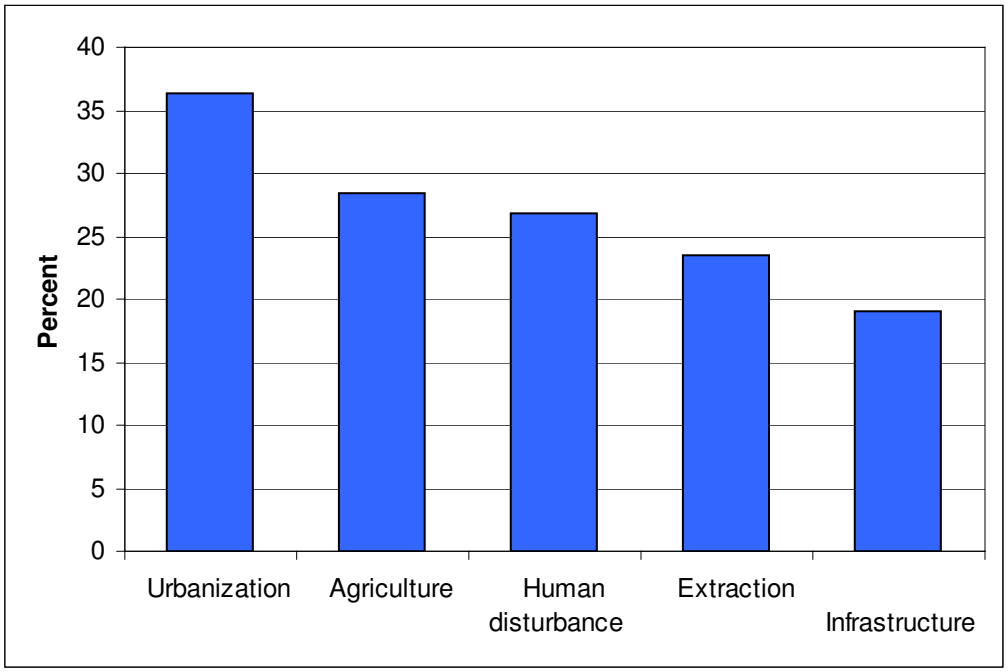
Supplementary Information: Details of threats from habitat loss

To provide more detail on habitat loss, this broader threat was subdivided into five subcategories for a finer scale analysis (Venter et al. 2006):

- Urbanization: Human settlements (urban, suburban, and rural), industrial and commercial buildings.
- Agriculture: Crops, wood plantations, nontimber plantations, livestock, ranching, aquaculture.

- Human disturbance: Recreation, tourism, military activities, research, transport, vehicle and vessel traffic.
- Extraction: Logging, mining, fishing, oil and gas extraction, groundwater and aquifer depletion.
- Infrastructure: Transportation, telecommunications, power lines, dams, impoundments, water diversions, pipeline construction.

Figure 9. Percentage of B.C.'s species at risk* affected by five types of habitat loss threat.



Source: Original data from COSEWIC database (2005) and analyzed according to methods outlined in Venter et al. 2006.

* Assessed as nationally at risk by COSEWIC.

The analysis showed that for all species combined, urbanization (36%) was the most common cause of habitat loss, followed by agriculture (29%), human disturbance (27%), extraction (24%), and infrastructure (19%) (Figure 9). The importance of specific types of habitat loss varied with species group (Table 7). For example, agriculture particularly threatened birds, terrestrial mammals, and reptiles, whereas human disturbance affected freshwater and marine fishes and marine mammals.

Table 7. The number of B.C.'s species at risk* affected by five types of habitat loss threats.

Species group	Urbanization	Agriculture	Human disturbance	Extraction	Infrastructure
All species (n = 179)	65 36%	51 29%	48 27%	42 24%	34 19%
Vascular plants (n = 46)	18 39%	4 9%	14 30%	6 13%	6 13%
Birds (n = 24)	9 38%	11 46%	3 13%	8 33%	1 4%
Freshwater fish (n = 22)	6 27%	3 14%	7 32%	2 9%	3 14%
Marine fish (n = 5)	1 20%	1 20%	3 60%	1 20%	3 60%
Terrestrial mammals (n = 18)	9 50%	13 72%	6 33%	8 44%	7 39%
Marine mammals (n = 13)	1 8%	0	6 46%	2 15%	0
Reptiles (n = 11)	8 73%	8 73%	0	3 27%	5 46%
Amphibians (n = 10)	4 40%	3 30%	1 10%	3 30%	5 50%
Butterflies and moths (n = 8)	3 38%	2 25%	2 25%	1 13%	0
Molluscs (n = 8)	3 38%	2 25%	2 25%	3 38%	1 13%
Mosses (n = 10)	3 30%	4 40%	3 30%	2 20%	3 30%
Lichens (n = 4)	0	0	1 25%	3 75%	0

Source: Original data from COSEWIC database (2005), analyzed according to methods outlined in Venter et al. 2006.

Note: One species may appear in more than one threat category, so the categories do not sum to 100% for each species group.

* Assessed as nationally at risk by COSEWIC.

4. Key Indicator: Progress toward completing recovery strategies for species at risk in B.C.

This is a response indicator. It addresses the question: What is being done to protect species at risk? The indicator shows the progress being made in one type of societal response to the issue—the development of species recovery strategies.

As signatory to the 1996 Accord for the Protection of Species at Risk, British Columbia is committed to action that will enable threatened and endangered species to recover. Recovery planning for species at risk involves the collaboration of government, industry, academia, and

individuals. Planning involves preparing two documents: a recovery strategy and a recovery action plan (see text box "Recovery Planning"). Because is it unlikely that species would recover without human intervention, tracking the listed species that have recovery strategies and action plans is one measure of societal effort and commitment toward species recovery. A study by Taylor et al. (2005) found that in the United States, the status of species with a dedicated action plan for at least two years was more likely to improve than the status of species without a recovery plan.

This indicator measures progress in preparing recovery strategies for species that have been assessed by COSEWIC as extirpated, endangered, or threatened. The timeline for completion of recovery strategies is one year for endangered species and two years for threatened species. A management plan, which has less stringent content and format requirements, is required within three years of listing for species designated as special concern. This indicator reports only the status of recovery strategies; there was insufficient information to report on the current status of action plans. The indicator does provide an indirect measure of recovery action, however, because most recovery teams actively engage in implementation of recovery action even before the strategy is complete.

RECOVERY PLANNING

Recovery planning in Canada involves preparation of two types of documents:

- Recovery strategy: Details the information known about a species, its habitat, and threats to its survival. The document also outlines objectives and identifies additional information on species status and different recovery approaches that will help teams plan the recovery of the species.
- Recovery action plan: Includes specific projects or activities needed to meet the objectives outlined in the recovery strategy. The plan evaluates the socio-economic costs and benefits of improving the species' status.

An action plan together with a recovery strategy is often called a "recovery plan."

Methodology and Data

This indicator focuses on B.C. species at risk that have undergone formal status assessments by COSEWIC. Data on the progress of recovery strategies are compiled and tracked by the Ecosystems Branch, B.C. Ministry of Environment. The B.C. Ministry of Environment is the lead agency on recovery strategies for many B.C. terrestrial species and it is a co-leading agency for recovery teams working on freshwater fish and molluscs. The Canadian Wildlife Service is responsible for recovery strategies for migratory birds, and Fisheries and Oceans Canada is

responsible for many marine mammals, fish, and invertebrate species; it also co-leads the recovery teams for freshwater fish and molluscs.

For COSEWIC data, the term "species" also includes subspecies and even specific populations of a single species where COSEWIC has deemed it necessary to assess these separately. There is not necessarily a one-to-one relationship between species and recovery strategies because recovery strategies may include multiple subspecies or populations, or even multiple species that inhabit the same ecological region. In some cases, several recovery strategies are being developed for a single species (e.g., caribou, white sturgeon).

Table 8. Progress, by species group, on development of recovery strategies for B.C. species assessed by COSEWIC as extirpated, endangered, and threatened (as of March 2007).

			In process			
Species group	No. listed species	Not yet started	Draft in preparation	Draft in review	Update in progress	Approved and published on SARA registry
Amphibians	6	0	2	3	1	0
Arthropods	8	0	3	3	0	2
Birds	16	1	5	9	0	1
Fish, freshwater	14	2	4	0	0	8
Fish, marine	5	0	2	3	0	0
Lichens	1	0	0	0	0	1
Mammals, marine	10	1	2	4	0	3
Mammals, terrestrial	10	1	6	2	1	0
Molluscs, aquatic	2	0	0	1	0	1
Molluscs, terrestrial	4	0	1	3	0	0
Mosses	8	1	2	5	0	0
Reptiles	9	1	3	2	2	1
Vascular plants	47	0	18	7	3	19
Total	140	7	48	42	7	36
	(100%)	(5%)	(34%)	(30%)	(5%)	(26%)

Sources: Species status: COSEWIC website: *www.cosewic.gc.ca/eng/sct5/index_e.cfm*. Data on progress in recovery: Ecosystems Branch, B.C. Ministry of Environment.
Note: Species assessed as Special Concern by COSEWIC are excluded because they do not require recovery strategies.

Interpretation

As of March 2007, recovery strategies for species at risk were in progress or completed across the full range of species groups and political jurisdictions (Table 8). Strategies were in process for 97 species (69%) and half of these were either completed and under review or were updates of existing strategies. An additional 36 species (26%) had an approved and published recovery strategy. These can be accessed through the SARA public registry (*www.sararegistry.gc.ca*). A strategy has not been started for 7 species.

Action plans that already exist for certain species, because they were part of previous processes, include:

- Marbled Murrelet (*Brachyramphus marmoratus*): a small seabird that uses old-growth coastal forests for nesting. An action plan was developed in 1993 (Kaiser et al. 1994) and recovery efforts continue.
- A subspecies of Peregrine Falcon (*Falco peregrinus anatum*): a predator threatened by habitat loss and small population size (Environment Canada 2004). An action plan was first developed in 1987 (Erickson et al. 1988). Initial goals have been met and an update is underway.
- Vancouver Island marmot (*Marmota vancouverensis*): a mammal living exclusively in alpine and subalpine habitats on a few Vancouver Island mountains. The first action plan was written in 1994; it was reassessed in 2000. Recovery efforts include research, monitoring, captive breeding, and reintroduction to the wild (Vancouver Island Marmot Recovery Team 2000).

As older plans such as these are revised they will better meet the requirements of SARA Action Plans. Recovery efforts for some species are initiated before recovery planning is completed, or even before the species is listed by COSEWIC.

Although writing and implementing a recovery plan does not guarantee improvement in the status of a species, it is a necessary step toward coordinating a recovery effort that has the greatest possible chance of being successful (Taylor et al. 2005). In addition to producing a plan, the process of recovery planning may encourage work on interim recovery measures. The process of regularly bringing together species experts, interest groups, industry representatives, and others to discuss the welfare of a species has other benefits, such as increasing communication and cooperation. Most recovery teams are also involved in implementing recovery actions, even before completing the recovery strategy or action plan.

As necessary as species recovery programs are, they are generally reactive, occurring once a species has declined to the point of near endangerment. Recovery is also generally slow and expensive—in the time it takes to improve the status of one species, several more may become at risk.

Supplementary Information: Conservation areas for rockfish recovery

Approximately 28 species of rockfish are caught commercially in B.C. They are mostly very long-lived fish with low productivity, which makes them vulnerable to overfishing. Inshore species are caught mainly in the groundfish hook and line fishery by commercial and recreational fishers. Offshore species are caught in the commercial longline, trap, and trawl fisheries.

The status of many offshore rockfish stocks is poorly understood; most stocks likely are fully exploited and some are overexploited. Bocaccio has been assessed by COSEWIC as Threatened, and COSEWIC is currently preparing species status reports for five species of rockfish.

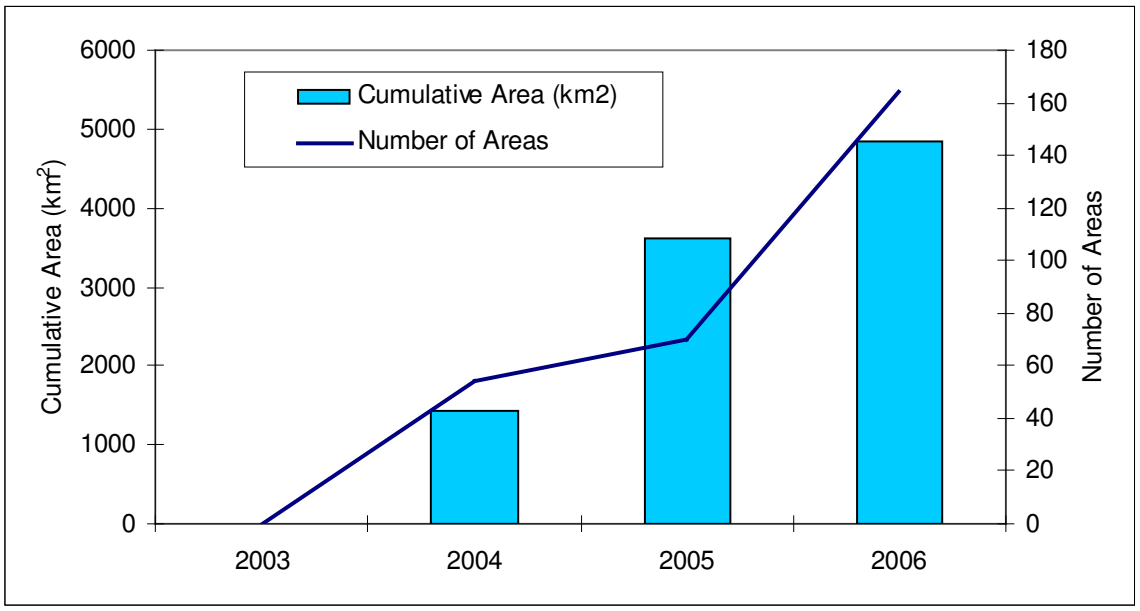
Serious conservation concerns for inshore rockfish species led to the development of the Rockfish/Lingcod Conservation Strategy in 2002 (DFO 2002). Under the strategy, 164 areas have been closed to fishing gear that causes rockfish mortality. These Rockfish Conservation Areas represent 30% of the rockfish habitat in the Strait of Georgia and just under 20% of rockfish habitat on the west coast of Vancouver Island, Central Coast, North Coast, and Haida Gwaii.

The management plan for the integrated commercial groundfish fishery outlines a sustainability strategy for inshore rockfish, including reducing bycatch, improving catch monitoring, and other steps to ensure a sustainable fishery (DFO 2007).

The area and number of rockfish conservation areas has increased annually (Figure 10). Although these areas are not in themselves permanent protected areas, they will likely be in place for at least one generation time of rockfish and probably much longer (30+ years). Yellow eye rockfish, for example, take 17 years to reach sexual maturity and can live to 115 years.

Some of these areas will probably be integrated into a system of Marine Protection Areas.

Figure 10. Rockfish conservation areas on the B.C. coast, 2003–2006.



Source: Groundfish Section, Pacific Biological Station, Fisheries and Oceans Canada.

5. Secondary Indicator: Number of alien species, by group, in B.C.

This is a pressure indicator. It addresses the questions: How many alien species have been introduced to B.C.? How much of a problem are invasive species in B.C.?

Alien, or exotic, organisms live outside their natural range usually because they have been deliberately or accidentally introduced there by humans. Because their natural predators or diseases are generally not present in the new environment, these alien species can become established and reproduce quickly. According to one estimate, about 10% of alien species become invasive (Menge and Branch 2001). Invasive alien species are particularly effective at becoming established in ecosystems under stress, such as those that are recently disturbed (Sorensen 1984).

Some studies suggest that alien species may be second only to habitat destruction in causing the loss of biological diversity worldwide (Vitousek et al. 1997). A recent study in Canada, however, ranked alien species last of six broad-scale threats to species at risk (Venter et al. 2006; also see Indicator 3: Threats to species at risk in B.C.). Current efforts to manage alien species have generally not been effective in controlling the problem (Simberloff et al. 2005). Global trade provides an increasing number of opportunities to transport organisms into non-native habitats where they may prey on, compete with, or alter the value of habitat for native organisms (Simberloff 2002).

In addition to the cost of ecological destruction, managing alien species is expensive. Economic costs include lost agricultural production and ecosystem services, control or eradication programs, and exclusion programs to keep out possible invaders. In 2000, alien species in the United States were estimated to cause environmental loss and damage worth US$137 billion per year (Pimental et al. 2000).

Methodology and Data

The data in this indicator came from three sources.

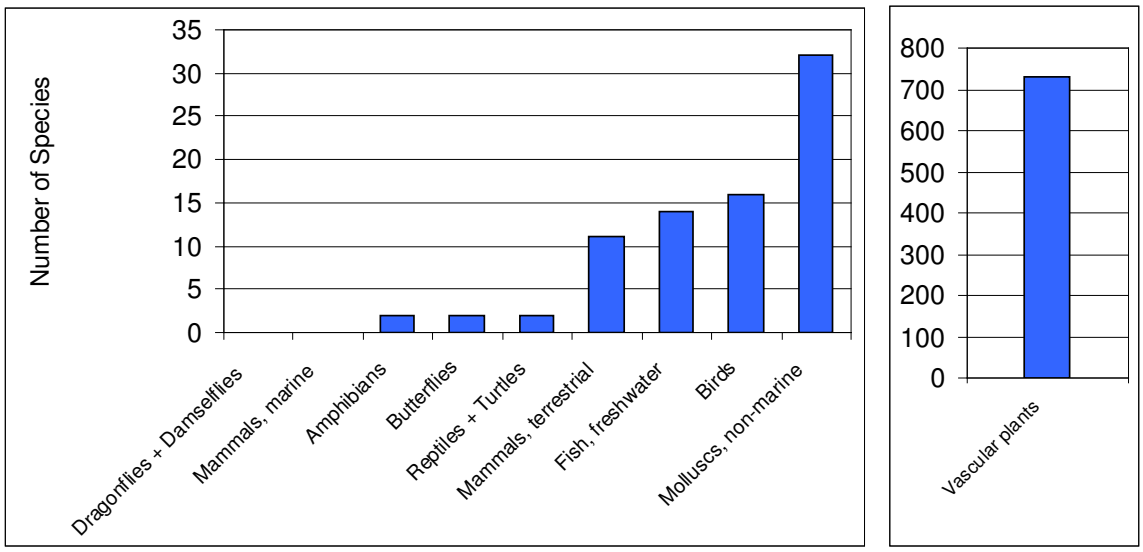
- The current number of alien species introduced to B.C. was compiled from the Conservation Data Centre (CDC) database (accessed 8 March 2007). The CDC database includes listings of both alien (exotic) and accidental species. Alien/exotic species have been moved beyond their natural range by human activity. Accidental species have moved beyond their natural range of their own accord, which occurs very rarely (L. Ramsay, B.C. Ministry of Environment, 2007, pers. comm.). Most accidental species are birds. Accidental species are not considered to be part of B.C.'s native fauna or flora, although if they eventually establish breeding populations, they would then be considered new immigrant species. For this indicator, only the species listed by CDC as "exotic" have been included.
- Trends in alien vascular plant species between 1996 and 2006 were compiled from an internal database maintained by the Research Branch of the B.C. Ministry of Forests and Range (British Columbia Plant Species Codes and Selected Attributes: Version 5, available at *www.for.gov.bc.ca/hre/becweb/resources/codes-standards/standards-species.html*). The data include several entries for each year, therefore the most recent entry was used for each year. An additional year of data, for 1994, was obtained from Douglas et al. 1994. To be considered an alien plant, a species must persist from year to year in natural or seminatural habitats (i.e., not in gardens).

- Trends in alien fish species between 1950 and 2005 were compiled by Hatfield and Pollard (2007) from a provincial database that documents individual occurrences of all fish species in B.C. The data came from biological surveys of freshwater systems in B.C. and were collected by multiple agencies and individuals. Although some geographic and species records were incomplete, there were enough complete data entries to analyze trends in alien fish species. The data set included species that have been introduced from outside B.C., along with three species (walleye, northern pike, and yellow perch) that have very limited native range in B.C. (all in the northeast of B.C.). These three species were included as aliens because they have been introduced to parts of B.C. that are a long way from their native B.C. ranges, often as migrants from introductions to lakes or rivers south of the Canada–US border (Hatfield and Pollard 2007).

Number of Alien Species in B.C.

As of March 2007, 809 alien species were recorded in B.C., representing nearly one-fifth of all recorded species, native and alien combined, in the province (Figure 11, Table 9). More than 90% of these alien species were vascular plants. Among animals the greatest number of alien species was in the nonmarine mollusc group (32 species or 17% of recorded nonmarine molluscs). The next largest group of aliens was birds (16 species or 4% of all birds), followed by freshwater fish (14 species or 14% of all fish), and terrestrial mammals (11 species or 8% of all mammals). There were no recorded alien species in the marine mammal and dragon- and damselflies groups. Although only 34 alien invertebrates were included in these data, it is known that there are more alien invertebrates in B.C., particularly in marine and estuarine ecosystems (see BCMOE 2006a). They were not included in this indicator, because data on these invertebrate groups have not yet been analyzed by the CDC.

Figure 11. The number of alien species in B.C., by species group, as of March 2007.



Source: Conservation Data Centre, 2007

Note the different scale for vascular plants.

Table 9. The number of alien species in B.C., by species group, as of March 2007.

Species group	Number of alien species	Percentage of all species in the group
Dragonflies + Damselflies	0	0
Mammals, marine	0	0
Amphibians	2	9.1%
Butterflies	2	0.9%
Reptiles + turtles	2	10.5%
Mammals, terrestrial	11	8.4%
Fish, freshwater	14	13.5%
Birds	16	4.1%
Molluscs, nonmarine	32	18.6%
Vascular plants	730	23.7%
Total	809	19.1%

Source: Conservation Data Centre, 2007.

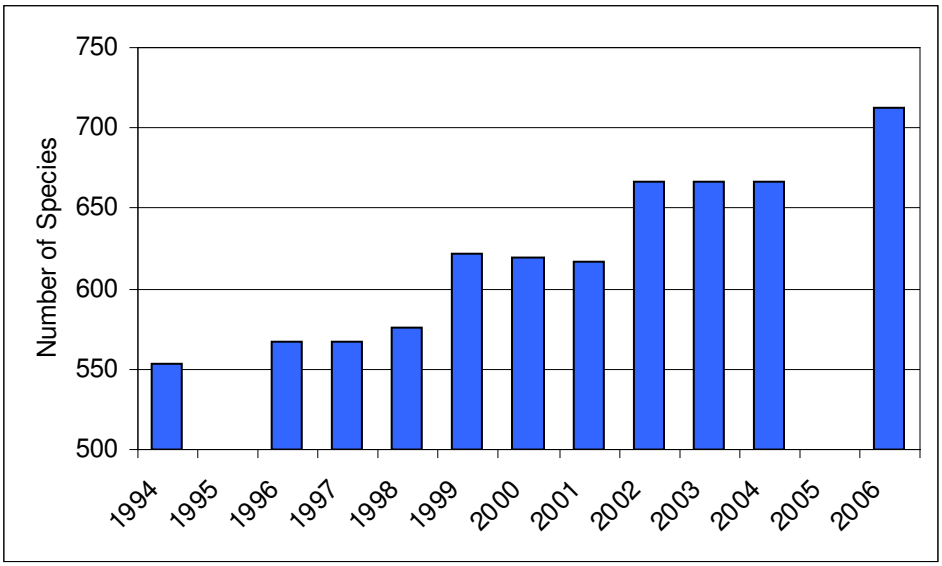
Note: Recorded species include Red-, Blue-, and Yellow-listed species and alien species.

Trends in Alien Vascular Plants

The number of alien vascular plant species in B.C. has increased steadily between 1994 and 2006 (Figure 12, Table 10). In 1994, 553 species were recorded and by 2006 there had been a 29% increase to 713 species. From 1999 to 2001, there was a small decline because five species were removed from the alien species list, possibly because they did not persist, their taxonomic identification was revised, or they had been misidentified (J. Penny, B.C. Ministry of Environment. 2007, pers. comm.).

Note that the trend data set lists 713 alien vascular plants for 2006 and the CDC data set of current status in early 2007 lists 730 species. The 17 species discrepancy is due to the difference in dates the data were obtained: the trend data were compiled October 2006 and the CDC data in March 2007. The CDC database is continually updated with new information, so by March 2007 it included 17 additional species not included in the October 2006 trend data.

Figure 12. Number of alien vascular plant species established in B.C., 1994 to 2006.



Sources: Douglas et al. 1994; BC Flora Database, Ministry of Forests and Range.

Table 10. Number and increase in alien vascular plant species established in B.C., 1994 to 2006.

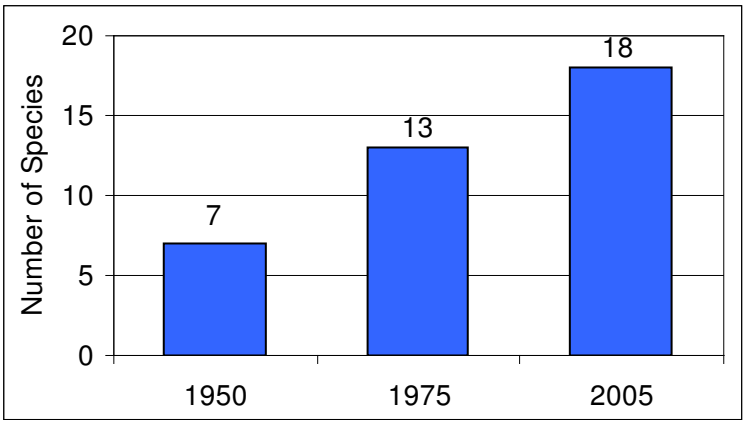
Year	Number of alien species	Change from 1994
1994	553	–
1996	567	+2.5%
1997	567	+2.5%
1998	576	+4.2%
1999	622	+12.5%
2000	620	+12.1%
2001	617	+11.6%
2002	667	+20.6%
2003	667	+20.6%
2004	667	+20.6%
2006	713	+28.9%

Sources: Douglas et al. 1994; BC Flora Database, Ministry of Forests and Range.

Trends in Alien Fish Species

The number of alien freshwater fish species has increased from 7 in 1950 to 18 in 2005 (Figure 13). In addition, the number of waterbodies that contain alien fish species has increased from 28 in 1950 to 625 in 2005 (Table 11).

Figure 13. Number of alien freshwater fish species in B.C. over a 55-year span.



Source: Hatfield and Pollard 2007.

Table 11. Number of waterbodies, by region, with one or more alien freshwater fish species.

Region	Waterbodies with alien species			No. of waterbodies surveyed
	1950	1975	2005	
1: Vancouver Island	4	37	84	104
2: Lower Mainland	4	28	57	93
3: Thompson	2	13	40	61
4: Kootenays	10	63	325	398
5: Cariboo	1	12	17	20
6: Skeena	1	3	6	11
7: Omineca	1	4	19	19
8: Okanagan	4	34	73	139
9: Peace	1	1	4	15
Total	28	195	625	860

Source: Hatfield and Pollard 2007.

Note: Some records in the database were not dated, so the total number of records differs from the final count in 2005.

Interpretation

Plants

Plants are overwhelmingly the most common group of alien species documented in B.C. About 65% of alien plants occur frequently and appear to be widely established (BCMOE 2006a). The number of alien plants is high, likely because they have been unintentionally imported along with livestock feed, as well as introduced for nursery and other agricultural purposes (Harding 1994). Others may have arrived on imported equipment or domesticated animals. Many of the

most invasive plants (e.g., Scotch broom, purple loosestrife, baby's breath, Japanese knotweed) were intentionally planted as ornamentals and have escaped from gardens.

Although many alien plants arrived in B.C. at the time of and soon after European settlement, other alien plants continue to be introduced to the province today. In the 12 years from 1994 to 2006, more than 150 alien plants were introduced to natural habitats and became established.

Fish

Some of the increase since 1950 in the number of alien fish species and of waterbodies with alien fish in B.C. may be due to the fact that more watersheds have been surveyed over time. However, Hatfield and Pollard (2007) state that the pattern of increase likely represents a true trend in the spread of alien fish species within B.C. Provincial regions with the greatest increase in distribution of alien species have been those with the largest human population: Vancouver Island, Lower Mainland, Okanagan, and Kootenays. The general trend of increased distribution of alien species is probably more pronounced than shown by the data, because, with the exception of walleye, northern pike, and yellow perch, this data set does not include species native to B.C. that have been introduced into waters outside their natural range.

The data in Hatfield and Pollard (2007) indicate two patterns. First, observations of alien fish species distribution tend to be focussed around urban areas, both for species mainly introduced through authorized stockings (e.g., brook trout and brown trout) and for those predominantly introduced illegally (e.g., bass species, yellow perch, and catfish). Frequently, small lakes and streams near urban areas have been stocked to enhance fishing opportunities. A larger human population also increases the likelihood that unwanted pets will be released, that organisms from man-made ponds will escape, and that individuals who would like to create a fishery close to home will intentionally move fish. On the other hand, more aliens species may be recorded close to urban areas because there is easier access for monitoring and a greater need to study these watersheds.

The second pattern is that introductions are more concentrated in southern regions of the province, which may reflect some or all of the following:

- Environmental conditions. The milder climate in southern areas may be more hospitable to warm-water species such as bass, carp, and bullhead.
- Areas of high population density. A large proportion of B.C.'s population lives close to the US border, allowing for the factors discussed above for urban areas.
- Associated disturbance. The Columbia and Kootenay watersheds have experienced large-scale habitat changes from hydroelectric and flood-control dams. Converting natural riverine habitats to the still or slow-moving habitat found in reservoirs has been associated with replacement of native species by aliens that are better adapted to the new environment (Quist et al. 2003).
- Forestry-related activities. Increased stream water temperature, which frequently accompanies forestry activities, can displace coldwater species, such as cutthroat and bull trout, in favour of species with greater temperature tolerance, such as brown and brook trout

(Rieman et al. 2006). Although forestry occurs throughout most of B.C., the effect on alien species' distributions may be more relevant in southern watersheds where more alien species are already present.

- Proximity to the US border. Illegal introductions from populations in the US and natural northward dispersal in shared watersheds, such as the Columbia, Kootenay, and Flathead rivers, are both possibilities for B.C. waterbodies close to the US border. In the past, waterbodies in northwestern US states have been stocked with walleye, bass, and yellow perch. For example, the walleye in the B.C. portion of the Columbia system likely originated in Washington (Fuller et al. 1999).

Alien Species in General

The number of alien species reported here is a total from only some of the better known groups of organisms and is not the total number of alien species established in B.C. Alien microorganisms, insects, and other invertebrates are not well documented but are likely abundant. For example, ballast water in cargo ships may contain thousands of tiny organisms, including algae and zooplankton, in each cubic metre of water (Levings et al. 1998). More than 3,000 species of animals and plants are estimated to be transported around the world daily in ballast water (NRC 1996). With respect to insects, Smith (1994) identified more than 300 alien insect species in British Columbia. Some are serious economic pests and others were introduced intentionally as part of biological control programs for pests. Earthworms are another group of organisms that have been poorly documented in B.C. but that contain several alien species. The activity of many alien earthworms alter processes in the forest floor and ultimately affect biodiversity in native forests (Hendrix and Bohlen 2002). More comprehensive monitoring would likely find more species.

Although they carry potential (or realized) costs to ecosystems and to native commercial species, lucrative industries have sprung up around some alien species, especially in coastal waters. For example, several alien marine invertebrates are commercially valuable. The Manila clam (*Tapes philippinarum*), unintentionally introduced in the 1930s, has colonized much of the province's south coast where it apparently co-exists with native clams (DFO 2001; BCSGA 2004) and supports a commercial clam industry valued at $7.6 million in 2003 (DFO 2004). The introduction of Atlantic salmon aquaculture to the B.C. coast has simultaneously fuelled an industry worth more than $300 million annually (Statistics Canada 2005) and controversy over threats to wild salmon fisheries (e.g., Special Committee on Sustainable Aquaculture 2007).

Left uncontrolled, some alien species could have large negative impacts on provincial ecosystems and some commercial industries. Two alien species in particular that have not become established in B.C., but which are the target of ongoing quarantine and eradication efforts, are the Asian gypsy moth (*Lymantria dispar*) and sudden oak death (*Phytophthora ramorum*) (Hunt et al. 2006). The gypsy moth threatens forestry, agriculture, and nursery sectors as well as the native Garry oak forests (Agriculture Canada 1986; Humble and Stewart 1994). Sudden oak death, a fungus, also threatens the forestry, agriculture, and nursery sectors and numerous native plant species, including Garry oak, arbutus, big-leaf maple, salmonberry, and Douglas-fir (BCMAFF 2004).

The threat from invasive species continues to rise as a result of many global factors, including a thriving horticulture industry, an increase in human travel and export around the world, and climate change. Climate change may increase the number of alien species in B.C. as conditions become more favourable for their establishment and spread (Hunt et al. 2006). Warmer average temperatures would be more likely to improve survival through the winter and stimulate faster development of individuals during the summer.

Supplementary Information: Biological control of alien species in B.C.

Some alien vascular plants are particularly aggressive at outcompeting native species and altering native ecosystem dynamics. These aggressive alien plants are often termed invasive species. In an attempt to stop the spread of invasive plants and control the damage they cause, the BC Ministry of Forests and Range has a biocontrol program to release biological agents that feed on the invasives. Most biocontrol agents are insects, but a few are fungi, mainly rusts. Developing a biocontrol agent requires a large commitment of time (8–10 years) and funds to complete all the testing that must be done to ensure that the agent will be effective and will not harm native species.

Since the 1950s, 70 species of biocontrol agents have been released in B.C. to target 27 invasive plant species. Some of these 70 agents, generally those imported early in the program, have disappeared or have not survived in B.C. Two areas of particular focus for current biocontrol research are compatibility with habitats in the importing country and the effectiveness of the agent at controlling the plant species. Several agents may be released to control a single plant species. The aim is to weaken the invasive plant at as many points as possible—e.g., at the stem, root, and bud. This gives native species a chance to coexist with the invasive plant, or ideally, to outcompete it.

Biocontrol of invasive plants in Canada began in B.C. in 1952 with releases of several species of *Chrysolina* beetles to control St. John's wort (*Hypericum perforatum*) (Powell et al. 1994). The plant contains a toxin that causes grazing animals to become sensitive to sunlight and develop skin irritation. The biocontrol insects feed heavily on the plant's foliage and flower buds (BCMOFR 2007). They have been effective at controlling St. John's wort, reducing dense stands to only scattered plants (Powell et al. 1994).

Other invasive plants targeted by biocontrol programs include the following:

- Spotted knapweed (*Centaurea biebersteinii*) and diffuse knapweed (*Centaurea diffusa*), both of which rapidly colonize disturbed areas as well as outcompete native plants in undisturbed areas (Powell et al. 1994). Several species of moths, flies, and beetles have been released since 1975 for diffuse knapweed and since 1985 for spotted knapweed (BCMOFR 2007).
- Tansy ragwort (*Senecio jacobeae*), another invasive plant poisonous to livestock, has been the target of biocontrol releases since the 1960s (BCMOFR 2007).
- Leafy spurge (*Euphorbia esula*), a plant that can tolerate many ecological conditions, has been targeted since the mid-1980s with several biocontrol agents, mostly species of *Aphthona* beetles (BCMOFR 2007).

WHAT IS HAPPENING IN THE ENVIRONMENT?

With the current state of knowledge, indications are that the overall status of many species is declining in the province, thus biodiversity in B.C. in general appears to be declining. The status of only a small number of species is regularly monitored, however, and the state of knowledge of ecosystems, which are an integral part of biodiversity is even less complete than the understanding of single species.

Most often, species are listed as being at risk because of the impact of human activities. Urban, agricultural, and other developments can encroach on habitat; chemicals and other types of pollutants can alter habitat conditions; overexploitation of a species can reduce the number of individuals; and alien species can prey upon or compete with a native species. There are also naturally occurring factors that can contribute to a species' decline, such as predation, disease, and extreme events, such as fire and drought. The combination of these numerous pressures can disturb natural ecosystems, extirpate local populations, and impair natural processes (e.g., Solan et al. 2004).

Results of analyses for the indicators in this paper indicate the following:

- The overall status of mammals and freshwater fish has declined over the past 13–15 years, as shown by the increase in species with a deteriorating conservation status. Red-listed vascular plants also showed an overall deterioration in conservation status during a 9-year period. The situation for birds is difficult to interpret because the number of new immigrant species has increased. More than one-third of fish, reptile, and turtle species in B.C. are on the provincial Red list of species at risk.
- B.C.'s ecosystems are incredibly diverse and have resulted in an enormous variety of plant and animal species throughout the province. Compared with other provinces and territories in Canada, B.C. has the largest number of amphibians, birds, fish, and mammals that are considered to be at risk according to COSEWIC and CDC designations.
- Federal accords and legislation have prompted the development of recovery strategies for most species that have been assessed by COSEWIC as being At Risk and occur in the province. Recovery strategies were in progress or completed for 69% of species, across the full range of species groups. An additional 26% of species had an approved and published recovery strategy. As necessary as species recovery programs are, they are generally reactive, slow, and expensive.
- Most of the B.C. species assessed to be nationally at risk face two or more threats, whether from natural or human sources. Habitat loss threatens 86% of these species, more than twice as many species as are threatened by any other examined threat. The large number of B.C. species threatened by habitat loss is consistent with results for Canada as a whole, as well as with results from elsewhere in the world (e.g., Baillie et al. 2004). Within the habitat loss category, most species were threatened by urbanization and agriculture. With continued population growth and development activities, habitat loss and alteration will continue to be a critical issue for many species.
- Alien species were the second greatest threat to B.C.'s species, based on analysis of the province's species that are nationally at risk. Although this differs from Canada-wide results,

the results are consistent with studies elsewhere (Miller et al. 1989; Wilcove et al. 1998) and likely reflect the large number of island species in B.C. More than 700 species of alien vascular plants have become established in B.C., and some of these have become serious problems. The provincial tracking system records 45 species of alien vertebrates and 34 species of invertebrates as introduced in B.C., but the true number of alien invertebrates is undoubtedly higher.

Species currently at risk are threatened by the growing human population and activities that place stress on the natural environment. In the long term, however, global climate change is likely to become the greatest threat to biodiversity in many regions of the world, resulting in severe impacts and extinctions as it compounds the effects of local threats (Thomas et al. 2004). Climate change has the potential to increase the frequency and extent of disturbances, such as fire and insect outbreaks (McKenzie et al. 2004), to create favourable conditions for invasive species, and to produce ecological shifts that may occur faster than species can adapt (Opdam and Wascher 2004). Although it is not possible to predict how much climate change will affect biodiversity in B.C., it is likely that it will create additional pressure in ecosystems that are already stressed in many ways.

Estimates of the global rate at which organisms are becoming extinct range from 100 to 1,000 times the historically "normal" rate of extinction, and scenarios for the future suggest this may increase a further 10 times (UNEP 2001; MEA 2005b). In terms of the global state of organisms, 33% of amphibian species (Stuart et al. 2004), 12% of birds (Birdlife International 2004), and 23% of mammals (IUCN 2003a) are considered vulnerable, endangered, or critically endangered.

This is a critical issue because research shows that the composition and richness of ecosystems can be changed dramatically by the loss of just one species. Loss of certain key species leads to rapid, systematic loss of others (Raffaelli 2004) and can result in reduced ecosystem function and stability because surviving species may not adequately replace the function of those lost (Solan et al. 2004). A damaged ecosystem becomes increasingly vulnerable to threats that it may formerly have been able to resist, such as invasive plants (Zavaleta and Hulvey 2004). Damaged ecosystems can no longer support the host of "ecosystem services" (e.g., MEA 2005a) on which humans are entirely dependent:

- Providing food, water, timber, and fibre harvests.
- Regulating climate, floods, water quality, and waste treatment.
- Supporting ecosystem functions, such as soil formation, pollination, and nutrient cycling.
- Supporting cultural activities, such as recreation, aesthetic enjoyment, and spiritual fulfilment.

Although ecosystem services provide life support for the planet, they are undervalued and poorly understood (Emerton and Bos 2004). In one analysis of the value of ecosystem services in B.C.'s lower Fraser valley, the authors concluded that protecting this ecosystem may save society hundreds of millions of dollars every year (Olewiler 2004).

Globally, the human use of all ecosystem services is growing rapidly, and yet recent research shows that approximately 60% of Earth's ecosystem services are being degraded or used unsustainably (MEA 2005a). The continued provision of ecosystem services relies on healthy

ecosystems, of which the diversity of species is a major and vulnerable part. Recent research has found that vital ecosystem functions, such as capturing carbon dioxide and purifying water, depend on many more species than previously thought—meaning that the impact of losing biodiversity may have been underestimated (Hector and Bagchi 2007).

WHAT IS BEING DONE ABOUT SPECIES CONSERVATION?

The status of species is affected by many areas of human activity, including industrial processes, land conversion, forestry, fishing and other harvesting, agriculture, environmental contamination, and climate change. The following key programs and policies address such pressures on individual species and ecosystems.

Key Federal Government Initiatives

- UN Convention on Biological Diversity (CBD): In 1992, Canada, with support from provincial and territorial governments, was the first industrialized nation to sign this convention. The main objective of the CBD is to achieve, by 2010, a significant reduction in the current rate of loss of biodiversity at global, national, and regional levels. The Canadian Biodiversity Strategy, published in 1996, is intended to guide implementation of the CBD in Canada. (*www.biodiv.org/default.shtml*)
- Species at risk agreements and legislation: In 1996, the Accord for the Protection of Species at Risk committed provinces and territories to work with the federal government to protect and recover species at risk. The federal *Species at Risk Act* (SARA), came into force in June 2004. It is intended to prevent Canadian indigenous species, subspecies, and distinct populations from becoming extirpated or extinct; to provide for the recovery of endangered or threatened species; and to encourage the management of other species to prevent them from becoming at risk. SARA has prompted recovery planning for species at risk all across the country. British Columbia and the federal government have endorsed a bilateral agreement to work cooperatively on the implementation of SARA. (*www.sararegistry.gc.ca/*).
- Committee on the Status of Endangered Wildlife in Canada: COSEWIC is an independent body of experts who use scientific, aboriginal, and community knowledge to classify species in Canada as extirpated, endangered, threatened, of special concern, or not at risk. COSEWIC includes representation from British Columbia. Under the *Species at Risk Act*, the government of Canada will take COSEWIC's recommendations into consideration when establishing the legal list of species at risk. (*www.cosewic.gc.ca/index.htm*)
- Invasive Alien Species Strategy for Canada: Published in 2004, the intent is to address the threat of invasive species to Canada's wildlife, forests, fisheries, and other resource sectors. The strategy prioritizes key actions and identifies the need for action plans on aquatic invaders, invasive plants, and introduced terrestrial animals. (*www.cbin.ec.gc.ca/primers/ias_invasives.cfm*)
- Canada's Oceans Strategy: Announced in 2002, the main objectives are understanding and protecting the marine environment, supporting sustainable economic development, and

providing international leadership and oceans governance. The strategy involves collaboration between the federal government, provinces, First Nations, oceans industries, academia, and the general public, as well as with other nations. In 2004, the federal and provincial governments signed a Memorandum of Understanding Respecting the Implementation of Canada's Oceans Strategy on the Pacific Coast of Canada to formalize the commitment of both governments to achieve the objectives. (*www.cos-soc.gc.ca/dir/cos-soc_e.asp*)

Key Provincial Government Initiatives

- B.C. Conservation Data Centre: The CDC systematically collects and disseminates information on plants, animals, and ecosystems (ecological communities) at risk in British Columbia. This information is compiled and maintained in a computerized database that provides a centralized and scientific source of information on the status, locations, and level of protection of these organisms and ecosystems. (*www.env.gov.bc.ca/cdc/*)
- Strategic land use planning: Strategic land use plans, which include identifying key areas for management and conservation of biodiversity, are under way and at various stages of completion throughout the province. (*ilmbwww.gov.bc.ca/lup/*)
- Revisions to the *Wildlife Act*: The *Wildlife Act* regulates wildlife harvest, establishes wildlife management areas and critical wildlife areas, and designates endangered species. In 2004, this act was amended to allow the provincial Cabinet to designate the full range of species provided for in the federal *Species at Risk Act*, including plants and invertebrates at risk. It expands the range of species that can be added to the extirpated, endangered, and threatened lists and allows for the protection of the habitat of species at risk. At time of writing (July 2007), the *Wildlife Act* was under review to make it more relevant to other issues, such as alien and invasive species, wildlife diseases, and ecotourism (BCMOE 2007).
- Species at risk under the *Forest and Range Practices Act*: In 2004, the Minister of Environment identified 39 species, all previously listed by COSEWIC, as Identified Wildlife, meaning that these species now require a greater level of consideration when planning forestry and range activities.
- In October 2007 British Columbia's Mountain Caribou Recovery Implementation Plan was announced. This collaboration between conservation organizations, First Nations, the forest industry, and outdoor recreation groups aims to restore the mountain caribou population to pre-1995 levels of more than 2,500 animals throughout their existing range.

BIODIVERSITY BC

In late 2004 a partnership of governments and nongovernmental organizations formed the BC Conservation Lands Forum. The mandate of the forum is to secure and improve the management of public and private lands to conserve biodiversity. An independent committee of the Forum was established to develop a provincial biodiversity strategy. Through an extensive consultation process with scientific experts on biodiversity, the committee, which is now called Biodiversity BC, produced a comprehensive report on the Status of Biodiversity in British Columbia in 2007. The report summarizes the current status of terrestrial and freshwater aquatic species and ecosystems in the province, their global significance, and gaps in current knowledge. Based on this and other reports, Biodiversity BC is developing a Biodiversity Action Plan Discussion Paper for release in late 2007. This will be the basis for consultation with stakeholders, including First Nations and the public, on options and priorities for conserving biodiversity in the province. The intent is to have a finalized 5-year action plan for biodiversity completed by the end of 2008 and to begin implementing that plan in 2009.

Organizations with representation on Biodiversity BC include land conservation groups: Ducks Unlimited Canada, The Land Conservancy of British Columbia, Nature Conservancy of Canada, The Nature Trust of British Columbia, Pacific Salmon Foundation, and the Canadian Parks and Wilderness Society (BC) representing other nongovernmental organizations; Habitat Conservation Trust Fund; the provincial government (Ministry of Agriculture and Lands and Ministry of Environment), the federal government (Environment Canada), and municipal governments (Union of British Columbia Municipalities). For more information and to follow the progress of the project e-mail *info@biodiversity.org*.

Other Initiatives

There are many other initiatives by international bodies, municipal governments, community groups, and volunteers. The following list includes only a few of them.

- The Greater Vancouver Regional District Biodiversity Strategy: This collaborative effort engages the public, land use planners, and decision-makers in conserving the ecosystem components, functions, and services that remain in the District—which is expected to have a population of nearly three million people by 2021. (*www.gvrd.bc.ca/growth/biodiversity.htm*)
- Nature Canada and Bird Studies Canada: These Canadian partners, with BirdLife International, designate Important Bird Areas (IBA) to protect and monitor a network of vital

habitats for the conservation of bird populations and biodiversity around the world. (*www.naturalists.bc.ca/projects/iba/iba_intro.htm*)

- Habitat Stewardship Program (HSP) for Species at Risk: This is a funding program to contribute to the recovery of species by engaging the public in conservation actions that benefit wildlife. The HSP provides funding stewardship projects that protect or conserve habitats for species designated by COSEWIC as endangered, threatened, or of special concern. The HSP is one of the three main federal funding programs implemented by Environment Canada, Fisheries and Oceans Canada, and the Parks Canada Agency. (*www.cws-scf.ec.gc.ca/hsp-pih/default.asp*)
- B.C. Trust for Public Lands: Established in 2004, the trust secures and manages ecologically sensitive lands, and plans for biodiversity conservation across the province. The Land Trust Alliance is delivered through the B.C. Conservation Lands Forum, a partnership between government and the conservation sector. (*www.landtrustalliance.bc.ca/*)

WHAT CAN YOU DO?

British Columbians make many personal choices that affect the natural environment and the species that live there. For example, choosing to consume fewer resources and produce less waste relieves some of the pressure on the native species and on ecosystems that are home to living organisms. The effect of this can be multiplied many times if everyone makes choices that reduce the pressure on the planet's ecosystems. Here are some other things you can do.

- Learn more about the animals and plants in British Columbia. Local natural history societies, as well as national and provincial parks, offer opportunities for learning about plants and animals in their natural environment. The Federation of B.C. Naturalists acts as the hub for a network of natural history societies in towns and cities across British Columbia. Find a local club at *www.naturalhistory.bc.ca/VNHS/index.htm*.
- Get involved! Join a local advisory board, wildlife enhancement group, or community planning team. Make sure protection of species at risk is on the agenda of your local community plan and regional or municipal governments. Participate in species at risk consultations. Support groups that are working on species at risk in British Columbia.
- Encourage backyard biodiversity by providing habitat for native animals and plants. Naturescape British Columbia is a program that helps people bring human communities closer to living in harmony with nature by providing information on how to restore, preserve, and enhance wildlife habitat in urban and rural landscapes and yards. Find out if you have species at risk on your land. Learn how to foster these species, and work with a local conservation group or recovery team. (*www.hctf.ca/nature.htm*)
- Participate in citizen science projects. You can enter bird sightings on the eBird website (*http://ebird.org/content/canada/*), participate in local butterfly counts, Christmas bird counts (*www.bsc-eoc.org/national/cbcmain.html*), BC Frogwatch (*www.env.gov.bc.ca/wld/frogwatch*), and surveys of breeding birds, plants, even worms (through Nature Canada *www.naturecanada.ca/*).

- Do not move alien species, such as fish, frogs, turtles, or problem wildlife to other areas. Work to reduce alien species in the environment and don't buy aggressive non-native plants for landscaping. If you have an alien plant species on your property that is seeding freely (such as ivy, Scotch broom, gorse) take responsibility for removing it.
- Be informed about sustainably harvested food from the wild, including fish, and buy accordingly. Buy from local outlets and farms that have species-friendly management.
- Keep pets from roaming free. Dogs, and especially cats, can kill or harass birds, snakes, and other wildlife in suburban and rural areas.
- Be responsible about recreation, including respecting closed areas and decommissioned roads.
- Consider protecting your land for the future with conservation covenants or agreements. See: Land Trust Alliance of B.C. (*www.landtrustalliance.bc.ca*)

Last, but not least: share your knowledge of, and passion for, biodiversity with friends, children, and co-workers. Project WILD provides wildlife-focussed conservation education for K–12 teachers and their students. (*www.projectwild.org/*)

References

Agriculture Canada. 1986. Gypsy moth: A destructive pest of forests and shade trees. Agriculture Canada, Ottawa, ON. Publication 1811/B.

Baillie, J.E.M., B. Collen, R. Amin, H.R. Akcakaya, S. Butchart, N. Brummitt, T.R. Meagher, M. Ram, and C. Hilton-Taylor. In press. Putting diversity into biodiversity: Meeting the CBD 2010 target.

Baillie, J.E.M., C. Hilton-Taylor, and S.N. Stuart (eds.). 2004. 2004 IUCN Red list of threatened species: A global species assessment. World Conservation Union, Cambridge, UK.

Baird, R.W. 1999. Status of killer whales in Canada. Contr. rep. to COSEWIC. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. 42pp.

BCMAFF (Ministry of Agriculture, Food and Fisheries). 2004. Sudden oak death. Victoria, BC. Available at *www.agf.gov.bc.ca/cropprot/sod.htm.*

BCMELP (Ministry of Environment, Lands and Parks). 1993. Garry oak ecosystems. Ecosystems at risk in British Columbia. Brochure. Available at *www.env.gov.bc.ca/wld/list.htm.*

BCMELP (Ministry of Environment, Lands and Parks). 1999a. Rare forest plants of southern British Columbia. Wildlife at risk in British Columbia. Brochure. Available at *www.env.gov.bc.ca/wld/list.htm.*

BCMELP (Ministry of Environment, Lands and Parks). 1999b. Rare grassland plants. Wildlife at risk in British Columbia. Brochure. Available at *www.env.gov.bc.ca/wld/list.htm.*

BCMELP and BCMOF (Ministry of Environment, Lands and Parks and Ministry of Forests). 1999. Biodiversity in British Columbia. Brochure, 6pp. Available at *http://wlapwww.gov.bc.ca/wld/documents/env.biod.pdf.*

BCMELP and EC (Ministry of Environment, Lands and Parks and Environment Canada). 1993. State of the environment report for British Columbia. Vancouver, BC. 127pp.

BCMOE (Ministry of Environment). 1999. Biodiversity in B.C. Available at *www.env.gov.bc.ca/wld/bio.htm.*

BCMOE (Ministry of Forests). 2004. 2004/05–2006/07 service plan. Available at *www.bcbudget.gov.bc.ca/bgt2004/sp2004/for/for_appendix1.htm.*

BCMOE (Ministry of Environment). 2006a. Alive and inseparable: British Columbia's coastal environment:2006. Available at *www.env.gov.bc.ca/soe/bcce.*

BCMOE (Ministry of Environment). 2006b. Estuaries in British Columbia. Ecosystems at risk in British Columbia. Brochure. Available at *www.env.gov.bc.ca/wld/list.htm.*

BCMOE (Ministry of Environment). 2007. The Wildlife Act: Managing for sustainability in the 21st century. Discussion paper. Fish and Wildlife Branch. Available at *www.env.gov.bc.ca/fw/wildlifeactreview/discussion/discussionpaper_wildlifeact.pdf.*

BCMOFR (Ministry of Forests and Range). 2007. Invasive alien plant program application (database). Available at *www.for.gov.bc.ca/hfp/invasive/IAP_01.htm.*

BCMSRM (Ministry of Sustainable Resource Management). 2004a. Grasslands of the Southern Interior. Ecosystems at risk in British Columbia. Brochure. Available at *www.env.gov.bc.ca/wld/list.htm.*

BCMSRM (Ministry of Sustainable Resource Management). 2004b. Wetlands of the Southern Interior valleys. Ecosystems at risk in British Columbia. Brochure. Available at *www.env.gov.bc.ca/wld/list.htm.*

BCMWLAP (Ministry of Water, Land and Air Protection). 2002. Environmental trends in British Columbia 2002. Victoria, BC. 64pp. Available at *www.env.gov.bc.ca/soerpt/.*

B.C. Mountain Caribou Science Team. 2005. Mountain caribou in British Columbia: A situation analysis. Available at *http://ilmbwww.gov.bc.ca/sarco/mc/mc_scienceteam_docs.html.*

B.C. Mountain Caribou Technical Advisory Committee. 2002. A strategy for recovery of mountain caribou in British Columbia. B.C. Ministry of Water, Land and Air Protection, Victoria, BC. 73pp.

BCSGA (B.C. Shellfish Growers Association). 2004. Clam culture in British Columbia. Available at *www.bcsga.ca/bcsgirs/clams/clam.htm.*

Bigg, M.A., P.F. Olesiuk, G.M. Ellis, J.K.B. Ford, and K.C. Balcomb. 1990. Social organization

and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. of International Whaling Commission, Special Issue 12:383–405.

BirdLife International. 2004. State of the world's birds 2004: Indicators for our changing world. Cambridge, UK.

Bunnell, F.L., and K.A Squires. 2005. Evaluating potential influences of climate change on historical trends in bird species. Report. B.C. Ministry of Environment, Victoria, BC.

Butchart, S.H.M., H.R. Akcakaya, J. Chanson, J.E.M. Baillie, B. Collen, S. Quader, W.R. Turner, R. Amin, S.N. Stuart, and C. Hilton-Taylor. 2007. Improvements to the Red list index. PLoSOne 2(1):e140. Available at w*ww.plosone.org/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1371%2Fjournal.pone.0000140.*

Butchart, S.H.M., A.J. Stattersfield, L.A. Bennun, S.M. Shutes, H.R. Akcakaya, J.E.M. Baillie, S.N. Stuart, C. Hilton-Taylor, and G.M. Mace. 2004. Measuring global trends in the status of biodiversity: Red list indices for birds. Public Library of Science, Biology 2:2294–2304.

Cannings, S.G., and J. Ptolemy. 1998. Rare freshwater fish of British Columbia. B.C. Ministry of Environment, Lands and Parks, Victoria, BC. 214pp.

CDC (BC Conservation Data Centre). 2004. Ecological communities in British Columbia: Conservation status assessment factors. Available at *www.env.gov.bc.ca/cdc/documents/ConsStatusAssessFactors.pdf.*

CDC (BC Conservation Data Centre). 2005. B.C. species and ecosystems explorer database. Available at *srmapps.gov.bc.ca/apps/eswp/.*

CDC (BC Conservation Data Centre). 2006. Standard for mapping ecosystems at risk in British Columbia: An approach to mapping ecosystems at risk and other sensitive ecosystems. Vers. 1. Available at *http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/habitat/assets/standards_for_mapping_ear_version1.pdf.*

CDC (BC Conservation Data Centre). 2007. Conservation status report: *Strix occidentalis*. Available at *http://srmapps.gov.bc.ca/apps/eswp/* (accessed April 18, 2007).

CESCC (Canadian Endangered Species Conservation Council). 2006. Wild species 2005: The general status of species in Canada. Available at *www.wildspecies.ca/wildspecies2005./*

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. COSEWIC assessment and update status report on the woodland caribou (*Rangifer tarandus caribou*) in Canada. Ottawa, ON. xi + 98pp.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2003a. COSEWIC

assessment and update status report on the humpback whale (*Megaptera novaeangliae*) in Canada. Ottawa, ON. viii + 25pp.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2003b. COSEWIC assessment and update status report on the Steller sea lion (*Eumetopias jubatus*) in Canada. Ottawa, ON. vii + 47pp.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2003c. COSEWIC assessment and update status report on the white sturgeon (*Acipenser transmontanus*) in Canada. Ottawa. vii + 51pp. Available at *www.sararegistry.gc.ca/status/status_e.cfm.*

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2003d. COSEWIC assessment and update status report on the wolverine (*Gulo gulo*) in Canada. Ottawa, ON. vi + 41pp.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2004. COSEWIC assessment and update status report on the grey whale (Eastern North Pacific population) (*Eschrichtius robustus*) in Canada. Ottawa, ON. vii + 31pp.

CWR (Center for Whale Research). 2007. K, L pod off Monterey Coast, March 24/25. Press release. Available at *www.whaleresearch.com/thecenter/News_KsLs_CA_L109_press_release.html.*

DFO (Department of Fisheries and Oceans Canada). 2001. Manila clams (Area 7). DFO science stock status report C6-03.

DFO (Department of Fisheries and Oceans Canada). 2002. Toward an inshore rockfish conservation plan: A structure for continued consultation. Department of Fisheries and Oceans Canada. 36pp.

DFO (Department of Fisheries and Oceans Canada). 2003. 2004 salmon stock outlook. Department of Fisheries and Oceans Canada. 9pp.

DFO (Department of Fisheries and Oceans Canada). 2004. The 2003 aquaculture production statistics. Available at *www.dfo-mpo.gc.ca/communic/statistics/aqua/aqua03_e.htm.*

DFO (Department of Fisheries and Oceans Canada). 2006. 2006 salmon stock outlook. Available at *www-ops2.pac.dfo-po.gc.ca/xnet/content/Salmon/webdocs/SALMON_OUTLOOK_2006.htm* (accessed May 4, 2007).

DFO (Department of Fisheries and Oceans Canada). 2007. Pacific Region, integrated fisheries management plan, groundfish, 10 March 2007 to 31 March 2008. Available at *www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/plans07/Groundfish0708pl.pdf.*

Douglas, G.W., G.B. Straley, and D.V. Meidinger. 1994. The vascular plants of British Columbia. B.C. Ministry of Forests Research Program, Victoria, BC. Special Report Series, No. 4: Monocotyledons.

Emerton, L., and E. Bos. 2004. Value. Counting ecosystems as an economic part of water. IUCN, World Conservation Union, Gland, Switzerland, and Cambridge, UK. 88pp.

Environment Canada. 2003. Environmental signals: Canada's national environmental indicator series 2003. Ottawa, ON.

Environment Canada. 2004. Species at risk. Available at *www.speciesatrisk.gc.ca/.*

Environment Canada. 2005. Species at Risk Act public registry. Available at *www.sararegistry.gc.ca/.*

Erickson, G., R. Fyfe, R. Bromley, G.L. Holroyd, D. Mossop, B. Munro, R. Nero, C. Shank, and T. Wiens. 1988. *Anatum* Peregrine Falcon recovery plan. Environment Canada, Canadian Wildlife Service, Ottawa, ON. 52pp.

Ford, J.K.B., G.M. Ellis, and P.F. Olesiuk. 2005. Linking prey and population dynamics: Did food limitation cause recent declines of resident killer whales (*Orcinus orca*) in British Columbia? Canadian Science Advisory Secretariat, Res. Doc. 2005/042. Fisheries and Oceans Canada, Pacific Biological Station. Nanaimo, BC. Available at *www.dfo-mpo.gc.ca/csas/.*

Fuller, P.L., L.G. Nico, and J.D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society Special Publication 27. Bethesda, MD.

Gregr, E.J., and A.W. Trites. 2001. Predictions of critical habitat for five whale species in the waters of coastal British Columbia. Can. J. Fish. Aquat. Sci. 58:1265–1285.

Harding, L.E. 1994. Exotic species in British Columbia. Ch. 17 *in* L.E. Harding and E. McCullum (eds.). Biodiversity in British Columbia: Our changing environment. Environment Canada and Canadian Wildlife Service, Pacific and Yukon Region.

Hatfield, T., and S. Pollard. 2007. Non-native freshwater fish species in British Columbia. Biology, biotic effects, and potential management actions. Report prep. for Freshwater Fisheries Society of British Columbia and Ministry of Environment, Victoria, BC.

Hay, D. 1999. Eulachon Research Council meeting notes on the status of eulachon in B.C. Department of Fisheries and Oceans Canada.

Hector, A., and R. Bagchi. 2007. Biodiversity and ecosystem multifunctionality. Nature 448:188–191.

Hendrix, P.F., and P.J. Bohlen. 2002. Exotic earthworm invasions in North America: Ecological and policy implications. Bioscience 52(9):801–811.

Humble, L., and A.J. Stewart. 1994. Gypsy moth. Pacific Forestry Centre, Canadian Forest Service, Victoria, BC. Forest Pest Leaflet 75.

Hunt, S., J. Newman, and G. Otis. 2006. Threats and impacts of exotic pests under climate change: Implications for Canada's forest ecosystems and carbon stocks. BIOCAP Research Integration Program, synthesis paper. Available at *www.biocap.ca/rif/report/Hunt_S.pdf.*

IUCN (World Conservation Union). 2003a. 2003 IUCN Red list of threatened species. Available at *www.redlist.org.*

IUCN (World Conservation Union). 2003b. Guidelines for application of IUCN Red list criteria at regional levels. Version 3.0. Gland, Switzerland, and Cambridge, UK.

Kaiser, G.W., H.J. Barclay, A.E. Burger, D. Kangasniemi, D.J. Lindsay, W.T. Munro, W.R. Pollard, R. Redhead, J. Rice, and D. Seip. 1994. National recovery plan for the Marbled Murrelet. Recovery of Nationally Endangered Wildlife Committee, Canadian Wildlife Service, Ottawa, ON. Rep. No. 8. 36pp.

Keith, D.A., and M.A. Burgman. 2004. The Lazarus effect: Can the dynamics of extinct species lists tell us anything about the status of biodiversity? Biological Conservation 117:41–48.

Killer Whale Recovery Team. 2005. Draft national recovery strategy for northern and southern resident killer whales (*Orcinus orca*). Prep. for Fisheries and Oceans Canada for public consultations, spring 2005. 70pp.

Laliberte, A.S. and W.J. Ripple. 2004. Range contractions of North American carnivores and ungulates. Bioscience 54:123–138.

Levings, C.D., G.E. Piercey, M. Galbraith, and G.S. Jamieson. 1998. Analyses of invertebrate fauna in ballast water collected in ships arriving at British Columbia ports, especially those from the western North Pacific. Pp. 111–124 *in* Proc. of 8th International Zebra Mussel and Aquatic Nuisance Species Conference, 16–18 March 1998, Sacramento, CA.

Lill, A. 2002. Greater Georgia Basin steelhead recovery action plan. Prep. by A.F. Lill and Associates Ltd. for Pacific Salmon Foundation, North Vancouver, BC. 52pp.

Master, L.L. 1991. Assessing threats and setting priorities for conservation. Conservation Biology 5:559–563.

McKenzie, D., Z. Gedalof, D.L. Peterson, and P. Mote. 2004. Climatic change, wildfire, and conservation. Conserv. Biol. 18:890–902.

McTaggart-Cowan, I., N.K. Dawe, R.W. Campbell, and A.C. Stewart. 2001. Avian biodiversity, ecological distribution, and patterns of change. Pp. 663–678 *in* R.W. Campbell, N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, A.C. Stewart, and M.C.E. McNall (eds.). The birds of British Columbia. Vol. 4: Passerines. U.B.C. Press, Vancouver, BC.

MEA (Millennium Ecosystem Assessment). 2005a. Ecosystems and human well-being: Biodiversity synthesis. World Resources Institute, Washington, DC. Available at

www.millenniumassessment.org//en/Products.Synthesis.aspx.

MEA (Millennium Ecosystem Assessment). 2005b. Ecosystems and human well-being: Synthesis. World Resources Institute, Washington, DC. Available at *www.millenniumassessment.org//en/Products.Synthesis.aspx.*

Menge, B.A., and G.M. Branch. 2001. Rocky intertidal communities. Pp. 221–250 *in* M.D. Bertness, S.D. Gaines, and M.E. Hay (eds.). Marine community ecology. Sinauer Associates Inc., Sunderland, MA.

Miller, R.R., J.D. Williams, and J.E. Williams. 1989. Extinctions of North American fishes during the past century. Fisheries 14:22–38.

NatureServe. 2006. Who we are. NatureServe, Arlington, VA. Available at *www.natureserve.org/aboutUs/index.jsp* (accessed August 2006).

NOAA (National Oceanic and Atmospheric Administration). 2007. Puget Sound steelhead get protection under Endangered Species Act. News release. Available at *www.nwr.noaa.gov/Newsroom/Current/upload/05_07_2007.pdf.*

NRC (National Research Council). 1996. Stemming the tide: Controlling introductions of nonindigenous species by ships' ballast water. Committee on Ships' Ballast Operations, Marine Board, Commission on Engineering and Technical Systems, National Research Council. National Academy Press, Washington, DC.

Olewiler, N. 2004. The value of natural capital in settled areas of Canada. Ducks Unlimited Canada and Nature Conservancy of Canada. 36pp. Available at *www.ducks.ca/aboutduc/news/archives/pdf/ncapital.pdf.*

Opdam, P., and D. Wascher. 2004. Climate change meets habitat fragmentation: Linking landscape and biogeographical scale levels in research and conservation. Biol. Conserv. 117:285–297.

Paine, R.T. 1974. Intertidal community structure: Experimental studies on the relationship between a dominant competitor and its principal predator. Oecologia 15:93–120.

Pimental, D., L. Lach, R. Zuniga, and D. Morrison. 2000. Environmental and economic costs of nonindigenous species in the United States. Bioscience 50:53–65.

Possingham, H.P., S.J. Andelman, M.A. Burgman, R.A. Medellin, L.L. Master, and D.A. Keith. 2002. Limits to the use of threatened species lists. Trends in Ecology and Evolution 17:503–507.

Powell, G.W., A. Sturko, B.M. Wikeem, and P. Harris. 1994. Field guide to the biological control of weeds in British Columbia. Ministry of Forests Research Program, Victoria, BC.

Quayle, J. F., and L.R. Ramsay. 2005. Conservation status as a biodiversity trend indicator:

Recommendations from a decade of listing species at risk in British Columbia. Conservation Biology 19:1306–1311.

Quayle, J.F., L.R. Ramsay, and D.F. Fraser. 2007. Trend in the status of breeding bird fauna in British Columbia, Canada, based on the IUCN Red list index method. Conservation Biology 21:1241–47.

Quist, M.C., C.S. Guy, R.D. Schultz, and J.L. Stephen. 2003. Latitudinal comparisons of walleye growth in North America and factors influencing growth of walleyes in Kansas reservoirs. North American Journal of Fisheries Management 23:677–692.

Raffaelli, D. 2004. How extinction patters affect ecosystems. Science 306:1141–1142.

Regan, T.J., L.L. Master, and G.A. Hammerson. 2004. Capturing expert knowledge for threatened species assessments: A case study using NatureServe conservation status ranks. Acta Oecologica 26:95–107.

Rieman, B.E., J.T. Peterson, and D.E. Myers. 2006. Have brook trout (*Salvelinus fontinalis*) displaced bull trout (*Salvelinus confluentus*) along longitudinal gradients in central Idaho streams? Can. J. Fish Aquat. Sci. 63:63–78.

Ross, P.S. 2006. Fireproof killer whales (*Orcinus orca*): Flame-retardant chemicals and the conservation imperative in the charismatic icon of British Columbia, Canada. Can. J. Fish. Aquat. Sci. 63:224–234.

Simberloff, D. 2002. Ecological and economic impacts of alien species: A phenomenal global change. Pp. 29–39 *in* R. Claudi, P. Nantel, and E. Muckle-Jeffs (eds.). Alien invaders in Canada's waters, wetlands and forests. Canadian Forest Service, Ottawa, ON.

Simberloff, D., I.M. Parker, and P.N. Windle. 2005. Introduced species policy, management and future research needs. Frontiers in Ecol. and the Environ. 3(1):12–20.

Smith, R. 1994. Effects of alien insects and microorganisms on the biodiversity of British Columbia's insect fauna. Pp. 190–219 *in* L.E. Harding and E. McCullum (eds.). Biodiversity in British Columbia: Our changing environment. Canadian Wildlife Service, Environment Canada.

Solan, M., B.J. Cardinale, A.L. Downing, K.A.M. Engelhardt, J.L. Ruesink, and D.S. Srivastava. 2004. Extinction and ecosystem function in the marine benthos. Science 306:1177–1180.

Sorensen, A.E. 1984. Seed dispersal and the spread of weeds. Pp. 121–132 *in* E.S. Delfosse (ed.). Proc. 6th Int. Symp. on biological control of weeds. Univ. British Columbia, Vancouver, BC.

Special Committee on Sustainable Aquaculture. 2007. Final report of the Special Committee on Sustainable Aquaculture for the 3rd Session of the 38th Parliament. Legislative Assembly of British Columbia. Available at *www.leg.bc.ca/cmt/38thparl/session-3/aquaculture/index.htm.*

Statistics Canada. 2005. Aquaculture Statistics. Catalogue No. 23-222-XIE. Available at *www.statcan.ca/english/freepub/23-222-XIE/23-222-XIE2005000.pdf.*

Stuart, S.N., J.S. Chanson, N.A. Cox, B.E. Young, A.S.L. Rodrigues, D.L. Fishman, and R.W. Walter. 2004. Status and trends of amphibian declines and extinctions worldwide. Science 306:1783–1786.

Taylor, M.F.J., K.F. Suckling, and J.J. Rachlinski. 2005. The effectiveness of the Endangered Species Act: A quantitative analysis. Bioscience 55:360–367.

Thomas, C.D., A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F.N. Erasmus, M. Ferreira de Siqueira, A. Grainger, L. Hannah, L. Hughes, B. Huntley, A.S. van Jaarsveld, G.F. Midgley, L. Miles, M.A. Ortega-Huerta, A.T. Peterson, O.L. Phillips, and S.E. Williams. 2004. Extinction risk from climate change. Nature 427:145–148.

Thomas, D.C., and D.R. Gray. 2002. Update COSEWIC status report on the woodland caribou (*Rangifer tarandus caribou*) in Canada, Pp. 1–98 *in* COSEWIC assessment and update status report on the woodland caribou (*Rangifer tarandus caribou*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON.

UNEP (United Nations Environment Programme). 2001. Global biodiversity outlook. United Nations. Available at *www.biodiv.org/gbo/default.asp.*

Vancouver Island Marmot Recovery Team. 2000. National recovery plan for the Vancouver Island marmot. Recovery of Nationally Endangered Wildlife (RENEW), Ottawa, ON. 38pp.

Venter, O., N.N. Brodeur, L. Nemiroff, B. Belland, I.J. Dolinsek, and J.W.A. Grant. 2006. Threats to endangered species in Canada. Bioscience 56:903–910.

Vitousek, P.M., H.A. Mooney, J. Lubchenco, and J.M. Melillo. 1997. Human domination of earth's ecosystems. Science 277:494–499.

Walters, C., J. Korman, and S. McAdam. 2005. An assessment of white sturgeon stock status and trends in the lower Fraser River. Prep. for B.C. Ministry of Water, Land and Air Protection and Fisheries and Oceans Canada. 67pp.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Philips, and E. Losos. 1998. Quantifying threats to imperilled species in the United States. Bioscience 48:607–615.

Zavaleta, E.S., and K.B. Hulvey. 2004. Realistic species losses disproportionately reduce grassland resistance to biological invaders. Science 306:1175–1176.