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Problem Analysis: Effects of Invasive Species on Species at Risk in British Columbia

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ABSTRACT

We reviewed available information on invasive (native and alien) species in British Columbia and assessed their potential interactions with forest- and range-dependent Species at Risk to evaluate the relative importance of the interactions. In so doing, we also tracked some of the key knowledge gaps and research questions that surround these interactions. We also discuss the importance of extension needs and opportunities both nationally and globally. Rather than an exhaustive account of all interactions between invasive species and Species at Risk, we list the potential significance of the interactions based on our review of reasonably available information. The plethora of interactions and information in combination with, in some cases, incomplete or lack of data, was such that we could only touch on some of the more studied and obvious associations. The sheer number of interactions indicates overwhelmingly that a more intensive investigation of invasive species' effect on Species at Risk is worthy of priority research.

KEYWORDS: British Columbia, invasive species, research priority, species at risk

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EXECUTIVE SUMMARY

Invasive species are thought to be second only to loss of habitat as the cause for native species decline. Due to our lack of knowledge and/or reasonable access to information sources, confident analysis of all of the impacts of invasive species on Species at Risk is extremely difficult or even impossible. We reviewed available information on invasive (native and alien) species in British Columbia and assessed their potential interactions with forest- and range-dependent Species at Risk to evaluate the relative importance of the interactions. In doing so, we also tracked some of the key knowledge gaps and research questions that surround these interactions. We also discuss the importance of extension needs and opportunities both nationally and globally. Rather than an exhaustive account of all interactions between invasive species and Species at Risk, we provide an indication of the potential significance of the interactions based on our review of reasonably available information. The plethora of interactions and information, in combination with often incomplete or lack of data, was such that we could only touch on some of the more studied and obvious associations. The sheer number of interactions indicates overwhelming evidence that deeper and more specific investigation of invasive species' effect on Species at Risk is a topic worthy of priority research.

The research topic could focus on a series of priorities building from a basic understanding (invasive pathways) through deeper understanding (ecological interactions) to management recommendations (mitigation measures). Although research should initially focus on Species at Risk as defined within the Sustainability Program Research Strategy[1], we also recommend a focus on known, highly detrimental, and significant invasive species; particularly if invasive pathways are known to be enhanced through industrial development of forest and range. The significance of specific interactions with Species at Risk will also partially depend on the nature of the invasive agent (alien or native) and, particularly for the latter, specific management objectives. Of the 230 interactions we evaluated, the top-ranked interactions were dominated by 5 invasive species that affect Garry oak; 2 invasive species that affect mountain caribou; and 1 invasive species, yellow perch, that affects a range of species.

We also recommend priority be placed on extending information from research and other information already known about interactions between invasive species and Species at Risk. Some of this extension would be suitably presented through the Stewardship Centre for BC[2] while other extension could be associated with FORREX[3].

Further work is needed to identify interactions with sufficient information upon which to base immediate management, rather than research, priority. Based on our review, we suggest that some interactions can likely be addressed immediately through enhanced management policy and others might be suitable for an adaptive management approach to mitigating effects on Species at Risk. We found preliminary efforts to set priorities for management of invasive alien species at provincial, national, and global levels but these are restricted in scope and require further work before aggressive action can be taken.

[1] ***http://www.bcfsp.com/webRimsProject/_CrossApplicationContent/Pages/AnonymousAccess/CallForProposal.aspx***
[2] ***http://www.stewardshipcentre.bc.ca/stewardshipcanada/home/scnBCIndex.asp***
[3] ***http://www.forrex.org/***

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INTRODUCTION

Invasive species have been identified as a major threat to our Species at Risk. The terms "invasive" and "alien species" are often used synonymously. The following definitions are given to clarify the terms used in the remainder of this analysis.

> *Alien species: The* BC *Ministry of Environment defines alien species as "plants, animals and microorganisms from one part of the world that are transported beyond their natural range and become established in a new area. They are sometimes also called 'alien,' 'introduced,' 'non-native,' 'non-indigenous,' or 'invasive' species." (BC Ministry of Environment 2006e)*
>
> *Invasive species: The word "invasive" alone simply means to encroach or intrude upon an area or region (Webster's Encyclopedic Dictionary). In the case of invasive species, it refers to a species that is invading or expanding its range at the expense of naturally occurring species. An invasive species may or may not be alien. The* BC *Ministry of Environment defines invasive alien species as "plants, animals and microbes that are not native to British Columbia and threaten its biodiversity (Rankin* et al. *2004)."*
>
> *Species at Risk: A species is "at risk" if it is in danger of extinction from the wild. There are different levels of risk. Canada assesses Species at Risk at both the federal and provincial levels. The Committee on the Status of Endangered Wildlife in Canada (*COSEWIC*) determines the national status for species in Canada. Provincially, the* BC *Conservation Data Centre (CDC) along with other scientists in British Columbia classify* BC*'s Species at Risk into two lists: Red and Blue. Species on the Red List are Extirpated, Endangered, or Threatened status and are therefore at risk and require investigation. Species on the Blue List are flagged as Special Concern and are therefore also considered at risk. (Garry Oak Ecosystem Recovery Team 2007)*

From these definitions, we forward the notion that an alien species may or may not be harmful depending largely on our own value systems. By comparison, the very nature of the term "invasive" implies that these species are a threat or potential threat to native species. It is estimated that 25% of our endangered species, 31% of our threatened species, and 16% of our species of special concern are negatively impacted by invasive alien species (COSEWIC in BC Ministry of Environment 2007). Invasive alien species are thought to be second only to loss of habitat as the cause for native species decline (Enserink 1999 and Wilcove *et al.* 1998, in Scudder 2002). Furthermore, rapid expansion into previously unoccupied range by some native species is affecting other native species (James *et al.* 2004; Darimont *et al.* 2005; Lessard 2005). However, Claudi *et al.* (2002) state that few are aware of the extent of the problem and how the introduction or spread of invasive (alien or otherwise) species can potentially lead to serious ecological and economic consequences. They further state that our lack of knowledge of these interactions makes confident analysis of the impacts of invasive species on our native species extremely difficult or even impossible.

On a global scale, the International Council for Science convened a group of scientists to address and document the extent of the problem of invasive species. The synthesis of this group's work established that invasive species had a major impact on nearly all ecosystems including those under protection (Neville 2002). In the United States, invasive alien species cost the economy an estimated $137 billion annually (Simberloff 2002a). In Canada, Scudder (2002) stated that invasive species have not been treated as a major concern. However, he noted that enough evidence indicates that Canada is not immune to the negative impacts of invasive species and that we must turn more attention in this direction.

As the definition indicates, invasive species may also be native. Changes in the landscape and climate have allowed these native species to spread into areas where they had not been previously found. Human

activities, such as agriculture, can open up new habitat. The brown-headed cowbird (*Molothrus ater*) is a classic example of these "opportunistic" species. This bird was once found only in the eastern United States, but due to the expansion of agricultural land, the cowbird has now spread across North America (Brittingham and Temple 1983). The expansion of species such as the brown-headed cowbird and more local examples, such as coyotes (*Canis latrans*), barred owl (*Strix varia*), white-tailed deer (*Odocoileus virginianus*), and moose (*Alces alces*), may significantly threaten our Species at Risk. Our lack of understanding about these interactions impacts our ability to effectively manage our Species at Risk.

We reviewed the available information on invasive (native and alien) wildlife, fish, invertebrates, and vascular plant species in British Columbia (BC) and their interaction with forest- and range-dependent Species at Risk to identify the extent of the problem, and identify knowledge gaps and research questions that surround these interactions. In this analysis, we restrict our focus to those Species at Risk potentially affected by invasive species and to those invasive species where information was reasonably available. Rather than an exhaustive and detailed review, our goal was to provide a general understanding of the extent of the potential interactions and the relative priority for research investment.

Review of Invasive Species and Their Effects on Forest- and Range-dependent Species at Risk

The definition of invasive is important in setting the context for our study of the interactions between invasive species and Species at Risk. Only about 0.1% of all introduced species are invasive (Williamson 1996) and only a small fraction of native species are invasive. Haber (2002) estimates that 20–27% of Canada's plant species are alien but many of these alien species may not be invasive or may not be invasive in all regions where they are found. However, even though the number of introduced species that are invasive is low, the effect of these few can be profound.

Approximately 540 Red-listed species, 800 Blue-listed species, and 1000 introduced or native invasive species are reviewed in this analysis (Appendices A and B). Of these, we found 44% of the Red- or Blue-listed amphibian species, 27% of Red- or Blue-listed reptile species, 32% of Red- or Blue-listed bird species, 18% of Red- or Blue-listed mammal species (not counting Red- or Blue-listed marine mammals), and 30% of Red- or Blue-listed fish species were in some way affected by invasive species. Even though we were unable to look at all possible interactions of invasive plant species and Species at Risk, we concur with Lea (T. Lea, pers. comm., March 23, 2006) who suspected a large percentage of our Red- and Blue-listed plant species may be threatened by alien species in some way and many plant Species at Risk are threatened by more than one invasive species. Our list of invasive species, and Species at Risk affected by invasive species, is incomplete due to our lack of knowledge, and/or reasonable access to information sources. Therefore, a complete analysis of the impacts of all invasive species on Species at Risk was extremely difficult or even impossible. The total number of invasive species and the number of native species they affect in British Columbia and Canada are key knowledge gaps that need to be addressed (Claudi *et al.* 2002).

Claudi *et al.* (2002) raised another key gap in our knowledge—our lack of understanding about many of these interactions. We know that invasive species can have both direct and indirect effects on our Species at Risk through competition, predation, herbivory, habitat alteration, hybridization, brood parasitism, disease, parasites, allelopathy, or any combination of these effects. Direct effects, such as predation, have obvious and often detrimental impacts on Species at Risk. Indirect effects, although less obvious, can also have serious consequences. For example, through their dam building, the introduced beaver (*Castor canadensis*) on the Queen Charlotte Islands has altered the level of water, which has then affected the spawning habitat of the Red-listed giant black stickleback (*Gasterosteus aculeatus*) (Cannings and Ptolemy 1998). Again, through lack of reasonably available information and limited scope of

this analysis, only some of the potential interactions have been explored. We have been unable to explore some lifeform groups such as fungi, lichens, and bryophytes while other groups such as the invertebrates have very limited interactions noted and are far from complete. Still, sufficient interactions are noted to have identified key information gaps and significant research priority.

Invasive species are often generalized to the classic invasives, such as rats (*Rattus* spp.), starlings (*Sturnus vulgaris*), and broom (*Cytisus scoparius*). However, the problem is much broader and often more elusive than the simple generalization. The subject of invasive species is now a global issue, especially for any of the species that can disperse long distances. One of the many research questions surrounding this issue is which species are interacting with each other and to what extent. To what extent do we subscribe to slow but dramatic change in ecosystems? Often these species' interactions are not straightforward and our interpretation of them is value-based. An alien species that has been in place for years can be non-invasive until another alien is introduced (Claudi *et al.* 2002). The new alien causes a whole new series of interactions to take place. The potential for these interactions to occur cannot be ignored, but our understanding of this possibility limits our capability to manage for the future.

For each lifeform group covered in this analysis we briefly review (1) possible invasion pathways, (2) ecological principles of how they interact with Species at Risk, and (3) mitigation measures. Each section has a table listing the known interactions between each invasive species in that lifeform group and Species at Risk (some species are listed as both invasive species and Species at Risk, depending on location and other factors, while many Species at Risk are listed more than once to reflect interaction with multiple invasive species). For some of these groups, these lists are incomplete. We focused on the more prevalent and obvious interactions to assess relative priority for research. Each table lists whether it is a native species or invasive alien or invasive native, lifeform group, Latin scientific name, English common name, global and provincial rank, provincial status, trend of expansion or decline, and type of threat posed. Global and provincial rank and provincial status use the international and provincial codes, and descriptions listed by the CDC and COSEWIC. We included an indication of population decline or expansion when found. The threat and comment sections briefly describe what type of interaction or threat is thought to occur between the listed invasive species and Species at Risk.

VERTEBRATES

In the past, many invasive vertebrates were introduced to British Columbia to make life easier or more pleasant for the human population. Unfortunately, our lack of understanding about the future implications of these introductions has detrimentally affected our native ecosystem. We have learned these lessons rather recently. For example, we introduce fish to lakes for sport fishing thereby changing the ecological balance of lake ecosystems. As well, we have only recently become aware of our effect on our native ecosystem through practices such as agriculture, forestry, and urbanization. These changes to the environment have presumably allowed native species to spread to areas they had not previously occupied (e.g., white-tailed deer). Now, not only are we dealing with the unknown consequences of introduced aliens, but also those of native species spreading to new areas.

The pathways that these invasive (both alien and native) species follow are not always well understood. However, for management, it is vital that these pathways be known, not only to the scientists studying these species, but also to policy makers, managers, other scientists, and the general public (Ruiz and Carlton 2003).

Amphibians and Reptiles

Native amphibian populations are thought to be declining all over the world. The risk of extinction for native amphibians in western North America is considered to be far greater than for birds or mammals (Wind 2000). In BC, the gaps in our knowledge of why these declines are occurring are wide and unclear, likely because even the baseline status of native amphibians is lacking (Corkran and Thoms 1996). Habitat alteration is thought to have had a large effect on our native amphibians but invasive amphibian species are also thought to have detrimental effects.

Two of the most common ways that invasive reptile and amphibian species have entered BC are through the pet and restaurant trade (Carl and Guiguet 1972; Green and Campbell 1992; Corkran and Thoms 1996). The bullfrog (*Rana catesbeiana*) was first introduced in the 1920s and 1930s through the restaurant trade (Corkran and Thoms 1996). Through the pet trade, undesirable pets are often released into the wild to fend for themselves, often with dire consequences to native species.

Invasive amphibians and reptiles affect native herpetiles, as well as other native species such as birds. Competition and predation are the two main ways that invasive amphibians and reptiles affect and interact with our Species at Risk (Table 1). The invasive bull frog will eat anything it can fit in its mouth. This species, by far the most detrimental of invasive amphibians, can successfully compete against and prey on practically every native amphibian it encounters. It is now thought to be invading higher elevation areas, previously considered too cold for its survival (Corkran and Thoms 1996).

Controlling an invasive species in this group is not just a matter of removing as many individuals as possible. Knowing the effect of removal at various life stages and population densities may influence how successful eradication will be. For example, Govindarajulu *et al.* (2005) found that most bullfrog eradication efforts have focused on removing breeding adults and tadpoles. However, their model indicated that partial tadpole removal would lead to higher survival and development rates because of decreased density-dependent competition. Also, early metamorphic survival is higher when the adults are removed because of reduced cannibalism. These results demonstrate the importance of understanding the consequences of a particular method of mitigation.

Table 1 is a partial list of the known interactions of invasive amphibian and reptile species with Species at Risk. Due to the limited scope of this analysis and a lack of reasonably available information, we focus on the more prevalent and obvious interactions for the sake of assessing relative priority for research.

TABLE 1 Invasive amphibian and reptile species (in grey) and the Species at Risk that they are known to affect[1]

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Amphibians	*Rana catesbeina*	American bullfrog	G5	SNA	no status	increasing > 10–25%	competition, predation	The bullfrog is a voracious predator on anything that can fit in its mouth. It has been known to eat birds, snakes, crayfish, and fish, as well as other amphibians (Murphy 2003). It is thought to be a threat to all our native frogs (Govindarajulu 2006; BC Ministy of Environment 2006d). Their tadpoles have also been observed feeding on other amphibians tadpoles (BC Ministry of Environment 2006d).	BC Ministry of Environment 2007
Native	Amphibians	*Rana pretiosa*	Oregon spotted frog	G2	S1	Red	rapidly declining 30–50% short term, 5–90% long term	The bullfrog can be both predator and resource competitor with this SAR.	The Oregon spotted frog is Red-listed in BC but also classified as "at risk" nationally.	BC Ministry of Environment 2007
Native	Amphibians	*Rana pipiens*	northern leopard frog	G5	S1	Red	severely to rapidly declining 30–> 70% short term, > 90% long term	The northern leopard frog is vulnerable to introductions of bullfrogs in breeding ponds (BC Ministry of Environment 2006d).	This species is Red-listed in BC but introduced on Vancouver Island.	BC Ministry of Environment 2007

TABLE 1 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Amphibians	*Rana aurora*	red-legged frog	G4	S3S4	Blue	unknown	The red-legged frog is vulnerable to both predation and competition from the bullfrog.		BC Ministry of Environment 2007
Native	Reptiles	*Emys marmorata*	western pond turtle	G3G4	SX	Red	decline 10–50%	The western pond turtle is vulnerable to predation from the bullfrog (BC Ministry of Environment 2007; Thompson Rivers University 2006b)		BC Ministry of Environment 2007
Invasive alien	Amphibians	*Rana clamitans*	green frog	G5	SNA	no status	stable	competition and predation	Green frogs are not thought to be as much of a threat as bullfrogs in BC as they are smaller and less aggressive (BC Ministry of Environment 2006d). However, they are successful where they have been introduced and will compete with our native amphibians.	BC Ministry of Environment 2007
Native	Amphibians	*Rana pretiosa*	Oregon spotted frog	G2	S1	Red	Rapidly declining 30–50% short term, 5–90% long term	The Oregon spotted frog may be vulnerable to competition and possibly some predation from the green frog.		BC Ministry of Environment 2007

TABLE 1 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Amphibians	*Rana aurora*	red-legged frog	G4	S3S4	Blue	unknown	The red-legged frog is vulnerable to competition and possibly some predation from the green frog.		BC Ministry of Environment 2007
Invasive alien	Amphibians	*Rana pipiens*	northern leopard frog	G5	S1	Red		Its impact on native amphibian species of Vancouver Island is unknown (Green 1978; Orchard 1984).	This species is Red-listed in BC but introduced on Vancouver Island.	BC Ministry of Environment 2007
Native	Amphibians	*Rana aurora*	red-legged frog	G4	S3S4	Blue	unknown	Its impact on native amphibian species of Vancouver Island, such as the red-legged frog, is unknown, although it may prey on the tadpoles of this species (Gregory and Campbell 1996).		BC Ministry of Environment 2007

TABLE 1 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Reptiles	*Trachemys scripta*	common slider	G5	SNA		variable	If there are enough individuals in a pond, they can have a detrimental effect on the local amphibian populations through predation and may outcompete native turtles (Thompson Rivers University 2006a).	This species is not thought to have a breeding population in BC (BC Ministry of Environment, Lands and Parks 2000).	BC Ministry of Environment 2007

[1]Information from Web sites retrieved in February 2006.

Birds

Due to their ability to fly, invasive birds have the potential for relatively efficient dispersal and to therefore become a serious threat to our native species. Some invasive species have been introduced to different areas of North America from other parts of the world and have since spread. As with other groups of species, habitat alteration and degradation are presumed to have allowed invasive bird species to expand far past their native area or site of introduction.

Invasive bird species may affect our Species at Risk in many different ways, such as competition, brood parasitism, predation, and habitat destruction and alteration. The extent to which these interactions affect our Species at Risk are not known for all species. However, species such as the mute swan (*Cygnus olor*) and European starling (*Sturnus vulgaris*) are already known to threaten some of our native Species at Risk. As well, the brown-headed cowbird is a brood parasite on some of our Species at Risk, but the extent to which the cowbirds affect those species' populations are not known. Some species such as the house finch (*Carpodacus mexicanus*), which has expanded northwards since its introduction in 1935, is also thought to threaten some of our native songbirds (Polster 2002), but again, the specific interactions are not known. Mute swans, when found in sufficient numbers, have been known to kill native waterfowl, uproot and consume large quantities of aquatic vegetation, and consume fish and tadpoles (Petrie 2003; M. Chutter, pers. comm., March 20, 2006). This swan is known to threaten Species at Risk, but the interactions have not been well documented.

The extent to which native invasive bird species, such as the barred owl, affect Species at Risk is also a relatively untapped topic. For example, although barred owl predation has not been proven as one of the causes of decline in screech owl (*Megascops kennicottii kennicottii* and *Megascops kennicottii macfarlanei*) populations, there is a known negative correlation between their populations (Darling 2003).

Due to this group's ability to fly, mitigation measures can be difficult and complex. Radio-telemetry studies of cowbird behaviour led Rothstein *et al.* (1987) to believe that it would be possible to control cowbirds over a large area if they were removed from a small number of feeding sites. However, when implemented, this control measure had a very limited effect because the birds in the area being controlled did not respond like those in the radio-telemetry study. Kus (1999) also found that although local control methods, such as cowbird egg removal, enhanced productivity of the host species by 11–44%, this was not an effective long-term solution: Kus felt that, rather than small localized control programs, long-term mitigation measures needed to emphasize landscape-level factors that influenced cowbird abundance.

Table 2 is a partial list of the known interactions of invasive bird species with Species at Risk. Due to the limited scope of this analysis and a lack of reasonably available information, we focus on the more prevalent and obvious interactions for the sake of assessing relative priority for research.

TABLE 2 Invasive bird species (in grey) and the Species at Risk that they are known to affect[1]

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless therwise marked)
Invasive alien	Birds	*Anser domesticus*	domestic goose			no status	variable	The threat from interbreeding with domestic geese is very low.	Domestic geese have been known to carry West Nile virus (Apic 2006)	
Native	Birds	*Branta canadensis occidentalis*	Canada goose, *occidentalis* subspecies	G5T2T3	S1N	Blue		Domestic geese have been known to breed and produce offspring with Canada geese. However, there is very little chance of interaction between domestic and this subspecies of Canada geese as their stop in Canada is brief and they breed in Alaska (M. Chutter, pers. comm., March 20, 2006).		BC Ministry of Environment 2007 Ocean Wanderers 2006
Invasive alien	Birds	*Branta canadensis canadensis*	Canada goose	G5	S5	Yellow	stable to increasing		The interior subspecies have been introduced to VI and the Lower Mainland since 1931 (Carl and Guiguet 1981).	

TABLE 2 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless therwise marked)
Native	Ecosystem		Garry oak			Red	decline > 50%	Threatening the Garry oak ecosystems on the Gulf Islands by trampling, feeding, and nutrient input as well as possibly introducing non-native seeds (Best in Garry Oak Ecosystem Recovery Team 2005).		
Invasive native	Birds	*Carpodacus mexicanus*	house finch	G5	S5B	Yellow	stable	May have significant impact on species such as song sparrow and wren (Polster 2002).	This species originated in the southwestern United States and Mexico. The species has since spread through the United States and southern Canada. (Cornell University 2006).	BC Ministry of Environment 2007
Invasive alien	Birds	*Cygnus olor*	mute swan	G5	SNA	no status		Mute swans have been reported to kill native water birds, hybridize with the Trumpeter swan, and consume and uproot large quantities of aquatic vegetation (Petrie 2003; M. Chutter, pers. comm., 2006). Mute swans have been known to impact species at risk when the numbers increase (M. Chutter, pers comm., 2006).		BC Ministry of Environment 2007

TABLE 2 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless therwise marked)
Invasive alien	Birds	*Meleagris gallopavo*	wild turkey	G5	SNA	no status	increasing	Thought to be on the increase and may have a large effect on native Galliformes; may contribute to dispersal of introduced plant species (Polster 2002).	Wild turkeys are known to put their eggs into other grouse species' nests. However, little research has been done on competition between turkeys and other upland game birds. There is some concern of negative effects (M. Chutter, pers. comm., March 20, 2006).	BC Ministry of Environment 2007
Native	Birds	*Centrocercus urophasianus*	greater sage-grouse	G4	SX	Red	extirpated	This grouse is extirpated in BC but was found previously only in the Okanagan. Turkeys are now found as far north as Kamloops and it is thought that if this species is allowed to spread it may have a major effect on the native Galliformes (Polster 2002). This species could contribute to the failure of any re-introduction efforts.	The greater sage-grouse was extirpated from BC for decades before the wild turkey invaded (M. Chutter, pers. comm., March 20, 2006). It had no influence on its extirpation but may affect any re-introduction efforts.	BC Ministry of Environment 2007

TABLE 2 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless therwise marked)
Native	Birds	*Tympanuchus phasianellus columbianus*	sharp-tailed grouse, *columbianus* subspecies	G4T3	S2S3	Blue	declining to stable (±10% fluctuation to 30% decline)	This species is extirpated in the Okanagan. Turkeys are now found as far north as Kamloops and it is thought that if this species is allowed to spread it may have a major effect on the native Galliformes (Polster 2002). This species could contribute to the failure of any re-introduction efforts.	The sharp-tailed grouse has already been extirpated from many of the areas that wild turkey is invading (M. Chutter, pers. comm., March 20, 2006).	BC Ministry of Environment 2007
Invasive native	Birds	*Molothrus ater*	brown-headed cowbird	G5	S5B	Yellow	decline –global 10–30%			
Native	Birds	*Ammodramus leconteii*	Le Conte's sparrow	G4	S3S4B	Blue	unknown	Brood parasitism on this species has been noted but the actual effect it has on success of this species is not known (NatureServe 2006).	Nests on the edge of small wetlands in northern BC.	BC Ministry of Environment 2007
Native	Birds	*Ammodramus nelsoni*	Nelson's sharp-tailed sparrow	G5	S2B	Red	decline	Because brood parasitism has been only noted in 1 nest, not thought to be a large threat (NatureServe 2006).	Nests on the edge of wetlands in northeastern BC.	BC Ministry of Environment 2007
Native	Birds	*Dendroica castanea*	bay-breasted warbler	G5	S2B	Red	decline	Cowbird has been known to be a brood parasite on both the Canada and Cape May warbler and thought that this could become more widespread (Blood and Backhouse 1998).		BC Ministry of Environment 2007

TABLE 2 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless therwise marked)
Native	Birds	*Dendroica tigrina*	Cape May warbler	G5	S2B	Red	stable to decline	Cowbird has been known to be a brood parasite on both the Canada and Cape May warbler and thought that this could become more widespread (Blood and Backhouse 1998).		BC Ministry of Environment 2007
Native	Birds	*Oporornis agilis*	Connecticut warbler	G4	S2B	Red	unknown–prob. decline to stable	Cowbird has been known to be a brood parasite on both the Canada and Cape May warbler and thought that this could become more widespread (Blood and Backhouse 1998).		BC Ministry of Environment 2007
Native	Birds	*Dendroica virens*	black-throated green warbler	G5	S3B	Blue	unknown–prob. decline to stable	Cowbird has been known to be a brood parasite on both the Canada and Cape May warbler and thought that this could become more widespread (Blood and Backhouse 1998).		BC Ministry of Environment 2007
Native	Birds	*Wilsonia canadensis*	Canada warbler	G5	S3S4B	Blue	unknown–prob. increase to stable	Cowbird has been known to be a brood parasite on both the Canada and Cape May warbler and thought that this could become more widespread (Blood and Backhouse 1998).		BC Ministry of Environment 2007
Native	Birds	*Empidonax wrightii*	gray flycatcher	G5	S3B	Blue	increase to stable	This species has been brood parasitized by the brown-headed cowbird (Cannings 1995a).		BC Ministry of Environment 2007

TABLE 2 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless therwise marked)
Native	Birds	*Icteria virens*	yellow-breasted chat	G5	S1B	Red	decline to stable 10–50% short term, 25–50% decline long term	This species has been brood parasitized by the brown-headed cowbird (Cannings 1995b).	Cowbird may not play a significant role in nesting failure (Cannings 1995b).	BC Ministry of Environment 2007
Native	Birds	*Dolichonyx oryzivorus*	bobolink	G5	S3B	Blue	decline	No record of brood parasitism by the cowbird in BC on this species has been recorded but it is thought that between the secrecy of this species nesting and the increase in cowbirds and edge habitat, parasitism on this species may increase (van Damme 1999).		BC Ministry of Environment 2007
Invasive alien	Birds	*Passer domesticus*	house sparrow	G5	SNA	no status	decrease	Thought to be associated with purple martin and western bluebird declines (Garry Oak Ecosystems Recovery Team 2003).	Nest in cavities —arriving before native species. Will also take over cavity nests of natives— aggressive bird. Also carrier of parasites and diseases (Garry Oak Ecosystems Recovery Team 2003).	BC Ministry of Environment 2007

TABLE 2 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless therwise marked)
Native	Birds	*Sialia mexicana* pop. 1	western bluebird (Georgia Depression population)	G5TNRQ	SHB	Red	unknown to decline	The house sparrow is an aggressive competitor that takes over cavities, and destroys nests, eggs, and nestlings (Garry Oak Ecosystem Recovery Team 2003).		BC Ministry of Environment 2007
Native	Birds	*Progne subis*	purple martin	G5	S2B	Blue	increase	The house sparrow is an aggressive competitor that takes over cavities, and destroys nests, eggs, and nestlings (Garry Oak Ecosystem Recovery Team 2003).		BC Ministry of Environment 2007
Invasive native	Birds	*Strix varia*	barred owl	G5	S5B	Yellow	stable to increasing			
Native	Birds	*Megascops kennicottii kennicottii*	western screech-owl, *kennicottii* subspecies	G5T4	S3	Blue	stable to decline 10–30%	It is unknown if barred owl predation is one of the causes of this species' decline. It is known, however, that as barred owl numbers increase, screech owls decrease (COSEWIC 2002).		BC Ministry of Environment 2007
Native	Birds	*Megascops kennicottii macfarlanei*	western screech-owl, *macfarlanei* subspecies	G5T4	S1	Red	decline	It is unknown if barred owl predation is one of the causes of this species' decline. It is known, however, that as barred owl numbers increase, screech owls decrease (COSEWIC 2002).		BC Ministry of Environment 2007

TABLE 2. ***Continued***

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless therwise marked)
Native	Birds	*Glaucidium gnoma swarthi*	northern pygmy-owl, *swarthi* subspecies	G5T3Q	S3	Blue	decline	The effect of barred owl population on the smaller owl species is not known although predation and competition may be contributing to these owls' decline (Darling 2003).		BC Ministry of Environment 2007
Native	Birds	*Strix occidentalis*	spotted owl	G3	S1	Red	short term decline 30–50%, long term 75–90%	Habitat loss and competition with the barred owl are stated as the reasons for this species' decline.		BC Ministry of Environment 2007
Invasive alien	Birds	*Sturnus vulgaris*	European starling	G5	SNA	no status		Associated with Lewis's woodpecker, purple martin and mountain and western bluebird declines; competes for nesting cavities (Royal BC Museum 2006).	The starling is also a carrier of diseases and parasites that can be passed on to native species. Since they flock, the large number of droppings can kill and damage trees, and can disperse seeds including exotic species - their large numbers feed on, and therefore deplete, soil inverts (Garry Oak Ecosystem Recovery Team 2003).	BC Ministry of Environment 2007

TABLE 2 *Concluded*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless therwise marked)
Native	Birds	*Sialia mexicana* pop. 1	western bluebird (Georgia Depression population)	G5TNRQ	SHB	Red	unknown to decline	The starling is an aggressive competitor for cavities (Garry Oak Ecosystem Recovery Team 2003).		BC Ministry of Environment 2007
Native	Birds	*Progne subis*	purple martin	G5	S2B	Blue	increase	The starling is an aggressive competitor for cavities (Garry Oak Ecosystem Recovery Team 2003).		BC Ministry of Environment 2007
Native	Birds	*Melanerpes Lewis* pop. 1	Lewis's woodpecker (Georgia Depression population)	G5TXQ	SXB	Red	decline to stable	The starling is an aggressive competitor for cavities (Garry Oak Ecosystem Recovery Team 2003).		BC Ministry of Environment 2007

[1]Information from Web sites retrieved in February 2006.
Note: Where an invasive species (in grey) is not followed by Species at Risk (in white), these invasive species are considered to be a potentially significant threat but no specific interactions were found.

Mammals

Invasive mammal species are often the most "visible" of the invasive species. The invasion pathways for mammals historically have been many and varied. Many of the smaller invasive species such as rats are accidental introductions via the import/export trade. As well, the pet trade and consequent "freeing" of these pets into the wild have contributed to the spread of invasive mammal species. Like birds and other groups, habitat alteration and degradation are often considered to be the driving force behind the spread of both alien and native invasive species.

Species such as the rat and feral cat (*Felis catus*) are well-known invasive species all around the world. In Canada, we have realized that we have native invasives as well as alien species affecting our Species at Risk through this lifeform group. Species such as the coyote are expanding their range and adding to the predation pressure of Species at Risk such as the Pacific water shrew (*Sorex bendirii*) and the washingtonii subspecies of the snowshoe hare (*Lepus americanus*). The white-tailed deer and moose are also expanding their range, and in so doing, are thought to indirectly lead to increased predation pressure on caribou (*Rangifer tarandus*) by wolves (*Canis lupus*) and cougars (*Puma concolor*) (Bergerud and Elliot 1986; Seip 1990). There is still debate as to the effect these expanding species have on our Species at Risk. However, even though the mechanisms are not understood, Lessard (2005) found that, as with the barred owl/screech owl interaction discussed earlier, as moose numbers increase, caribou populations decline.

Invasive alien mammals can interact and affect our Species at Risk both directly and indirectly through predation, competition, disease, and habitat alteration and destruction. Invasive mammal species can have a detrimental affect on Species at Risk populations. The cat (both feral and domestic) is thought to be extremely devastating to native bird, amphibian, reptile, and small mammal species, and contributes to the decline of various species, especially those that are considered vulnerable or endangered (Keddy *et al.* 1999).

Mitigation measures for species such as the cat are very difficult, especially considering their association to humans as pets. As with other lifeform groups, the use of biological control methods has been tried with varying degrees of success. For example, feline panleukopenia virus (*parvovirus*) has been used on islands to successfully reduce feral cat populations (Howell 1984; van Aarde 1984). However, using such methods on populations that mix with domestic populations would not be feasible. Eradication of any invasive species is rare and successful control is more likely when a long-term ecosystem-wide strategy is employed (Mack *et al.* 2000).

Table 3 is a partial list of the known interactions of invasive mammal species with Species at Risk. Due to the limited scope of this analysis and a lack of reasonably available information, we focus on the more prevalent and obvious interactions for the sake of assessing relative priority for research.

TABLE 3 Invasive mammal species (in grey) and the Species at Risk that they are known to affect[1]

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive native	Mammals	*Alces alces*	moose	G5	S5	Yellow	expanding			
Native	Mammals	*Rangifer tarandus* pop. 1	caribou (southern population)	G5T2Q	S1	Red	decline 10–50% short term, 50–90% long term	Expansion of white-tailed deer and moose has increased predator pressure from wolves and cougars (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Native	Mammals	*Rangifer tarandus* pop. 15	caribou (northern mountain population)	G5T4Q	S3S4	Blue	stable in the short term; decline 25–50% long term	Expansion of moose has brought with it increased predator pressure from wolves (Seip 1990).		BC Ministry of Environment 2007
Invasive alien	Mammals	*Bos bison bison*	Plains bison	G4TU	S3	Blue	stable		Unlike the other introduced species in BC, the Plains bison is protected in its introduced range (Shackleton 1999).	
Native	Mammals	*Bos bison athabascae*	wood bison	G4T2Q	S1	Red	stable	The Plains bison introduced to Wood Bison Park hybridized with the native wood bison and introduced tuberculosis and brucellosis to the herd. As these herds are connected to those in BC, there is the threat of spread (Harper 2002).		BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Mammals	*Canis familiaris*	feral dog				fluctuates	The effect of feral dogs on local fauna is unknown. However, feral dogs have been known to "pack" and kill large ungulates such as deer, often killing more than they can eat (Nowak and Paradiso 1983).	Feral dogs have been known to occur throughout the province, particularly near settlements where humans have abandoned unwanted pets in the wilderness (Carl and Guiguet 1981).	
Native	Mammals	*Lepus americanus washingtonii*	snowshoe hare, *washingtonii* subspecies	G5T3T5	S1	Red	unknown	Predation on young snowshoe hares by dogs, cats, and recently colonized coyotes is thought to be a contributing factor (Cannings *et al.* 1999).	Trend of this species is unknown but thought to have declined in the recent past (Cannings *et al.* 1999).	BC Ministry of Environment 2007
Native	Mammals	*Sorex bendirii*	Pacific water shrew	G4	S1S2	Red	decline	Predation by dogs and cats is thought to be high for this species (Cannings *et al.* 1999; BC Ministry of Water, Land and Air Protection. 2004).		BC Ministry of Environment 2007
Invasive native	Mammals	*Canis latrans*	coyote	G5	S5	Yellow	expanding			BC Ministry of Environment 2007
Native	Mammals	*Lepus americanus washingtonii*	snowshoe hare, *washingtonii* subspecies	G5T3T5	S1	Red	unknown	Predation on young snowshoe hares by dogs, cats, and the recently colonized coyotes is thought to be a contributing factor (Cannings *et al.* 1999).	Trend of this species is unknown but thought to have declined in the recent past (Cannings *et al.* 1999).	BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Mammals	*Sorex bendirii*	Pacific water shrew	G4	S1S2	Red	decline	The effect of the spread of coyotes is not known but may be a factor for this species (Cannings *et al.* 1999; BC Ministry of Water, Land and Air Protection 2004).		BC Ministry of Environment 2007
Native	Mammals	*Sorex trowbridgii*	Trowbridge's shrew	G5	S3S4	Blue	unknown	The effect of the spread of coyotes is not known but may be a factor for this species (Cannings *et al.* 1999).		BC Ministry of Environment 2007
Invasive alien	Mammals	*Castor canadensis*	beaver	G5	S5	Yellow			Native to BC but introduced to the QCI (Carl and Guiguet 1981).	
Native	Fish	*Gasterosteus* sp.	giant black stickleback	G1	S2	Red	stable to unknown	Introduced beavers on QCI affect the water level in spawning areas.	This species is restricted to three known locations on VI and QCI (Cannings and Ptolemy 1998).	Cannings and Ptolemy (1998)
Invasive alien	Mammals	*Didelphis virginiana*	North American opossum	G5	SNA	no status		The opossum can have a detrimental effect on native vertebrates especially amphibians on Hornby (Nagorsen 1996).	Has expanded its range north from an introduced population in Washington State. It was introduced to Hornby Island in 1986 and in 1992 was sighted several times around Victoria (Nagorsen 1996).	BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Amphibians	*Rana aurora*	red-legged frog	G4	S3S4	Blue	unknown	The opossum can have a detrimental effect on native vertebrates especially amphibians on Hornby I. (Nagorsen 1996).		BC Ministry of Environment 2007
Invasive alien	Mammals	*Felis catus*	feral cat	G5	SNA	no status	fluctuates	The feral cat is very harmful to native bird, amphibian, reptile, and small mammal species and can influence declines especially in species that are considered vulnerable or endangered (Keddy *et al.* 1999).		BC Ministry of Environment 2007
Native	Birds	*Asio flammeus*	short-eared owl	G5	S3B, S2N	Blue	decline	Along with other factors, feral cats' consumption of rodents reduces food availability for this species of owl (BC Ministry of Environment, Lands and Parks 1998).		BC Ministry of Environment 2007
Native	Birds	*Eremophila alpestris strigata*	horned lark, *strigata* subspecies	G5T2	SX	Red	decline to almost extirpated	Along with factors such as loss of habitat to invasive plant species such as broom, predation by domestic cats threatens this species (COSEWIC 2003).		BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Birds	*Athene cunicularia*	burrowing owl	G4	S1B	Red	short term, unknown; long term > 90%	Along with other factors, predation by domestic animals such as the cat add to the threat against this species (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Native	Reptiles	*Eumeces skiltonianus*	western skink	G5	S2S3	Blue	unknown	Predation by the cat may be a contributing threat to the skink (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Native	Mammals	*Antrozous pallidus*	pallid bat	G5	S1	Red	unknown	Predation by the cat may be a contributing threat to this species (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Native	Mammals	*Lepus americanus washingtonii*	snowshoe hare, *washingtonii* subspecies	G5T3T5	S1	Red	unknown	Predation on young snowshoe hares by dogs, cats, and the recently colonized coyotes is thought to be a contributing factor (Cannings *et al.* 1999).		BC Ministry of Environment 2007
Native	Mammals	*Mustela erminea haidarum*	ermine, *haidarum* subspecies	G5T2	S2	Red	unknown	The cat may be a significant predator on ermine (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Native	Mammals	*Sorex bendirii*	Pacific water shrew	G4	S1S2	Red	decline	Predation by dogs and cats is thought to be high for this species (Cannings *et al.* 1999; BC Ministry of Water, Land and Air Protection 2004).		BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Mammals	*Sorex palustris brooksi*	common water shrew, *brooksi* subspecies	G5T2	S2	Red	unknown, probably decline	Predation by the cat may be a contributing threat to this species (BC Ministry of Water, Land and Air Protection 2004).		BC Ministry of Environment 2007
Native	Mammals	*Sorex trowbridgii*	Trowbridge's shrew	G5	S3S4	Blue	unknown	Predation by the cat may be a contributing threat to this species (Cannings *et al.* 1999).		BC Ministry of Environment 2007
Invasive alien	Mammals	*Odocoileus hemionus sitkensis*	Sitka deer						Introduced to the QCI (Shackleton 1999).	
Native	Birds	*Aegolius acadicus brooksi*	northern saw-whet owl, *brooksi* subspecies	G5T3	S3	Blue	decline 10–50%	This species is threatened by loss of habitat, including the drastic effect the deer has on the understorey which likely affects the owls' prey population (Fraser *et al.* 1999).		BC Ministry of Environment 2007
Native	Mammals	*Mustela erminea haidarum*	ermine, *haidarum* subspecies	G5T2	S2	Red	unknown	Loss of undercover affects both the understorey for the ermine and its main prey, dusky shrews, ground nesting birds, and Keen's mouse. Deer have also indirectly affected the increase in native martin, which competes with ermine for prey (BC Ministry of Environment 2007).		BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive native	Mammals	*Odocoileus virginianus*	white-tailed deer	G5	S5	Yellow	expanding		Previous to Europeans in BC, this species was only found in pockets. Due to agriculture and forest fragmentation, this species is now widespread in the province (Eder and Pattie 2001).	
Native	Mammals	*Rangifer tarandus* pop. 1	caribou (southern population)	G5T2Q	S1	Red	decline 10–50% short, 50–90% long	Expansion of white-tailed deer and moose have brought increased predator pressure from wolves and cougars (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Invasive alien	Mammals	*Oryctolagus cuniculus*	European rabbit	G5	SNA	no status		Introduced populations can devegetate an island (NatureServe 2006).		BC Ministry of Environment 2007
Native	Ecosystem		Garry oak			Red	decline	Although the European rabbit is not as widespread as the cottontail, it has been found in Garry oak ecosystems. Rabbits can kill trees and shrubs, eat plants at risk. Overgrazing causes plant community changes and seed dispersal (Garry Oak Ecosystem Recovery Team 2003; Resources Information Standards Committee 1998).	No one is currently looking at the effect this species has on the Garry oaks, research is needed (E. Gonzales, pers. comm., March 21, 2006). A. MacDougall has not found negative effects in the Cowichan River Garry oak ecosystem (E. Gonzales, pers. comm., March 21, 2006).	

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Mammals	*Procyon lotor*	raccoon	G5	S5	Yellow			Introduced to Graham Island in the 1940s, and since has successfully colonized many islands in QCI. Will swim up to 1 km to remote islands (Hartman 1993, in Golumbia 2000).	
Native	Birds	*Ptychoramphus aleuticus*	Cassin's auklet	G4	S2S3B, S4N	Blue	stable to decline	Introduced predators like the rat and the raccoon pose the largest immediate threat to this species (BC Ministry of Water, Land and Air Protection 2004).		BC Ministry of Environment 2007
Native	Birds	*Synthliboramphus antiquus*	ancient murrelet	G4	S2S3B, S4N	Blue	short-term decline, 10–30%, long term, 50–75%	Introduced rat and the raccoon pose a very serious threat to this species (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Native	Mammals	*Mustela erminea haidarum*	ermine, *haidarum* subspecies	G5T2	S2	Red	unknown	Introduced raccoon impacts ermine on the QCI (C. Engelstoft, pers. comm., March 23, 2006).		BC Ministry of Environment 2007
Native	Birds	*Picoides villosus picoideus*	hairy woodpecker , *picoideus* subspecies	G5T3	S3	Blue	unknown	Raccoon prey on hairy woodpecker on the QCI (C. Engelstoft, pers. comm., March 23, 2006).	The trends for other hairy woodpeckers are on the rise but the trend is unknown for this subspecies (Fraser *et al.* 1999).	BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Birds	*Ardea herodias fannini*	great blue heron, *fannini* subspecies	G5T5	S3B, S4N	Blue	declining	Introduced raccoon impacts great blue heron on the QCI (C. Engelstoft, pers. comm., March 23, 2006).	The great blue heron on the coast is declining (Gebauer and Moul 2001).	BC Ministry of Environment 2007
Native	Birds	*Aegolius acadicus brooksi*	northern saw-whet owl, *brooksi* subspecies	G5T3	S3	Blue	decline 10–50%	Introduced raccoon impacts this owl species on the QCI (C. Engelstoft, pers. comm., March 23, 2006).		BC Ministry of Environment 2007
Invasive alien	Mammal	*Rattus norvegicus*	Norway rat	G5	SNA	no status			First introduced in the 1700s, Norway rats are found throughout settled areas in BC. Found on 18 islands in the QCI archipelago (Carl and Guiguet 1972).	BC Ministry of Environment 2007
Native	Birds	*Fratercula cirrhata*	tufted puffin	G5	S3B, S4N	Blue	stable	Rats and other introduced predators contribute to the threats on this species. Predation such as this in Alaska has extirpated colonies (Cannings *et al.* 1999).		BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Mammal	*Rattus rattus*	black rat	G5	SNA	no status			Thought to have been introduced into North America on the ships of the early explorers (Maser *et al.* 1981).	BC Ministry of Environment 2007
Native	Mammals	*Mustela erminea haidarum*	ermine, *haidarum* subspecies	G5T2	S2	Red	unknown	By adding to the prey base for martin, the rat indirectly effected the increase in native martin, which competes with ermine for prey (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Native	Birds	*Fratercula cirrhata*	tufted puffin	G5	S3B, S4N	Blue	stable	Rats and other introduced predators contribute to the threats on this species. Predation such as this in Alaska has extirpated colonies (Cannings *et al.* 1999).		BC Ministry of Environment 2007
Native	Birds	*Ptychoramphus aleuticus*	Cassin's auklet	G4	S2S3B, S4N	Blue	stable to decline	Introduced predators like the rat and the raccoon pose the largest immediate threat to this species (BC Ministry of Water, Land and Air Protection 2004).		BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Birds	*Synthliboramphus antiquus*	ancient murrelet	G4	S2S3B, S4N	Blue	decline, 10–30% short term, 50–75% long term	Introduced rat and the raccoon pose a very serious threat to this species (Bertram and Nagorsen 1995; BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Invasive alien	Mammals	*Sciurus carolinensis*	eastern grey squirrel	G5	SNA	no status	10–50%	On Vancouver Island, grey squirrels are common to the endangered Garry oak ecosystems. High densities of grey squirrels could prevent natural regeneration (Shaw 1968; Gill *et al.* 1995) in Bruemmer 2000). Localized competition with native mammals and birds—some predation on birds/eggs and moderate herbivory on bulbs and acorns (E. Gonzales, pers. comm., March 21, 2006).	Introduced in the early 1900s. Now in many areas of the Lower Mainland as well as Quesnel, Nelson, Bowen Island, and Squamish (Bruemmer *et al.* 2000). They are abundant in Victoria as well as farther north in Duncan and Nanaimo (Polster 2002).	BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Ecosystem		Garry oak			Red	decline	Grey squirrels can kill trees and shrubs, eat plants at risk—can negatively affect oak regen by biting out the tip of the acorn before caching it. They also compete with other species for food and cavities, and can displace the native red squirrel (Garry Oak Ecosystem Recovery Team 2003).	Even though this species is believed to impede regen, it is possible that they may also help. They are important to hardwood tree regen where they are native and can co-occur with red squirrels In some parts of NA, have been noted to displace in other areas —needs more study as the effects they have in our Garry oaks has not been tested (E. Gonzales, pers. comm., March 21, 2006).	
Invasive alien	Mammals	*Sylvilagus floridanus*	eastern cottontail	G5	SNA	no status			Introduced to Washington State around 1926, moved into BC near Huntingdon, BC around 1950, and has since spread (Carl and Guiguet 1972).	BC Ministry of Environment 2007

TABLE 3 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
									The species has since spread throughout the Lower Mainland. Was also introduced to Vancouver Island in 1964/65. It has spread throughout southern VI north to Campbell River (Polster 2002) and throughout the Saanich Peninsula.	
Native	Mammals	*Lepus americanus washingtonii*	snowshoe hare, *washingtonii* subspecies	G5T3T5	S1	Red	unknown	Competition especially in conjunction with habitat changes are thought to be a contributing factor (Cannings *et al.* 1999).		BC Ministry of Environment 2007
Native	Ecosystem		Garry oak				decline	Rabbits can kill trees and shrubs, eat plants at risk, overgraze causing plant community changes and seed dispersal (Garry Oak Ecosystem Recovery Team 2003; Resources Information Standards Committee 1998). No formal work has been done on the effect this species has on Garry oak ecosystems. In the Cowichan GO ecosystem, little effect has been seen (E. Gonzales, pers. comm., March 21, 2006).		

TABLE 3 *Concluded*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Mammals	*Tamiasciurus hudsonicus*	red squirrel	G5	S5	Yellow	decline 10–50%	The red squirrel on the QCI impacts northern saw-whet owl and ermine.	Native to BC but introduced to the QCI and Sydney I. (Carl and Guiguet 1981).	BC Ministry of Environment 2007
Native	Mammals	*Mustela erminea haidarum*	ermine, *haidarum* subspecies	G5T2	S2	Red	unknown	Introduced red squirrel impacts ermine on the QCI (C. Engelstoft, pers. comm., March 23, 2006).		BC Ministry of Environment 2007
Native	Birds	*Aegolius acadicus brooksi*	northern saw-whet owl, *brooksi* subspecies	G5T3	S3	Blue	decline 10–30%	Introduced red squirrel impacts this owl species on the QCI (C. Engelstoft, pers. comm., March 23, 2006). It may be a nest predator of this species.		BC Ministry of Environment 2007

[1]Information from Web sites retrieved in February 2006.

Fish

The two main invasion pathways for fish are both human-caused: fish stocking for sport and release of pet stock. Introductions of fish began with the arrival of Europeans to North America (Crossman 1991). The first recorded introduction is thought to be of goldfish (*Carassius aurutus*) in the United States in the late 1600s (DeKay 1842). The first alien fish introduction into Canada was thought to be of the common carp (*Cyprinus carpio*) in Ontario around 1880 (Crossman 1991). Carp have also been introduced for biological control of insects and vegetation (Simberloff and Stiling 1996). Like other groups, habitat alteration and destruction can aid in the success and expansion of invasive fish. The building of hydroelectric dams, for example, has been found to facilitate the success of alien and introduced species through alteration of flow regimes (Bunn and Arthington 2002).

Introduced fish can have a detrimental effect on an aquatic ecosystem. They can affect native fish, amphibians, invertebrates, and vegetation through habitat alteration, predation, competition, disease, and gene pool deterioration (Crossman 1991). Introduced species such as the brown bullhead (*Ameiurus nebulosis*) and the pumpkinseed (*Lepomis gibbosus*) have been known to drive a species to extinction (Hadley Lake stickleback, *Gasterosteus* sp.) (Cannings and Ptolemy 1998). Many of the unique populations of sticklebacks, such as the Misty Lake stickleback (*Gasterosteus* sp. giant black stickleback) on northern Vancouver Island, are threatened by the introduction of alien species (BC Ministry of Environment 2007). Native species that are intentionally introduced to water systems can also have serious consequences. Trout stocking has decimated at least two major populations of tiger salamander (*Ambystoma tigrinum*; BC Ministry of Water, Land and Air Protection 2004).

The red-legged frog and the Great Basin spadefoot toad (*Spea intermontana*), as well as other native amphibians, are threatened by introduced fish species (BC Ministry of Environment 2007). Freshwater molluscs are indirectly affected by introduced alien fish: the presence of alien species reduces or eliminates the native fish, which are needed as hosts for the larval stage of the molluscs (Lee and Ackerman 2000). Many introduced fish also feed on dragonfly larvae (Cannings 2002). Introduced fish compete, prey on, and displace our native fish Species at Risk, such as the Westslope cutthroat trout (*Oncorhyncus clarki lewisi*; BC Ministry of Water, Land and Air Protection 2004).

Various methods, such as chemically treating their habitat and/or physically removing invasive individuals, can be used to control fish (Meronek *et al.* 1996). Meronek *et al.*'s (1996) review of 250 fish control projects, although not specific to introduced fish, indicates that physical removal methods such as various net methods, traps, electrofishing, drawdowns, or combinations of any of these methods, were successful 33–57% of the time. Other studies have also experimented with the use of pheromones to capture introduced fish (Ackerman 2007). Meronek *et al.* (1996) summarize by stating that due to the complexity of fish communities and the factors that can affect them, control projects should include "critical evaluation of assumptions and of suspected causes of problems, explicit rationale and objectives, and pretreatment and long-term post treatment study."

Table 4 is a partial list of the known interactions of invasive fish species with Species at Risk. Due to lack of data and the limited scope of a problem analysis, in-depth research was unable to be done and therefore the amount of species and the extent of the interactions between invasive species and Species at Risk may be incomplete.

TABLE 4 Invasive fish species (in grey) and the Species at Risk that they are known to affect[1]

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Fish	*Ameiurus melas*	black bullhead	G5	SNA	no status	stable	This species can reach populations as high as 227 kg/ha; individuals have been found with large amounts of vegetation in their stomachs (NatureServe 2006).	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 4 & 8 (BC Ministry of Environment 2006a).	BC Ministry of Environment 2006
Native	Molluscs/ aquatic invertebrates		molluscs/ aquatic inverts			Red/blue		The black bullhead, an omnivorous bottom feeder, feeds heavily on mollusks. If present in areas with At Risk mollusks, could present a serious threat (Scott and Crossman 1985; NatureServe 2006).	Introduced fish pose a serious threat to non-marine molluscs (BC Ministry of Environment 2007).	
Invasive alien	Fish	*Ameiurus melas*	brown bullhead (catfish)	G5	SNA	no status	stable	In small lakes, for example, on Lasqueti I. This species and pumpkinseeds can extirpate a stickleback population in 2 years (Cannings and Ptolemy 1998). The catfish feeds on the eggs of the stickleback (Backhouse 2000).	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 1& 2/ uncertainty regarding the occurrence of the species in region 4 following unauthorized releases (BC Ministry of Environment 2006a).	BC Ministry of Environment 2006

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish	*Gasterosteus* sp.	Enos Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Enos Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Paxton Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish	*Gasterosteus* sp .	Paxton Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Priest Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Priest Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish	*Gasterosteus* sp.	Balkwill Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Balkwill Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Emily Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish	*Gasterosteus* sp.	Emily Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of catfish or pumpkinseeds threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Hadley Lake limnetic stickleback	GX	SX	Extinct	Extinct	This species was eliminated by the introduction of the catfish to this lake. This species was found only in this lake (McPhail 1988, in Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Hadley Lake benthic stickleback	GX	SX	Extinct	Extinct	This species was eliminated by the introduction of the catfish to this lake. This species was found only in this lake (McPhail 1988, in Cannings and Ptolemy 1998).		

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Fish	*Carassius auratus*	goldfish	G5	SNA	no status	stable	These fish are prolific breeders and can survive in a wide range of conditions so can be a serious competitor for food with native fish in the smaller systems (Scott and Crossman 1985; S. Voller, pers. comm., March 20, 2006).	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 1, 2, 3, 4, & 8 (BC Ministry of Environment 2006a).	BC Ministry of Environment 2007
Native	Fish		native fish			Red/blue		These fish are prolific breeders and can survive in a wide range of conditions so can be a serious competitor for food with native fish in the smaller systems (Scott and Crossman 1985; S. Voller, pers. comm., March 21, 2006).		
Invasive alien	Fish	*Cyprinus carpio*	common carp	G5	SNA	no status	stable	This prolific species causes turbidity through spawning and feeding. It feeds extensively on aquatic vegetation and native fish eggs (Scott and Crossman 1985; NatureServe 2006).	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 1, 2, 3, 4, & 8 (BC Ministry of Environment 2006a).	BC Ministry of Environment 2007

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish		native fish			Red/blue		The carp feeds on the eggs of native fish, and feeds extensively on aquatic vegetation, which the young native fish depend on (Scott and Crossman 1985; NatureServe 2006).		
Invasive alien	Fish	*Lepomis gibbosus*	pumpkin-seed	G5	SNA	no status	stable	In small lakes, for example on Lasqueti I. This species and catfish can extirpate a stickleback population in 2 years (Cannings and Ptolemy 1998).	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 1, 2, 4, & 8 (BC Ministry of Environment 2006a).	BC Ministry of Environment 2007
Native	Fish	*Gasterosteus* sp.	Paxton Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of pumpkinseeds and other introduced fish threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish	*Gasterosteus* sp.	Paxton Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of pumpkinseeds and other introduced fish threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Priest Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of pumpkinseeds and other introduced fish threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Priest Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of pumpkinseeds and other introduced fish threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish	*Gasterosteus* sp.	Balkwill Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of pumpkinseeds and other introduced fish threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Balkwill Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of pumpkinseeds and other introduced fish threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Native	Fish	*Gasterosteus* sp.	Emily Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of pumpkinseeds and other introduced fish threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish	*Gasterosteus* sp.	Emily Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and the possible introduction of pumpkinseeds and other introduced fish threatens this species. Introduction of these exotic species has caused the extinction of another stickleback on Lasqueti I. (Cannings and Ptolemy 1998).		
Invasive alien	Fish	*Micropterus dolomieu*	smallmouth bass	G5	SNA	no status		Introduced populations can affect frog populations (NatureServe 2006).	This species was introduced by approved stocking programs, although the species may have subsequently spread to unintended waters. WLAP reg 1, 4, & 8 (BC Ministry of Environment 2006a). Also has expanded its population by invasion via populations in Washington (Scott and Crossman 1985).	BC Ministry of Environment 2007

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Amphibians	*Rana aurora*	red-legged frog	G4	S3S4	Blue	unknown	Kiesecker and Blaustein (1998) found that the red-legged frog was negatively impacted by this species, especially when in conjunction with bullfrog predation (NatureServe 2006).		BC Ministry of Environment 2007
Invasive alien	Fish	*Micropterus salmoides*	largemouth bass	G5	SNA	no status		This species is a predator on fish, amphibians, insects, and crayfish. It tolerates various conditions (Scott and Crossman 1985).	Species is present due to unauthorized releases, escapes, or has invaded BC from stockings in the United States. WLAP reg 2, 4, & 8 (BC Ministry of Environment 2006a).	BC Ministry of Environment 2007
Invasive alien	Fish	*Oncorhynchus kisutch*	coho salmon	G4	S4	Yellow	unstable to declining in native range	Introduced to stream on Texada I.	Cannings and Ptolemy (1998)	
Native	Fish	*Gasterosteus* sp.	Paxton Lake limnetic stickleback	G1	S1	Red	stable	This species is only found in the one lake and these sticklebacks are the predominant prey of the introduced coho (Cannings and Ptolemy 1998).		

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish	*Gasterosteus* sp.	Paxton Lake benthic stickleback	G1	S1	Red	stable	This species is only found in the one lake and these sticklebacks are the predominant prey of the introduced coho (Cannings and Ptolemy 1998).		
Invasive alien	Fish	*Pimephales promelas*	fathead minnow	G5	SNA	no status	stable		Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 2 & 7 (BC Ministry of Environment 2006a).	BC Ministry of Environment 2007
Native	Fish	*Margariscus margarita*	pearl dace	G5	S3?	Blue	unknown	Where this species was found with fathead minnow, dace numbers decreased as minnow numbers increased. (American Fisheries Society 2006)		BC Ministry of Environment 2007
Invasive alien	Fish	*Pomoxis nigromaculatus*	black crappie	G5	SNA	no status			Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 2 & 8 (BC Ministry of Environment 2006a).	BC Ministry of Environment 2007

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish		native sport fish					The adult black crappie feeds on the young of native sport fish and can be a significant threat (Canadian Fishing 2006).		Cannings and Ptolemy (1998)
Invasive alien	Fish	*Salmo trutta*	brown trout	G5	SNA	no status		This species is incompatible with the native fish species (i.e., cutthroat and Gila trout) (NatureServe 2006).	This species was introduced by approved stocking programs, although the species may have subsequently spread to unintended waters. WLAP reg 1 & 8 (BC Ministry of Environment 2006a).	BC Ministry of Environment 2007
Native	Fish	*Oncorhynchus clarki clarki*	cutthroat trout, *clarki* subspecies	G4T4	S3S4	Blue	decline 30–> 70%	This species is incompatible with the native fish species (i.e., cutthroat and Gila trout) (NatureServe 2006).		BC Ministry of Environment 2007
Invasive alien	Fish	*Salvelinus fontinalis*	brook trout	G5	SNA	no status		This species has contributed to the decline of invertebrates, native fish, and amphibians (NatureServe 2006).	This species was introduced by approved stocking programs, although the species may have subsequently spread to unintended waters. WLAP reg 1 to 8 (BC Ministry of Environment 2006a).	BC Ministry of Environment 2007

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish		native fish			Red/blue		This species has contributed to the decline of invertebrates, native fish, and amphibians (NatureServe 2006).		
Native	Amphibians		amphibians			Red/blue		This species has contributed to the decline of invertebrates, native fish, and amphibians (NatureServe 2006).		
Native	Invertebrates		invertebrates			Red/blue		This species has contributed to the decline of invertebrates, native fish, and amphibians (NatureServe 2006).		
Invasive alien	Fish	*Perca flavescens*	yellow perch					Illegal introductions of the yellow perch in Utah contributed to the demise of a trout fishery (NatureServe 2006).	Introduced in the Columbia River Drainage (McPhail and Carveth 1993)	
Native	Fish		native fish			Red/blue		Illegal introductions of the yellow perch in Utah contributed to the demise of a trout fishery (NatureServe 2006).		
Invasive alien	Fish	*Stizostedion vitreum*	walleye				stable	This species is a voracious predator eating any kind of fish; they are thought to threaten the native species in the Columbia system (BC Ministry of Fisheries 1999).	Introduced in the Columbia River Drainage (McPhail and Carveth 1993)	

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Fish		native fish			Red/blue		This species is a voracious predator eating any kind of fish; they are thought to threaten the native species in the Columbia system (BC Ministry of Fisheries 1999).		
Invasive alien	Fish		sport fish stocking programs				N/A			
Native	Amphibians	*Ambystoma tigrinum*	tiger salamander	G5	S2	Red	unknown, possibly declining	At least 2 major populations of tiger salamander have been decimated or eliminated by trout stocking (Cannings *et al.* 1999). The trout feeds on the eggs and larvae and may compete for prey with the adults. Introduced rainbows are thought to be a major threat to this species (bc Ministry of Water, Land and Air Protection 2004).		BC Ministry of Environment 2007
Native	Molluscs	*Gonidea angulata*	western ridged mussel	G3	S2	Red	decline 25–50%	The larva is an obligate parasite on fish so it can be affected by introduction of exotic or population changes such as fish stocking (BC Ministry of Environment 2007).		BC Ministry of Environment 2007

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Birds	*Pelecanus erythrorhynchos*	American white pelican	G3	S1B	Red	increase > 10%	The stocking of fish in pelican's foraging lakes could reduce fish prey species through competition for food and/or predation by the stocked fish on their prey fish species (BC Ministry of Water, Land and Air Protection 2004).		BC Ministry of Environment 2007
Native	Molluscs	*Fluminicola fuscus*	ashy pebblesnail	G2	SH	Red	unknown	Stocked fish can affect the lacustrine habitat important for this species (Lee 2000).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Molluscs	*Fossaria parva*	pygmy fossaria	G5	S3S4	Blue	unknown	Stocked fish can affect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Molluscs	*Fossaria vancouverensis*		GHQ	SH	Red	unknown	Stocked fish can affect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Molluscs	*Musculium partumeium*	swamp fingernail clam	G5	SH	Red	unknown	Stocked fish can affect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007

TABLE 4 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Molluscs	*Physa sibirica*	frigid physa	G4G5	S2	Red	unknown	Stocked fish can affect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Molluscs	*Physella heterostropha*	pewter physa	G5Q	S1S3	Red	unknown	Stocked fish can affect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Molluscs	*Physella hordacea*	grain physa	G1	S1?	Red	unknown but critical	Stocked fish can affect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Molluscs	*Planorbula armigera*	thicklip rams-horn	G5	S3	Blue	unknown	Stocked fish can affect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Molluscs	*Promenetus umbilicatellus*	umbilicate sprite	G4	S3S4	Blue	unknown	Stocked fish can affect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Molluscs	*Sphaerium occidentale*	Herrington fingernail clam	G5	SH	Red	unknown	Stocked fish can affect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007

TABLE 4 *Concluded*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Molluscs	*Stagnicola apicina*	abbreviated pondsnail	G5	S2S3	Blue	unknown	Stocked fish can effect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Molluscs	*Valvata humeralis*	glossy valvata	G5Q	SH	Red	unknown	Stocked fish can effect the lacustrine habitat important for this species (BC Ministry of Environment 2007).	The effect of stocked fish is one of many threats this species faces and may not be a large contributor.	BC Ministry of Environment 2007
Native	Insects		dragonflies/ damselflies			Red/Blue		Fish are major predators on dragonfly larvae and stocking of lakes threatens this group of insects (Cannings 2002).		
Native	Fish	*Oncorhynchus clarki lewisi*	cutthroat trout, *lewisi* subspecies	G4T3	S3	Blue	stable or increasing	Cutthroat will hybridize with introduced rainbow trout (BC Ministry of Water, Land and Air Protection 2004).		BC Ministry of Environment 2007

[1]Information from Web sites retrieved in February 2006.
Note: Where an invasive species (in grey) is not followed by Species at Risk (in white), these invasive species are considered to be a potentially significant threat but no specific interactions were found.

INVERTEBRATES

Invertebrates make up over 98% of more than 1 million described animal species in the world (Pechenik 2005). Invertebrates are made up of a vast and heterogeneous assemblage of groups and therefore, for research, should be studied and reviewed individually. However, due the enormity of the field of invertebrate zoology and the limitations of this analysis, we have only been able to touch on some of these groups.

Invertebrate animals are currently divided into at least 35 phyla (Pechenik 2005). They vary tremendously in body size and ecological lifestyle, and exploit a diversity of habitats. Despite this diversity, most introduced species that potentially directly interact negatively with our native species in freshwater and terrestrial ecosystems are found in two phyla: the Arthropoda (notably the insects) and the Mollusca (notably terrestrial and freshwater species of snails, slugs, and bivalves). Two diverse phyla that also may impact Species at Risk through their role as internal parasites (and thus may cause disease in the hosts they infect) are the Nematoda and the Platyhelminthes.

Invertebrates enter Canada through innumerable pathways, ranging from accidental introductions via the import/export trade to intentional introductions as biological control agents. Introduction of invasive invertebrates has increased as global trade has expanded. A study estimating arrival rates at U.S. ports of entry and border crossings found a new insect every 54 inspections of refrigerated maritime cargo (Work *et al.* 2005). Serious forest pests, such as the Asian long-horned beetle, although not yet thought to be established in BC, have been detected in shipments usually associated with wood-packing material (Humphreys *et al.* 1998). Invertebrate parasites are introduced via a host. The invasive parasite may be the passenger of humans, of an introduced alien species, or of a translocated native species. The possibility of introducing parasites via wildlife translocations is now recognized (Cunningham 1996). Due to their nature, the pathways of invasion for invertebrates are diverse and difficult to manage.

More than 900,000 species of insects are described (Smithsonian Institute 2007) and this list is constantly growing. There are more species of insects than all other groups of animals combined (Pechenik 2005). Over 180 invasive (alien) woody plant eating insects are found in Canada (Hendrickson 2002). These insects kill their host plants, eliminate native plant species, destabilize whole forest ecosystems, and eliminate their native counterparts. Other types of invasive insect pests and parasites have also wrought havoc on our native plants and animals. Invasive (alien) soil invertebrates can have detrimental effects on native plants (Hendrickson 2002).

Lafontaine and Troubridge (1998) state that there are 89 introduced butterfly and moth species in BC and the list is most likely growing. Most of these introduced species are thought to be restricted to the Pacific Maritime Ecozone as many were introduced in the Vancouver area, except those introduced through agriculture (Lafontaine and Troubridge 1998).

Approximately 25% of BC's terrestrial molluscs are introduced species (Royal BC Museum 2007). Invasive non-marine molluscs can cause problems for native Species at Risk. Species such as the zebra mussel are well known for their detrimental effects. The zebra mussel attaches to the shells of our native species and disturbs feeding, respiration, balance, burrowing, and locomotion, as well as competes for food resources (Lee and Ackerman 2000).

Six species of terrestrial gastropods have been introduced in the Columbia Basin Region: *Arion rufus*, *Deroceras reticulatum*, *Limax maximus*, *Vallonia pulchella*, *Vallonia excentrica*, and *Cepaea nemoralis* (Royal BC Museum 2007). These slugs and snails are considered voracious eaters and different species can consume algae, fungi, lichens, green plants, carrion, animal feces, centipedes, insects, worms, as well as other slugs (Oregon State University 2005). These introduced species have the potential to affect our Species at Risk. *Limax maximus*, for example, is a predator on other slugs and travels four times faster

than the native banana slug (*Ariolimax columbianus*) on which it preys (Oregon State University 2005; Royal BC Museum 2007). The following native slugs and snails are classified as Species at Risk and are potentially threatened by predation or competition from introduced gastropods: Oregon forestsnail (*Allogona townsendiana*), Puget Oregonian (*Cryptomastix devia*), dromedary jumping-slug (*Hemphillia dromedarius*), warty jumping slug (*Hemphillia glandulosa*), and blue-grey taildropper (*Prophysaon coeruleum*) (BC Ministry of Environment 2007).

Means of mitigating the effects of invasive invertebrates on our Species at Risk are as diverse as the number of species involved. The method used depends on what alien species is being targeted. Methods may be mechanical (i.e., trapping), biological (i.e., introduction of biological control agents), chemical (i.e., pesticides) or any combination of these methods. Biological methods, such as the introduction of host-specific parasites and chemical methods, such as the use of pheromones, have been attempted in Canada on species such as the gypsy moth (Mosquin 1997).

Similar to the plant community, invertebrates are so numerous and diverse that it was impossible, in this analysis, to extensively review all potential interactions with Species at Risk. In this section, we make the reader aware of the vastness of the subject and focus on some of the more prevalent and obvious interactions of invasive invertebrate species with Species at Risk. Our coverage is incomplete due to the extensive list of invasive invertebrates, noting that the likely effect on Species at Risk is far more serious than we can present. However, we have highlighted some of the significant interactions to establish research priorities. We have not included a table for this section due to the many different groups and the paucity of readily available information on the status of the invertebrates of BC.

VASCULAR PLANTS

The plant kingdom has over 250,000 species, second only to the arthropods (University of California 2007). The plant kingdom has 12 phyla or divisions: Anthocerophyta (hornworts), Anthophyta (flowering plants), Bryophyta (mosses), Coniferophyta (conifers), Cycadophyta (cycads), Ginkgophyta (maidenhair tree), Gnetophyta, Hepatophyta (liverworts), Lycophyta (club mosses), Psilophyta (whisk ferns), Pterophyta (ferns), and Sphenophyta (horsetails) (Montgomery College 2005). We restrict our discussion to species found in the 7 extant phyla of vascular plants.

In Canada, our awareness and identification of invasive vascular plant species in natural ecosystems grew rapidly in the last century, especially in the last few decades. Haber estimates that 20–27% of Canada's plant species are alien. However, many of these alien species may not be invasive, or may not be invasive in all regions where they are found (Haber 2002). To manage effectively and economically, not only do we need to understand the extent of interactions between invasive plant species and Species at Risk, but we also need to understand the "invasiveness" of each species (E. Gonzales, pers. comm., March 21, 2006). We lack the data to manage effectively for all species at this level, although our knowledge is increasing constantly.

The pathways of invasion for plants are extremely varied. The increase in trade and travel is responsible for a rapid rise in intentional and accidental introductions of invasive plant species to Canada (Environment Canada 2006). Many invasive plants enter through the import of agricultural crops, nursery stock, and garden stock (Environment Canada 2006). Invasive plants can also enter Canada as passengers on or in humans or other invasive species.

Invasive plants can have far-reaching effects, both economically and ecologically. Without control, invasive plants have spread at a rate of 12–14% per year (Darling 2006). Wetlands infested with purple loosestrife (*Lythrum salicaria*) can lose 50–100% of their native biomass. In Colorado, Dalmatian toadflax (*Linaria genistifolia* ssp. *dalmatica*) increased its area by 1200% in just 6 years (Darling 2006).

The rapid spread of invasive plant species is very much a global issue. Haber (2002) states that invasive plant species are a significant threat to global biodiversity and natural ecosystems. Every year in North America, billions of dollars are spent on control programs in an attempt to control the spread of invasive plants that have an economic impact. However, Haber (2002) states that in comparison, little is spent on controlling species that affect natural ecosystems and Species at Risk. Nevertheless, the invasive plants that invade our natural ecosystems can be equally drastic, forming monospecific populations that not only dominate the native plants but also drastically affect native animal species dependent on the native plants (Haber 2002). Invasive plants can affect air and water quality, thereby further affecting our natural ecosystem (Darling 2006). Invasive plant species, such as Russian knapweed (*Acroptilon repens*), are allelopathic; not only does it displace native plants but the allelopathic compound from this plant can stay in the soil for years (Polster 2002). Species such as scotch broom (*Cytisus scoparius*) have a large impact on other species and can alter the fire regime. Species such as cheatgrass (*Bromus tectorum*) have also dramatically changed fire cycles and therefore have led to altered community structure and function (Scudder 2002).

Mitigation measures for invasive plants may be mechanical (i.e., hand pulling, tilling of the soil, fire), chemical (i.e., herbicides), biological (i.e., introduction of biological control agents), or any combination of these (University of British Columbia 2006a). Hand removal of plants, although time consuming, is probably one of the most "ecologically friendly" and cost-effective methods (when volunteers are used) to remove invasive alien plant species (Mosquin 1997). Herbicides are often used to "spot spray" areas of alien grasses in prairie ecosystems (Mosquin 1997). More indirect methods such as community succession may also be used to decrease alien species and increase native plants (Mosquin 1997). Polster (2002), although not specific for Species at Risk, is an excellent reference that discusses ecosystem restoration and the role of invasive species management.

Similar to the insect community, plants are so numerous and diverse that it was impossible, in this analysis, to review all potential interactions with Species at Risk. In Table 5, we focus on the more prevalent and obvious interactions of invasive vascular plant species with Species at Risk. Our coverage is incomplete due to the extensive list of invasive plant species noting that the likely effect on Species at Risk is far more serious than we are able to present. However, we have highlighted some of the significant interactions for the sake of establishing research priority.

TABLE 5 Invasive plant species (in grey) and the Species at Risk that they are known to affect[1]

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Vascular plant	*Acroptilon repens*	Russian knapweed	GNR	SNA	no status		This species displaces native plants and inhibits other plants from growing near it. The allelopathic compound from this plant can stay in the soil for some years (Polster 2002).		BC Ministry of Environment 2007
Native	Vascular plants		native plants			Red/blue		This species displaces native plants and inhibits other plants from growing near it. The allelopathic compound from this plant can stay in the soil for some years (Polster 2002).		
Invasive alien	Vascular plant	*Aira praecox*	early hairgrass	GNR	SNA	no status		This species is an invasive species in the Garry oak sites on Vancouver Island and the Gulf I. (Haber 2000, in Polster 2002). It competes for water and nutrients (Polster 2002).		BC Ministry of Environment 2007
Native	Ecosystem		Garry oak			Red	decline	This species is an invasive species in the Garry oak sites on Vancouver Island and the Gulf I. (Haber 2000, in Polster 2002). It competes for water and nutrients (Polster 2002)		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Vascular plants	*Alliaria petiolata*	garlic mustard	GNR	SNA	no status		This species is listed as potentially invasive or not invasive, but Thompson (1997 in Polster 2002) states that it has a high invasive potential and once established is difficult to control. It can very quickly spread and replace native plants and may have allelopathic chemicals that inhibit growth of other plants. It can also contain a strain of turnip mosaic virus (Polster 2002). This species is one of the few exotic herbs that invades and dominates understorey in forested areas of NA (Nuzzo 2000 in Polster 2002)		BC Ministry of Environment 2007
Native	Vascular plants		native plants			Red/blue		This species is listed as potentially invasive or not invasive, but Thompson (1997 in Polster 2002) states that it has a high invasive potential and once established is difficult to control. It can very quickly spread and replace native plants and may have allelopathic chemicals which inhibit growth of other plants.		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
								It can also contain a strain of turnip mosaic virus (Polster 2002). This species is one of the few exotic herbs that invades and dominates understorey in forested areas of NA (Nuzzo 2000 in Polster 2002).		
Invasive alien	Vascular plants	*Ammophila arenaria*	European beachgrass	GNR	SNA	no status		Native plants are taken over by the dense growth of this species. The presence of this species has resulted in a series of fore dunes along the coast and also causes the fore dunes to increase in size (Polster 2002).		BC Ministry of Environment 2007
Native	Vascular plants		native plants			Red/blue		Native plants are taken over by the dense growth of this species. The presence of this species has resulted in a series of fore dunes along the coast and also causes the fore dunes to increase in size (Polster 2002).		
Invasive alien	Vascular plants	*Ammophila breviligulata*	sand reed	G5	SNA	no status		Native plants are taken over by the dense growth of this species. The presence of this species has resulted in a series of fore dunes along the coast and also causes the fore dunes to increase in size (Polster 2002).		BC Ministry of Environment 2007

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Vascular plants		native plants			Red/blue		Native plants are taken over by the dense growth of this species. The presence of this species has resulted in a series of fore dunes along the coast and also causes the fore dunes to increase in size (Polster 2002).		
Invasive alien	Vascular plants	*Anthoxanthum odoratum*	sweet vernalgrass	GNR	SNA	no status		This species is invasive in the Garry oak savannah sites and sensitive ecosystems on Vancouver Island and the Gulf Islands (Haber 2000, in Polster 2002). It also has allelopathic properties to inhibit the growth of other plants (Polster 2002). This species is highly competitive with other grasses (NatureServe 2006).		BC Ministry of Environment 2007
Native	Ecosystem		Garry oak			Red	decline	This species is an invasive species in the Garry oak savannah sites and sensitive ecosystems on Vancouver Island and Gulf Islands (Haber 2000, in Polster 2002).		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
								It also has allelopathic properties to inhibit the growth of other plants (Polster 2002). This species is highly competitive with other grasses (NatureServe 2006).		
Invasive alien	Vascular plants	*Arctium minus*	common burdock	GNR	SNA	no status		This species is classed as a noxious weed (BC Ministry of Environment 2007). It is an invasive species in the sensitive ecosystems on Vancouver Island and Gulf Islands (McPhee *et al.* 2000, in Polster 2002) as well as in other areas of BC. It is a host to root rot and powdery mildew (Polster 2002).		BC Ministry of Environment 2007
Native	Ecosystem		Sensitive ecosystems of east VI and Gulf Islands			Red	decline	This species is classed as a noxious weed (BC Ministry of Environment 2007). It is an invasive species in the sensitive ecosystems on Vancouver Island and the Gulf Islands (McPhee *et al.* 2000, in Polster 2002). It is a host to root rot and powdery mildew (Polster 2002).		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Vascular plants	*Azolla caroliniana*	eastern mosquito fern	G5	SNA	no status		This species can grow very rapidly and completely cover a body of water, it can become very thick and therefore has an impact on plants and animals that depend on open water for sunlight, oxygen, space for food and growth, and other needs.Water under mats has lower oxygen concentration, inhibits growth of plants under mat, > CO^2 and hydrogen sulphide, < pH and > water temps and reduces concentration of nutrients (invasive.org 2006).		BC Ministry of Environment 2007
Native	Birds, fish, aquatic invertebrates, and plants		native birds, fish, aquatic invertebrates, and plants			Red/blue		This species can grow very rapidly, completely cover a body of water, and become very thick; it therefore has an impact on plants and animals that depend on open water for sunlight, oxygen, space for food, and growth and other needs.		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
								Water under mats has lower oxygen concentration, inhibits growth of plants under mat, > CO^2 and hydrogen sulphide, < pH and > water temps and reduces concentration of nutrients (invasive.org 2006).		
Invasive alien	Vascular plants	*Betula pendula*	European birch	GNR	SNA	no status		This species is thought by some to be an aggressive species that can dominate wetlands and alter habitat by shading (www.serontario.org). It is also reported by some as only a "limited problem of a local nature" but is classed as a problem in BC wetlands (Canadian Wildlilfe Service 2006a). Mosquin and Whiting (1992, in Polster 2002 and Canadian Wildlilfe Service 2006a) state that 1 of 5 invasive exotic plants have a major impact on natural ecosystems of Canada.		BC Ministry of Environment 2007

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Aquatic species		aquatic species			Red/ Blue		This species is thought by some to be an aggressive species that can dominate wetlands and alter habitat by shading (Ontario Society for Ecological Restoration 2006). It is also reported by some as only a "limited problem of a local nature" but is classed as a problem in BC wetlands (Canadian Wildlife Service 2006a). Mosquin and Whiting (1992, in Polster 2002 and Canadian Wildlife Service 2006a) state that 1 of 5 invasive exotic plants have a major impact on natural ecosystems of Canada.		
Invasive alien	Vascular plants	*Bromus hordeaceus* ssp. *hordeaceus*	soft brome	GNRTNR	SNA	no status				BC Ministry of Environment 2007
Native	Ecosystem		Garry oak			Red	decline	This is an invasive species in the Garry oak sites on Vancouver Island and the Gulf Islands (E. Gonzales, pers. comm., March 21, 2006).		
Invasive alien	Vascular plant	*Bromus rigidus*	rip-gut brome	GNR	SNA	no status				BC Ministry of Environment 2007

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Ecosystem		Garry oak			Red	decline	This is an invasive species in the Garry oak sites on Vancouver Island and the Gulf Islands (E. Gonzales, pers. comm., March 21, 2006).		
Invasive alien	Vascular plant	*Bromus sterilis*	barren brome	GNR	SNA	no status				BC Ministry of Environment 2007
Native	Ecosystem		Garry oak			Red	decline	This is an invasive species in the Garry oak sites on Vancouver Island and the Gulf Islands (E. Gonzales, pers. comm., March 21, 2006).		
Invasive alien	Vascular plant	*Centaurea biebersteinii*	spotted knapweed	GNR	SNA	no status		This species of knapweed is prolific and can quickly dominate over native plants. It may be allelopathic so can exclude the growth of native species (US army Corps of Engineers 2006).		BC Ministry of Environment 2007
Native	Vascular plants		native plants			Red/ Blue	unknown	This species of knapweed is prolific and can quickly dominate over native plants. It may be allelopathic so can exclude the growth of native species (US army Corps of Engineers 2006).		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Vascular plant	*Centaurea diffusa*	diffuse knapweed	GNR	SNA	no status		This species of knapweed reproduces by seed and can dominate disturbed and undisturbed sites. It is allelopathic so can exclude the growth of native species (US army Corps of Engineers 2006).		BC Ministry of Environment 2007
Native	Vascular plants		native plants			Red/ Blue		This species of knapweed reproduces by seed and can dominate disturbed sites as well as undisturbed. It is allelopathic so can exclude the growth of native species (US army Corps of Engineers 2006)		
Native	Insects	*Apodemia mormo*	mormon metalmark	G5	S1	Red		Weeds such as diffuse knapweed, Dalmatian toadflax, and downy brome compete with the plants that make quality habitat for this species. They compete with species such as snow buckwheat (COSEWIC 2002c).		BC Ministry of Environment 2007
Invasive alien	Vascular plants	*Centaurea jacea*	brown knapweed	GNR	SNA	no status		This species of knapweed is prolific and can quickly dominate native plants. It is a category 1 weed in NW BC (Polster 2002).		BC Ministry of Environment 2007

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Vascular plants		native plants			Red/ Blue		This species of knapweed is prolific and can quickly dominate native plants. It is a category 1 weed in NW BC (Polster 2002).		
Invasive alien	Vascular plants	*Cirsium palustre*	marsh thistle	GNR	SNA	no status		The marsh plume thistle is thought to be a major problem in the Prince George Forest Region for its ability to colonize and dominate undisturbed riparian areas (BC Ministry of Forests 2000, in Polster 2002).		BC Ministry of Environment 2007
Native	Vascular plants		native plants			Red/ Blue		The marsh plume thistle is thought to be a major problem in the Prince George Forest Region for its ability to colonize and dominate undisturbed riparian areas (BC Ministry of Forests 2000, in Polster 2002).		
Invasive alien	Vascular plants	*Cynosurus echinatus*	hedgehog dogtail	GNR	SNA	no status		This species is an invasive species in the Garry oak sites on Vancouver Island and the Gulf Islands (Haber 2000 and Ward *et al.* 1998, in Polster 2002)		BC Ministry of Environment 2007

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Ecosystem		Garry oak			Red	decline	This species is an invasive species in the Garry oak sites on Vancouver Island and the Gulf Islands (Haber 2000 and Ward *et al.* 1998, in Polster 2002) This species is dominant on many study plots (E. Gonzales, pers. comm., March 21, 2006) especially where there are high levels of herbivory.		
Invasive alien	Vascular plants	*Cytisus scoparius*	Scotch broom	GNR	SNA	no status				BC Ministry of Environment 2007
Native	Reptiles	*Pituophis catenifer catenifer*	gopher snake, catenifer subspecies	G5T5	SX	Red	extirpated	It is thought that the presence of Scotch broom contributed to its extirpation (Backhouse 2000).		BC Ministry of Environment 2007
Native	Birds	*Pooecetes gramineus affinis*	vesper sparrow, affinis subspecies	G5T3	S1B	Red	unknown, long term decline 25–75%	The infilling of meadows mostly by broom and gorse is a major threat to this species (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Native	Birds	*Eremophila alpestris strigata*	horned lark, strigata subspecies	G5T2	SX	Red	decline to almost extirpated	Along with other factors, loss of habitat to invasive plant species such as broom, gorse, and Himalayan blackberry is threatening this species (COSEWIC 2003).		BC Ministry of Environment 2007

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Ecosystem		Garry oak			Red	decline	This species is an invasive species in the Garry oak sites on Vancouver Island and the Gulf Islands (Haber 1998, in Polster 2002).		
Native	Vascular plants		native plants			Red/blue		Broom is a highly invasive species and competes very successfully with native plants (Polster 2002).		
Invasive alien	Vascular plants	*Dactylis glomerata*	orchard-grass	GNR	SNA	no status		This is an invasive species in the sensitive ecosystems on Vancouver Island and the Gulf Islands (Ward *et al.* 1998 and Haber 2000, in Polster 2002).		BC Ministry of Environment 2007
Native	Ecosystem		sensitive ecosystems of east VI and Gulf Islands (incl. Garry oak)			Red	decline	This is an invasive species in the sensitive ecosystems on Vancouver Island and the Gulf Islands (Ward *et al.* 1998 and Haber 2000 in Polster 2002) orchard grass.		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
								It appears appears to be highly competitive species—dense clumps—litter takes a long time to break down and shades other species (E. Gonzales, pers. comm., March 21, 2006). Gonzales (pers. comm., March 21, 2006) also reports that in her sites, it reduces germination and establishment of native plants to 0.		
Invasive alien	Vascular plants	*Daphne laureola*	spurge-laurel	GNR	SNA	no status				BC Ministry of Environment 2007
Native	Ecosystem		Garry oak			Red	decline	This species is an invasive species in the Garry oak sites on Vancouver Island and the Gulf Islands (E. Gonzales, pers. comm., March 21, 2006).		
Invasive alien	Vascular plants	*Euphorbia esula*	leafy spurge	GNR	SNA	no status		This aggressive invasive species can completely take over openings including undisturbed forest openings. It has allelopathic properties (Polster 2002).		BC Ministry of Environment 2007

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Vascular plants		native plants			Red/blue		This aggressive invasive species can completely take over openings including undisturbed forest openings. It has allelopathic properties (Polster 2002).		
Invasive alien	Vascular plants	*Geranium robertianum*	Herb Robert's geranium	G5	SNA	no status		This species can invade the forest understorey and dominates native species, decreasing species diversity (Polster 2002).		BC Ministry of Environment 2007
Native	Ecosystem		sensitive ecosystems of east VI and Gulf Islands			Red	decline	This species can invade the forest understorey and dominates native species, decreasing species diversity (Polster 2002).	In Garry oak ecosystems, the HR geranium is common but doesn't form monotypic stands and doesn't seem to displace native species (E. Gonzales, pers. comm., March 21, 2006).	
Invasive alien	Vascular plants	*Hedera helix*	English ivy	GNR	SNA	no status				BC Ministry of Environment 2007
Native	Ecosystem		Garry oak			Red	decline	This species is invasive in the Garry oak sites on VI and the Gulf Islands (E. Gonzales, pers. comm., March 21, 2006).		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Vascular plants	*Lepidium latifolium*	broad-leaved pepper-grass	GNR	SNA	no status		This highly invasive species decreases diversity by creating monospecific stands. It can also hinder nesting waterfowl (Polster 2002).		BC Ministry of Environment 2007
Native	Vascular plants		native plants			Red/blue		This highly invasive species decreases diversity by creating monospecific stands. It can also hinder nesting waterfowl (Polster 2002).		
Invasive alien	Vascular plants	*Leucanthemum vulgare*	oxeye daisy	GNR	SNA	no status		This species is invasive in the sensitive ecosystems of east VI and the Gulf Islands (Polster 2002).		BC Ministry of Environment 2007
Native	Ecosystem		sensitive ecosystems of east VI and Gulf Islands			Red	decline	This species is invasive in the sensitive ecosystems of east VI and the Gulf Islands (Polster 2002).		
Invasive alien	Vascular plants	*Linaria genistifolia* ssp. *dalmatica*	Dalmatian toadflax	G5T5?	SNA	no status				BC Ministry of Environment 2007
Native	Ecosystem		Garry oak			Red	decline	This species is invasive in the Garry oak sites on VI and the Gulf Islands (E. Gonzales, pers. comm., March 21, 2006).		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Insects	*Apodemia mormo*	mormon metalmark	G5	S1	Red		Weeds such as diffuse knapweed, Dalmatian toadflax, and downy brome compete with the plants that make quality habitat for this species. They compete with species such as snow buckwheat (COSEWIC 2002c).		BC Ministry of Environment 2007
Invasive alien	Vascular plants	*Lythrum salicaria*	purple loosestrife	G5	SNA	no status		Purple loosestrife is a major problem species (Haber 1996, in Polster 2002). It is prolific and can dominate native species and decrease biodiversity. It can affect birds and mammals through habitat alteration (Canadian Wildlife Service 2006b).	Purple loosestrife is linked to disturbed sites and may be linked to positive plant and insect diversity (Hager and Vinebrooke 2004; E. Gonzales, pers. comm., March 21, 2006).	BC Ministry of Environment 2007
Native	Birds, mammals, plants		native birds, mammals, plants			Red/blue		Purple loosestrife is a major problem species (Haber 1996, in Polster 2002). It is prolific and can dominate native species and decrease biodiversity. It can affect birds and mammals through habitat alteration (Canadian Wildlife Service 2006b).		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Vascular plants	*Myriophyllum spicatum*	Eurasian water-milfoil	GNR	SNA	no status		Populations of this species can be dense and can drastically alter the habitat in lakes and streams, including shading out algae in the water column important in the aquatic food web (Invasive Species Specialist Group IUCN 2006). Altering the habitat of lakes and streams can have drastic effects on species dependent on these habitats.		BC Ministry of Environment 2007
Native	Fish, aquatic invertebrates, and plants		native fish, aquatic invertebrates, and plants			Red/blue		Populations of this species can be dense and can drastically alter the habitat in lakes and streams, including shading out algae in the water column important in the aquatic food web (Invasive Species Specialist Group IUCN 2006). Altering the habitat of lakes and streams can have drastic effects on species dependent on these habitats.		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Ecosystem		sensitive ecosystems of east VI and Gulf Islands			Red	decline	This species is invasive in the sensitive ecosystems of east VI and the Gulf Islands (McPhee *et al.* 2000, in Polster 2002) Populations of this species can be dense and can drastically alter the habitat in lakes and streams including shading out algae in the water column important in the aquatic food web (Invasive Species Specialist Group IUCN 2006). Altering the habitat of lakes and streams can have drastic effects on species dependent on these habitats.		
Invasive alien	Vascular plant	*Phalaris canariensis*	canary grass	GNR	SNA	no status				BC Ministry of Environment 2007
Native	Amphibians	*Rana pretiosa*	Oregon spotted frog	G2	S1	Red	rapidly declining 30–50% short term, 5–90% long term	Reed canary grass overgrows shallow water where Oregon spotted frogs breed and forage. Every site in BC known to have these frogs has reed canary grass (Haycock 2000, in University of British Columbia 2006b)		BC Ministry of Environment 2007

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Birds, fish, aquatic invertebrates and plants		native birds, fish, aquatic invertebrates, and plants			Red/ Blue		Reed canary grass is a highly invasive species. It can form a dense mat, which competes with native plants and alters habitat for species dependent on this habitat such as turtle, frogs, marsh-nesting birds (Polster 2002) as well as fish.		
Invasive alien	Vascular plant	*Polygonum sachalinense*	giant knotweed	GNR	SNA	no status		The giant knotweed forms dense stands along watercourses dominating native species (Polster 2002).		BC Ministry of Environment 2007
Native	Plants		native plants			Red/ Blue		The giant knotweed forms dense stands along watercourses dominating native species (Polster 2002).		
Native	Ecosystem		sensitive ecosystems of east VI and Gulf Islands			Red	decline	The giant knotweed forms dense stands along watercourses dominating native species (Polster 2002). It is found in sensitive ecosystems on east VI and the Gulf Islands (McPhee *et al.* 2000, in Polster 2002).		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Vascular plant	*Potentilla recta*	sulphur cinquefoil	GNR	SNA	no status		Sulphur cinquefoil, a very aggressive species, is of great concern in the S Okanagan and other areas in BC where it is found. It is highly competitive and is allelopathic (Polster 2002)		BC Ministry of Environment 2007
Native	Plants		native plants			Red/ Blue		Sulphur cinquefoil is a very aggressive species and is of great concern in the S Okanagan and other areas in BC where it is found. It is highly competitive and is allelopathic (Polster 2002)		
Invasive alien	Vascular plant	*Rubus discolor*	Himalayan blackberry	GNR	SNA	no status				BC Ministry of Environment 2007
Native	Birds	*Eremophila alpestris strigata*	horned lark, strigata subspecies	G5T2	SX	Red	decline to almost extirpated	Along with other factors, loss of habitat to invasive plant species such as broom, gorse, and Himalayan blackberry is threatening this species (COSEWIC 2003).		BC Ministry of Environment 2007
Invasive alien	Vascular plant	*Salicornia europaea*	European glasswort			no status		An invasive species found in sensitive wetlands of east VI and the Gulf Islands (Ward *et al.* 1998 and McPhee *et al.* 2000, in Polster 2002).		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Ecosystem		sensitive wetlands of east VI and Gulf Islands			Red	decline	An invasive species found in sensitive wetlands of east VI and the Gulf Islands (Ward *et al.* 1998 and McPhee *et al.* 2000, in Polster 2002).		
Invasive alien	Vascular plants	*Solanum dulcamara* var. *dulcamara*	European bittersweet	GNRTNR	SNA	no status		The European bittersweet can dominate native plants in Cottonwood Riparian Ecosystems of the southern Interior —one of the rarest ecosystems of BC (BC Ministry of Environment, Lands and Parks 1997, in Polster 2002). It is also invasive in the east VI and Gulf Islands sensitive ecosystems (McPhee *et al.* 2000, in Polster 2002).		BC Ministry of Environment 2007
Native	Ecosystem		sensitive ecosystems of east VI and Gulf Islands			Red	decline	This species is invasive in the east VI and Gulf Islands sensitive ecosystems (McPhee *et al.* 2000, in Polster 2002).		
Native	Ecosystem		cottonwood riparian ecosystems of southern Interior			Red	decline	The European bittersweet can dominate native plants in Cottonwood Riparian Ecosystems of the southern Interior. One of the rarest ecosystems of BC (BC Ministry of Environment, Lands and Parks 1997, in Polster 2002).		

TABLE 5 *Continued*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Invasive alien	Vascular plants	*Sonchus oleraceus*	common sow-thistle	GNR	SNA	no status		This species is invasive in the east VI and Gulf Islands sensitive ecosystems (McPhee *et al.* 2000, in Polster 2002).		BC Ministry of Environment 2007
Native	Ecosystem		sensitive ecosystems of east VI and Gulf Islands			Red	decline	This species is invasive in the east VI and Gulf Islands sensitive ecosystems (McPhee *et al.* 2000, in Polster 2002).	E. Gonzales (pers. comm., March 21, 2006) reports that it occurs on study sites but is not dominant.	
Invasive alien	Vascular plants	*Ulex europaeus*	gorse	GNR	SNA	no status				BC Ministry of Environment 2007
Native	Birds	*Pooecetes gramineus affinis*	vesper sparrow, affinis subspecies	G5T3	S1B	Red	unknown, long term decline 25–75%	The infilling of meadows mostly by broom and gorse is a major threat to this species (BC Ministry of Environment 2007).		BC Ministry of Environment 2007
Native	Birds	*Eremophila alpestris strigata*	horned lark, strigata subspecies	G5T2	SX	Red	decline to almost extirpated	Along with other factors, loss of habitat to invasive plant species such as broom, gorse, and Himalayan blackberry is threatening this species (COSEWIC 2003).		BC Ministry of Environment 2007

TABLE 5 *Concluded*

Native, invasive alien, or invasive native	Lifeform group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Trend of expansion or decline	Threat	Comments	Citation (unless otherwise marked)
Native	Ecosystem		sensitive ecosystems of east VI and Gulf Islands (incl. Garry oak)			Red	decline	This is an invasive species in the sensitive ecosystems on Vancouver Island and the Gulf I. (Ward *et al.* 1998, in Polster 2002), displaces native riparian vegetation (S. Rimmer, pers. comm., March 27, 2006).		

[1]Information from Web sites retrieved in February 2006.

IMPORTANCE OF INVASIVE SPECIES/SPECIES AT RISK INTERACTIONS

To identify the importance of the interactions between invasive species and Species at Risk, we relied on the broader definition for invasive (i.e., including interactions among native species). Also, we considered that under some value systems, introduced species can be benign and some may be beneficial. Almost all the earthworms found in Canada are from Eurasia and because this group is such an important part of ecosystem function, they could be expected to radically affect the whole ecosystem and therefore be considered detrimental. However, this may not be the case (Claudi *et al.* 2002). Earthworms are an example of a prolific introduced and invasive species group that is not always considered detrimental. Understanding the extent of "invasiveness" of an introduced (or range-expanding) species is crucial to determining the importance of the interaction between invasive species and Species at Risk. Is this interaction benign, beneficial, or detrimental? These questions need to be answered to effectively manage both our "invasive" species and our Species at Risk.

To rank importance of known interactions between invasive species and Species at Risk, we designed a model based on criteria that could be gathered from literature sources. We also sent a survey to experts as a complementary method for gathering information to fill our model criteria. For each interaction between an invasive species and a Species at Risk, this model (Figure 1) incorporates:

- the type of invasive species or Species at Risk, as either native or alien (for this analysis, "alien" refers to species that have been introduced from outside the region in question);
- the Species at Risk status (i.e., provincial CDC status): Red- or Blue-listed;
- the percentage of a Species at Risk range that is affected: (< 33%, 33–66%, > 66%, or unknown);
- the general lifestyle trend of the invasive species (< 10%, 10–50%, > 50%, or unknown);
- the general lifestyle trend of the Species at Risk (< 10%, 10–50%, > 50% or unknown);
- the type of interaction. For the model, these interactions were limited to the following six: habitat alteration, predation/allelopathy, competition, competition and predation, and hybridization. The tables in the previous sections display the full interaction;
- the extent of research (low to moderate or moderate to high);
- the complexity of the problem (low to moderate or moderate to high). Note: This criterion is intended to address issues such as: time and effort required to address the problem, the level of expertise, and whether an incremental approach is required; and
- the overall importance of the "Invasive/Species at Risk" interaction as a research question (i.e., an interpretation of the relative importance of the species' interaction using a rating of 0 – low importance, to 10 – highly important).

We modelled importance values for the interactions as a Bayesian Belief Network (BBN) using Netica (Norsys Software Corp., Vancouver, BC). BBNs are influence diagrams that use nodes and linkages among nodes to describe, in our application, how the state or condition of the criteria above determines a resulting state of importance for the species interaction. The criteria were assumed to provide information on the relative species emphasis (i.e., a relative comparison of the importance of the two interacting species), the severity of the interaction, urgency in attempting to manage the interaction, and the extent of knowledge gaps about the interaction (Figure 1). Data gathered from literature research and from the expert survey (Appendix C) were then used to generate a case file used in Netica; we summarized results in Figure 2. Importance values were taken to be the expected value from the importance node (i.e., the probability of a state multiplied by the state value, summed across all states) classified into a range of outcomes from 0 (low importance) to 10 (highly important).

Of the 230 species interactions that we evaluated, the majority (n = 209) had importance values between 7.5 and 8.5. We interpreted the 11 interactions greater than 8.5 as being relatively more impor-

tant and those less than 7.5 as being relatively less important. The 11 interactions of higher importance were dominated by 5 invasive species that interact with Garry oak ecosystems (interaction numbers 179, 66, 147, 154, and 9, Appendix C). Three out of 5 of these interactions were with invasive plants, one was with the introduced Canada goose and one was with the eastern grey squirrel (interaction number 66, Appendix C).

Gonzales (2000) states there is confusion as to the effect the grey squirrel may have on our Garry oak ecosystem and that it needs to be studied. It is generally believed, however, that the grey squirrel could have drastic effects by impeding regeneration, displacing native squirrels, preying on bird nests, and competing for cavities as well as herbivory on bulbs and acorns. However, where this species is native, it is known to help hardwood tree regeneration and can apparently co-exist with native red squirrels. Also dominating the interactions of highest importance were the interactions between white-tailed deer/moose and mountain caribou (interaction numbers 53 and 31, Appendix C). The most important interaction from the model was that of the caribou and the white-tailed deer and greater sage-grouse and the wild turkey (interaction number 10, Appendix C). However, the weight given the interaction between the greater sage grouse and the wild turkey would only be from a mitigation standpoint as this grouse species is currently extirpated from BC. The wild turkey is on the increase and is thought to have a large effect on our native Galliformes, therefore contributing heavily to the failure of any re-introduction efforts. Also ranking high was the interaction between yellow perch and native fish Species at Risk (interaction number 108, Appendix C). This species has been blamed for the demise of a trout fishery in Utah (NatureServe 2006).

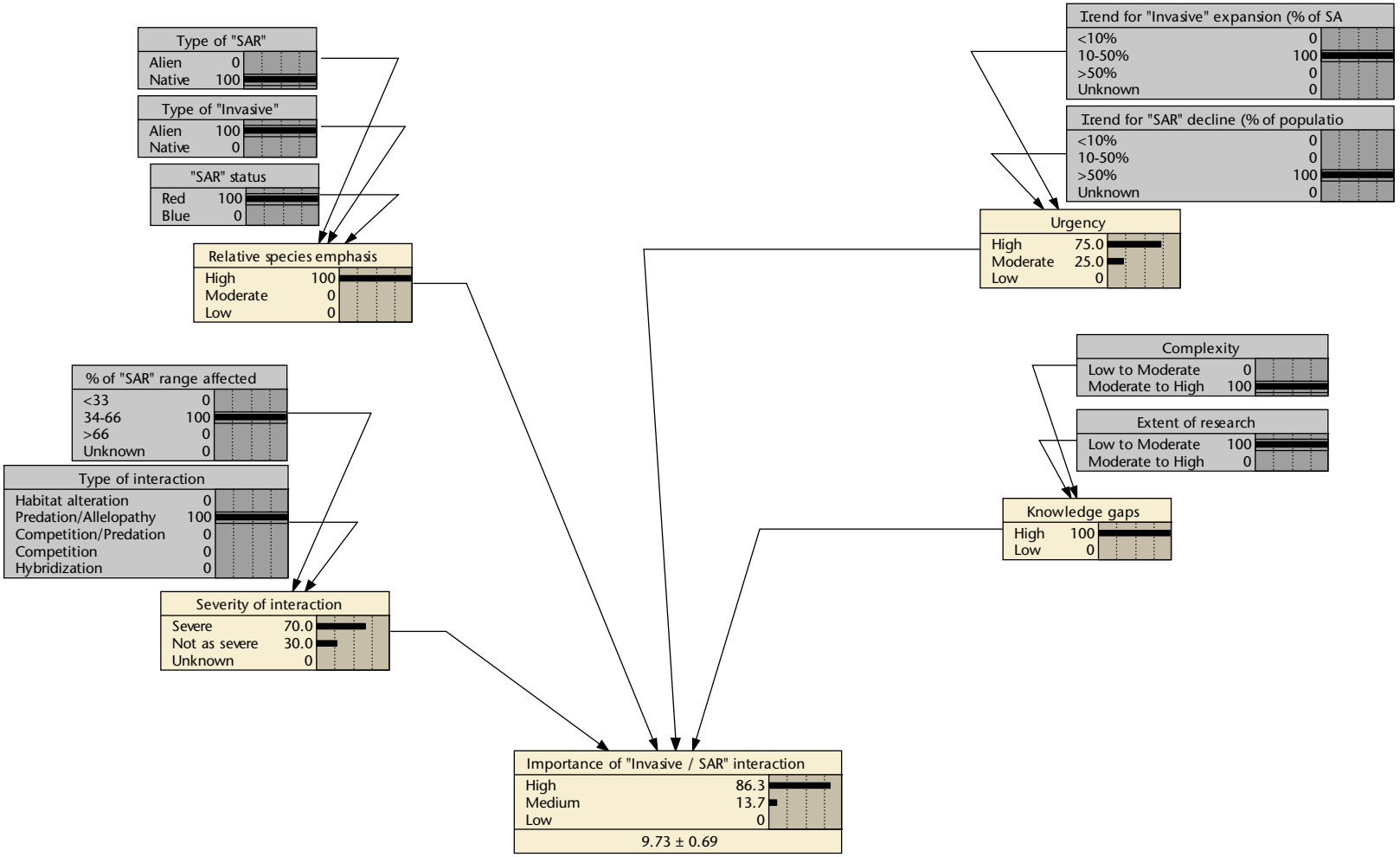

FIGURE 1 A Bayesian Belief Network used to assess importance of interactions between invasive species and Species at Risk (SAR) in British Columbia.

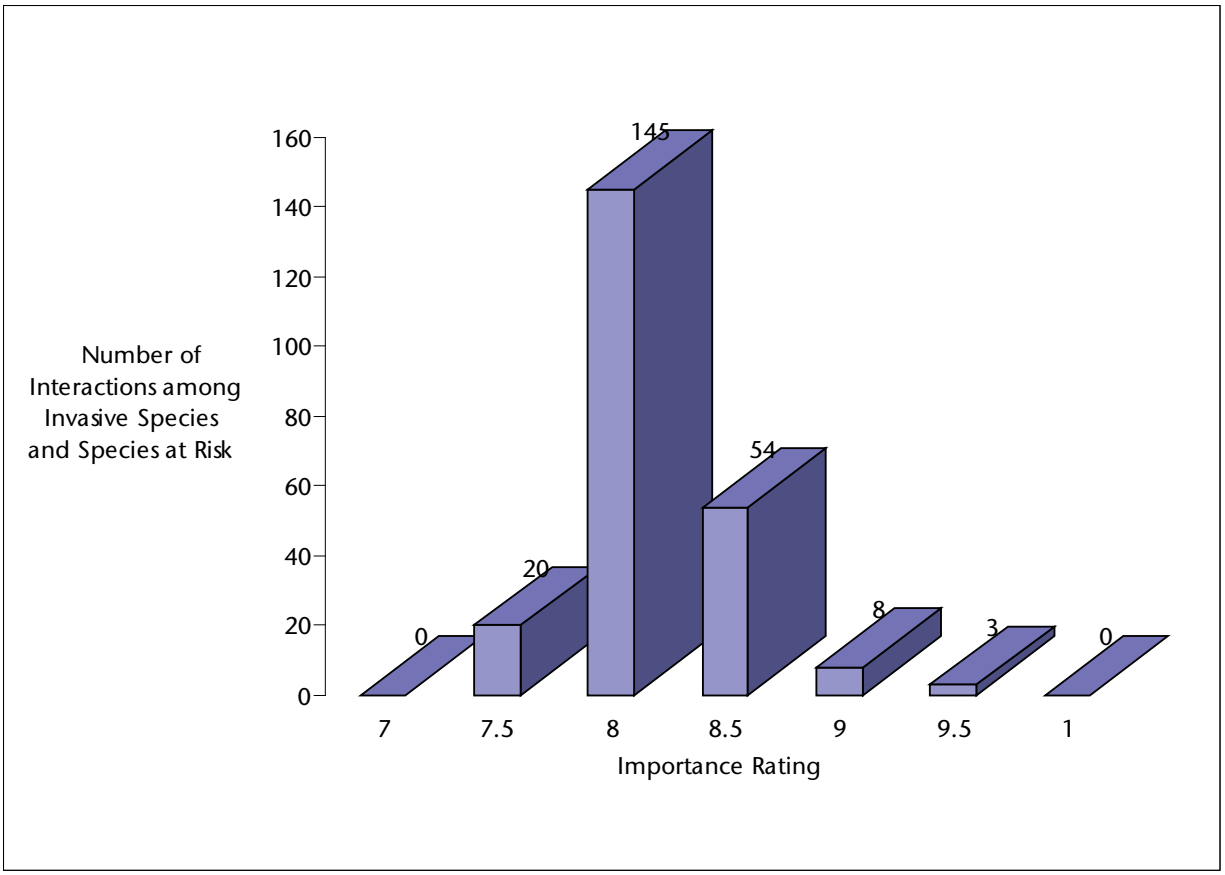

FIGURE 2 Number of interactions between invasive species and Species at Risk in British Columbia classified by a modelled importance rating.

KEY KNOWLEDGE GAPS AND RESEARCH QUESTIONS

Setting Priorities

Identifying key knowledge gaps and thereby coming up with appropriate research questions are the first steps in managing the effects that invasive species may have on Species at Risk. The lack of funding directed towards invasive species research and monitoring has contributed to the serious lack of accurate data on the total number of these species and the impact they have on our ecosystems and Species at Risk (Claudi *et al.* 2002). Without this knowledge we cannot hope to manage Species at Risk that are affected, even indirectly, by invasive species.

This leads to an extremely important underlying truth: "He who defends everything, defends nothing" (Frederick the Great, in Mack 2003). Setting priorities for research questions is as important as understanding our knowledge gaps. Emily Gonzales (pers. comm., March 21, 2006) makes a good point: because funds are limited, we need to first identify the non-native species that actually have a negative impact on our Species at Risk: this may be as little as 0.1% of all introduced species (Williamson 1996). Perhaps the importance ranking we assigned, our list of interactions, or some similar approach would be helpful in defining specific priorities for research. Maguire (2004) also discusses the use of multi-attribute decision analysis to identify management priorities concerning invasive species.

In British Columbia, some documents have begun to identify priorities for management, such as

Rankin *et al.* (2004: *Invasive Alien Species Framework: Identifying and Addressing Threats to Biodiversity*) and Polster (2002: *The Role of Invasive Species Management in Terrestrial Ecosystem Restoration*). As well, the *Ecological Restoration Guidelines for British Columbia* (BC Ministry of Water, Land and Air Protection 2002) discuss terrestrial restoration priorities for BC: the subzones of the biogeoclimatic ecosystem classification (BEC) system are rated for their level of restoration need based on the degree of departure from the "natural range of variability." On a national level, there are documents such as Mosquin (1997: *Management Guidelines for Invasive Alien Species in Canada's National Parks*) and Hovorka (2005: *Invasive Species: Toward a National Plan for Canada*). On an international level, the Global Invasive Species Program provides "a toolkit of best prevention and management practices" (Wittenberg and Cook [editors] 2001) that discusses setting priorities for management.

Here are four general research priorities.

Priority 1: What Interactions Are Currently Not Documented?

Identifying and compiling actual names and status of invasive species and identifying which have viable populations is necessary to manage our Species at Risk and their ecosystems (Claudi *et al.* 2002). This list needs constant updating as the amount and type of invasive species is constantly fluctuating. Our knowledge in this area is growing. For example, the Garry oak ecosystems are being studied intensively, and plant surveys are constantly improving our knowledge base. However, many unanswered questions still need to be researched to effectively manage this moderately well-studied ecosystem (Parks Canada Agency 2005).

Due to the lack of support for invasive species research, some invasive species have gone undetected for years, making management more difficult and expensive (Hendrickson 2002). Some lifeform groups, such as fungi and some groups of insects, may play a decisive role in a species' survival but are so poorly documented that management is extremely difficult. Palm and Rossman (2003, in Ruiz and Carlton 2003) state that only about 10% of fungi that exist are described, and that new fungi are constantly being discovered. They further state that without the knowledge of these species and their natural range and level of invasiveness, it is impossible to predict the risk that these species might pose to our native species.

Identifying the pathways of invasion is also vital for management of invasive species and the Species at Risk that they may affect (Claudi *et al.* 2002). If their pathways are not understood, management of an invasive species is rather a moot point: managing their "way in" is a vital step in controlling invasives. Even though invasive species and their damage have been well documented, the pathways by which they enter are often unknown (Kraus 2003). To understand and to document all the pathways of invasive species are daunting tasks (Mack 2003). But like Frederick the Great implies, this approach would be unproductive and probably impossible. As in other areas of research, priorities must be set to first study and control the invasion pathways of those species deemed most harmful to our Species at Risk.

Through the limited scope of this analysis, we concluded that the largest lifeform groups were probably also the groups having many information gaps concerning the effects of invasive species on Species at Risk: invertebrates, especially insects, and plant species. We also suspect many information gaps within other groups that we did not gather information for (e.g., lichens, fungi, microbes). Not only are these groups extremely diverse and complex but their potential pathways to invasion are some of the most diverse and complicated to control. To be more precise, it is the diversity of these groups that makes them so difficult to document. This lack of reasonably available documentation cannot be taken lightly as these groups can also have some of the most detrimental effects on our Species at Risk.

Priority 2: What Is the Extent of the Known Interactions?

Understanding which invasive species is interacting with which Species at Risk (directly or indirectly) and the extent of that interaction is also critical. Parks Canada Agency (2005), in its recovery strategy for Garry oak ecosystems, lists its number one priority for research as the study of the "effects of invasive species and the response of invasive species, Species at Risk and habitat to management." Gurevitch and Padilla (2004) and Davis (2003) note that data on invasion as a cause for extinction are often limited and anecdotal. Introduction of pathogens and predators are well-documented causes of extinction but there are few cases where competition, for example, has been responsible for extinctions (Davis 2003). However, in some cases, data seem to imply that "something important is going on" (i.e., moose and caribou) but the interactions and mechanisms are so poorly understood that the approach to management of these species is uncertain. In such cases, empirical data need to be gathered to understand why the population changes are taking place (Parker *et al.* 1999).

Some species may interact, but the extent of this interaction is unknown. However, understanding the extent of this interaction is necessary for constructive management. If a species interacts in an unharmful way, management can be more low key or may not be needed at all, and funds can be turned to management of more harmful species.

The extent to which competition (versus predation) threatens our Species at Risk is unknown. Unlike predation, proof as to the existence of competition as a pathway to extinction is based mostly on anecdotal evidence. Understanding the extent to which competition (and other types of interaction) can threaten our Species at Risk may go a long way in setting priorities for tackling the large list of invasive species/Species at Risk interactions. The extent to which various invasive plant species interact with our Species at Risk is largely unknown. Competition in this sense may prove to be a strong link to extinction or at least extirpation of many of our Species at Risk. Being that plants can have such a detrimental effect on many Species at Risk, the "invasiveness" of introduced plants is an important research question. The extent to which well-known invasive species interact in BC would also seem to be important. There is debate for example, as to the extent that species such as the European rabbit, eastern grey squirrel, eastern cottontail (E. Gonzales, pers. comm., March 21, 2006), and purple loosestrife (Hagar and Vinebrooke 2004) have on our ecosystem. Some researchers have found little effect by these species but others have indicated they can be detrimental.

Priority 3: What Are Potential Mitigating Activities?

Once a species is identified as harmfully interacting with a Species at Risk, data about the biology of the invasive species are necessary. If the species is not well understood, whatever management regime is thought necessary to control the invasive species has the potential to fail. For example, if eradication is thought to be necessary, it is important to understand enough about the species to know that eradication will be successful. Millions of dollars can be spent to eradicate a species, so success needs to be maximized (Simberloff 2002b).

As well, understanding the species invasion pathway is important because there needs to be confidence that re-invasion is unlikely or at least controllable (Simberloff 2002b; Ruiz and Carlton 2003). Simberloff (2002b) also points out that the end result of eradication must be understood and predicted so as not to lead to a bigger problem (e.g., the eradication of an introduced large herbivore from an island in California led to an enormous increase in invasive weeds). Understanding the effects of a mitigation method on the environment as a whole is necessary before it is practiced. For example, some mitigation methods involve the introduction of alien species as a means of controlling an invasive species. Unless all potential aspects of how these species may interact in our environment are understood, this mitigation method may prove as detrimental as the species they are trying to control.

Finding and understanding the effects of various mitigation methods for well-studied species such as the bullfrog may prove vital in their control. Millions of dollars can be spent to eradicate such species. Research and potential for success are needed before various methods can be practiced on a large scale. The complexity of such interactions as moose/caribou and barred owl/screech owl makes mitigation extremely difficult. Research into the species relationship and the effects of various mitigation possibilities is necessary before any wide-scale management practices can take place. As in all research, adaptive management is key.

Priority 4: Extension Needs and Opportunities

Studying invasive species and Species at Risk is obviously the most important and necessary first step in management. However, if the findings are not extended to those who need to know, the research will be less effective. These findings need to be extended to management agencies as well as the general public (Claudi *et al.* 2002). The control of invasive plants (and ultimately their effect on Species at Risk) is a perfect example for the need to incorporate extension and education programs as a component of research. Because many of the invasive pathways that weeds follow are facilitated by humans, an educated public is an important part of management.

The Stewardship approach, which is part of most recovery programs, involves the voluntary cooperation of land and water owners (Parks Canada Agency 2005). Stewardship is part of the federal Species at Risk Act and is recognized in the bilateral agreement between the Province and the federal government. It states that "Stewardship by land and water owners and users is fundamental to preventing species from becoming at risk and in protecting and recovering species that are at risk…cooperative, voluntary measures are the first approach to securing the protection and recovery of Species at Risk." However, to get this cooperation, the involved parties must be informed and educated about the risks and necessary steps needed in the recovery process.

As the problem of invasive species is now a borderless issue, international cooperation and the sharing of information are vital in its control. International opportunities allow the sharing of data. For example, the Convention on Biological Diversity, first established in 1992 (Neville 2002), was key in facilitating the development of a shared database on invasive alien species. A conference in Norway in 1996 brought together experts to examine the extent of the invasive species problem and how to address it. Out of this conference, the Global Invasive Species Program (GISP) emerged. This program is a joint effort between invasive species specialists, scientists, resource managers, environmentalists, economists, policy makers, lawyers, and others. The main objective of the program is to inform and allow organizations to access best management practices when dealing with invasive species (Neville 2002). One of the working groups within this program's framework is "Education, Communication and Outreach."

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The provincial Red and Blue lists are constantly changing as new information is gathered by scientists and the CDC. To provide up-to-date information, we have provided the link to the BC Species and Ecosystems Explorer Web site:

URL: ***http://srmapps.gov.bc.ca/apps/eswp/***

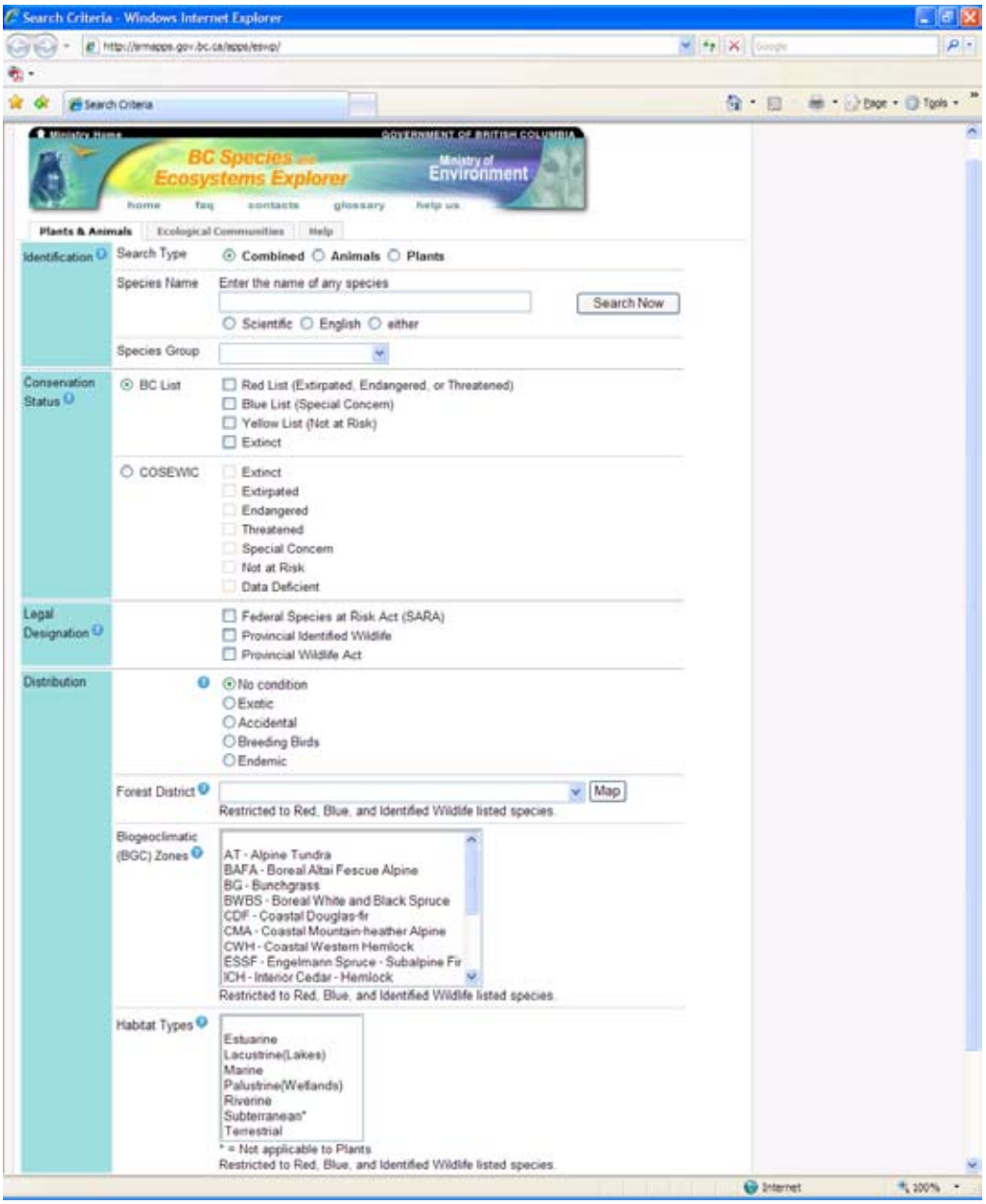

FIGURE A-1 Screen capture showing search input interface for BC Species and Ecosystems Explorer Web site.

The simplest method of obtaining a list is to enter the "Species Group" of choice, mark "Red List or Blue List" under "Conservation Status," then just hit "Search". Once the list is compiled, you can print it or export it to Excel by selecting "Export" and choosing "export to Excel."

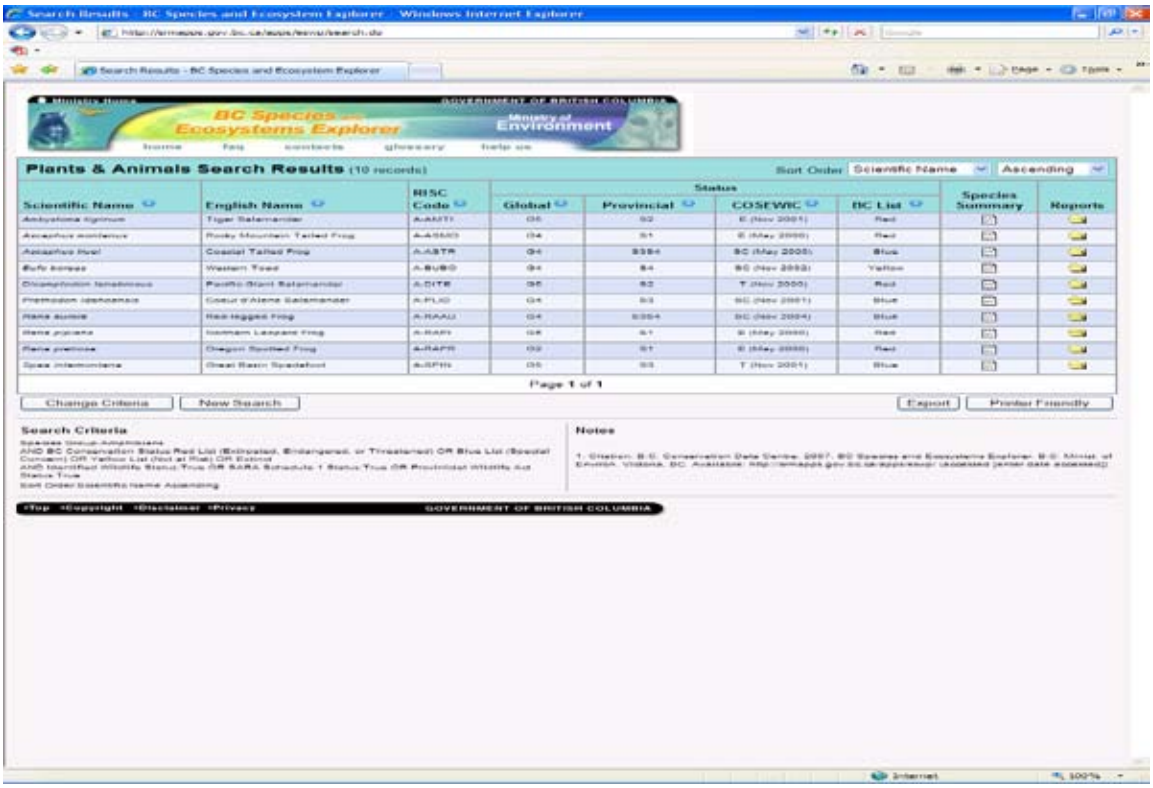

FIGURE A-2. Screen capture showing search results interface for BC Species and Ecosystems Explorer Web site.

As some invasive species are not exotic (species that are native to some parts of BC, but are introduced or spreading to parts of BC not previously occupied), compiling a list from the BC Species and Ecosystems Explorer Web site will not provide a complete list. We have therefore provided a table of invasive vertebrate species listing both the exotic species and the native invasive species (Table B-1).

For the other lifeform groups, the link to the BC Species and Ecosystems Explorer Web site will provide an up-to-date list of exotic species in BC.

URL: ***http://srmapps.gov.bc.ca/apps/eswp/search.do***

The simplest method of obtaining a list is to enter the "Species Group" of choice, mark "Exotic" under "Distribution," then just hit "Search". Once the list is compiled, you can print it or export it to Excel by selecting "Export" and choosing "export to Excel."

TABLE B–1 Invasive vertebrate species.

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Amphibians	*Aneides vagrans*	wandering salamander	G4	S4	Yellow	
Amphibians	*Hyla regilla*	Pacific tree frog	G5	S5	Yellow	This species was introduced to the QCI (Orchard 1984; Green and Campbell 1992; BC Ministry of Environment 2007), native to southern BC.
Amphibians	*Rana catesbeiana*	bullfrog	G5	SNA	no status	
Amphibians	*Rana clamitans*	green frog	G5	SNA	no status	
Amphibians	*Rana pipiens*	northern leopard frog	G5	S1	Red	Red-listed in BC, but introduced on Vancouver Island.
Birds	*Acridotheres cristatellus*	crested myna	G5	SNA	no status	Not thought to have spread from the Lower Mainland. Some sightings on Vancouver Island (Carl and Guiguet 1981).
Birds	*Alauda arvensis*	sky lark	G5	SNA	no status	Introduced to Vancouver Island (Carl and Guiguet 1981) and has now spread to the mainland.
Birds	*Alauda arvensis arvensis*	sky lark, arvensis subspecies	G5T5	SNA	no status	Can be found in Garry oak habitat (Garry Oak Ecosystem Recovery Team).
Birds	*Alectoris chukar*	chukar	G5	SNA	no status	

TABLE B–1 *Continued*

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Birds	*Anas rubripes*	American black duck	G5	SNA	no status	
Birds	*Anser domesticus*	domestic goose			no status	Domestic geese have been known to carry West Nile virus (Association for Professionals in Infection Control and Epidemiology 2006).
Birds	*Branta canadensis canadensis*	Canada goose	G5	S5	Yellow	Introductions of the interior subspecies have been made to VI and the Lower Mainland since 1931 (Carl and Guiguet 1981).
Birds	*Callipepla californica*	California quail	G5	SNA	no status	Is a primary dispersal agent of Scotch broom (Polster 2002).
Birds	*Carpodacus mexicanus*	house finch	G5	S5B	Yellow	This species originated in the southwestern United States and Mexico. Introduced to NY and the species has since spread through eastern United States and southern Canada (Cornell University 2006).
Birds	*Colinus virginianus*	northern bobwhite	G5	SNA	no status	An established population in Washington may expand into southern BC. Was once introduced to BC but not thought to be present now (Carl and Guiguet 1981).
Birds	*Columba livia*	rock dove	G5	SNA	no status	
Birds	*Cygnus olor*	mute swan	G5	SNA	no status	
Birds	*Meleagris gallopavo*	wild turkey	G5	SNA	no status	Thought to be on the increase and may contribute to dispersal of introduced plant species (Polster 2002).
Birds	*Molothrus ater*	brown-headed cowbird	G5	S5B	Yellow	
Birds	*Oreortyx pictus*	mountain quail	G5	SNA	no status	It is not certain if this species is introduced—may be native.
Birds	*Passer domesticus*	house sparrow	G5	SNA	no status	Nest in cavities; arriving before native species; will also take over cavity nests of natives; aggressive bird (Garry Oak Ecosystems Recovery Team 2003). Thought to be associated with purple martin and western bluebird declines (Garry Oak Ecosystems Recovery Team 2003).
Birds	*Perdix perdix*	gray partridge	G5	SNA	no status	

TABLE B–1 ***Continued***

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Birds	*Phasianus colchicus*	ring-necked pheasant	G5	SNA	no status	
Birds	*Streptopelia decaocto*	Eurasian collared dove	G5	SNA	no status	
Birds	*Strix varia*	barred owl	G5	S5B	Yellow	
Birds	*Sturnus vulgaris*	European starling	G5	SNA	no status	Associated with Lewis's woodpecker, purple martin, and mountain and western bluebird declines. Competes for nesting cavities (Royal BC Museum 2006).
Mammals	*Alces alces*	moose	G5	S5	Yellow	
Mammals	*Bos bison bison*	Plains bison	G4TU	S3	Blue	Unlike the other introduced species in BC, the Plains bison is protected in its introduced range (Shackleton 1999).
Mammals	*Bos taurus*	feral cattle			no status	The northern populations of feral cattle are thought to have disappeared but in the 1960s herds were still present on the east coast at Cape Ball and Oeanda River (Carl and Guiguet 1981).
Mammals	*Canis familiaris*	feral dog				Feral dogs have been known to occur throughout the province, particularly near settlements where humans have abandoned unwanted pets in the wilderness (Carl and Guiguet 1981). The effect of feral dogs on local fauna is unknown. However, feral dogs have been known to "pack" and kill large ungulates such as deer, often killing more than they can eat (Nowak and Paradiso 1983).
Mammals	*Canis latrans*	coyote	G5	S5	Yellow	
Mammals	*Capra hircus*	feral goat			no status	Populations are found on Saturna, Jedediah, Lasqueti, and Texada islands. A population may still exist on Pender Island (Shackleton 1999). On Saturna Island, the feral goats are found in Garry oak habitat and are therefore impacting vegetation in a Red-listed ecosystem.
Mammals	*Castor canadensis*	beaver	G5	S5	Yellow	Native to BC but introduced to the QCI (Carl and Guiguet 1981).

TABLE B–1 *Continued*

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Mammals	*Cervis elaphus elaphus*	European red deer			no status	Red deer are thought to be eradicated from the QCI but they may have first interbred with the Rocky Mountain elk that were introduced there in 1928 (Shackleton 1999).
Mammals	*Cervus elaphus nelsoni*	Rocky Mountain elk				Introduced to the QCI (Carl and Guiguet 1981; Shackleton 1999) and into McNab Creek, along Howe Sound east of Sechelt (D. Janz, pers. comm., September 2001). The population on Graham Island is thought to have interbred with the red deer (*Cervus elaphus*, European subspecies) that were introduced there in 1918.
						As well, a population living in the Chilliwack Valley is the result of an expanding population of introduced elk from Washington State. There were 2 introductions of Manitoba elk, 24 elk into the Kootenay Lake region in 1949, and 57 to the Kechika River Valley in 1984 (Shackleton 1999).
Mammal	*Dama dama*	fallow deer	G5	SNA	no status	
Mammal	*Didelphis virginiana*	North American opossum	G5	SNA	no status	Has expanded its range north from an introduced population in Washington State. It was introduced to Hornby Island in 1986 and in 1992 had several sightings around Victoria (Nagorsen 1996).
Mammals	*Equus caballus*	feral horse	GNA	SNA	no status	Found in the central interior west of Williams Lake.
Mammal	*Felis catus*	feral cat	G5	SNA	no status	The feral cat is very harmful to native bird, amphibian, reptile and small mammal species and can influence declines, especially in species that are considered vulnerable or endangered (Keddy *et al.* 1999).
Mammal	*Glaucomys volans*	southern flying squirrel			no status	Introduced through accidental or intentional pet releases. It is breeding in Alberta (Polster 2002).
Mammals	*Lama glama*	llama			no status	Escaped from ranches, Nelson Forest Region (Polster 2002).
Mammals	*Mus musculus*	house mouse	G5	SNA	no status	

TABLE B–1 *Continued*

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Mammals	*Mustela vison*	mink	G5	S5	Yellow	This species is native to Vancouver Island but has been introduced to Lanz Island within the Scott Island group (Carl and Guiguet 1972, Nagorsen 2001 in Polster 2002).
Mammal	*Myocastor coypus*	nutria			no status	Reported occasionally on the Lower Mainland and Vancouver Island. No feral populations are known to exist (Nagorsen 2001 in Polster 2002).
Mammals	*Neotamias townsendii*	western or Townsend chipmunk	G5	S4S5	Yellow	In 1965, 36 chipmunks were released on Sydney Island and are well established. Individuals also escaped from a petting zoo in Beacon Hill Park (Carl and Guiguet 1972).
Mammals	*Odocoileus hemionus sitkensis*	Sitka deer				Introduced to the QCI (Shackleton 1999).
Mammal	*Odocoileus virginianus*	white-tailed deer	G5	S5	Yellow	Previous to Europeans in BC, this species was only found in pockets. Due to agriculture and forest fragmentation, this species is now widespread in the province (Eder and Pattie 2001).
Mammal	*Ondatra zibethicus*	muskrat	G5	S5	Yellow	Introduced to Vancouver Island and Pender Island (Carl and Guiguet 1972). Also introduced to the QCI (Nagorsen 2001 in Polster 2002).
Mammals	*Oryctolagus cuniculus*	European rabbit	G5	SNA	no status	
Mammals	*Ovis canadensis*	Rocky Mountain bighorn sheep				Two herds have been introduced into areas considered native range of California bighorn sheep (Shackleton 1999).
Mammals	*Peromyscus maniculatus augustus*	white-footed mouse				Introduced to Chatham, Discovery, and Trial islands in 1951 as part of a small mammal study (Carl and Guiguet 1972).
Mammals	*Procyon lotor*	raccoon	G5	S5	Yellow	Introduced to Graham Island in the 1940s, and since has successfully colonized many islands in the QCI. Will swim up to 1 km to remote islands (Hartman 1993 in Golumbia 2000).

TABLE B–1 *Continued*

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Mammals	*Rattus norvegicus*	Norway rat	G5	SNA	no status	First introduced in the 1700s. Norway rats are found throughout settled areas in BC. Found on 18 islands in the QCI archipelago (Carl and Guiguet 1972).
Mammals	*Rattus rattus*	black rat	G5	SNA	no status	Thought to have been introduced into North America on the ships of the early explorers (Maser *et al.* 1981).
Mammals	*Sciurus carolinensis*	eastern grey squirrel	G5	SNA	no status	Introduced in the early 1900s. Now in many areas of the Lower Mainland as well as Quesnel, Nelson, Bowen Island, and Squamish (Bruemmer 2000). They are abundant in Victoria as well as further north in Duncan and Nanaimo (Polster 2002). On Vancouver Island, the grey squirrels are common to the endangered Garry oak ecosystems. High densities of grey squirrels could prevent natural regeneration (Shaw 1968, Gill *et al.* 1995 in Bruemmer 2000).
Mammals	*Sciurus niger*	eastern fox squirrel	G5	SNA	no status	Found in the southern Okanagan Valley north to Oliver from an expanded introduced population in Washington State.
Mammals	*Sus scrofa*	European wild boar			no status	Illegally introduced near Harrison Hot Springs and the east side of Cultus Lake. It is thought that all these animals have since been removed (Shackleton 1999; Polster 2002).
Mammals	*Sylvilagus floridanus*	eastern cottontail	G5	SNA	no status	Introduced to Washington around 1926, moved into BC near Huntingdon, BC, around 1950 and has since spread (Carl and Guiguet 1972). The species has since spread throughout the Lower Mainland. Was also introduced to Vancouver Island in 1964/65. It has spread throughout southern VI north to Campbell River (Polster 2002) and throughout the Saanich Peninsula.
Mammals	*Tamiasciurus hudsonicus*	red squirrel	G5	S5	Yellow	Native to BC but introduced to the QCI and Sydney I. (Carl and Guiguet 1981).

TABLE B–1 *Continued*

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Mammals	*Vulpes vulpes*	red fox	G5	S4S5	Yellow	This species is native throughout BC but was introduced to Vancouver Island; large numbers were reported in the late 1940s from Courtenay north (Carl and Guiguet 1981). Sightings have not been reported in recently.
Fish	*Alosa sapidissima*	American shad	G5	SNA	no status	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 2 (BC Ministry of Environment 2006a).
Fish	*Ameiurus melas*	black bullhead	G5	SNA	no status	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 4 & 8 (BC Ministry of Environment 2006a).
Fish	*Ameiurus nebulosus*	brown bullhead	G5	SNA	no status	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 1 & 2/ uncertainty regarding the occurrence of the species in region 4 following unauthorized releases (BC Ministry of Environment 2006a).
Fish	*Carassius auratus*	goldfish	G5	SNA	no status	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 1, 2, 3, 4, & 8 (BC Ministry of Environment 2006a).
Fish	*Cyprinus carpio*	common carp	G5	SNA	no status	Species is present due to unauthorized releases, escapes, or has invaded BC from stockings in the United States. WLAP reg 1, 2, 3, 4, & 8 (BC Ministry of Environment 2006a).
Fish	*Lepomis gibbosus*	pumpkinseed	G5	SNA	no status	In small lakes, for example on Lasqueti I. This species and catfish can extirpate a stickleback population in 2 years (Cannings and Ptolemy 1998). Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 1, 2, 4, & 8 (BC Ministry of Environment 2006a).
Fish	*Micropterus dolomieu*	smallmouth bass	G5	SNA	no status	This species was introduced by approved stocking programs, although the species may have subsequently spread to unintended waters. WLAP reg 1, 4, & 8 (BC Ministry of Environment 2006a).

TABLE B–1 *Continued*

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Fish	*Micropterus salmoides*	largemouth bass	G5	SNA	no status	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 2, 4, & 8 (BC Ministry of Environment 2006a).
Fish	*Oncorhynchus mykiss aguabonita*	golden trout				Uncertainty regarding the occurrence of the species in this region following unauthorized releases. WLAP Reg 2, 4, and 8 (BC Ministry of Environment 2006a).
Fish	*Oncorhynchus kisutch*	coho salmon				Introduced to stream on Texada I.
Fish	*Oncorhynchus clarki lewisi*	westslope cutthroat				Introduced to the MacKenzie System (McPhail and Carveth 1993).
Fish	*Pimephales promelas*	fathead minnow	G5	SNA	no status	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 2 & 7 (BC Ministry of Environment 2006a).
Fish	*Pomoxis nigromaculatus*	black crappie	G5	SNA	no status	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 2 & 8 (BC Ministry of Environment 2006a).
Fish	*Salmo salar*	Atlantic salmon	G5	SNA	no status	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 1 & 2 (BC Ministry of Environment 2006a).
Fish	*Salmo trutta*	brown trout	G5	SNA	no status	This species was introduced by approved stocking programs, although the species may have subsequently spread to unintended waters. WLAP reg 1 & 8 (BC Ministry of Environment 2006a).
Fish	*Salvelinus fontinalis*	brook trout	G5	SNA	no status	This species was introduced by approved stocking programs, although the species may have subsequently spread to unintended waters. WLAP reg 1 to 8 (BC Ministry of Environment 2006a).
Fish	*Tinca tinca*	tench	G5	SNA	no status	Species is present due to unauthorized releases or escapes, or has invaded BC from stockings in the United States. WLAP reg 4 & 8 (BC Ministry of Environment 2006a).
Fish	*Salvelinus namaycush*	lake trout				Introduced in the Columbia River Drainage (McPhail and Carveth 1993).

TABLE B–1 *Continued*

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Fish	*Cregonus clupeaformis*	lake whitefish				Introduced in the Columbia River Drainage (McPhail and Carveth 1993).
Fish	*Perca flavescens*	yellow perch				Introduced in the Columbia River Drainage (McPhail and Carveth 1993).
Fish	*Stizostedion vitreum*	walleye				Introduced in the Columbia River Drainage (McPhail and Carveth 1993).
Reptiles	*Chelydra serpentina*	common snapping turtle				The snapping turtle is aggressive (Carl and Guiguet 1972). It has not been sighted in recent years so it has been removed from the current BC species list (Stevens 1995). Due to low numbers, its impact on our native species is probably minimal or non-existent.
Reptiles	*Chinemys reevesi*	Reeve's turtle, Asiatic turtle, Chinese 3-keeled pond turtle				It has not been sighted in recent years so it has been removed from the current BC species list (Stevens 1995). Due to low numbers, its impact on our native species is probably minimal or non-existent.
Reptiles	*Chrysemys picta*	painted turtle	G5	S3S4	Blue	This species is on the provincial Blue List. The populations of the mainland coast, Gulf Islands, and Vancouver Island have uncertain origins. It is presumed these populations originate from escaped pets. All the coastal populations are low in number (Gregory and Campbell 1996). Introduced turtles can have a dramatic effect on the local amphibian populations; however, the actual effect of this species on these populations is unknown.
Reptiles	*Diadophus punctatus*	ringneck snake				This species has a spotty distribution in its natural range, and it may be possible for it to expand its range into southern BC. It is also an elusive snake and may occur naturally in BC but in low numbers (Gregory and Campbell 1996).Currently, this snake has not been observed in BC and so concern over its impact on our local species is most likely minimal.

TABLE B–1 ***Concluded***

Group	Scientific name	English name	Global rank	Prov. rank	Prov. status	Comments
Reptiles	*Hypsiglena torquata*	night snake	G5	S1	Red	The night snake is currently on the provincial Red List, ranked as critically imperilled. Globally, this species is ranked as secure. It is currently managed as a Red-listed species. There is little concern about the impact this species may have as an invasive species due to the uncertainty of its status as a native species. However, little is known about this elusive snake and most of our current information is from more southern populations (Gregory and Campbell 1996).
Reptiles	*Podarcis muralis*	European wall lizard	G5	SNA		May impact the northern alligator lizard. The wall lizard occupies the same habitat type on VI and it may outcompete and therefore displace the native species (Polster 2002). Currently, no known SAR are threatened by this lizard.
Reptiles	*Sceloporus occidentalis*	western fence lizard				This species may potentially expand its range from Washington State into BC (Gregory and Campbell 1996). Currently, this species causes no concern.
Reptiles	*Trachemys scripta*	common slider	G5	SNA		This species is not thought to have a breeding population in BC (BC Ministry of Environment, Lands and Parks 2000). If there are sufficient number of individuals in a pond, they can have a detrimental effect on the local amphibian populations through predation and may outcompete native turtles (Thompson Rivers University 2006a).
Reptiles	*Uta stansburiana*	side-blotched lizard				This species may potentially expand its range from Washington State into BC (Gregory and Campbell 1996).

Note: Citation, unless otherwise noted, is: BC Ministry of Environment 2007 (retrieved February 2006).

TABLE C–1 Model data input on invasive species and Species at Risk interactions

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
1	American bullfrog	Alien	Amphibians	Oregon spotted frog	Native	Amphibians	Red	unknown	10–50	10–50	Competition predation	low to mod	mod to high
2	American bullfrog	Alien	Amphibians	Northern leopard frog	Native	Amphibians	Red	unknown	10–50	> 50	Competition predation	low to mod	low to mod
3	American bullfrog	Alien	Amphibians	Red-legged frog	Native	Amphibians	Blue	unknown	10–50	unknown	Competition predation	low to mod	mod to high
4	American bullfrog	Alien	Amphibians	Western pond turtle	Native	Amphibians	Red	unknown	10–50	10–50	Predation	low to mod	mod to high
5	Green frog	Alien	Amphibians	Oregon spotted frog	Native	Amphibians	Red	unknown	< 10	10–50	Competition predation	low to mod	low to mod
6	Green frog	Alien	Amphibians	Red-legged frog	Native	Amphibians	Blue	unknown	< 10	unknown	Competition predation	low to mod	low to mod
7	Northern leopard frog	Alien	Amphibians	Red-legged frog	Native	Amphibians	Blue	unknown	unknown	unknown	Predation	low to mod	low to mod
8	Domestic goose	Alien	Birds	Canada Goose, *occidentalis* subspecies	Native	Birds	Blue	< 33	unknown	< 10	Hybridization	low to mod	low to mod
9	Canada goose	Alien	Birds	Garry oak	Native	Ecosystem	Red		< 10	> 50	Habitat alteration	mod to high	mod to high
10	Wild turkey	Alien	Birds	Greater sage-grouse	Native	Birds	Red	< 33	10–50	> 50	Competition	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
11	Wild turkey	Alien	Birds	Sharp-tailed grouse, *columbianus* subspecies	Native	Birds	Blue	< 33	10–50	10–50	Competition	low to mod	mod to high
12	Brown-headed cowbird	Native	Birds	Le Conte's sparrow	Native	Birds	Blue	unknown	< 10	unknown	Competition	mod to high	mod to high
13	Brown-headed cowbird	Native	Birds	Nelson's sharp-tailed sparrow	Native	Birds	Red	unknown	< 10	10–50	Competition	low to mod	low to mod
14	Brown-headed cowbird	Native	Birds	Bay-breasted warbler	Native	Birds	Red	unknown	< 10	10–50	Competition	low to mod	mod to high
15	Brown-headed cowbird	Native	Birds	Cape May warbler	Native	Birds	Red	unknown	< 10	< 10	Competition	low to mod	mod to high
16	Brown-headed cowbird	Native	Birds	Connecticut warbler	Native	Birds	Red	unknown	< 10	unknown	Competition	low to mod	mod to high
17	Brown-headed cowbird	Native	Birds	Black-throated green warbler	Native	Birds	Blue	unknown	< 10	unknown	Competition	low to mod	mod to high
18	Brown-headed cowbird	Native	Birds	Canada warbler	Native	Birds	Blue	unknown	< 10	unknown	Competition	low to mod	mod to high
19	Brown-headed cowbird	Native	Birds	Gray flycatcher	Native	Birds	Blue	unknown	< 10	< 10	Competition	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
20	Brown-headed cowbird	Native	Birds	Yellow-breasted chat	Native	Birds	Red	unknown	< 10	10–50	Competition	low to mod	low to mod
21	Brown-headed cowbird	Native	Birds	Bobolink	Native	Birds	Blue	unknown	< 10	10–50	Competition	low to mod	mod to high
22	House sparrow	Alien	Birds	Western bluebird (Georgia Depression population)	Native	Birds	Red	unknown	< 10	unknown	Competition	low to mod	mod to high
23	House sparrow	Alien	Birds	Purple martin	Native	Birds	Blue	> 66	< 10	< 10	Competition	low to mod	mod to high
24	Barred owl	Native	Birds	Western screech-owl, *kennicotii* subspecies	Native	Birds	Blue	unknown	< 10	10–50	Competition predation	low to mod	mod to high
25	Barred owl	Native	Birds	Western Screech-Owl, *macfarlanei* subspecies	Native	Birds	Red	unknown	< 10	10–50	Competition predation	low to mod	mod to high
26	Barred owl	Native	Birds	Northern pygmy-owl, *swarthi* subspecies	Native	Birds	Blue	unknown	< 10	10–50	Competition predation	low to mod	mod to high
27	Barred owl	Native	Birds	Spotted owl	G3	S1	Red	unknown	< 10	10–50	Competition	mod to high	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
28	European starling	Alien	Birds	Western bluebird (Georgia Depression population)	Native	Birds	Red	unknown	unknown	unknown	Competition	mod to high	mod to high
29	European starling	Alien	Birds	Purple martin	Native	Birds	Blue	unknown	unknown	< 10	Competition	mod to high	mod to high
30	European starling	Alien	Birds	Lewis's woodpecker (Georgia Depression population)	Native	Birds	Red	unknown	unknown	< 10	Competition	mod to high	mod to high
31	Moose	Native	Mammal	Caribou (southern population)	Native	Mammal	Red	34-66	10-50	> 50	Competition predation	mod to high	mod to high
32	Moose	Native	Mammal	Caribou (northern mountain population)	Native	Mammal	Blue	34-66	10-50	10–50	Competition predation	mod to high	mod to high
33	Plains bison	Alien	Mammal	Wood bison	Native	Mammal	Red	unknown	< 10	< 10	Hybridization	mod to high	low to mod
34	Feral dog	Alien	Mammal	Snowshoe Hare, *washingtonii* subspecies	Native	Mammal	Red	unknown	unknown	unknown	Predation	low to mod	mod to high
35	Feral dog	Alien	Mammal	Pacific water shrew	Native	Mammal	Red	unknown	unknown	10–50	Predation	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
36	Coyote	Native	Mammal	Snowshoe hare, *washingtonii* subspecies	Native	Mammal	Red	unknown	unknown	unknown	Predation	low to mod	mod to high
37	Coyote	Native	Mammal	Pacific water shrew	Native	Mammal	Red	unknown	unknown	10–50	Predation	low to mod	mod to high
38	Coyote	Native	Mammal	Trowbridge's shrew	Native	Mammal	Blue	unknown	unknown	unknown	Predation	low to mod	mod to high
39	Beaver	Alien	Mammal	Giant black stickleback	Native	Fish	Red	unknown	unknown	< 10	Habitat alteration	low to mod	mod to high
40	North American opossum	Alien	Mammal	Red-legged frog	Native	Amphibians	Blue	unknown	unknown	unknown	Predation	low to mod	mod to high
41	Feral cat	Alien	Mammal	Short-eared owl	Native	Birds	Blue	unknown	unknown	10–50	Competition predation	low to mod	mod to high
42	Feral cat	Alien	Mammal	Horned Lark, *strigata* subspecies	Native	Birds	Red	unknown	unknown	> 50	Predation	low to mod	mod to high
43	Feral cat	Alien	Mammal	Burrowing owl	Native	Birds	Red	unknown	unknown	> 50	Predation	low to mod	mod to high
44	Feral cat	Alien	Mammal	Western skink	Native	Reptiles	Blue	unknown	unknown	unknown	Predation	low to mod	mod to high
45	Feral cat	Alien	Mammal	Pallid bat	Native	Mammal	Red	unknown	unknown	unknown	Predation	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
46	Feral cat	Alien	Mammal	Snowshoe hare, *washingtonii* subspecies	Native	Mammal	Red	unknown	unknown	unknown	Predation	low to mod	mod to high
47	Feral cat	Alien	Mammal	Ermine, *haidarum* subspecies	Native	Mammal	Red	unknown	unknown	unknown	Predation	low to mod	mod to high
48	Feral cat	Alien	Mammal	Pacific water shrew	Native	Mammal	Red	unknown	unknown	10–50	Predation	low to mod	mod to high
49	Feral cat	Alien	Mammal	Common water shrew, *brooksi* subspecies	Native	Mammal	Red	unknown	unknown	unknown	Predation	low to mod	mod to high
50	Feral cat	Alien	Mammal	Trowbridge's shrew	Native	Mammal	Blue	unknown	unknown	unknown	Predation	low to mod	mod to high
51	Sitka deer	Alien	Mammal	Northern saw-whet owl, *brooksi* subspecies	Native	Birds	Blue	unknown	unknown	10–50	Habitat alteration	low to mod	mod to high
52	Sitka deer	Alien	Mammal	Ermine, *haidarum* subspecies	Native	Mammal	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
53	White-tailed deer	Native	Mammal	Caribou (southern population)	Native	Mammal	Red	34–66	10–50	> 50	Competition predation	low to mod	mod to high
54	European rabbit	Alien	Mammal	Garry oak	Native	Ecosystem	Red	unknown	unknown	> 50	Habitat alteration	low to mod	low to mod

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
55	Raccoon	Alien	Mammal	Cassin's auklet	Native	Birds	Blue	unknown	unknown	< 10	Predation	mod to high	mod to high
56	Raccoon	Alien	Mammal	Ancient murrelet	Native	Birds	Blue	unknown	unknown	10–50	Predation	mod to high	mod to high
57	Raccoon	Alien	Mammal	Ermine, *haidarum* subspecies	Native	Mammal	Red	unknown	unknown	unknown	Predation	mod to high	mod to high
58	Raccoon	Alien	Mammal	Northern saw-whet owl, *brooksi* subspecies	Native	Birds	Blue	unknown	unknown	10–50	Predation	mod to high	mod to high
59	Raccoon	Alien	Mammal	Hairy woodpecker, *picoideus* subspecies	Native	Birds	Blue	unknown	unknown	unknown	Predation	mod to high	mod to high
60	Raccoon	Alien	Mammal	Great blue heron, *fannini* subspecies	Native	Birds	Blue	unknown	unknown	unknown	Predation	mod to high	mod to high
61	Norway rat	Alien	Mammal	Tufted puffin	Native	Birds	Blue	unknown	unknown	< 10	Predation	mod to high	mod to high
62	Black rat	Alien	Mammal	Ermine, *haidarum* subspecies	Native	Mammal	Red	unknown	unknown	unknown	Predation	mod to high	mod to high
63	Black rat	Alien	Mammal	Tufted puffin	Native	Birds	Blue	unknown	unknown	< 10	Predation	mod to high	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
64	Black rat	Alien	Mammal	Cassin's auklet	Native	Birds	Blue	unknown	unknown	< 10	Predation	mod to high	mod to high
65	Black rat	Alien	Mammal	Ancient murrelet	Native	Birds	Blue	unknown	unknown	10–50	Predation	mod to high	mod to high
66	Eastern grey squirrel	Alien	Mammal	Garry oak	Native	Ecosystem	Red	34–66	10–50	> 50	Habitat alteration	mod to high	mod to high
67	Eastern cottontail	Alien	Mammal	Snowshoe hare, *washingtonii* subspecies	Native	Mammal	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
68	Eastern cottontail	Alien	Mammal	Garry oak	Native	Ecosystem	Red	unknown	unknown	> 50	Habitat alteration	mod to high	mod to high
69	Red squirrel	Alien	Mammal	Ermine, *haidarum* subspecies	Native	Mammal	Red	unknown	unknown	unknown		low to mod	low to mod
70	Red squirrel	Alien	Mammal	Northern saw-whet owl, *brooksi* subspecies	Native	Birds	Blue	unknown		10–50	Predation	low to mod	low to mod
71	Black bullhead	Alien	Fish	Molluscs	Native	Molluscs	Red	unknown	< 10	unknown	Predation	low to mod	mod to high
72	Black bullhead	Alien	Fish	Molluscs	Native	Molluscs	Blue	unknown	< 10	unknown	Predation	low to mod	mod to high
73	Brown bullhead (catfish)	Alien	Fish	Enos Lake benthic stickleback	Native	Fish	Red	> 66	< 10	< 10	Competition predation	low to mod	low to mod

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
74	Brown bullhead (catfish)	Alien	Fish	Enos Lake limnetic stickleback	Native	Fish	Red	> 66	< 10	< 10	Competition predation	low to mod	low to mod
75	Brown bullhead (catfish)	Alien	Fish	Paxton Lake limnetic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
76	Brown bullhead (catfish)	Alien	Fish	Paxton Lake benthic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
77	Brown bullhead (catfish)	Alien	Fish	Priest Lake limnetic stickleback	Native	Fish	Red	> 66	< 10	< 10	Competition predation	low to mod	low to mod
78	Brown bullhead (catfish)	Alien	Fish	Priest Lake benthic stickleback	Native	Fish	Red	> 66	< 10	< 10	Competition predation	low to mod	low to mod
79	Brown bullhead (catfish)	Alien	Fish	Balkwill Lake limnetic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
80	Brown bullhead (catfish)	Alien	Fish	Balkwill Lake benthic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
81	Brown bullhead (catfish)	Alien	Fish	Emily Lake benthic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
82	Brown bullhead (catfish)	Alien	Fish	Emily Lake limnetic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
83	Goldfish	Alien	Fish	Fish	Native	Fish	Red	unknown	< 10	unknown	Competition	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
84	Goldfish	Alien	Fish	Fish	Native	Fish	Blue	unknown	< 10	unknown	Competition	low to mod	mod to high
85	Common carp	Alien	Fish	Fish	Native	Fish	Red	unknown	< 10	unknown	Competition predation	low to mod	mod to high
86	Common carp	Alien	Fish	Fish	Native	Fish	Blue	unknown	< 10	unknown	Competition predation	low to mod	mod to high
87	Pumpkinseed	Alien	Fish	Paxton Lake limnetic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
88	Pumpkinseed	Alien	Fish	Paxton Lake benthic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
89	Pumpkinseed	Alien	Fish	Priest Lake limnetic stickleback	Native	Fish	Red	> 66	< 10	< 10	Competition predation	low to mod	low to mod
90	Pumpkinseed	Alien	Fish	Priest Lake benthic stickleback	Native	Fish	Red	> 66	< 10	< 10	Competition predation	low to mod	low to mod
91	Pumpkinseed	Alien	Fish	Balkwill Lake limnetic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
92	Pumpkinseed	Alien	Fish	Balkwill Lake benthic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
93	Pumpkinseed	Alien	Fish	Emily Lake benthic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
94	Pumpkinseed	Alien	Fish	Emily Lake limnetic stickleback	Native	Fish	Red	unknown	< 10	< 10	Predation	mod to high	mod to high
95	Smallmouth bass	Alien	Fish	Red-legged frog	Native	Amphibians	Blue	34-66	10-50	unknown	Predation	low to mod	low to mod
96	Coho salmon	Alien	Fish	Paxton Lake limnetic stickleback	Native	Fish	Red	unknown	unknown	< 10	Predation	low to mod	low to mod
97	Coho salmon	Alien	Fish	Paxton Lake benthic stickleback	Native	Fish	Red	unknown	unknown	< 10	Predation	low to mod	low to mod
98	Fathead minnow	Alien	Fish	Pearl dace	Native	Fish	Blue	unknown	< 10	unknown	Competition	low to mod	mod to high
99	Black crappie	Alien	Fish	Sport fish	Native	Fish	Red	unknown	unknown	unknown	Predation	low to mod	mod to high
100	Black crappie	Alien	Fish	Sport fish	Native	Fish	Blue	unknown	unknown	unknown	Predation	low to mod	mod to high
101	Brown trout	Alien	Fish	Cutthroat trout, *clarki* subspecies	Native	Fish	Blue	< 33	< 10	> 50	Competition predation	low to mod	low to mod
102	Brook trout	Alien	Fish	Fish	Native	Fish	Red	unknown	unknown	unknown	Predation	low to mod	mod to high
103	Brook trout	Alien	Fish	Fish	Native	Fish	Blue	unknown	unknown	unknown	Predation	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
104	Brook trout	Alien	Fish	Amphibians	Native	Amphibians	Red	unknown	unknown	unknown	Predation	low to mod	mod to high
105	Brook trout	Alien	Fish	Amphibians	Native	Amphibians	Blue	unknown	unknown	unknown	Predation	low to mod	mod to high
106	Brook trout	Alien	Fish	Invertebrates	Native	Invertebrates	Red	unknown	unknown	unknown	Predation	low to mod	mod to high
107	Brook trout	Alien	Fish	Invertebrates	Native	Invertebrates	Blue	unknown	unknown	unknown	Predation	low to mod	mod to high
108	Yellow perch	Alien	Fish	Fish	Native	Fish	Red	unknown	> 50	10–50	Competition predation	low to mod	mod to high
109	Yellow perch	Alien	Fish	Fish	Native	Fish	Blue	unknown	> 50	10–50	Competition predation	low to mod	mod to high
110	Walleye	Alien	Fish	Fish	Native	Fish	Red	unknown	< 10	unknown	Predation	low to mod	low to mod
111	Walleye	Alien	Fish	Fish	Native	Fish	Blue	unknown	< 10	unknown	Predation	low to mod	low to mod
112	Sport fish stocking programs	Alien	Fish	Tiger salamander	Native	Amphibians	Red	unknown	unknown	unknown	Predation	low to mod	low to mod
113	Sport fish stocking programs	Alien	Fish	Western ridged mussel	Native	Molluscs	Red	unknown	unknown	10-50	Competition predation	low to mod	mod to high
114	Sport fish stocking programs	Alien	Fish	American white pelican	Native	Birds	Red	unknown	unknown	< 10	Competition predation	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
115	Sport fish stocking programs	Alien	Fish	Ashy pebblesnail	Native	Molluscs	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
116	Sport fish stocking programs	Alien	Fish	Pygmy fossaria	Native	Molluscs	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
117	Sport fish stocking programs	Alien	Fish		Native	Molluscs	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
118	Sport fish stocking programs	Alien	Fish	Swamp fingernailclam	Native	Molluscs	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
119	Sport fish stocking programs	Alien	Fish	Frigid physa	Native	Molluscs	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
120	Sport fish stocking programs	Alien	Fish	Pewter physa	Native	Molluscs	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
121	Sport fish stocking programs	Alien	Fish	Grain physa	Native	Molluscs	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
122	Sport fish stocking programs	Alien	Fish	Thicklip rams-horn	Native	Molluscs	Blue	unknown	unknown		Habitat alteration	low to mod	mod to high
123	Sport fish stocking programs	Alien	Fish	Umbilicate sprite	Native	Molluscs	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
124	Sport fish stocking programs	Alien	Fish	Herrington fingernailclam	Native	Molluscs	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
125	Sport fish stocking programs	Alien	Fish	Abbreviated pondsnail	Native	Molluscs	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
126	Sport fish stocking programs	Alien	Fish	Glossy valvata	Native	Molluscs	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
127	Sport fish stocking programs	Alien	Fish	Dragonflies/ damselflies	Native	Insects	Red	unknown	unknown	unknown	Predation	low to mod	low to mod
128	Sport fish stocking programs	Alien	Fish	Dragonflies/ damselflies	Native	Insects	Blue	unknown	unknown	unknown	Predation	low to mod	low to mod
129	Sport fish stocking programs	Alien	Fish	Amphibians	Native	Amphibians	Red	unknown	unknown	unknown	Predation	mod to high	mod to high
130	Sport fish stocking programs	Alien	Fish	Amphibians	Native	Amphibians	Blue	unknown	unknown	unknown	Predation	mod to high	mod to high
131	Sport fish stocking programs	Alien	Fish	Cutthroat trout, *lewisi* subspecies	Native	Fish	Blue	unknown	unknown	< 10	Hybridization	mod to high	mod to high
132	Molluscs	Alien	Molluscs	Molluscs	Native	Molluscs	Red	unknown	unknown	unknown	Competition	mod to high	mod to high
133	Molluscs	Alien	Molluscs	Molluscs	Native	Molluscs	Blue	unknown	unknown	unknown	Competition	mod to high	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
134	Molluscs	Alien	Molluscs	Oregon forestsnail	Native	Molluscs	Red	unknown	unknown	unknown	Competition	mod to high	mod to high
135	Molluscs	Alien	Molluscs	Puget oregonian	Native	Molluscs	Red	unknown	unknown	10–50	Competition	mod to high	mod to high
136	Molluscs	Alien	Molluscs	Dromedary jumping-slug	Native	Molluscs	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
137	Molluscs	Alien	Molluscs	Warty jumping slug	Native	Molluscs	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
138	Molluscs	Alien	Molluscs	Grain physa	Native	Molluscs	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
139	Molluscs	Alien	Molluscs	Blue-grey taildropper	Native	Molluscs	Red	unknown	unknown	10–50	Competition	low to mod	mod to high
140	Zebra mussel	Alien	Molluscs	Molluscs	Native	Molluscs	Red	unknown	unknown	unknown	Competition	mod to high	mod to high
141	Zebra mussel	Alien	Molluscs	Molluscs	Native	Molluscs	Blue	unknown	unknown	unknown	Competition	mod to high	mod to high
142	Eurasian weeds	Alien	Vascular plants	Mormon metalmark	Native	Insects	Red	unknown	10–50	unknown	Habitat alteration	low to mod	mod to high
143	Noxious weeds	Alien	Vascular plants	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high
144	Noxious weeds	Alien	Vascular plants	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high
145	Russian knapweed	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
146	Russian knapweed	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high
147	Early hairgrass	Alien	Vascular plant	Garry oak	Native	Ecosystem	Red	34–66	unknown	> 50	Habitat alteration	mod to high	mod to high
148	Garlic mustard	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high
149	Garlic mustard	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high
150	European beachgrass	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
151	European beachgrass	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
152	Sand reed	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
153	Sand reed	Alien	Vascular plant	plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
154	Sweet vernalgrass	Alien	Vascular plant	Garry oak	Native	Ecosystem	Red	34–66	10–50	> 50	Competition/ allelopathy	mod to high	mod to high
155	Common burdock	Alien	Vascular plant	Sensitive ecosystems of East VI and Gulf Islands	Native	Ecosystem	Red	unknown	decline	> 50	Competition	mod to high	mod to high
156	Eastern mosquito fern	Alien	Vascular plant	Birds	Native	Birds	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
157	Eastern mosquito fern	Alien	Vascular plant	Birds	Native	Birds	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
158	Eastern mosquito fern	Alien	Vascular plant	Fish	Native	Fish	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
159	Eastern mosquito fern	Alien	Vascular plant	Fish	Native	Fish	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
160	Eastern mosquito fern	Alien	Vascular plant	Aquatic invertebrates	Native	Aquatic invertebrates	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
161	Eastern mosquito fern	Alien	Vascular plant	Aquatic invertebrates	Native	Aquatic invertebrates	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
162	Eastern mosquito fern	Alien	Vascular plant	Aquatic plants	Native	Aquatic plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
163	Eastern mosquito fern	Alien	Vascular plant	Aquatic plants	Native	Aquatic plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
164	European birch	Alien	Vascular plant	Aquatic species	Native	Aquatic species	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
165	European birch	Alien	Vascular plant	Aquatic species	Native	Aquatic species	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
166	European birch	Alien	Vascular plant	Aquatic plants	Native	Aquatic plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
167	European birch	Alien	Vascular plant	Aquatic plants	Native	Aquatic plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
168	Soft brome	Alien	Vascular plant	Garry oak	Native	Ecosystem	Red	unknown	unknown	> 50	Competition	mod to high	mod to high
169	Rip-gut brome	Alien	Vascular plant	Garry oak	Native	Ecosystem	Red	unknown	unknown	> 50	Competition	mod to high	mod to high
170	Barren brome	Alien	Vascular plant	Garry oak	Native	Ecosystem	Red	unknown	unknown	> 50	Competition	mod to high	mod to high
171	Spotted knapweed	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high
172	Spotted knapweed	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high
173	Diffuse knapweed	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high
174	Diffuse knapweed	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition/ allelopathy	mod to high	mod to high
175	Brown knapweed	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition	mod to high	mod to high
176	Brown knapweed	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition	mod to high	mod to high
177	Marsh thistle	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
178	Marsh thistle	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
179	Hedgehog dogtail	Alien	Vascular plant	Garry oak	Native	Ecosystem	Red	34–66	10–50	> 50	Competition	low to mod	mod to high
180	Scotch broom	Alien	Vascular plant	Gopher snake, *catenifer* subspecies	Native	Reptiles	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
181	Scotch broom	Alien	Vascular plant	Vesper sparrow, *affinis* subspecies	Native	Birds	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
182	Scotch broom	Alien	Vascular plant	Horned lark, *strigata* subspecies	Native	Birds	Red	unknown	unknown	> 50	Habitat alteration	low to mod	mod to high
183	Scotch broom	Alien	Vascular plant	Garry oak	Native	Ecosystem	Red	unknown	unknown	> 50	Competition	mod to high	mod to high
184	Scotch broom	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
185	Scotch broom	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
186	Orchard-grass	Alien	Vascular plant	Sensitive ecosystems of East VI and Gulf Islands (incl Garry Oak)	Native	Ecosystem	Red	< 33	decline	unknown	Competition	mod to high	mod to high
187	Spurge-laurel (daphne)	Alien	Vascular plant	Garry oak	Native	Ecosystem	Red	unknown	unknown	> 50	Competition	mod to high	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
188	Leafy spurge	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition/ allelopathy	low to mod	mod to high
189	Leafy spurge	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition/ allelopathy	low to mod	mod to high
190	Herb Robert geranium	Alien	Vascular plant	Sensitive ecosystems of East VI and Gulf Islands	Native	Ecosystem	Red	34–66	decline	unknown	Competition	low to mod	mod to high
191	English ivy	Alien	Vascular plant	Garry Oak	Native	Ecosystem	Red	unknown	unknown	> 50	Competition	mod to high	mod to high
192	Broad-leaved pepper-grass	Alien	Vascular plant	Plants	Native	Vascular plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
193	Broad-leaved pepper-grass	Alien	Vascular plant	Plants	Native	Vascular plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
194	Oxeye daisy	Alien	Vascular plant	Sensitive ecosystems of East VI and Gulf Islands	Native	Ecosystem	Red	unknown	decline	unknown	Competition	mod to high	mod to high
195	Dalmatian toadflax	Alien	Vascular plant	Garry oak	Native	Ecosystem	Red	unknown	unknown	> 50	Competition	mod to high	mod to high
196	Purple loosestrife	Alien	Vascular plant	Birds	Native	Birds	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
197	Purple loosestrife	Alien	Vascular plant	Birds	Native	Birds	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
198	Purple loosestrife	Alien	Vascular plant	Mammal	Native	Mammal	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
199	Purple loosestrife	Alien	Vascular plant	Mammal	Native	Mammal	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
200	Purple loosestrife	Alien	Vascular plant	Plants	Native	Plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
201	Purple loosestrife	Alien	Vascular plant	Plants	Native	Plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
202	Eurasian water-milfoil	Alien	Vascular plant	Fish	Native	Fish	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
203	Eurasian water-milfoil	Alien	Vascular plant	Fish	Native	Fish	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
204	Eurasian water-milfoil	Alien	Vascular plant	Aquatic invertebrates	Native	Aquatic invertebrates	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
205	Eurasian water-milfoil	Alien	Vascular plant	Aquatic invertebrates	Native	Aquatic invertebrates	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
206	Eurasian water-milfoil	Alien	Vascular plant	Aquatic plants	Native	Aquatic plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
207	Eurasian water-milfoil	Alien	Vascular plant	Aquatic plants	Native	Aquatic plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
208	Eurasian water-milfoil	Alien	Vascular plant	Sensitive ecosystems of East VI and Gulf Islands	Native	Ecosystem	Red	unknown	decline	unknown	Competition	mod to high	mod to high
209	Canarygrass	Alien	Vascular plant	Oregon spotted Frog	Native	Amphibians	Red	unknown	unknown	10-50	Habitat alteration	mod to high	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
210	Canarygrass	Alien	Vascular plant	Birds	Native	Birds	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
211	Canarygrass	Alien	Vascular plant	Birds	Native	Birds	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
212	Canarygrass	Alien	Vascular plant	Fish	Native	Fish	Red	unknown	10–50	unknown	Habitat alteration	low to mod	mod to high
213	Canarygrass	Alien	Vascular plant	Fish	Native	Fish	Blue	unknown	10–50	unknown	Habitat alteration	low to mod	mod to high
214	Canarygrass	Alien	Vascular plant	Aquatic invertebrates	Native	Aquatic invertebrates	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
215	Canarygrass	Alien	Vascular plant	Aquatic invertebrates	Native	Aquatic invertebrates	Blue	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
216	Canarygrass	Alien	Vascular plant	Aquatic plants	Native	Aquatic plants	Red	unknown	unknown	unknown	Competition	low to mod	mod to high
217	Canarygrass	Alien	Vascular plant	Aquatic plants	Native	Aquatic plants	Blue	unknown	unknown	unknown	Competition	low to mod	mod to high
218	Giant knotweed	Alien	Vascular plant	Plants	Native	Plants	Red	unknown	10–50	unknown	Competition	low to mod	mod to high
219	Giant knotweed	Alien	Vascular plant	Plants	Native	Plants	Blue	unknown	10–50	unknown	Competition	low to mod	mod to high
220	Giant knotweed	Alien	Vascular plant	Sensitive ecosystems of East VI and Gulf Islands	Native	Ecosystem	Red	unknown	10–50	unknown	Competition	low to mod	mod to high
221	Sulphur cinquefoil	Alien	Vascular plant	Plants	Native	Plants	Red	unknown	unknown	unknown	Competition/ allelopathy	low to mod	mod to high

TABLE C–1 *Continued*

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
222	Sulphur cinquefoil	Alien	Vascular plant	Plants	Native	Plants	Blue	unknown	unknown	unknown	Competition/ allelopathy	low to mod	mod to high
223	Himalayan blackberry	Alien	Vascular plant	Horned Lark, *strigata* subspecies	Native	Birds	Red	unknown	unknown	> 50	Habitat alteration	low to mod	mod to high
224	European glasswort	Alien	Vascular plant	Sensitive wetlands of East VI and Gulf Islands	Native	Ecosystem	Red	unknown	decline	unknown	Competition	low to mod	mod to high
225	European bittersweet	Alien	Vascular plant	Sensitive ecosystems of East VI and Gulf Islands	Native	Ecosystem	Red	unknown	unknown	unknown	Competition	mod to high	mod to high
226	European bittersweet	Alien	Vascular plant	Cottonwood riparian ecosystems of the Southern Interior	Native	Ecosystem	Red	unknown	unknown	unknown	Competition	mod to high	mod to high
227	Common sow-thistle	Alien	Vascular plant	Sensitive ecosystems of East VI and Gulf Islands	Native	Ecosystem	Red	< 33	< 10	unknown	Competition	low to mod	low to mod
228	Gorse	Alien	Vascular plant	Vesper sparrow, *affinis* subspecies	Native	Birds	Red	unknown	unknown	unknown	Habitat alteration	low to mod	mod to high
229	Gorse	Alien	Vascular plant	Horned Lark, *strigata* subspecies	Native	Birds	Red	unknown	unknown	> 50	Habitat alteration	low to mod	mod to high

TABLE C–1 ***Concluded***

Interaction Number	Invasive species (English name)	Type of invasive: native or alien	Invasive group	Species at Risk affected (English name)	Type of Species at Risk: native or alien	Species at Risk group	Species at Risk status (prov. status)	% of Species at Risk range affected (< 33, 34–66, > 66 or unknown)	Trend* of invasive species (increase of < 10, 10–50, > 50 or unknown)	Trend* of Species at Risk (decline of < 10, 10–50, > 50 or unknown)	Type of interaction (i.e., competition, predation)	Extent of research (low to mod or mod to high)	Complexity of problem (low to mod or mod to high)
230	Gorse	Alien	Vascular plant	Sensitive ecosystems of East VI and Gulf Islands (incl. Garry Oak)	Native	Ecosystem	Red	unknown	10–50	unknown	Competition	low to mod	mod to high

Note: *Trend = its trend in population, range, area occupied, and/or condition of occurrences (as defined in CDC conservation status reports 2006). Source: Compiled from other tables in this report.

Appendix D Institutions and individuals currently involved in work on invasive species/Species at Risk interactions

Name	Affiliation	Phone	Email	Specialization
Peter Arcese	University of BC, Faculty of Forestry, Department of Forest Sciences	(604) 822-1886	arcese@interchg.ubc.ca	general, birds, Garry oak
Robb Bennett	BC Ministry of Forests and Range		robb.bennett@gov.bc.ca	invasive spiders and insects
Rebecca Best	University of BC, Faculty of Forestry, Department of Forest Sciences		rbest@interchange.ubc.ca	introduced grasses and geese
Joerg Bohlmann	Michael Smith Laboratories, University of BC	(604) 822-0282	bohlmann@interchange.ubc.ca	plants, insects
Fred Bunnell	University of BC, Faculty of Forestry, Department of Forest Sciences	(604) 822-8287	fbunnell@interchange.ubc.ca	climate change/ rare and endangered
Adolf and Oldriska Ceska	Private consultants	(250) 477-1211	aceska@telus.net	Species at Risk and invasive plants, plants, and fungi
Kai M.A. Chan	University of BC, Institute for Resources, Environment and Sustainability		kaichan@ires.ubc.ca	general
Trudy Chatwin	BC Ministry of Environment, Wildlife Branch	(250) 751-3100	trudy.chatwin@gov.bc.ca	rare and endangered species
David Clements	Trinity Western University, Biology Department	(604) 888-7571	clements@twu.ca	invasive species, Species at Risk, Garry oak
Coastal Invasive Plant Council	Coastal Invasive Plant Council	(250) 857-2472	***http://coastalinvasiveplants.com/contact.php***	invasive plants – extension, coordinating management, inventory, mapping, prevention, and mitigation
Brenda Costanzo	BC Ministry of Environment	(250) 387-9611	brenda.costanzo@gov.bc.ca	plant Species at Risk and invasive plants
Elizabeth Elle	Simon Fraser University Plant Evolutionary Ecology		eelle@sfu.ca	plants, bees, Garry oak ecosystems

Name	Affiliation	Phone	Email	Specialization
Matt Fairbarnes	Private consultant		aruncus_consulting@yahoo.ca	plants
Lauchlan Fraser	Thompson Rivers University, Biology Department		lfraser@tru.ca	invasive and native plants/ conservation fresh water resources
Laura Friis	BC Ministry of Environment	(250) 387-9755	laura.friis@gov.bc.ca	reptiles and amphibians at risk and invasives
Mike Gillingham	University of Northern BC		michael@unbc.ca	invasive species (moose) and caribou
Emily Gonzales	University of BC, Department of Forest Sciences, Faculty of Forestry		phd student under peter arcese emilyg@interchange.ubc.ca	eastern grey squirrels and non-native plants (particularly grasses)
Tim Goater	Malaspina University-College, Biology Department	(250) 753-3245	goatert@mala.bc.ca	bullfrogs/parasites/ invertebrates
Purnima Govindarajulu	University of Victoria, School of Environmental Studies	(250) 721-7354	purnimap@uvic.ca	amphibians and reptiles/ emerging infectious disease
David Green	Simon Fraser University, Department of Biological Sciences		djgreen@sfu.ca	birds
Chris Harley	University of BC, Department of Zoology	(604) 827-3431	harley@zoology.ubc.ca	marine invertebrates and algae
Doug Heard	BC Ministry of Environment	(250) 614-9903	doug.heard@gov.bc.ca	invasive species (moose) and caribou
Brian Heise	Thompson Rivers University, Department of Natural Resource Sciences	(250) 371-5530	bheise@tru.ca	aquatic invertebrates and fish – native as well as invasives and Species at Risk
Margaret Henigman	BC Ministry of Environment	(250) 751-3214	margaret.henigman@gov.bc.ca	plants
Jennifer Heron	BC Ministry of Environment	(604) 222-6759	jennifer.heron@gov.bc.ca	invertebrate Species at Risk specialist

Name	Affiliation	Phone	Email	Specialization
William Hintz	University of Victoria, Department of Biology		whintz@uvic.ca	mycology, plants
Lee Humble	Canadian Forest Service, Natural Resources Canada, Pacific Forestry Centre	(250) 363-0644	lhumble@pfc.cfs.nrcan.gc.ca	arthropods, invasive insects
Duane Jesson	BC Ministry of Environment		duane.jesson@gov.bc.ca	Species at Risk – Texada stickleback
Kelly Jewell	University of BC, Faculty of Forestry, Department of Forest Sciences		contact through p. arcese arcese@interchg.ubc.ca	birds – cowbird
J.P. (Hamish) Kimmins	University of BC, Faculty of Forestry, Department of Forest Sciences	(604) 822-3549	kimmins@interchange.ubc.ca	general –- ecosystem disturbance, ecological succession, biomass, energy and nutrient cycling, climate change effects, ecosystem management models
Brian Klinkenberg	University of BC, Department of Geography	(604) 822-3534	brian@geog.ubc.ca	recovery strategies for Species at Risk, prioritizing Species at Risk and natural habitats, E-Flora list
Rose Klinkenberg	Private consultant		carex@telus.net	Species at Risk and invasive plants
Norbert Kondla	Private consultant		colias@shaw.ca	butterflies
John Krebs	Columbia Basin Fish and Wildlife Compensation Program		john.krebs@bchydro.bc.ca	Species at Risk and invasive species
Maja Krzic	University of BC, Faculty of Forestry/ Faculty of Land and Food Systems,	(604) 822-0252	krzic@interchange.ubc.ca	forest and rangeland soils
Ted Lea	BC Ministry of Environment	(250) 387-1110	ted.lea@gov.bc.ca	plant Species at Risk and invasive plants
Sylvia Letay	BC Ministry of Environment		sylvia.letay@gov.bc.ca	terrestrial exotics

Name	Affiliation	Phone	Email	Specialization
Andrew MacDougall	University of Guelph	(519) 824-4120 ext 5670	amacdo02@uoguelph.ca	Garry oak ecosystems
John McLean	University of BC, Department of Forest Sciences, Faculty of Forestry	(604) 822-3360	john.mclean@ubc.ca	insects, Garry oaks, surveys for invasive insects
Judith Myers	University of BC, Zoology		myers@zoology.ubc.ca	insects/weeds
Stan Orchard	President, BullfrogControl.com Inc., 69A Burnside Road West, Victoria, BC V9A 1B6	(250) 388-5831 or 858-FROG	bullfrogcontrol@shaw.ca www.bullfrogcontrol.com	amphibians/reptiles and research and development of strategies and techniques to manage invasive species worldwide
Imre S. Otvos	Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre	(250) 363-0620	iotvos@pfc.cfs.nrcan.gc.ca	insects – forestry winter moth, Garry oak
Kristina Ovaska	Biolinx Environmental Research Ltd.	(250) 727-9708	kovaska@shaw.ca	amphibians, reptiles, terrestrial gastropods
Nick Page	Raincoast Applied Ecology	(604) 742-9890	napage@interchange.ubc.ca	plants, invertebrates
Mike Pearson	Pearson Ecological		mike@pearsonecological.com	fish Species at Risk, invasive fish, plants, and bullfrogs
Sue Pollard	BC Ministry of Environment		sue.pollard@gov.bc.ca	management of invasive fish species to minimize effect on native species and Species at Risk, risk assessments
Dave Polster	Polster Environmental Services	(250) 746-8052	d.polster@telus.net	Species at Risk and invasive plants, restoration, ecological vegetation management
Brian Reader	Parks Canada		brian.reader@pc.gc.ca	Species at Risk recovery, monitoring, and research

Name	Affiliation	Phone	Email	Specialization
John Richardson	University of BC, Faculty of Forestry, Department of Forest Sciences	(604) 822-3360	jrichard@interchg.ubc.ca	general – invasive species
Kristina Rothley	Simon Fraser University, Biology		krothley@sfu.ca	general
Lisa Scott	South Okanagan-Similkameen Invasive Plant Society		sosips@shaw.ca	invasive plants – extension, coordination, inventory, mapping, prevention, and mitigation
Dale Seip	BC Ministry of Forests and Range, Prince George Forest Region, Wildlife Ecologist		dale.seip@gov.bc.ca	caribou
Rob Serrouya	Columbia Mountains Caribou Project	(250) 837-3878	serrouya@shaw.ca	invasive species (moose/ deer) and caribou
Jackie Shaben	University of BC, Zoology Department/ Jacques Whitford/ Axys		jshaben@jaqueswhitford.com	broom in Garry oak, invasive plants
Pippa Shepherd	Parks Canada, Resource Conservation Western and Northern Service Centre	(604) 666-7378	pippa.shepherd@pc.gc.ca	Garry oak ecosystems recovery planning – proposal development re alien invasive species and Species at Risk interactions
Jonathan Shurin	University of BC, Zoology		shurin@zoology.ubc.ca	general – invasive species
Lennart Sopuck	Biollinx Environmental Research	(250) 655-4602	biolinx@shaw.ca	birds, mammals, terrestrial gastropods
Erin Stoddard	BC Ministry of Environment		erin.stoddard@gov.bc.ca	invasive species and Species at Risk
Eric Taylor	University of BC, Zoology	(604) 822-9152	etaylor@zoology.ubc.ca	fish
Ross Vennesland	Parks Canada – Western and Northern Service Centre	(250) 666-4648	ross.vennesland@pc.gc.ca	species at Risk recovery, monitoring, and research
Carl Walters	University of BC, Zoology		c.walters@fisheries.ubc.ca	fish

Name	Affiliation	Phone	Email	Specialization
Conan Webb	Parks Canada		conan.webb@pc.gc.ca	plants
Kym Welstead	BC Ministry of Environment	(604) 582-5279	kym.welstead@gov.bc.ca	Species at Risk
Robert Wielgus	Washington State University		wielgus@wsu.edu	large mammals
Cory Williamson	BC Ministry of Environment		cory.williamson@gov.bc.ca	feral brook trout
Elke Wind	E. Wind Consulting		ewind@telus.net	impacts of non-native species on aquatic ecosystems and fish and bullfrogs on native amphibians – extension
Paul Wood	University of BC, Forest Resources Management Department	(604) 822-0951	paul.wood@ubc.ca	Species at Risk policies, biodiversity conservation