
Invasive Alien Species Framework for BC: Identifying and Addressing Threats to Biodiversity

*A working document to address issues
associated with biodiversity in British Columbia*

Prepared for:

**Biodiversity Branch
Ministry of Water, Land & Air Protection**

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Preface

The Invasive Alien Species Framework is a background document on invasive alien species issues that affect biodiversity in British Columbia. It sets out a framework for the use of science, and coordinated involvement of partners, to address the threats to BC's environment and economy posed by invasive alien species.

Invasive alien plants and animals present a growing environmental and economic threat to British Columbia. Conservation biologists have globally ranked invasive alien species (or "exotics") as the second most serious threat to species at risk after habitat destruction. Alien species introductions are one of the most important threats to "Red Listed" (endangered or threatened) plants and animals in BC. About a quarter of Canada's species at risk are adversely affected in some way because of alien species.

Invasive alien plant species inflict a heavy toll on agriculture, reducing forage potential and infesting hundreds of thousands of hectares of crop and rangeland in British Columbia. Invasive alien plants reduce crop yields by an average of 10-15% but the effect of some species can be much higher. The loss of cattle forage to knapweed currently costs BC ranchers more than \$400,000 per year, and the loss could exceed \$13 million per year if knapweed spreads to the limits of its range. North American forests are particularly vulnerable to invasions of European and Asian insects, which often out-compete their native counterparts with dramatic negative effects. Invasive alien species can also threaten human health, as illustrated by increased public health concerns surrounding emerging infectious diseases such as the introduced West Nile virus, which can be transmitted to humans by certain species of mosquitoes and other species that feed on the blood of infected birds.

Non-invasive alien species (such as crops, many garden plants, and livestock) are part of our everyday life in British Columbia. It would be neither desirable nor possible to eradicate them from our human and natural landscapes. A measured approach must be adopted that reflects the benefits and enjoyment we receive from alien species as well as the potential economic and environmental costs when they become invasive and result in undesirable outcomes. The framework set out in the paper does not prescribe an answer to these difficult decisions, but rather suggests actions and processes that will allow us to proceed in a manner that is based on the best available scientific and socio-economic information.

The Ministry's Response: Elements of the Invasive Alien Species Framework

The Ministry of Water, Land and Air Protection (MWLAP) promotes a science-informed approach to the conservation of biodiversity that supports improved environmental performance and a strong and vibrant provincial economy. The Biodiversity Branch, with responsibility for biodiversity science, standards and policy, leads the development of strategies and action plans to address issues associated with biodiversity. Using the guidance of documents such as the *Alien Invasive Species Framework*, the Ministry will lead in specific areas under its jurisdiction, such as provincial parks and protected areas, and will work in cooperation with partners who share objectives with the Ministry – providing scientific expertise and information intended to maintain British Columbia's biodiversity and associated environmental, economic and social benefits.

Collaborative leadership, organization and action are key to addressing invasive alien species concerns in British Columbia. As a priority, MWLAP will support coordinated efforts, providing expertise in biodiversity science, policy and standards and other resources as available and feasible.

Recent work in which the Ministry of Water, Land and Air Protection has participated includes:

- Development of an Invasive Plant Strategy for British Columbia, led by the Fraser Basin Council, which includes the formation of a provincial Invasive Plant Council
- Participation on an Inter-ministry Invasive Plant Committee which is involved in the coordination of provincial invasive plant initiatives across the province.
- Development of a Federal/Provincial/Territorial Invasive Species Strategy, including plans dealing with invasive Aquatic Species, Terrestrial Plants and Plant Pests and Terrestrial Animals and Diseases.
- Revision of the Community Charter in order to provide local governments with tools to assist in the effective management, including containment, reduction, control and/or elimination of alien species.
- Investment of financial and human resources – within and outside parks and protected areas

Biodiversity Branch
Ministry of Water, Land and Air Protection
February 2005

Summary of the Framework

This is a working document addressing invasive alien species issues related to biodiversity in British Columbia. It sets out a clear framework for the use of science, and coordinated involvement of partners, to address the threats to BC's environment and economy posed by invasive alien species.

The Invasive Species Threat

Invasive alien species – plants, animals and microbes that are not native to British Columbia and threaten its biodiversity – present a growing environmental and economic threat to the province. Conservation biologists have globally ranked invasive alien species (or “exotics”) as the second most serious threat to species at risk (after habitat destruction). The ecological effects of invasive alien species are often irreversible and, once established, invasive species are extremely difficult and costly to control or eradicate. The threat of invasive alien species varies considerably, based on the invading species in question, the extent of the invasion, and the vulnerability of the ecosystem being invaded. It may also be difficult to determine if an alien species is invasive prior to its introduction to new locations and/or ecosystems.

Threats to Biodiversity

Invasive alien species have had extensive effects on the habitats they have invaded, altering forest fire cycles, nutrient cycling, hydrology and energy budgets in native ecosystems. They can also compete with, prey on, and carry and cause diseases in native species. Alien species introductions are one of the most important threats to “Red Listed” (endangered or threatened) plants and animals in BC. Nationally, about a quarter of Canada's endangered species are at risk in some way because of alien species. Human degradation of natural ecosystems increases the vulnerability of native species to alien species invasions.

Threats to BC's Economy

Invasive alien plant species inflict a heavy toll on agriculture, reducing forage potential and collectively infesting hundreds of thousands of hectares of crop and rangeland in British Columbia. Invasive alien plants reduce crop yields by an average of 10-15% but the effect of some species can be much higher. Knapweed, for example, can reduce forage potential by up to 90%. Knapweed species alone infest more than 40,000 hectares in BC, with the potential to spread to one million hectares of grassland range and fringe forest. The loss of cattle forage to knapweed currently costs BC ranchers more than \$400,000 per year, and the loss could exceed \$13 million per year if knapweed spreads to the limits of its range.

North American forests are particularly vulnerable to invasions of European and Asian insects, which often out-compete their native counterparts with dramatic effects on forests – losses caused by alien forest pests in the United States are estimated to exceed \$2 billion (US) per year. Invasive alien species can also threaten human health, as illustrated by increased public health concerns surrounding emerging infectious diseases such as the introduced West Nile virus, a virus that is transmitted to humans by mosquitoes and other species that feed on the blood of infected birds.

The Ministry's Response: Elements of the Invasive Alien Species Framework

The Ministry of Water, Land and Air Protection promotes a science-informed approach to the conservation of biodiversity – supporting a strong and vibrant provincial economy, as well as improving environmental performance. The Biodiversity Branch of the Ministry – with responsibility for biodiversity science, standards and policy – is presently leading development of strategies and action plans to address issues associated with biodiversity. As the Alien Invasive Species Framework and associated strategies and action plans are implemented, the Ministry will lead in specific areas under its

jurisdiction and work in cooperation with partners who have objectives in common with the Ministry – providing scientific expertise and information intended to protect and maintain British Columbia’s biodiversity and sustain economic activities.

This strategic framework for addressing the threat of Invasive Alien Species to British Columbia includes:

- ◆ A *vision* and *mission* statement, congruent with other strategies and action plans addressing issues associated with biodiversity;
- ◆ Identified *drivers* that provide the impetus for framework development and implementation;
- ◆ *Objectives*, establishing clear statements for directing Ministry effort and assessing effectiveness; and
- ◆ *Action areas* for Ministry activities, most commonly undertaken in cooperation with partners, to achieve the framework’s objectives and vision.

Objectives

Work with partners to achieve the following objectives:

1. To reduce the likelihood of alien species invasions by decreasing stresses to vulnerable at-risk ecosystems and species.
2. To prevent both intentional and accidental introductions of harmful invasive alien species to the freshwater, marine or terrestrial realms of British Columbia.
3. To enable early detection of, and rapid response to, invasive alien species occurrences in BC.
4. To undertake effective control and management strategies for invasive alien species occurrences in BC – in a manner that does not put native species and natural ecosystems at risk.
5. To restore native species and habitat conditions in at-risk ecosystems that have been invaded by alien species, and to encourage use of ecological restoration as a means of invasive alien species control and management.

Action Areas

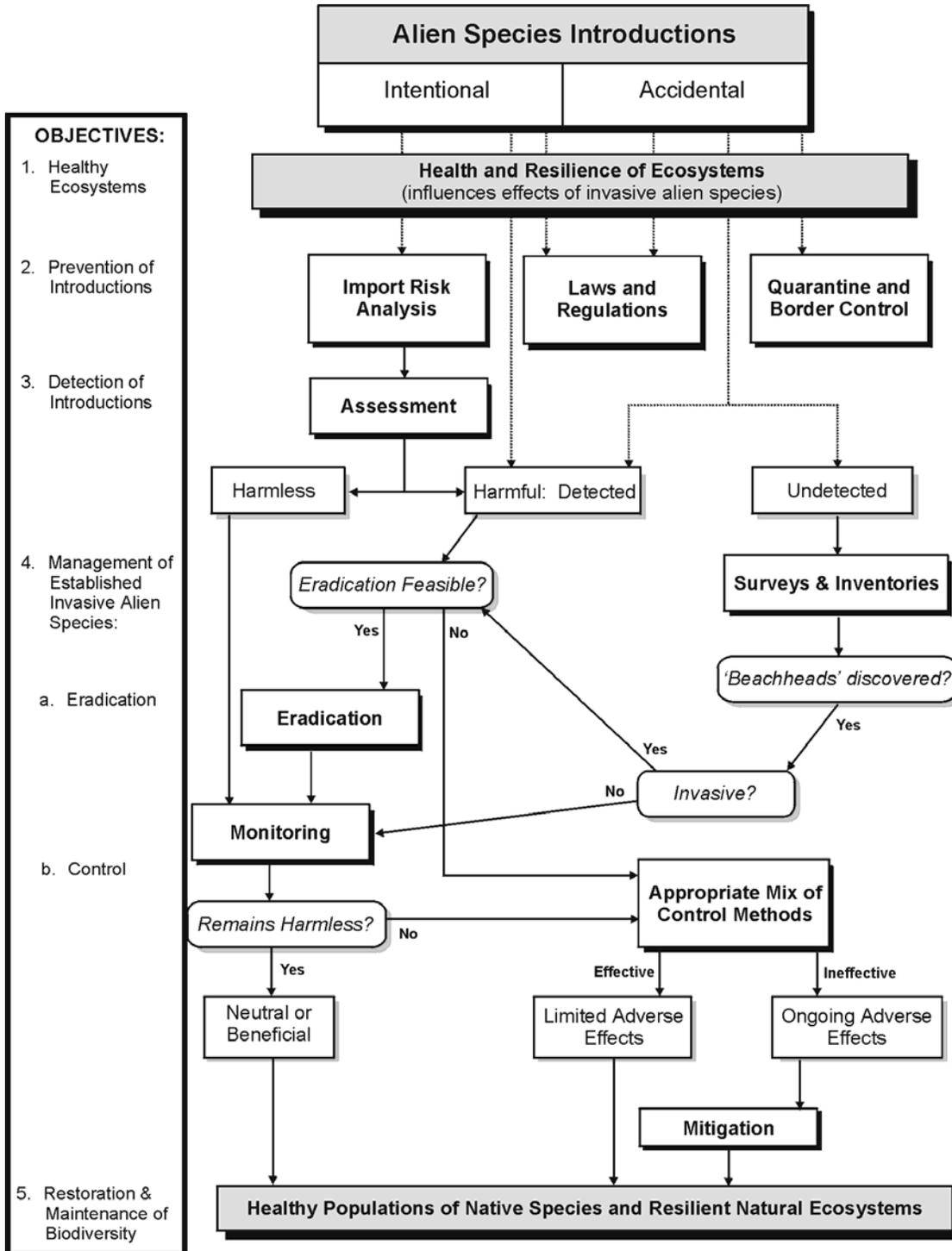
Work with partners in activities that support achieving strategic objectives in the following action areas:

- A. Leadership and coordination initiatives.
- B. Science-informed inventories, risk assessment and monitoring.
- C. Information and awareness.
- D. Development, implementation and assessment of effective management measures.
- E. Policy direction and effective legislation and regulations to minimize and address threats of invasive alien species to British Columbia’s environment, economy and human health.

Cooperative leadership and organization is a central element of addressing invasive alien species concerns in British Columbia. As a priority, MWLAP will support coordinated efforts, providing expertise in biodiversity science, policy and standards and other resources as available and feasible.

Invasive Alien Species Decision and Management Matrix

This figure is a schematic summary of the relationships between objectives, key tools and decisions involved in the management of invasive alien species.



BC Ecosystems of Particular Vulnerability to Alien Species Invasions

1. Southern Interior Valleys – Grassland Ecosystems

Unforested dry grasslands cover less than 0.5% of BC's land area while supporting the only Canadian populations of several species and 23 nationally listed at-risk species. The introduction of invasive alien species, such as largemouth bass, purple loosestrife and European starling, has negatively affected native species and habitats in the area. As well, fire suppression has had significant effects on wildlife habitat and has facilitated the spread of alien plant species such as cheatgrass (*Bromus tectorum*). The South Okanagan and Similkameen valleys for example, are among the three most biologically diverse areas in Canada, as well as being among the three most endangered ecosystems in the nation.

2. Pacific Coastal Islands

Island species, notably nesting seabirds, lack defenses against grazing or predation and are particularly vulnerable to introduced species. The isolation of the Pacific Coastal Islands, notably the Queen Charlotte Islands (Haida Gwaii) from mainland populations has also led to the evolution of endemic mammals of special conservation interest. The most disruptive species include herbivores (such as deer and rabbits), vertebrate and invertebrate predators (including rats and raccoons), species that can alter ecosystem-level characteristics and species that are able to colonize undisturbed native ecosystems (such as grasses).

3. Eastern Vancouver Island – Garry Oak Meadow Ecosystem

Many invasive alien species that threaten biodiversity are present in the Lower Fraser Valley, along the Sunshine Coast and across eastern Vancouver Island. In part, this concentration of invasive species is due to the influence of human settlement and activities (habitat disturbance, port and other transportation pathways, and land uses such as cultivated gardens). Wetlands and other biologically diverse areas in the region are also of ecological importance. The Garry oak (*Quercus garryana*) meadow ecosystem along the southeastern coast of Vancouver Island and the Gulf Islands is under particular threat to alien species invasions. With much less than 5% of the original habitat remaining in a near-natural condition, and 91 species provincially-designated as at risk, the ecosystem is both biologically rich and very vulnerable. The introduction of European species, combined with suppression of fire and habitat destruction, has resulted in substantial changes to the Garry oak meadow community – introduced grasses, for example, now likely make up over 90% of the herb layer biomass.

4. Freshwater Ecosystems: River and Lake Systems, Wetland Habitats and Coastal Estuaries

Freshwater species are among the most threatened of all taxa groups – their extinction rate is predicted to be five times faster than all other groups of species and at a rate equal to that of forest species in the world's tropics. Invasive alien species are thought to be the cause of over 70% of this century's extinctions of native freshwater species and are a significant impediment to recovery of species at risk. Although threats from invasive alien fish species (through both unauthorized public introductions and past intentional (stocking) programs) are concentrated in the southern half of British Columbia, almost all aquatic habitats in the province are vulnerable.

Wetlands – which cover just over 6% of BC – are very productive biologically, rich in biodiversity (notably amphibians, reptiles, aquatic invertebrates, insects and aquatic vegetation) and are vital staging and resting areas for migratory birds. Coastal estuaries are of particular importance. Although the northeastern portion of BC contains the highest proportion of wetlands, it is the Pacific coastal and mountain wetlands that are currently most threatened by alien species invasions. Wetlands along the bottoms of the large valleys of southern BC are also important and vulnerable to invasive alien species (as well as destruction and degradation). Alien species threatening wetlands include plants, such as purple loosestrife, and intentionally and unintentionally introduced fish. Coastal habitats are particularly susceptible to trans-boundary invasions of alien species through ocean currents and international shipping.

Acronyms and Abbreviations

ANS	Aquatic Nuisance Species
BC	British Columbia
BGC	Biogeoclimatic Ecological Classification (system)
CBD	Convention on Biological Diversity
CESCC	Canadian Endangered Species Conservation Council
CDC	Conservation Data Centre
CEC	(North American) Commission for Environmental Cooperation
CFIA	Canadian Food Inspection Agency
CITES	Convention for International Trade in Wild Fauna and Flora
FAO	Food and Agriculture Organization
GISP	Global Invasive Species Program
GMO/LMO	Genetically-modified organism/Living modified organism
IAS	Invasive Alien Species
ICAO	International Civil Aviation Organization
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
ISSG	Invasive Species Specialist Group
IUCN	The World Conservation Union
IMO	International Maritime Organization
MWLAP	Ministry of Water, Land and Air Protection
MOU	Memorandum of Understanding
NAFTA	North American Free Trade Agreement
NGO	Non-government Organization
SOE	State of Environment (Reporting)
UN	United Nations
US	United States
WHO	World Health Organization
WTO	World Trade Organization

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1. Introduction

This is a working document addressing invasive alien species issues related to biodiversity in British Columbia. It sets out a clear framework for the use of science, and coordinated involvement of partners, to address the threats to British Columbia's environment and economy posed by invasive alien species.

The Ministry of Water, Land and Air Protection promotes a science-informed approach to the conservation of biodiversity, supporting a strong and vibrant provincial economy, as well as improving environmental performance. The Biodiversity Branch, with responsibility for biodiversity science, standards and policy, is presently leading development of strategies and action plans addressing issues associated with biodiversity in British Columbia. As the Alien Invasive Species Framework and associated strategies and action plans are implemented, the Ministry will lead in specific areas under its jurisdiction and, most commonly, work with partners in a supporting role, providing scientific expertise and information intended to protect and maintain British Columbia's biodiversity.

The document contains the following sections:

- ◆ Summary of the Framework;
- ◆ Acronyms used in the document;
- ◆ Introduction and background (Section 1);
- ◆ A rationale explaining the threats to British Columbia's environment and economy posed by invasive alien species and the "drivers" behind development of the framework (Section 2);
- ◆ An overview of the Framework, including schematic diagrams (Section 3);
- ◆ The five strategic objectives, and associated priority activities, identified in the framework: Objective 1) decreasing stresses to at-risk or high value ecosystems and native species; Objective 2) preventing introduction of invasive alien species; Objective 3) enabling early detection and rapid response to alien species occurrences; Objective 4) establishing effective control and management strategies; and Objective 5) providing for restoration of native species and habitat conditions (Sections 4-8);
- ◆ Action areas and further priority activities: Action Area A) leadership and coordination; Action Area B) inventories, risk assessment and monitoring; Action Area C) information and awareness; Action Area D) management measures; and Action Area E) policy and legislation (Section 9);
- ◆ Specific summaries of threats and priority actions of invasive alien species for marine and freshwater aquatic ecosystems in British Columbia (Section 10);
- ◆ A description of the methodologies used to map the threat of invasive alien species to biodiversity in BC for marine, terrestrial and freshwater realms, including ratings of the susceptibility of ecosystems to alien species invasions by biogeoclimatic subzone, and ratings of a "short-list" of known invasive alien species in BC using an approach recently developed by NatureServe (Section 11);
- ◆ Definitions of technical terms associated with alien species (Section 12);
- ◆ References, with internet links to materials where available (Section 13); and
- ◆ Appendices, listing: i) summaries of international and federal agreements and legislation related to alien species; ii) selected websites pertaining to invasive species; and iii) a brief description of the NatureServe methodology, and the detailed scores and cumulative rating of the initial "sample short-list" of invasive alien species, used to produce the spatial assessment of invasive alien species threats to biodiversity in BC.

Endnotes, providing supplementary information and references, are included at the conclusion of each section.

Preparation Team and Acknowledgements

This document has been prepared under contract to the Biodiversity Branch of the Ministry of Water, Land and Air Protection, with input from the Invasive Alien Species Working Group of the Ministry, led by Ted Lea. Members of the Invasive Alien Species Working Group are Jordan Rosenfeld, Laura Darling, Laura Friis, Juanita Ptolemy, Helen Schwantje, Myke Chutter, Tim Yesaki, Dave Fraser, Cindy Haddow and Patrick Daigle. The contractor team was led by Colin Rankin of C. Rankin & Associates, with expert support provided by Syd Cannings, Jacqueline Booth, Kristy Ciruna of the Nature Conservancy of Canada and Bill Harper of Osiris Wildlife Consulting. Spatial assessment and mapping products were prepared by a team from Madrone Environmental Services Ltd., led by Jeff Bertoia, with support from Tania Tripp and Harry Williams. Document editing and publishing services have been provided by Louise Beinhauer of Word Works, Victoria.

The team that developed the framework would like to thank all those who contributed their time and expertise to the initiative. Any errors remain the responsibility of the authors. If you have comments or questions concerning the document or the Ministry's efforts to address alien species threats, please contact Ted Lea of the Biodiversity Branch, Ministry of Water, Land and Air Protection.

2. Why Does British Columbia Need an Invasive Alien Species Framework?

“Global trade has enabled modern societies to benefit from the unprecedented movement and establishment of species around the world. Agriculture, forestry, fisheries, the pet trade, the horticultural industry, and many industrial consumers of raw materials today depend on species that are native to distant parts of the world. The lives of people everywhere have been greatly enriched by their access to a greater share of the world’s biodiversity. Expanding global trade is providing additional opportunities for societal enrichment. These movements of species by humans are also having, in some cases, negative effects on local ecosystems and the species of which they are composed. Local and national economies are also being affected. A new challenge is to identify when these alien or non-indigenous species are bringing about changes that are harmful to ecosystems, biodiversity, health, economics or other aspects of human welfare...Invasive species are now recognized as one of the greatest biological threats to our planet’s environmental and economic well-being.”¹

Invasive alien species², plants, animals and microbes that are not native to British Columbia and threaten its biodiversity, present a growing environmental and economic threat to the province. Globally, conservation biologists rank invasive alien species (or “exotics”) as the second most serious threat to species at risk after habitat destruction.³ The ecological effects of alien species are often irreversible and, once established, invasive species are extremely difficult and costly to control or eradicate.

Drivers to the Invasive Alien Species Framework

The following six factors provide the driving rationale (or “drivers”) for development and implementation of British Columbia’s Invasive Alien Species Framework. Their relationship with other elements of the framework is described in the following section, and in Figure 5: Strategic Framework, page 14.

1. Threats to BC’s Environment

Invasive alien species have had extensive effects on the habitats they have invaded, altering forest fire cycles, nutrient cycling, hydrology, and energy budgets in native ecosystems. They can also compete with, prey on, and carry and cause diseases in native species.⁴ Alien species introductions are one of the most important threats to “Red Listed” plants and animals at risk in BC.⁵ Nationally, about a quarter of Canada’s listed species at risk are threatened in some way because of alien species.⁶ Human degradation of natural ecosystems increases the vulnerability of some native species to alien species invasions. The threat of invasive alien species varies considerably, based on the invading species in question, the extent of the invasion, and the vulnerability of the ecosystem being invaded.

Invasive alien species can produce major ecological effects through habitat change, competition, predation, disease and hybridization.⁷ Invasive alien species may have multiple effects and may interact to amplify these effects. The effects may also worsen through time, sometimes through rapid population explosions after a long period of innocuous and restricted presence in an area. It may also be difficult to determine if an alien species is invasive prior to its introduction to new locations and/or ecosystems. While only a minority of alien species become invasive, it is not presently possible to effectively predict all the species that will have substantial adverse effects, relative to those that will remain relatively innocuous.

While the absolute number of alien species causing harm to native ecosystems and species may be low, individually and cumulatively they have had extensive negative effects in Canada.⁸ However, information

specific to British Columbia or Canada on the harmful effects from invasive species is widely scattered, highly variable in quality and scientific rigour, and concentrated on effects related to economic rather than ecological interests.

Ecological effects of invasive alien species can include:

- ◆ Changes in physical habitat;
- ◆ Changes in environmental regimes (e.g., hydrological, disturbance, water or soil chemistry);
- ◆ Alterations to connectivity (e.g., travel or habitat corridors);
- ◆ Effects on biological communities; and/or
- ◆ Species population or genetic effects.

(See endnote 7 at the end of this section for a more complete table of effects.)

2. Threats to BC's Economy and Public Health

Invasive alien plant species inflict a heavy toll on agriculture, reducing forage potential and collectively infesting hundreds of thousands of hectares of crop and rangeland in British Columbia. Invasive plants

reduce crop yields by an average of 10-15% but the adverse effects of some species can be much higher. Knapweed, for example, can reduce forage potential by up to 90%. Knapweed species alone presently infest more than 40,000 hectares in BC, with the potential to spread to one million hectares of grassland range and fringe forest. The loss of cattle forage to knapweed currently costs BC ranchers more than \$400,000 per year, and the loss could exceed \$13 million per year if knapweed spreads to the limits of its range.⁹

North American forests are particularly vulnerable to invasions of European and Asian insects, which often out-compete their native counterparts with dramatic effects on forests. Losses caused by alien forest pests in the United States are estimated to exceed \$2 billion (US) per

year.¹⁰ Invasive alien species can also threaten human health, as illustrated by increased public health concerns surrounding emerging infectious diseases such as the introduced West Nile virus, a virus that is transmitted to humans by mosquitoes and other species that feed on the blood of infected birds.¹¹

Figure 1: Some Ecological Effects of Invasive Alien Species

Alien species can:

- ◆ Out-compete native flora and fauna, including species at risk
- ◆ Alter or destroy the natural habitat of native species
- ◆ Prey on native species
- ◆ Eat or defoliate native flora (herbivory)
- ◆ Cause, carry and disseminate diseases
- ◆ Hybridize with native species
- ◆ Initiate complex effects and combinations of effects, weakening native species and altering natural ecosystems
- ◆ Through synergism with other alien species, lead to "invasional meltdown"

Figure 2: Some Socio-Economic Effects of Invasive Alien Species

Alien species can:

- ◆ Destroy grazing habitat for livestock or wildlife using rangelands
- ◆ Reduce yield and quality of agricultural crops
- ◆ Interfere with the regeneration of forests
- ◆ Increase wildfire hazard
- ◆ Increase soil erosion and stream sedimentation
- ◆ Degrade water quality
- ◆ Destroy habitat of fish and other aquatic organisms used for commercial or recreational purposes
- ◆ Reduce yields of commercial fisheries
- ◆ Increase costs for maintaining resources and public utilities
- ◆ Decrease land values
- ◆ Clog waterways used for swimming and boating
- ◆ Endanger public and animal health and safety
- ◆ Decrease the value of marketable livestock
- ◆ Destroy recreational opportunities
- ◆ Replace understory botanical products

Invasive alien species can have both market and non-market effects. Market effects, such as loss of cropland productivity due to invasive alien plant infestations, result in clear changes to productivity or costs, negatively affecting gross domestic product, as well as affecting individuals and/or businesses and communities. Non-market effects of invasive alien species relate to non-monetized goods and services, such as air quality and natural capital, and can affect human health and quality of life. Non-market effects often have significant “secondary” (and unquantified) monetary costs (such as demands on health care services).¹²

3. Government Commitments – Role of the Ministry of Water, Land and Air Protection

The British Columbia Government and the Ministry of Water, Land and Air Protection (MWLAP) are committed to protecting and enhancing the quality of the province’s environment. The Ministry supports a science-informed approach to the conservation of biodiversity, promoting a strong and vibrant provincial economy, as well as improving environmental performance. The Ministry has set out explicit objectives and strategies with the goal of maintaining and restoring the natural diversity of ecosystems, and fish and wildlife species and their habitats under the core business area of environmental stewardship.¹³ MWLAP is also explicitly responsible for the management of about 14% of the province’s land base, primarily under various protected area designations (e.g., provincial park, ecological reserve) and, as such, is responsible for the control and management of invasive alien species on those lands and waters. This Invasive Alien Species Framework is an example of a “made-in-BC” approach to addressing issues associated with biodiversity in the province. It is intended to support: the development of clear strategies and action plans; assessment of effective legislation and regulations to protect and restore ecosystems, species and their habitats; improved use of science for the development of standards and for effective monitoring and reporting; and increased partnerships to conserve ecosystems, species and their habitats.

The Biodiversity Branch is responsible for biodiversity science, standards and policy for the Ministry. The Biodiversity Branch will work together with government agencies and other partners to support a science-informed approach to the conservation of biodiversity, promoting a strong and vibrant provincial economy, as well as improving environmental performance. This framework is a working document to address invasive alien species issues associated with biodiversity in British Columbia. It sets out a clear framework for the use of science, and coordinated involvement of partners, to address the threats to BC’s environment and economy posed by alien species.

MWLAP is committed to implementing made-in-BC strategies and action plans to address issues associated with biodiversity. These include provincial commitments and actions aimed to maintain and restore

biodiversity, building on the Canadian Biodiversity Strategy (1995) endorsed by all of the provinces and the federal government, and the United Nations Convention on the Conservation of Biological Diversity (CBD) (1992). Provisions, commitments and resolutions to address the threats posed by invasive alien

Figure 3: Overview of Key Terms (See section 12, for a complete list of definitions.)

Invasive alien species: an alien species (a species, subspecies, or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce), whose introduction and/or spread threaten biological diversity (Global Invasive Species Program – Decision VI/23/COP6). Often referred to as, but not necessarily synonymous with: weeds, pests, exotics, noxious species. (Acronym: IAS.) It may not be known whether an alien species is invasive until after it has been introduced to a new environment or ecosystem.

Native species (synonyms: indigenous species): a species, subspecies or lower taxon living within its natural range.

Noxious Weed: a harmful invasive plant designated under the *BC Weed Control Act* (or other legislation).

Weeds (synonyms: plant pests, harmful species, noxious plants, problem plants): Plants (not necessarily alien) that grow in sites where they are not wanted and have detectable negative economic or environmental effects; non-native weeds are invasive alien species.

species are a component of many international agreements, as well as federal and provincial legislation. These provisions are discussed in detail in Section 9, page 48 and in Appendix 1 of this Framework.

4. Legislative Responsibilities

British Columbia has several statutes addressing issues associated with invasive alien species. However, there is not a core policy and legislative framework of common elements, goals and definitions nor has a concerted attempt been made to harmonize the relevant laws and regulations to ensure uniform and consistent practice. As well, there are gaps in addressing maintenance and restoration of biological diversity in legislation and policy. Relevant provincial legislation includes the *Weed Control Act* (RSBC 1996) and an associated Provincial and Regional District Noxious Weed List (Schedule A). The *Wildlife Act* and *Fisheries Act* (RSBC 1996) and associated *Regulations* also have some provisions for protecting native fish and wildlife, and controlling the introduction of alien species. The *Fur Farm* and *Game Farm Acts* (RSBC 1996) also address elements of invasive alien species threats to biodiversity and contain regulatory provisions.

As invasive alien species relate to inter-provincial and international trade and transport and other federal responsibilities, there are many federal acts and regulations related to invasive alien species that affect British Columbians. These include (among many others summarized in Appendix 1¹⁴) the *Plant Protection Act*, *Seeds Act*, *Weed Seeds Order*, *Wild Animal and Plant Protection and Regulation of International and Inter-provincial Trade Act* (WAPPRIITA),

Feeds Act, *Fisheries Act*, *Fish Inspection Act*, *Health of Animals Act*, *Canadian Agricultural Products Act* and the *Canada Shipping Act*. As with provincial legislation, there has not been a concerted attempt to rationalize the many pieces of legislation in order to establish a consistent and effective legislative framework that addresses the threats that alien species pose to the country, including B.C.¹⁵

Figure 4: Costs and Benefits of Early Detection of Gypsy Moth in BC – A Case for Partnership

The Gypsy moth (*Lymantria dispar*), was brought intentionally from Europe to North America in the late 1800s. It feeds on a wide variety of mostly broadleaf tree hosts. The Asian Gypsy moth (*Lymantria dispar ssp.*) also feeds on coniferous tree species. Since its release in the eastern US, the moth has spread across NE states and east and central Canada despite several efforts to establish barrier zones. On the west coast, individual infestations of Gypsy moth have been found in BC, Washington and Oregon since 1911, however, the moth has not yet become established on the Pacific coast.

The Canadian Food Inspection Agency (CFIA) currently maintains a detection network of 8-10,000 gypsy moth pheromone traps in BC at a cost of about \$250,000 per year. When an infestation occurs, eradication efforts (e.g., aerial spraying of the bacterial insecticide btk) have a significant cost, \$6.5 million was spent to eradicate the moth from 19,000 ha in Vancouver and \$3.7 million was spent in 1999 to treat 13,000 ha of southern Vancouver Island. However, if BC was infested with Gypsy moth, the provincial government estimates annual losses would exceed \$20 million and so is committed to maintaining “Gypsy moth-free” status in the province.

The national scope of the existing and potential areas of Canada that are threatened by Gypsy moth mean that federal leadership is required for an effective program to prevent infestation of western Canada by the insect. Successful implementation, however, will involve a partnership among federal and provincial agencies and the private sector. While the federal government has the legislated authority for critical aspects of the issue (e.g., through the *Plant Protection Act*, see Appendix 1**), British Columbia’s government and private sector have the operational capacity of supporting the monitoring, inspection, auditing and information gathering elements of a prevention, detection and rapid response system. The BC government may need to assume leadership given the magnitude of potential losses if the Gypsy moth becomes established in the province. Both the public and private sector would benefit directly from a close partnership with the goal of maintaining Gypsy moth-free status for BC.

Statistics and information drawn from a case study by Vince Nealis in Claudi et al., pp.: 151-159.

5. Trade Relationships

Invasive alien species can seriously damage or destroy native commercial species or make them unacceptable for export. Infection or infestation of commercially exported species can cause trading partners to impose restrictions on British Columbia goods, with potentially enormous costs to the economy. BC's heavy reliance on exports of natural resources and agricultural products makes it vulnerable to trade sanctions or disputes and their consequences.

Effects on trade associated with invasive alien species occurrences are real and significant. For example, in October 2000, the US Department of Agriculture imposed a prohibition on all imports of Prince Edward Island potatoes because of an occurrence of the potato wart virus. Although the ban was lifted within six months, the costs stemming from lost sales, compensation and lost employment were as much as \$83.5 million.¹⁶ In British Columbia, the potential cost of quarantine is a primary incentive for monitoring and eradicating gypsy moth. If a gypsy moth infestation occurs in BC, annual costs of quarantine measures would likely exceed \$20 million, mostly from the nursery sector.¹⁷ Movement and export of raw logs would affect forestry exports and, perhaps most importantly, trading relationships would likely be severely damaged as British Columbia and states in the Western US have jointly committed to keep gypsy moth out of the region (See Gypsy Moth Case Study, Figure 4, page 6).

6. Support from Public and Potential Partners

Farmers, ranchers, scientists, local government representatives and outdoor enthusiasts – among many others, have long recognized the adverse effects of alien species on the Province's environment and economy. As any farmer or rancher who has attempted to control weeds on crop or rangelands can attest, effective management of invasive plants depends on shared awareness, cooperative effort and persistence, and prevention is the best approach! An effective response to the threats posed by invasive alien species will depend on the engagement and cooperation of many partners, including several provincial Ministries, and federal and local governments. Both leadership and coordination is needed. An example of the support that exists among partners to address invasive alien species concerns is the development of an *Invasive Plant Strategy for British Columbia* in 2004, concurrent with establishment of a Noxious Weed Sub-committee of the Government Caucus Committee on Natural Resources and the Economy. The Fraser Basin Council has acted as the initial coordinating and facilitating body for the initiative.¹⁸

Section Endnotes:

¹ McNeely, J.A., H.A. Mooney, L.E. Neville, P. Schei and J.K. Waage (eds.) 2001. *A Global Strategy on Invasive Alien Species*. IUCN Gland Switzerland, and Cambridge UK, in collaboration with the Global Invasive Species Programme, p.1. There are two estimates of the economic costs of invasive species at the national level, both relating to the United States. In 1993, the US Office of Technology Assessment (OTA) estimated cumulative damage costs from 79 particularly harmful species over the preceding 85 years at \$97 billion (US). Pimental et al. in 2000 estimated the damage costs from a much wider set of invasive species to be \$137 billion (US). This estimate still likely understates the costs, as it deals only with a subset of the effects of invasive alien species. The full economic costs of biological invasions include more than the direct damage or control costs of invasive species. They also include the effects of invasives on host ecosystems, and on the human populations dependent on them. No estimates currently exist concerning the value of the more widespread effects of invasions. Invasive alien species, for example, are one of the main causes of extinctions world wide. They have also disrupted key ecological functions in many systems, with far-reaching implications for economic activities supported by those systems. Indeed, most ecosystem types (terrestrial, freshwater and marine, animal, plant and microbial) have been affected to a greater or lesser extent by invasions – but the economic implications of these interspecific (or “indirect”) effects have not been quantified. See Charles Perrings, et al. (2002) for a more detailed economic perspective on biological invasion risks and additional references (www.consecol.org/vol6/iss1/art1).

² The Global Invasive Species Program (GISP) defines an invasive alien species as: an alien species (a species, subspecies, or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes,

seeds, eggs, or propagules of such species that might survive and subsequently reproduce), whose introduction and/or spread threaten biological diversity (Decision VI/23/COP6). Complete definitions of key terms used in this document are included in Section 12, page 77. See also Figure 3, page 5 for a summary of common terms and their definitions.

³ Hill, Barry, 2003. Testimony before the Subcommittee on Fisheries, Wildlife, and Water, Committee on Environment and Public Works, United States Senate. *Invasive Species: Federal Efforts and State Perspectives on Challenges and National Leadership*. United States General Accounting Office, June 17, 2003. www.gao.gov/cgi-bin/getrpt?GAO-030916T. See, also Wilcove, D.S., D. Rothstein, J. Dubrow, A. Phillips, E. Losos, 1998 and 2000. Wilcove et al. examined the causes of imperilment for the 1,880 species whose existence in the United States was recognized as threatened. They found habitat loss to be the most common problem (85% of all imperiled species), followed by alien species (49%), which exceeded the sum of the next three most common factors, pollution (24%), over-exploitation (17%) and disease (3%).

⁴ For a concise overview and description of the effects of alien species on the environment, see Daniel Simberloff, *Ecological and Economic Impacts of Alien Species: A Phenomenal Global Change* Pages 29-39, in Claudi, Renate, et al. 2002. *Alien Invaders in Canada’s Waters, Wetlands, and Forests*.

⁵ BC State of Environment Reporting 2002. www.wlapwww.gov.bc.ca/soerpt/2risk/importance.html

⁶ Environment Canada. 2002. The threat of invasive alien species in Canada’s terrestrial and freshwater ecosystems: reporting on the state of Canada’s environment. Draft September 2002.

⁷ Ciruna, K. 2003 (in press) has listed in the table below some of the ecological effects of invasive alien species on aquatic ecosystems by “type” (e.g., changes in environmental regimes, habitat changes, effects on populations) and “means” (or sub-type). Such effects can be pervasive and profound, but may go unnoticed or unattributed due to the complex and interconnected ecological processes involved.

Ecological Effects	Means of Influence
Change in Physical Habitat	Loss of native habitat
	Creation of non-native habitat and ecological niches
	Loss of native habitat heterogeneity/complexity
	Alteration of natural riparian habitat
	Alteration of natural soil structure/composition
	Alteration of natural microclimate(s)
	Alteration of natural bed / bank stability and structure
	Alteration of natural instream habitat/channel morphology
	Alteration of natural organic matter
	Alteration of natural stream shading / light availability
	Alteration of natural water temperature regime
	Alteration of natural nutrient regime
	Alteration of natural sediment regime
Change in Hydrologic Regime	Alteration of natural surface water flow regime
	Alteration of natural surface water run-off regime
	Alteration of natural groundwater regime
	Alteration of natural soil moisture regime
	Alteration of natural evapo-transpiration regime

Ecological Effects	Means of Influence
Change in Water Chemistry Regime	Alteration of natural dissolved oxygen concentration(s)
	Alteration of natural dissolved mineral concentrations
	Alteration of natural dissolved organic matter
	Alteration of natural turbidity
	Alteration of natural pH
Change in Connectivity	Alteration of natural latitudinal connectivity (e.g., river - floodplain connectivity)
	Alteration of natural longitudinal connectivity (e.g., upstream - downstream connectivity)
	Alteration of natural vertical connectivity (e.g., river - groundwater connection through the hyporheic zone)
Biological Community Effects	Loss of native species
	Alteration of native trophic structure
	Alteration of native community composition
	Loss of native species richness and diversity
	Alteration of native food web structure
	Alteration of native community structure
	Alteration of native community function
	Alteration of native biomass
	Alteration of native primary and secondary productivity
	Alteration of native keystone species' dominance
Species Population Effects	Loss of or decrease in native species populations through predation
	Loss of or decrease in native species populations through competition for food, shelter, habitat and other important resources
	Loss of or decrease in native species populations through pathogens / parasites carried by invasive alien species
	Dispersal/relocation of native species populations through over-crowding and aggressive behavior
	Decrease in reproduction rate of native species populations
	Decrease in fecundity of native species populations
	Decrease in growth rates of native species populations
	Alteration of meta-population dynamics of native species populations
	Alteration of behavior in native species populations
	Decrease in species populations through pathogens or parasitism
Genetic Effects	Loss of genetic variability through hybridization
	Loss of genetic variability through introgression / gene-swapping (i.e., erosion of the native species population's gene pool)

⁸ Keddy, C.A., M. Smith, and B. Tegler, 1999. *The Role of Importation Control In Protecting Native Canadian Biodiversity*. Canadian Wildlife Service.

⁹ See www.agf.gov.bc.ca/cropprot/invasiveplant.htm; and www.pnwr.org/Working_Group/Agriculture/InvasivePriorityList.htm.

¹⁰ Pimentel, et al., *Environmental and economic costs associated with non-indigenous species in the United States*, p. 294 in Pimentel 2002.

¹¹ For a more complete recent discussion of the economic costs of alien species and benefits of control, see Perrings, C., M. Williamson, E. B. Barbier, D. Delfino, S. Dalmazzone, J. Shogren, P. Simmons, and A. Watkinson. 2002.

Biological invasion risks and the public good: an economic perspective. Conservation Ecology 6(1): 1. www.consecol.org/vol6/iss1/art1.

¹² Ciruna (*ibid.*) has listed some of market and non-market effects of invasive alien species in the following tables:

Market Effects	Means of Influence
Income	Loss or decrease in individual or household income
	Decrease in local economic activity
	Decrease in jurisdiction's gross domestic product
Expenditure and/or Debt	Increase in individual or household expenditure and/or debt
	Increase in government expenditure and/or debt
Food supply	Loss or reduction of food supplies
Employment	Loss of individual employment or employment opportunities
Access to local resources	Loss or decrease in access to local resources such as fisheries
	Decrease in access to water
	Decrease in water supply for household use
	Decrease in drinking water supply
	Decrease in water supply for commercial use
Industry	Loss or decrease in agricultural productivity
	Loss or decrease in aquaculture productivity
	Increased costs and/or losses due to effects on livestock health
	Decrease in transportation efficiency (e.g., navigation and shipping)
	Decrease in labor productivity
	Loss or decrease in electrical production capacity
	Loss or decrease in recreation opportunities (e.g., fishing, boating, swimming)
	Loss or decrease in tourism
Business diversity and viability	Decrease in the number of businesses within an industry
	Decrease in total employment per industry
Investment	Loss of investment in local businesses
Infrastructure	Damage to infrastructure (e.g., clogging of pipes)
Property value	Decrease in property value
Trade	Creation of or increase in trade conflicts

Non- Market Effects	Means of Influence
Health	Loss of human life
	Loss of human health
	Decrease in life expectancy
Population	Loss of human population(s)
	Decrease in population size
	Decrease in fertility rate
	Decrease in net migration
	Alteration of age group structure
Essential Capital	Decrease in the effectiveness of local governance
	Increase in government costs for regulation, monitoring, information & awareness, etc.
	Decrease in security from crime and violence
Natural Capital	Loss / decrease in ecosystem services
Aesthetic capital	Loss of aesthetic capital

¹³ British Columbia 2003. Budget 2003 Ministry of Water, Land and Air Protection Service Plan 2003/04 – 2005/06, Victoria, p. 14. See: <http://www.bcbudget.gov.bc.ca/sp2003/wlap/>.

¹⁴ See Appendix 1: International and National Agreements, Legislation and Policy with Provisions Pertaining to Invasive Alien Species.

¹⁵ The Commissioner of the Environment and Sustainable Development, in his 2002 report to the House of Commons explicitly criticized the federal government for not identifying a “federal department [that] sees the big picture or has overarching authority to ensure that federal priorities are established and action is taken...to prevent invasive species from harming Canada’s ecosystems, habitats, or native species” despite the range of legislation and programs available to it. Office of the Auditor General of Canada. 2002. *Report of the Commissioner of the Environment and Sustainable Development to the House of Commons*, Chapter 4: Invasive Species, 4.1, p. 1.

¹⁶ Report of the Commissioner of the Environment and Sustainable Development to the House of Commons, *ibid.* Chapter 4, p. 7.

¹⁷ Claudi, R.; Nantel P.; Muckle-Jeffs, E. 2002. *Alien Invaders in Canada’s Waters, Wetlands, and Forests*. Natural Resources Canada, Canadian Forest Service Science Branch, Ottawa. p. 154-155.

¹⁸ A workshop including over 45 participants from federal, provincial, local, First Nations and non-government agencies and representatives of industry met in February of 2003 to direct development of a province-wide strategy for invasive plants. Strategy development was coordinated by the Fraser Basin Council. A copy of the strategy document, completed in 2004, can be downloaded from the Council’s website, or directly from: http://www.fraserbasin.bc.ca/news/documents/invasive_plant_strategy04.pdf .

Further information concerning the Invasive Plant Strategy can be obtained through the Cariboo-Chilcotin Regional Office of the Fraser Basin Council, telephone: (250) 392-1400 or e-mail: Gail Wallin (Coordinator) gwallin@fraserbasin.bc.ca

3. How is British Columbia Responding to the Challenge? An Overview of the Invasive Alien Species Framework

The Ministry of Water, Land and Air Protection is committed to addressing the threats posed by invasive alien species through provision of scientific biodiversity expertise, standards and policy – in cooperation with partners in federal, provincial and local government agencies, First Nations, non-government organizations and industry. This framework, addresses invasive alien species issues associated with biodiversity in British Columbia¹ and highlights the importance of:

- ◆ Maintaining healthy ecosystems – to reduce the likelihood and minimize the adverse effects of alien species invasions;
- ◆ Assessing and managing alien species that are intentionally introduced to British Columbia or are moved to new locations within the province to serve social or economic interests, but which could result in significant negative effects on the province’s economy or environment; and
- ◆ Detecting, and eradicating or controlling species that are transported to new environments inadvertently and have significant negative effects on human welfare and British Columbia’s biodiversity.

As the framework and its components are implemented, the Ministry will lead in specific areas under its jurisdiction and work in cooperation with partners who have objectives in common with the Ministry – providing scientific expertise and information intended to protect and maintain British Columbia’s biodiversity.

Strategic Framework

This strategic framework for addressing the threat of Invasive Alien Species to British Columbia includes:

- ◆ Identified *drivers* that provide the rationale for response;
- ◆ *Vision* and *goal* statements;
- ◆ *Objectives*, establishing clear statements for directing effort and assessing effectiveness; and
- ◆ *Action areas* for activities, most commonly undertaken in cooperation with partners, to achieve goal and objectives.

The five objectives provide an explicit framework to guide activities, and clear target statements against which to assess progress. The action areas are commonly shared among partners involved in preventing and controlling alien species invasions in British Columbia. The Biodiversity Branch of the Ministry – with responsibility for biodiversity science, standards and policy – will most commonly work with partners in a supporting role, providing scientific expertise and information. In its activities, the Ministry will be dedicated to promoting a science-informed approach to the conservation of biodiversity – supporting a strong and vibrant provincial economy, as well as improving environmental performance.

These elements are described below and summarized in Figure 5: Strategic Framework, page 14.

Drivers

Drivers provide the rationale and impetus for responding to the threat of Invasive Alien Species. They are described in detail in the previous section of this document (Section 2. Why Does British Columbia Need an Invasive Alien Species Framework?, page 3). The six drivers are:

- ◆ Threats to British Columbia’s environment;
- ◆ Threats to British Columbia’s economy and public health;
- ◆ Provincial Government commitments;
- ◆ Legislative responsibilities;
- ◆ Trade relationships; and
- ◆ Support from public and potential partners.

Vision

A province where the viability of native species and natural ecosystems is assured, and where introduced invasive alien species do not put native species or ecosystems at risk, thus supporting a strong and vibrant provincial economy.

Goal

To minimize and address threats of invasive alien species to British Columbia’s environment, economy and human health, thus maintaining and restoring the natural diversity of BC’s ecosystems, fish and wildlife species and their habitats.

Objectives

Work with partners to achieve the following objectives:

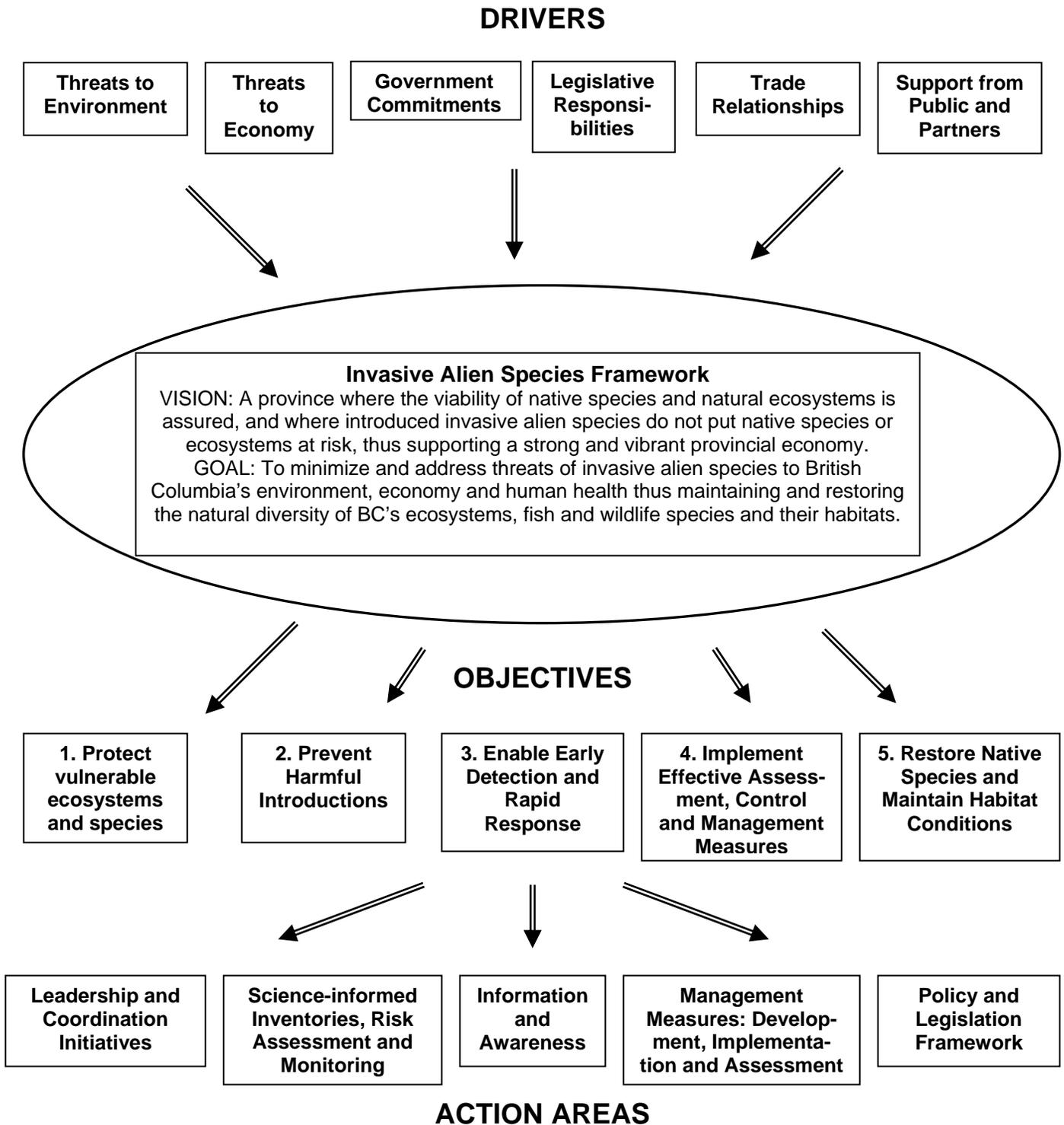
1. To reduce the likelihood of alien species invasions by decreasing stresses to vulnerable ecosystems and native species.
2. To prevent both intentional and accidental introductions of harmful invasive alien species to the freshwater, marine or terrestrial realms of British Columbia.
3. To enable early detection of, and rapid response to, invasive alien species occurrences in BC.
4. To establish effective control and management strategies and actions for invasive alien species occurrences in BC that do not put native species, natural ecosystems, nor the economy at risk.
5. To restore native species and habitat conditions in at-risk ecosystems that have been invaded by alien species, and to encourage use of ecological restoration as a means of invasive alien species control and management.

Action Areas

Work with partners in activities in support of achieving strategic objectives in the following action areas:

- A. Leadership and coordination initiatives.
- B. Science-informed inventories, risk assessment and monitoring.
- C. Information and awareness.
- D. Development, implementation and assessment of effective management measures.
- E. Policy direction and effective legislation and regulations to minimize and address threats of invasive alien species to British Columbia’s environment, economy and human health.

Figure 5: Strategic Framework



Invasive Alien Species Decision and Management Matrix

Figure 6 provides a schematic summary of the relationships between objectives, key tools and decisions involved in the management of invasive alien species.

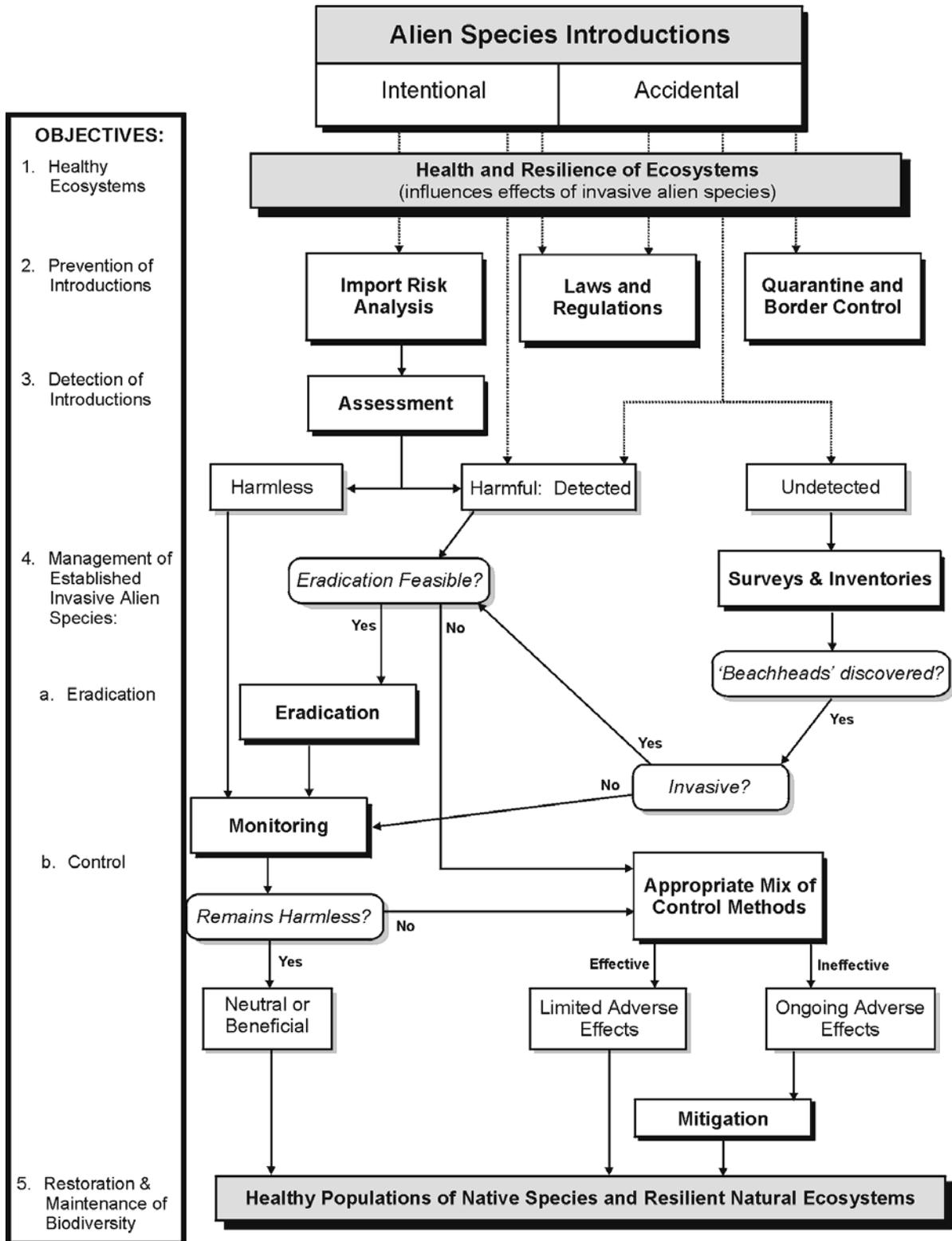
Objectives, in the shaded left hand column of the figure, are shown in relation to the sequence of actions and decisions involved in preventing, monitoring and managing the introduction of potential or known invasive alien species. **Tools** or **actions** that can be taken are highlighted with shaded boxes in the figure. **Key questions** determining subsequent management actions are shown in hexagonal boxes, with alternative pathways following from the resulting assessment.

Invasive alien species introductions, shown in the uppermost box of the figure, can be either *intentional* or *accidental*. Healthy populations of native species and resilient ecosystems are less susceptible to alien species invasions than species and ecosystems under stress. Hence, a fundamental objective of the invasive alien species framework is determining the status of and *maintaining the health of all species and ecosystems – and in particular, those at risk and/or vulnerable to alien species invasions*. The next objective, *prevention of introductions*, involves coordinated and consistent application of: *import risk analysis* (to assess known intended introductions); *laws and regulations*; and *quarantine and border controls* (addressing pathways for both known and accidental introductions – e.g., air and water ports, transportation and utility corridors, waterways).

Detection of introduced species relies on: (1) thorough *assessment* and ongoing *monitoring* of deliberate introductions; and (2) regular *inventories* and *surveys* of key sites for “beachheads” of invasive species. Once detected and assessed to be invasive, the *management of established invasive alien species* focuses first on *eradication*; and, if this effort is unsuccessful, then *control* of the invader, using a mix of control methods (e.g., manual, chemical and/or biological methods).

Restoration and maintenance of biodiversity can be achieved through ongoing *monitoring* of the health of species and ecosystems, and applying a mix of *control* methods and *mitigation* targeting invasive alien species. The focus of such effort should be to reduce stresses to at-risk species and ecosystems – maintaining the health and function of ecosystems and their component species – reinforcing the maintenance and restoration of biodiversity in British Columbia, and decreasing negative effects of biodiversity loss on the provincial economy.

Figure 6: Invasive Alien Species Decision and Management Matrix



Guiding Principles for Addressing the Invasive Alien Species Threat

The following set of guiding principles has been adapted from the principles used by the National Invasive Species Council in developing a National Invasive Species Management Plan for the United States.² The principles provide the general scope and direction for specific actions to be taken under the Invasive Alien Species Framework for BC. They are intended to support efforts to prevent and control invasive alien species at local and provincial scales, as well as supporting effort at national and international scales.

Guiding Principle #1 – Base action on clear direction and the best available scientific and socio-economic information

Efforts to manage invasive species are most effective when they: (1) have goals and objectives that are clearly defined and prioritized; (2) are proactive rather than reactive; (3) are based on current biological, social and economic information; (4) are applied rapidly, even when a reasonable degree of uncertainty is present; and (5) benefit a diversity of stakeholders.

Guiding Principle #2 – Take action based on a clear line of authority and identified priorities

Early detection and eradication of invasive alien species depends on rapid and effective response by a lead agency or coordinating body with a clear line of authority and pre-established resources (e.g., an “invasive alien species emergency response fund”). In far too many instances, there has been confusion regarding just “who” is responsible for responding to invasive alien species infestations and unnecessary delay while resources for eradication efforts are marshaled.

Effective triage – using sound risk assessment with clear priorities – is the first step in effective management of invasive alien species. Many alien species are non-invasive and support human livelihoods or a preferred quality of life; however, others can have substantive or even catastrophic negative economic and environmental effects. Focus first on those invasive alien species that cause substantial, negative effects to the environment, economies, and human health.

Introduction and establishment of invasive alien species can be a consequence of human activities such as trade and travel. Changes in human values, beliefs and behavior are necessary to alleviate the introduction and spread of invasive alien species. In order to protect food, health and the environment (and reduce subsequent economic and environmental costs), decisive actions must be taken to detect and control invasive alien species at the earliest stage possible. Different cultural groups and economic sectors may have difficulty supporting these actions at first, and need to understand and believe the rationale before their trust and support can be obtained.

Guiding Principle #3 – Be cautious and consistent

Invasions are often unpredictable – caution is warranted in the intentional and unintentional (see list on page 33) relocation of all non-native organisms.

An effective management strategy for invasive alien species integrates information exchange, public awareness, prevention, early detection, rapid response, scientifically informed control and restoration. A comprehensive strategy for preventing the introduction and spread of invasive alien species should address intentional and unintentional, authorized and unauthorized, movement of organisms among and within countries and provinces.

In order to be effective, provincial, national and international goals and actions relevant to the management of invasive alien species need to be congruent, integrated and mutually supportive. Policies that address the problem of invasive alien species will be most effective if they are consistently applied (across pathways, means of invasion and invaders), are comprehensive in scope, and consider stakeholder concerns and interests. Inter-jurisdictional agreements and cooperative action are of particular importance

in marine and freshwater aquatic situations (i.e., oceans and waterways commonly cross provincial and national borders). Many terrestrial species of interest also have wide-ranging distributions that cross national or provincial boundaries.

Guiding Principle #4 – Inspire action – balance incentives and enforcement

The prevention and management of invasive alien species can support economic growth and sustainable development and should be incorporated into policies to meet these objectives. Develop policies and incentive programs that encourage voluntary cooperation of federal, provincial and local public agencies, and other key stakeholders. Back these measures with effective enforcement authorities and capabilities. Strive for control methods that are scientifically, socially, culturally and ethically acceptable, and provide the desired effect on the target organism while minimizing the negative effects on the environment and the economy.

The current efforts of the Canadian federal and the British Columbia provincial governments to prevent and manage invasive alien species are often fragmented and inefficient, and lack sufficient enforcement. Coordination and an effective regulatory framework are required at federal, provincial and local government levels – and a complementary, flexible approach is needed to address the complex, broad needs of stakeholders to ensure support for, and compliance with, regulatory measures.

Guiding Principle #5 – Seek partnerships and cooperation – pull together

The adverse effects of invasive alien species can be significantly reduced if stakeholders work cooperatively to: (1) undertake applied, interdisciplinary research; (2) develop or adopt, and apply, technologies to prevent and control invasive alien species; and (3) incorporate these advances into management and policy decision making.

A system to coordinate and integrate information on invasive species is desirable, as is an organized approach to disseminating data and ensuring that management strategies evolve based on new information. Cooperative relationships among federal, provincial and local governments, as well as other stakeholders, need to be encouraged and supported to ensure the development and implementation of an effective invasive alien species prevention and control program nationwide. British Columbia can raise the profile of the invasive alien species issue, provide leadership in the management of invasive alien species, share information and technologies and contribute technical assistance to address the problem locally and on a global scale.

Guiding Principle #6 – Be inclusive, meet specific needs

Many different groups and interests have a stake in the management of invasive alien species and therefore need to be involved in efforts to address the problem. Awareness and outreach programs on invasive species will be most effective when they target the information needs and interests of specific audiences, indicate that positive progress can be made and recommend specific actions. Stakeholder involvement can be expanded by communicating the inter-relationships between invasive species and quality of life issues and by delivering a consistent message through a diversity of messengers and media.

Priority Activities – By Objective and Action Area

This section of the framework provides a summary of priority activities by objective and action area. The rationale for these priorities, as well as further background information related to the objectives and action areas, is discussed in more detail in subsequent sections of the document.

Objective 1: To reduce the likelihood of alien species invasions by decreasing stresses to vulnerable ecosystems and species.

Priority Activities:

- 1.1 Identify ecosystems and native species that are vulnerable to alien species invasions.
- 1.2 Maintain the vigour of terrestrial and aquatic ecosystems being managed under Ministry authority (e.g., Provincial Parks, Ecological Reserves, Wildlife Management Areas) by identifying stresses to the systems and managing the areas to reduce stressors wherever possible.
- 1.3 Work cooperatively with partners to reduce stresses to ecosystems and species on private and public lands and waters beyond direct Ministry management authority (e.g., through Species or Ecosystem Recovery Plans, Land Use Plans, Watershed Management Plans, Forest Stewardship Plans, Memoranda of Understanding (MOUs), and development of Standards, Guidelines and Best Management Practices).
- 1.4 Assess and monitor the health of native species and ecosystems.
- 1.5 Conduct regular surveys to detect the establishment and/or spread of invasive alien species.

Objective 2: To prevent both intentional and accidental introductions of harmful invasive alien species to the freshwater, marine or terrestrial realms of British Columbia.

Priority Activities:

- 2.1. Assess the risks and current extent of accidental introductions of invasive alien species through land- and water-based recreation activities in British Columbia, in conjunction with partner organizations and agencies.
- 2.2. Provide technical information regarding high value and at-risk ecosystems and native species to coordinating bodies and partners involved in assessing the risks and potential environmental effects of intentional introductions of non-native species.
- 2.3. Identify known and potential pathways of introduction (and subsequent vectors of spread) of invasive alien species (e.g., ports, highways, waterways) and monitor sites under Ministry authority (e.g., recreation sites, campgrounds), as well as targeted high value and at-risk regions of the province (e.g., Okanagan, Georgia Basin, Pacific Coastal Islands, wetlands and large estuaries), as part of a coordinated provincial invasive alien species prevention and management program.
- 2.4. Participate in partnerships such as the Invasive Plant Council of British Columbia working toward the prevention, early detection and eradication of invasive alien plant species invasions.
- 2.5. Participate in local partnerships as well as national programs such as the National Wildlife Disease Strategy with wildlife, agriculture and human health agencies to prevent the entry, perform surveillance, respond to and manage the entry and spread of existing and emerging animal diseases (e.g. Avian Influenza, Monkeypox, Chronic Wasting Disease).

Objective 3: To enable early detection of, and rapid response to, invasive alien species occurrences in BC.

Priority Activities:

- 3.1 Support development and use of a centralized, coordinated and current identification, assessment and inventory system for invasive alien species (including surveillance of diseases).
- 3.2 Contribute scientific expertise (e.g., at-risk species and ecosystems) and allocate resources to a coordinated provincial alien species early detection and rapid response program.

Objective 4: To undertake effective control and management strategies for invasive alien species occurrences in BC in a manner that does not put native species, natural ecosystems, or the economy at risk.

Priority Activities:

- 4.1 In partnership with other government agencies, industries and communities establish and share clear protocols – utilizing the principles of Integrated Pest Management – for the control of invasive alien species that may affect ecosystems and native species. MWLAP will focus control and management effort on provincial protected areas, and work with partners in support of efforts in other areas.
- 4.2 Utilize an appropriate mix of control methods and mitigation measures for the management of invasive alien species on lands under management jurisdiction of the Ministry (e.g., provincial protected areas).

Objective 5: To restore native species and habitat conditions in at-risk ecosystems that have been invaded by alien species, and to encourage use of ecological restoration as a means of invasive alien species control and management.

Priority Activities:

- 5.1 Support partnerships to restore at-risk ecosystems and maintain healthy populations of native species threatened by alien invasions.
- 5.2 Establish a program to assess and disseminate information regarding the effectiveness of ecological restoration as a means of invasive alien species control in different ecosystems and regions of the province.

Action Areas

A. Leadership and Cooperation

Priority Activities:

- A.1. Dedicate staff and resources to ensure effective initiation and ongoing success of the Invasive Plant Council of British Columbia (*cf.* Activity 2.4).
- A.2. Investigate interest in establishing “Invasive Alien Species Councils” that address the full spectrum of invasive alien species issues in British Columbia (i.e., terrestrial animal and freshwater and marine aquatic species) among potential government and non-government partners.
- A.3. Develop strategies and action plans to address issues associated with biodiversity in British Columbia, that support provincial, national and international efforts to address the problems of invasive alien species.

- A.4. Working with federal and provincial agencies in nationally coordinated initiatives, participate in the establishment of cooperative certification and/or monitoring programs for high priority industries (such as aquarium and pet trade, aquaculture and agriculture, horticultural and landscaping trade, international transport and import export businesses) that could serve as invasive alien species pathways of entry.

B. Science-informed Inventories, Risk Assessment and Monitoring

Priority Activities:

- B.1. Work with the provincial Conservation Data Centre (CDC), and other partners, to establish common methodologies for assessing invasive alien species that threaten biodiversity in British Columbia, and to maintain a current and accessible inventory of invasive alien species data (*cf.* Activity 3.1).
- B.2. Participate in the development and utilization of risk assessment processes that review proposals for intentional introductions of alien species to British Columbia (e.g., Committee on Introductions and Transfers of Aquatic Organisms) (*cf.* Activity 2.2).
- B.3. Contribute scientific expertise (e.g., botany, taxonomy, wildlife biology and disease, terrestrial and aquatic ecology, forestry, agrology) to develop and review invasive alien species monitoring and surveillance programs, and conduct regular surveys for alien species on lands and waters under Ministry jurisdiction (*cf.* Activities 1.4 and 2.3).
- B.4. Contribute scientific expertise to the development and implementation of invasive alien species “early detection and rapid response” strategies (*cf.* Activity 3.2).

C. Information and Awareness

Priority Activities:

- C.1. Provide specialist information regarding the vulnerability of high value and at-risk ecosystems and native species to alien species invasions, the current and potential adverse effects of invasive alien species on biodiversity in BC, and actions that can be taken to reduce or prevent such effects for use in information and awareness campaigns.
- C.2. Develop specific and targeted information and awareness programs to support the Ministry’s goal of maintaining biodiversity and protecting high value and at-risk ecosystems and native species (e.g., “British Columbia’s Least Wanted Invasive Alien Species”).
- C.3. Support a coordinated review of industry sectors of high priority industries (such as aquarium and pet trade, aquaculture and agriculture, horticultural and landscaping trade, international transport and import export businesses), for subsequent development of targeted information and awareness initiatives (*cf.* Activity A.4).

D. Development, Implementation and Assessment of Management Measures

Priority Activities:

- D.1. Identify priority areas under Ministry jurisdiction (e.g., protected areas) for action to eradicate, contain or control alien species invasions, and work with partner organizations to implement and assess effectiveness of management protocols (*cf.* Activities 4.1 and 4.2).
- D.2. Support partnership efforts to develop and assess invasive alien species management measures that utilize the principles of Integrated Pest Management (IPM) and minimize use of pesticides and herbicides – by providing scientific expertise (at-risk species and ecosystems characteristics, IPM practices) and identifying potential pilot areas for assessment (e.g., sensitive ecosystems facing alien species invasions).

E. Policy Direction and Legislation

Priority Activities:

- E.1. Participate in a coordinated (inter-agency) review of provincial legislation, regulations and policy direction (including connections with federal statutes) relevant to the prevention and control of alien species invasions, to establish an efficient and effective framework for coordinated management.
- E.2. Examine need for appropriate amendments to legislation and/or regulations under the Ministry's authority (e.g., *Wildlife Act*) to enable appropriate and coordinated actions to identify, prevent, eradicate and/or control invasive alien species.
- E.3. Participate, as appropriate, in targeted federal-provincial groups tasked with the development and/or implementation of coordinated invasive alien species legislation and policy (e.g., prevention network, risk assessment protocols and decision-making, rapid response measures).

Section Endnotes:

¹ Other made-in-BC strategies and action plans to address issues associated with biodiversity in British Columbia currently under development address Ecosystems at Risk, and Species at Risk.

² National Invasive Species Council. 2001. *Meeting the Invasive Species Challenge: National Invasive Species Management Plan*. Appendix 6: p. 73.

4. Objective 1: Protect Vulnerable Ecosystems and Species

Objective 1: To reduce the likelihood of alien species invasions by decreasing stresses to vulnerable at-risk or high value ecosystems and native species.

Priority Activities:

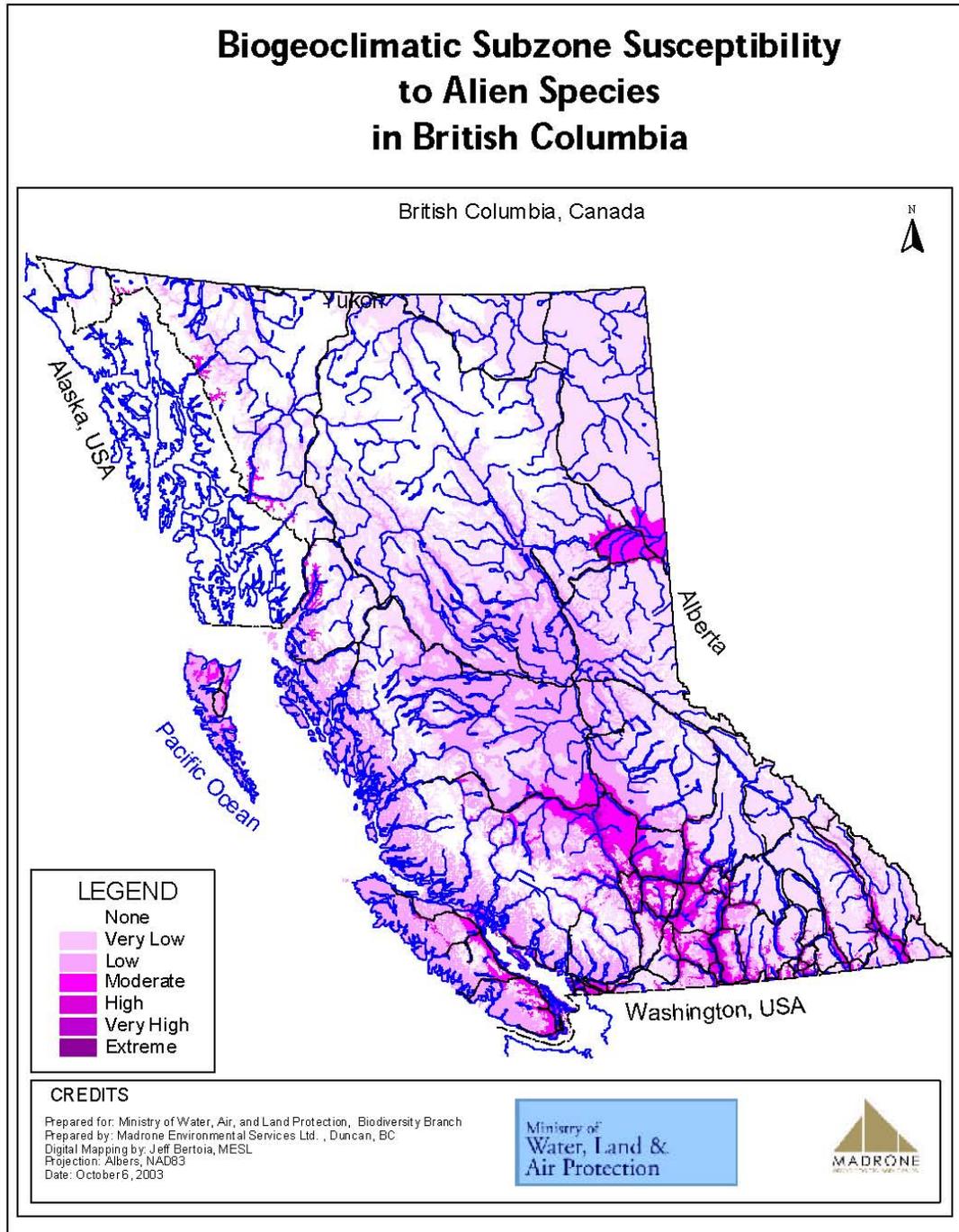
- 1.1 Identify ecosystems and native species that are vulnerable to alien species invasions.
- 1.2 Maintain the vigour of terrestrial, freshwater and marine ecosystems being managed under Ministry authority (e.g., Provincial Parks, Ecological Reserves, Wildlife Management Areas) by identifying stresses to the systems and managing the areas to reduce stressors wherever possible.
- 1.3 Work cooperatively with partners to reduce stresses to ecosystems and species on private and public lands and waters beyond direct Ministry management authority (e.g., through Species or Ecosystem Recovery Plans, Land Use Plans, Watershed Management Plans, Forest Stewardship Plans, Memoranda of Understanding (MOUs), and development of Standards, Guidelines and Best Management Practices).
- 1.4 Assess and monitor the health of native species and ecosystems.
- 1.5 Conduct regular surveys to detect the establishment and/or spread of invasive alien species.

Stresses (such as climate change, disease or contaminants) and habitat alteration (such as soil disturbance, dams and diversions, grazing, fires or control of fires) can increase the likelihood of alien species invasion.¹ Furthermore, stressors frequently interact to increase risk of extinction or extirpation of native species.² Taking action to reduce stresses on individual species (e.g., at-risk species) and to protect the integrity of important vulnerable ecosystems (e.g., freshwater ecosystems (wetlands, lakes, and rivers), estuaries, native grasslands, Garry oak ecosystems, islands) can serve to increase resistance to alien species invasions, and to protect at-risk species and ecosystems a fundamental element of maintaining British Columbia's biodiversity.

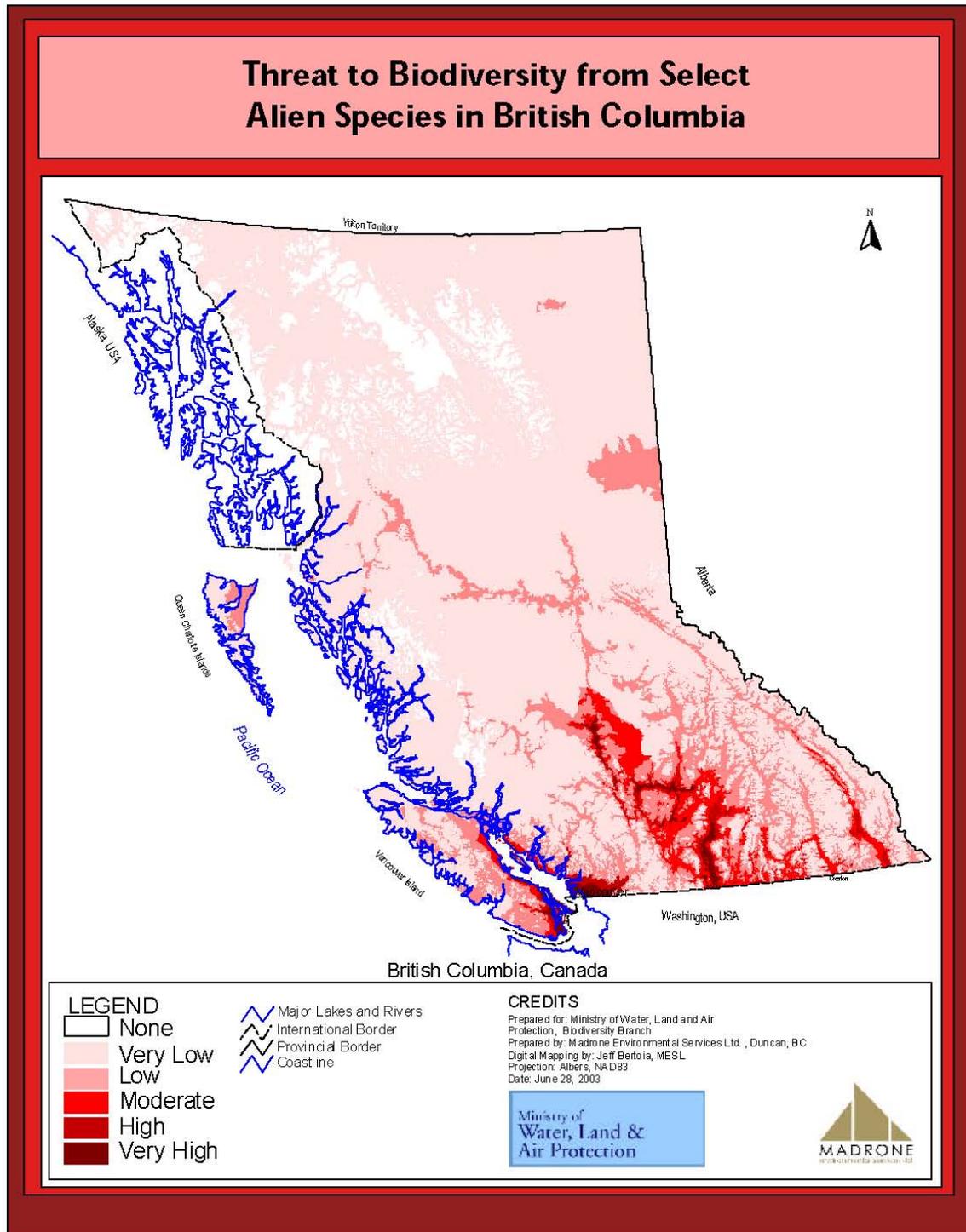
Four of the important human actions that affect key ecosystem processes and play a significant role in stressing vulnerable ecosystems and individual species-at-risk (and increasing the likelihood of alien species invasions) are:

1. Altering natural disturbance regimes, notably in fire-based ecosystems, and altered hydrologic regime and thermal regimes in freshwater ecosystems;
2. Changing plant succession patterns through agriculture, grazing or forestry practices;
3. Disturbing vegetation and soils, through road building, construction or other activity; and
4. Removing keystone species (e.g., top predators, burrowing species) or introducing new species (e.g., rats, deer, sports fish), with resultant ecosystem changes (e.g., changes to populations of native ungulate species, changes in the nature and extent of soil disturbance and vegetation growth).

In an initial effort to identify ecosystems and native species that are vulnerable to alien species invasions, the Ministry has mapped at a provincial scale: 1) biogeoclimatic subzones that are susceptible to invasive alien plant species (Map 1); and 2) biogeoclimatic subzones where known invasive alien species are concentrated (Map 2).³ Alien species invasions in British Columbia (and in other Canadian provinces) are concentrated toward the temperate southern border of the province often in areas of high diversity where several species reach the northern limit of their distribution.⁴



Map 1: Biogeoclimatic Subzone Susceptibility to Invasive Alien Plant Species in British Columbia



Map 2: Summary Map of Threats of Invasive Alien Species in British Columbia

BC Ecosystems of Particular Vulnerability to Alien Species Invasions

The following section identifies and describes the ecosystems in British Columbia that are most vulnerable to invasive alien species.

Southern Interior Valleys – Grassland Ecosystems

Unforested dry grasslands cover less than 0.5% of BC's land area⁵ while supporting the only Canadian populations of several species and 23 nationally listed at-risk species.⁶ The introduction of invasive alien species, such as largemouth bass, purple loosestrife and European starling, has negatively affected native species and habitats in the area.⁷ As well, fire suppression has significantly altered wildlife habitat and facilitated the spread of such alien plant species as cheatgrass (*Bromus tectorum*). The South Okanagan and Similkameen valleys, for example, are among the three most biologically diverse areas in Canada, as well as being among the three most endangered ecosystems in the nation.⁸

Pacific Coastal Islands

Island species, notably nesting seabirds, lack defenses against grazing or predation and are particularly vulnerable to introduced species. The isolation of the Pacific Coastal Islands, notably the Queen Charlotte Islands (Haida Gwaii), from mainland populations has also led to the evolution of endemic mammals of special conservation interest. The most disruptive species include herbivores (such as deer and rabbits), vertebrate and invertebrate predators (including rats and raccoons), species that can alter ecosystem-level characteristics and species that are able to colonize undisturbed native ecosystems (such as grasses).

Eastern Vancouver Island – Garry Oak Meadow Ecosystems

Many invasive alien species that threaten biodiversity are present in the Lower Fraser Valley, along the Sunshine Coast and across eastern Vancouver Island (see Map 2 above). In part, this concentration of invasive species is due to the influence of human settlement and activities (habitat disturbance, port and other transportation pathways, and land uses such as cultivated gardens). Wetlands and other biologically diverse areas in the region are also of ecological importance. The Garry oak meadow ecosystem is under particular threat to alien species invasions.

The Garry oak (*Quercus garryana*) meadow ecosystem, along the southeastern coast of Vancouver Island and the Gulf Islands, is one of the most endangered in Canada, with much less than 5% of the original habitat remaining in a near-natural condition, and 91 species provincially-designated as at risk, the ecosystem is both biologically rich and very vulnerable. Together, Garry oak and associated ecosystems are home to more plant species than any other terrestrial ecosystem in coastal British Columbia. Many of these species occur nowhere else in Canada.⁹ The introduction of European species, combined with suppression of fire and habitat destruction, has resulted in substantial changes to the Garry oak meadow community. Introduced grasses, for example, now likely make up over 90% of the herb layer biomass.

A vegetation survey in 1972 found that 25% of the species within the core of the Garry oak range in British Columbia were introductions from the Mediterranean and other parts of Europe. The survey noted that these species are so fully integrated into the ecosystem that they comprise a part of the characteristic plant association. Subsequent sampling at different sites in 1995 revealed that 40-76% of the herbaceous species in camas meadows of the core area were alien species, and that such species comprised 59-82% of

the herbaceous cover, suggesting an increased presence in non-native species over the two decades. Another assessment of regional parks within the Capital Regional District concluded that 100% of the parks are threatened by the invasion of alien plant species, 36% of them severely so. Out of 546 currently identified species of vascular plants of Garry oak and associated ecosystems, 29% of them are introduced.¹⁰

Freshwater Ecosystems: River and Lake Systems, Wetland Habitats and Coastal Estuaries

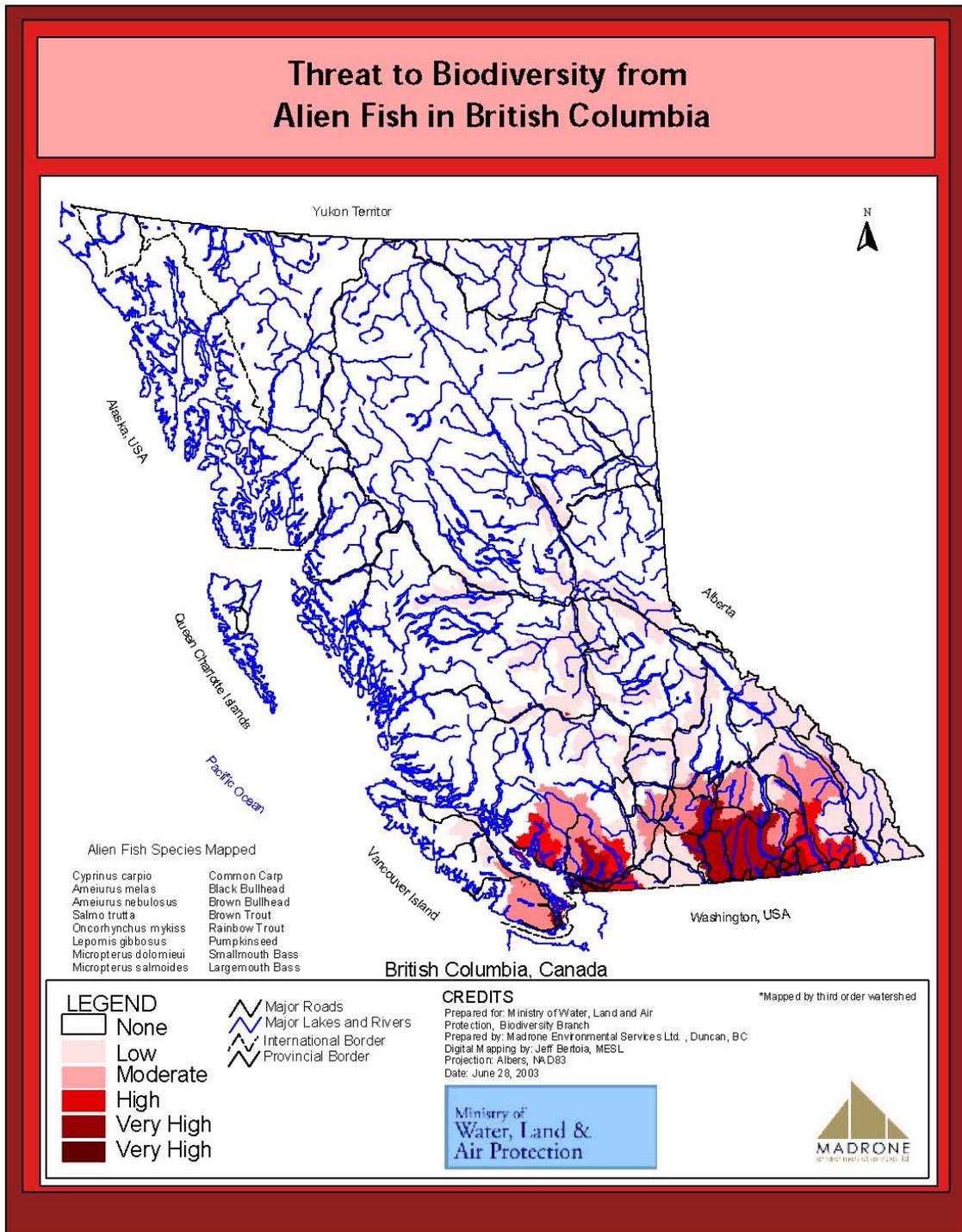
See also Section 10 for further details regarding the characteristics of, and the threat of invasive alien species to, freshwater ecosystems.

Freshwater species are among the most threatened of all taxa groups. Their extinction rate is predicted to be five times faster than all other groups of species and at a rate equal to that of forest species in the world's tropics.¹¹ Between 20% and 35% of the world's freshwater fish species have become endangered, threatened, or extinct. Since 1970, the health of the world's freshwater ecosystems has declined by 50%.¹² The effects of global climate change and increasing human demands for fresh water will put further stresses on already compromised freshwater ecosystems.

Invasive alien species are thought to be the cause of over 70% of this century's extinctions of native freshwater species; are implicated as a contributing factor to 42% of currently endangered freshwater species; and are a significant impediment to recovery of species at-risk.¹³ In the Columbia Basin, introduced fish stocks are a factor in 80% of the documented aquatic extinctions.¹⁴ Although threats from invasive alien fish species (through both unauthorized public introductions and past intentional stocking programs) are concentrated in the southern half of British Columbia, almost all aquatic habitats in the province are vulnerable. In general, freshwater ecosystems that are of high ecological integrity and function within their natural ranges of variation have a higher resiliency to alien species invasion than those that have been degraded through human alteration for water use.

Wetlands, which cover just over 6% of BC are very productive biologically, rich in biodiversity (notably amphibians, reptiles, aquatic invertebrates, insects and aquatic vegetation) and are vital staging and resting areas for migratory birds.¹⁵ Coastal estuaries are of particular importance. Half of the world's wetlands are estimated to have been lost during the 20th century, a trend that is echoed in British Columbia where, for example some 28% of the Fraser River Delta wetlands (which support the highest densities of over-wintering waterfowl, shorebirds, and birds of prey anywhere in Canada) were destroyed between 1976 and 1982 by urban and agricultural land uses.¹⁶

Although the northeastern portion of BC contains the highest proportion of wetlands, it is the Pacific coastal and mountain wetlands that are currently most threatened by alien species invasions. Wetlands cover less than 5% of these regions but include important coastal freshwater and salt marshes, as well as forest swamps and fens. Wetlands along the bottoms of the large valleys of southern BC are also important and vulnerable to invasive alien species (as well as destruction and degradation). Alien species threatening wetlands include plants, such as purple loosestrife, and intentionally and unintentionally introduced fish. Coastal habitats are particularly susceptible to trans-boundary invasions of alien species, through ocean currents and international shipping.



Map 3: Threat of Invasive Alien Fish Species to Biodiversity in British Columbia

Section Endnotes:

- ¹ See, for example, references in Canadian Wildlife Service. 2003. *Impacts on Canadian Species at Risk from Invasive Alien Species*. Draft Report. Prepared by Astrid Vik Stronen, June 12th, 2003.
- ² For example, see: Kling, G.W., et al. 2003. *Confronting Climate Change in the Great Lakes Region: Impacts on our Communities and Ecosystems*. Union of Concerned Scientists, Cambridge Massachusetts, and Ecological Society of America, Washington, D.C. www.ucsusa.org/greatlakes. This study of the implications of climate change in the Great Lakes region predicts that “invasions of warm-water non-native species such as carp will be more likely, [further] increasing the stress on native plant and animal populations in the region
- ³ The methodology used to derive these maps is described in further detail in Appendix 3: Rating a Sample Short-list of Invasive Alien Species for Threat to Biodiversity in British Columbia.
- ⁴ See: Haber, E. 2002a, <http://24.43.24.85/nbs/ipcan/impact.html> and Canadian Endangered Species Conservation Council (CESCC), 2001. Impacts of invasive plants especially with regard to plants at risk in Canada, for example, are most evident in: the Pacific Maritime and Montane Cordillera Ecozones of BC (particularly the Eastern Vancouver Island and the Thompson-Okanagan Plateau Ecozones); the Prairies Ecozone; and the Mixed Plains Ecozone (especially within the Lake Erie Lowland Ecozone) of Ontario.
- ⁵ BC Ministry of Environment, Lands and Parks and Environment Canada. 1993. *State of the Environment Report for British Columbia*, Victoria, p. 43.
- ⁶ Krannitz 2002, cited in Canadian Wildlife Service. 2003. *Impacts on Canadian Species at Risk from Invasive Alien Species*. Draft Report. Prepared by Astrid Vik Stronen, June 12th, 2003.
- ⁷ Cannings, R.J. and E. Durance. 1998. *Human use of natural resources in the South Okanagan and Lower Similkameen valleys* in Smith, I.M., and G.G.E. Scudder, eds. *Assessment of Species Diversity in the Montane Cordillera Ecozone*. Burlington: Ecological Monitoring and Assessment Network, 1998.
- ⁸ Canadian Wildlife Service, 2003, *ibid*.
- ⁹ Garry Oak Ecosystem Recovery Team (GOERT), 2003. www.goert.ca.
- ¹⁰ 1972 and 1995 surveys by Hans Roemer, BC Parks, 1998 CRD Park survey by Fleming. See GOERT *ibid*., “Exotic Plant Species in Garry Oak Ecosystems” for complete references.
- ¹¹ Ricciardi A. and J.B. Rasmussen. 1999. *Extinction Rates of North American Freshwater Fauna*. *Conservation Biology* 13 (5): 1220-1222.
- ¹² Loh, J. (ed.). 2000. *Living Planet Report 2000*. UNEP-WCMC, World Wide Fund for Nature (WWF). Gland, Switzerland.
- ¹³ Heywood, V.H. 1995. *Global Biodiversity Assessment*. Cambridge University Press. 1140 pp.
- ¹⁴ Statistic of the American Fisheries Society, quoted by the Columbia Kootenay Fisheries Renewal Partnership, 2003: www.ckfrp.com/issues.htm .
- ¹⁵ BC Ministry of Environment, Lands and Parks and Environment Canada. 1993. *State of the Environment Report for British Columbia*, Victoria, p. 43.
- ¹⁶ Global reference from The Nature Conservancy Freshwater Initiative, 2003, <http://www.freshwaters.org/bio/decline.shtml>. BC reference from Canada’s Aquatic Environments, 2002, *op cit*.

5. Objective 2: Prevent Introductions of Harmful Invasive Alien Species

Objective 2: To prevent both intentional and accidental introductions of harmful invasive alien species to the freshwater, marine or terrestrial realms of British Columbia.

Priority Activities:

- 2.1 Assess the risks and current extent of accidental introductions of invasive alien species through land- and water-based recreation activities in British Columbia, in conjunction with partner organizations and agencies.
- 2.2 Provide technical information regarding high value and at-risk ecosystems and native species to coordinating bodies and partners involved in assessing the risks and potential environmental effects of intentional introductions of invasive alien species.
- 2.3 Identify known and potential pathways of introduction (and subsequent vectors of spread) of invasive species (e.g., ports, highways, waterways) and monitor sites under Ministry authority (e.g., recreation sites, campgrounds), as well as targeted high value and at-risk regions of the province (e.g., Okanagan, Georgia Basin, Pacific Coastal Islands, wetlands and large estuaries), as part of a coordinated provincial invasive alien species prevention and management program.
- 2.4 Participate in partnerships such as the Invasive Plant Council of British Columbia¹ working toward the prevention, early detection and eradication of alien plant species invasions.
- 2.5 Participate in local partnerships as well as national programs such as the National Wildlife Disease Strategy with wildlife, agriculture and human health agencies to prevent the entry, perform surveillance, respond to and manage the entry and spread of existing and emerging animal diseases (e.g. Avian Influenza, Monkeypox, Chronic Wasting Disease).

Prevention First!

Introductions of invasive alien species can be either intentional (e.g., importation of an ornamental plant, smuggling of exotic species) or unintentional (e.g., species “hitchhiking” on boats or commodities such as produce, nursery stock or livestock, or passively transported by wind and currents). Whatever the means of entry however, prevention is the first and most cost-effective line of defense against invasive alien species.

An important feature of invasions that argues strongly in favour of prevention is that once an introduced species has become established, particularly if it has become invasive, it becomes costly and extremely difficult or impossible to eradicate it. Most attempts to eradicate such species fail, and even failed attempts are often expensive.² Once eradication has

Figure 7: Potential Ecological Effects of Invasive Alien Species

The ecological effects of invasive alien species can:

- Occur at any level or across levels of biotic organization;
- Result from direct and/or indirect influences of the invasive alien species;
- Occur immediately or years after the introduction (i.e., after a prolonged (lag) time following arrival);
- Persist for the short- or long-term;
- Act synergistically to magnify or amplify other effects on the system (including habitat destruction, see Sala et al. 2000);
- Be so subtle that they are not readily perceived, but be cumulative over time; and/or
- Interact and have cascading effects (i.e., effects that trigger additional effects throughout the system).

failed (the usual result), society is faced with damage and management costs in perpetuity. Such costs have the potential to affect important sectors of British Columbia's economy (with the agricultural sector being particularly vulnerable).

The benefit/cost ratio for investment in prevention of unintentional invasive alien species introductions is high. If only a small fraction of inadvertently introduced species become established and only a small fraction of these become invasive alien species, there is still an enormous cost to society, far outweighing any unexpected benefits that unplanned introductions might confer and the costs of maintaining prevention apparatus. Had the zebra mussel been prevented from entering North America (and it has not yet entered BC) by ballast water transfer control measures, billions of dollars of industrial damage (from clogged water pipes and other consequences of incrustation) would have been avoided, and the threat of extinction to many aquatic species would be far lower than it now is. The costs of such measures are not negligible, but they pale in comparison to the ongoing monetary, commercial, public nuisance and ecosystem cost.³

A coherent invasive alien species prevention program has three components:

- ◆ **Import laws and regulations** – such as “red” and “green” lists (see Figure 8), that identify species and categories of concern, and establish means for intercepting, assessing and prohibiting introductions of undesirable alien species;
- ◆ **Import risk analysis** – procedures for assessing and monitoring the risk of introduction of alien species; and
- ◆ **Quarantine and border control** – including *interception measures* such as regulations, inspections and fees, addressing accidental and intentional introductions, as well as smuggling, and downwind and downcurrent monitoring in areas of particular concern for invasions; *treatment facilities* and trained personnel able to apply biocides (e.g., fumigation, pesticide application) and other measures such as heat and cold treatment, water immersion, pressure or irradiation; and *prohibition controls* – a final measure, when even strict measures may not prevent introductions (e.g., trade prohibition based on international regulations for high-risk pathways).

Although primary responsibility for cross-border aspects of an alien species prevention program rests with the federal government (e.g., through interception at international shipping and travel ports), it is in the best economic and environmental interests of the province to support and actively participate in a coordinated and comprehensive prevention program.⁴

Reviewing Proposed Intentional Introductions

Most of the current prevention measures in British Columbia target certain species known to be “pests” or “weeds.” These species are predominantly of economic importance for the agricultural or forestry sector, or of concern to human health. Prevention of species on these “black (or red) lists” is the most common goal of

Figure 8: Using “Stoplight Lists” to Prevent Undesirable Intentional Introductions

A tiered system can be used to screen specific species being proposed for introduction to BC. The system has three categories, based on “red”, yellow” and “green” lists:

1. *Undesirable invasive alien species* (“red list”): species not wanted in the province (i.e., posing an “ecological threat”), such as those known to be invasive (or that are considered to be at high risk of carrying invasive organisms) under similar conditions elsewhere, with strict regulations and measures to ensure “pest-free” imports;
2. *Species cleared for introduction* (a “green list”): organisms declared as safe; known to be non-invasive and not harmful to human health or the environment; and
3. *Species not yet assessed* (“yellow list”): species proposed for introduction that pose a potential threat to biodiversity, ecosystems or economic activities; the species would have to be considered at low risk for introduction through a risk assessment process.

current quarantine programs. A more recent “stoplight” approach, involves using “green lists” of known alien species approved for safe introduction. A third category for “species not assessed” (or “yellow listed”) involves a risk assessment process, followed by a designation (“green” or “red”) based on the results of the assessment (see Figure 7). This risk assessment should be conducted following scientific standards and guidelines that are recognized by all appropriate levels of government (e.g., federal and provincial governments for intended inter-provincial transfers of species). Since invasiveness can vary with time, genetic composition of the introduced population and changes in human behaviour (e.g., land use), the species on the “green list” should be reviewed at regular intervals.

The risk of the introduction, establishment and spread of invasive alien species depends on a vast number of socio-economic, political, cultural and ecological factors. These include: the demand for goods and services and how and from where they are transported; the human alteration of ecosystems for land and water uses; and the fragility and adaptability of an invasive alien species to a new ecosystem.

Pathways of Introduction

Rather than targeting individual species, exclusion methods based on pathways of introduction, concentrating efforts to where invasive alien species are most likely to enter provincial boundaries, are a cost-efficient use of resources. A systematic “pathways analysis” for invasive alien species entering British Columbia has not yet been undertaken. Such an analysis would be a useful early undertaking for a provincial Invasive Alien Species Council. Ciruna, et al. have compiled an initial table of vectors and means of entry for terrestrial aquatic invasive alien species that could be adapted for terrestrial and marine aquatic species and a starting point for a provincial pathways analysis.⁵ (See also discussion of pathway management and vectors of spread in Section 6. Objective 3: Early Detection and Rapid Response.)

The following paragraphs list some of the most common entry pathways for invasive alien species.

Intentional Introductions:

- ◆ Plants used for agricultural purposes;
- ◆ Non-native plants grown for forestry use;
- ◆ Non-native plants used for “soil improvements” (e.g., slope stabilization, N-fixing);
- ◆ Ornamental plants;
- ◆ Germplasm;

Figure 9: Planned Introductions Gone Awry

Many of the invasions that have caused the most economic and environmental damage were intentional. For example:

- The European gypsy moth (*Lymantria dispar*) escaped from an experimental rearing program intended to produce a better silkworm and ravaged forests in NE US for a century.
- Africanized honeybees, escaped from scientific rearing facilities in Brazil, have invaded Central America, Mexico and the United States, causing deaths and greatly complicating beekeeping.
- The American bullfrog (*Rana catesbeiana*), a large frog that preys on other amphibians, reptiles, mice and young birds, was initially brought to BC over a hundred years ago for commercial production of frogs’ legs. Since escaping from aquaculture facilities, the bullfrog has increased in numbers and range, displacing native frogs and markedly altering aquatic ecosystems.
- The Sitka black-tailed deer (*Odocoileus hemionus sitkensis*, a sub-species of the mule deer) was intentionally introduced to the Queen Charlotte Islands (Haida Gwaii) in 1878. Subsequently, islands with deer populations have reduced vegetation cover and biodiversity, and deer browsing impairs forest regeneration and increases forest management costs.

- ◆ Birds and mammals released for hunting purposes;
- ◆ Biological control;
- ◆ Fish and shellfish released (for recreational or commercial uses); and
- ◆ Pets released into the wild, the “freeing” of non-native animals for religious or ethical reasons; and reintroductions and releases to “enrich” native flora and fauna.

Accidental Introductions:

- ◆ Contaminants of agricultural produce and seed contaminants;
- ◆ Soil inhabiting species;
- ◆ Seed and invertebrate contamination of nursery plants;
- ◆ Seed and invertebrate contamination of cut flowers;
- ◆ Organisms in or on timber or timber products
- ◆ Machinery, equipment, vehicles, trailered boats;
- ◆ “Hitchhikers” in or on packaging, on mail and cargo, and in or on planes or cruise ships/tour boats;
- ◆ Ballast water of ships, sediment in ballast water tanks;
- ◆ Hull fouling;
- ◆ Marine debris (e.g., “pelagic plastic”, seaweeds, logs);
- ◆ Tourists and their luggage/equipment;
- ◆ Parasites and pathogens in animals used for agricultural, recreational or other purposes; and
- ◆ Parasites, pathogens and hitchhikers on marine fish, invertebrates and plants introduced for aquaculture and mariculture.

Introductions from captive or commercial cultivation:

- ◆ Escapes from zoos, aquaria, botanical gardens, private collections and game farms;
- ◆ Farmed animals (mammals, amphibians and birds);
- ◆ Aquaculture and mariculture; and
- ◆ Escapes from research institutes and “controlled” releases for research purposes.

Figure 10: Shipping and Ballast Water: A Major Pathway for Aquatic Invaders

Ships, as well as the cargo they carry, have been identified as one of the primary pathways by which invasive alien species reach new ecosystems. Invasive alien species have been transported on hulls, clinging to anchor chains, in cargo areas, with ships' crews and passengers and in ballast. However, it is ballast water that has attracted the most concern as a pervasive pathway for invasive alien species introductions.

Ships are equipped with ballast tanks that can be filled with water to reduce their buoyancy and increase stability when needed. The water pumped into ballast tanks can contain large numbers of living organisms (including micro-organisms, algae, plants, small fish and invertebrates), which are then transported by the ship to another destination, often on a different continent. Ballast water is discharged from the tanks when ships are being loaded with cargo – along with any living organisms in the water. Over time, a layer of sediment accumulates in the tanks, and it can also contain invasive alien species.

Carleton et al. (1995) estimate that over 3,000 species a day are transported between the harbours and ports of the world in the ballast tanks of the deep-sea fleet. The volume of water involved is enormous. Between June and Sept. 1999, for example, inner Vancouver Harbour received about 4.9 million tonnes of ballast water (Vancouver Port Authority, quoted in Claudi, et al. p. 233). Human pathogens are also transported in ship ballast water. A 1998 study that sampled the ballast water of 28 transoceanic vessels en route to the Great Lakes found several human pathogens (including salmonella, *Vibrio cholerae*, *Giardia* and fecal coliforms such as *E. coli*) in one or more of the samples (See: Commissioner of the Environment and Sustainable Development, Chap. 4, p. 8.).

The Federal Commissioner of the Environment and Sustainable Development views ship ballast as the most important source of unintentional introductions of aquatic invasive species. Yet, in his 2002 report, the Commissioner found that: "Transport Canada does not regulate ballast water discharges; nor does it monitor or report on compliance with existing guidelines on ballast water exchange... there is no official arrangement between Transport Canada and the US authorities to cooperate on inspection and enforcement...[and, although regulations are planned for the Great Lakes by late 2002,]...there will continue to be no federal requirement for ballast water management [on Canada's coasts] and gaps will remain in the federal government's ability to control introductions of invasive species from ship ballast" (*ibid.* p. 16).

Coordinated Risk Assessment and Targeted Prevention Measures

Risk assessment is a tool that can be used to support exclusion of appropriate undesirable species, as well as to assess the potential effects of those that have become established. The risk assessment process and its results can:

- ◆ Help determine if action should be taken, and if so, what kind;
- ◆ Assist in setting priorities for best use of time and funds, particularly where there are multiple threats; and
- ◆ Be used to build and obtain public support and needed funding for exclusion and/or eradication.

Assessing risk of entry, establishment and spread of potentially invasive alien species is still a developing field. Australia has implemented a Weed Risk Assessment system using a question-based scoring method involving answering 49 questions on the species being proposed for introduction.⁶ The National Invasive Species Council for the United States is also developing a "fair, feasible and risk-based comprehensive screening system for evaluating first-time intentionally introduced non-native species" intended to be implemented by December 2003.⁷

The Canadian Food Inspection Agency (CFIA) has an internationally recognized risk assessment process and has undertaken scientific risk assessment of more than 350 specific commodities and invasive species. However, although inspection rates are higher for regulated commodities and targeted shipments, on average CFIA can manage to inspect only 1-2% of incoming shipments. There has not yet been a

comprehensive assessment of the risks and costs that stem from the effects of regulated or unregulated, intended or unintended alien species invasions on natural ecosystems in Canada.⁸

Figure 11: Risk Assessment Tools – The National Code on Introductions and Transfers of Aquatic Organisms

This Code, approved by Canadian federal, provincial and territorial governments in 2002, sets in place a mechanism for assessing proposals to move aquatic organisms from one water body to another. The Code is intended to protect aquatic ecosystems while encouraging responsible use of aquatic resources. The involved governments agree to work cooperatively in applying national and regional regulations and policies and to establish an “Introductions and Transfers Committee” in each province or territory, as well as a national registry of introductions and transfers.

A key element of the Code is the Risk Analysis undertaken to identify whether the proposed introduction or transfer presents a low, medium or high risk for the receiving environment. The Ministry of Water, Land and Air Protection is interested in ensuring that the risk analysis and assessment process includes science-based expertise regarding the receiving environment and potential consequences of establishment in terms of ecological, genetic or disease effects. As stated in the Risk Analysis procedures, “the strength of the review process is not in the ratings [high, medium or low] but in the detailed biological and other relevant information statements that motivate them.”

Reference: Canadian Council of Ministers of Fisheries. 2002.

Section Endnotes:

¹ Establishment of the Invasive Plant Council of British Columbia was recommended under the *Invasive Plant Strategy for British Columbia* (available through the Fraser Basin Council website: www.fraserbasin.bc.ca). The Council is responsible for coordinating invasive plant management in BC.

² For example, the failed 22-year long campaign to eradicate the South American fire ant (*Solenopsis invicta*) from the southeastern United States cost \$200 million (US). See: Simberloff, Daniel, 1996: Impacts of Introduced Species in the United States. *Consequences* 2(2), p. 13-23. In a recent paper in *Conservation Biology* (Vol. 17(1): Feb 2003), Simberloff provides detailed examples of the consequences and costs of “failure to exclude” and “failure to eradicate early.” He also discusses examples of some successful early interventions, including eradication of the giant African snail (*Achatina fulica*) from Florida, the white-spotted tussock moth (*Orgyia thyellina*) from New Zealand, and various non-indigenous plants from Australia and New Zealand. In Simberloff’s opinion, “in all of these cases, success was not a question of population biological research but of acting quickly with brute-force methods.”

³ See: Office of the Auditor General, *Report of the Commissioner of the Environment and Sustainable Development*, 2002. Chapter 4 p. 4. Ontario Power Generation, for example, estimates that as a direct consequence of zebra mussels, its operating costs increased by between \$500,000 and \$1 million per year at its nuclear stations and \$225,000 per year at its fossil fuel stations. The utility has spent over \$20 million installing and maintaining chlorine applicators at its Great Lakes facilities to deter zebra mussels, and over \$13 million on research to reduce or eliminate the use of chlorine as a controlling agent.

⁴ There are significant costs associated with prevention:

- First, and most obvious, is the expense of maintaining a coherent prevention and screening system (salary and training of personnel, costs of inspection and quarantine facilities);
- Second, is the cost borne by individuals or companies who wish to profit by bringing an alien species to BC (whether or not the species is intended for release into the environment); and

- Third, is the potential cost that may be borne by citizens who may have to withstand regulatory control or who might have benefited in some way from a planned introduction that may be disallowed by prevention.

Against these costs, the benefits that accrue to British Columbian society from prevented invasions must be tallied. It is important to consider that many of the invasions that have caused significant economic and environmental damage and cost have resulted from planned and intentional introductions of alien species. The fact that an introduction is planned, even by scientists, does not mean that it will necessarily be beneficial. When considering any deliberate introduction, unless there is very clear evidence to the contrary, it should be assumed that the introduced species could escape into the wild. Hence, if the species has the potential to become naturalized and invasive, then it should be assessed as though it will eventually do so.

⁵ Ciruna, et al. 2003. The following table (adapted from Carleton 2001) systematically lists means of introduction (I=intentional; U=unintentional) by vector for freshwater invasive alien species.

Vector	Means of Introduction
Aquaria (Private)	1. (I/U) Aquaria plants and animals escape/released into the environment.
	2. (U) Pathogens, parasites, algae associated with aquaria plants/animals escape into the environment.
Aquaria (Public)	1. (I/U) Display organisms escape/released into the environment.
	2. (I/U) Pathogens, parasites, algae, or other fish species transported or associated with display species escape/released into the environment.
Bait	1. (I/U) Live bait and/or its live packaging (e.g., aquatic plants) released/escaped into the environment.
	2. (U) Organisms associated with live bait / packaging released into the environment.
Biological Supply	1. (I/U) Organisms intended for scientific study and their associated organisms released into the environment.
	2. (I/U) Organisms (e.g., insects, animals, plants) used for classroom study that escape or are released into the environment.
	3. (I/U) Organisms (e.g., pathogens, parasites) associated with study specimens that escape or are released into the environment.
Shipping Vessels (land, water and air transport)	1. (U) Organisms released when ships discharge ballast water.
	2. (U) Organisms attached to interior or exterior structures and equipment (i.e., "fouling organisms") released into the environment.
	3. (U) Organisms contaminating cargo (e.g., wood casks, water containers) released into the environment.
Cargo	1. (I) Organisms released into the environment.
	2. (U) Organisms contaminating cargo (e.g., wood products) released into the environment.
Dry Docks / Jetties	1. (U) Organisms attached to structures that have been relocated
	2. (U) Organisms released when ballast water is discharged.
Floating Debris	1. (U) Organisms moving on garbage (e.g., bottles, buoys, nets, packaging) that have been relocated.
Fisheries & Wildlife (Recreational)	1. (I/U) Government or private introduction or release of organisms for recreational or sporting purposes, including organisms intended to serve as their feed (e.g., tadpoles for bass). Also included are associated organisms (e.g., pathogens) that are unintentionally released.
	2. (U) Escape of fisheries stocks, wildlife species and their associated organisms during transport, transplantation and/or holding.
	3. (U) Introduction of organisms associated with relocated fishing gear (e.g., lines, nets, floats).
	4. (I/U) Introduction of aquatic plants and associated material to enhance habitat fisheries/wildlife stocks.
	5. (U) Release of organisms (esp. pathogens/parasites) from waste produced by processing of fish/ wildlife.
Food (aquaculture & agriculture)	1. (U) Escape of animals and their associated organisms from holding facilities/transport containers.
	2. (I/U) Release of organisms by private citizens for propagation and harvest. Includes associated organisms.
	3. Government sanctioned release of organisms for propagation and harvest.
	4. (I/U) Organisms associated with food packaging, released when packaging is discarded.

Vector	Means of Introduction
Horticulture & Flora Culture	1. (I/U) Introduction of plants and associated organisms into gardens, waterways, and riparian areas 2. (U) Introduction of organisms associated with water and soil storage/transport media.
Pest Control	1. (I/U) Release of organisms as biological control agents. Includes their associated organisms.
Restoration	1. (I/U) Introduction of organisms (esp. plants and fish) and their associated organisms for habitat restoration/conservation purposes. 2. (U) Release of organisms associated with re-introduced or re-established native species.
Water Diversion Projects	1. (I/U) Movement of organisms into new aquatic systems as a result of projects designed to redirect the flow of water (e.g., inter-basin water transfer, canals, dams, and diversions)
Recreation	1. (U) Introduction of organisms associated with relocated recreational gear (e.g., SCUBA tanks, rafts, inner tubes, ATVs, hiking boots, etc.) 2. (I/U) Movement of organisms along transportation corridors - roads, trails, etc.
Natural Dispersal & Hitchhiking	1. (I/U) Dispersal of organisms under their own influence or aided by other organisms (e.g., birds moving snails from one wetland system into another)
Military and Development Actions	1. (U) Introduction of organisms associated with transport of military and development aid.
Drinking Water Shipments	1. (U) Introduction of organisms associated with bottled water.
Smuggling	1. (I) Illegal transport of organisms

⁶ The questions in the Australian Weed Risk Assessment system include information on the plant’s climatic preferences, biological attributes and reproductive and dispersal method. The responses to the questions generate a numerical score that is used to determine whether to accept, reject or further evaluate the species. The system also makes a prediction as to whether a species may be a threat to agriculture and/or natural ecosystems. See the Australian Quarantine Inspection Service website at www.agis.gov.au/docs/plpolicy/weeds1.htm. Reference from: Wittenberg, Rudiger and M.J.W. Cock, eds. 2001. *Invasive Aliens: A Toolkit of Best Prevention and Management Practices*. CAB International, Wallingford, Oxon UK.

⁷ The screening system will include: introduction of non-native biological control organisms for animal pest-control to complement measures already in place for screening of plant biological control organisms; *all* non-native freshwater or terrestrial organisms into US island states or territories (because of the vulnerability of insular areas); non-native propagative plants or seeds (e.g., for horticulture or botanical gardens); non-native land animals (e.g., insects, zoo animals, terrestrial pets, food animals); and non-native aquatic organisms (e.g., fish or shellfish stocking, aquarium organisms, aquaculture stock, aquatic plants, biological control agents). National Invasive Species Council. 2001. *Meeting the Invasive Species Challenge: Management Plan*, pp. 32-33.

⁸ Commissioner of the Environment and Sustainable Development, Chapter 4: pp. 5 and 8.

6. Objective 3: Early Detection and Rapid Response

Objective 3: To enable early detection of, and rapid response to, invasive alien species occurrences in BC.

Priority Activities:

- 3.1 Support development and use of a centralized, coordinated and current identification, assessment and inventory system for invasive alien species (including surveillance of diseases).
- 3.2 Contribute scientific expertise (e.g., at-risk species and ecosystems) and allocate resources to a coordinated provincial invasive alien species early detection and rapid response program.

Even the best prevention efforts cannot stop all introductions. Early detection of incipient invasions and quick coordinated responses are needed to eradicate or contain invasive alien species before they become too widespread and control becomes technically and financially impossible. Populations that are not addressed or eradicated early in their invasion may require costly ongoing control efforts.

Currently, there is no comprehensive provincial (or national) system for the assessing, responding to and monitoring incipient invasions of alien species based on threats to biodiversity, the economy and human health. This is a critical gap in British Columbia's approach to managing alien species invasions. Such a program is currently being proposed for alien plant species under the auspices of a partnership-based Invasive Plant Council.¹ The Ministry fully supports, and is participating in, this initiative. A National Strategy on Invasive Alien Species is also under development, involving several federal agencies, as well as provincial counterparts, with Environment Canada acting in a leadership and coordination role.²

Key elements in an early detection and rapid response system include:

1. Access to current and reliable scientific and management information;
2. Regular, carefully designed and targeted surveillance surveys and an effective reporting system;
3. Rapid and accurate species and sub-species identification (accessible and knowledgeable experts with taxonomic training and expertise in particular species groups and sub-groups, such as plants, fish, terrestrial vertebrates and invertebrates);
4. Standard and broadly accessible and understood procedures for rapid risk assessment;

Figure 12: Carpet Burweed, An Opportunity for "Rapid Response" to an Invasive Alien Threat

Carpet burweed (*Soliva sessilis*), an introduced weed originating from South America, has become a major nuisance in the United States on golf courses and in parks and lawns. The sharply pointed spines on carpet burweed seed structures can easily pierce the skin. In the absence of competition, or on compacted soils, plants will cover the ground "like a carpet."

The first, and to date only, confirmed sighting in BC was at Ruckle Provincial Park on Salt Spring Island in 1997. The invasive weed threatens the destruction of a number of at risk plant species at this site. Although initial attempts have been made to remove carpet burweed from the site, subsequent surveys show an increasing, but still localized, spread of the plant within the park. Further concerted effort to eradicate this "beachhead" is underway.

Carpet burweed presents an opportunity to publicize alien species threats and pilot test containment, eradication and monitoring tools. It may not yet be too late!

5. Targeted training and mechanisms for coordinating the efforts of federal, provincial, Regional District and local government agencies, First Nations, NGOs and private interests (e.g., through shared stewardship with a community of leaders who are informed and motivated to act quickly);
6. Adequate technical assistance (e.g., quarantine, monitoring, information sharing, research and development and technology transfer);
7. Quick access to stable funding for emergency response efforts (and a separate funding envelope (“pot”) for early detection and eradication efforts); and
8. Clear eradication protocols and procedures, including clear delineation of lead, coordination and other responsibility/authority.

We can draw on emerging experience from other jurisdictions. In the United States, for example, the National Invasive Species Council has compiled taxonomic resources and posted information on their website, developed detection and monitoring systems, and is in the process of developing a program for coordinated rapid response to incipient invasions of natural and agricultural areas.³ In Australia, a national task force was set up to evaluate the response to a 1999 invasion of the zebra mussel (*Mytilopsis* sp.) that was seen as posing a threat to the environment, infrastructure and fisheries of northern Australia.

Figure 13: The Green Crab is Eating its Way to BC’s Coast

The European green crab (*Carcinus maenas* (L.)), known colloquially as “the cockroach of the sea” invaded the coast of North America at Cape Cod more than a century ago. Green crabs are known to be voracious predators, preferring bivalves (e.g., clams, oysters, mussels) and other infaunal organisms, but are also known to prey on other species of crab. The green crab was associated with the demise of the softshell clam industry in northern New England and Nova Scotia in the mid-1950s.

The green crab was first reported on the west coast in San Francisco in the late 1980s – most likely arriving in either ballast water or the packing material for live bait or Atlantic lobsters. The crab spread northward at a rate of about 55 km per year through to 1997. In Humbolt Bay California, research has shown a 40% drop in Manila clam harvest since the European green crab became established in the bay.

The rate of green crab range expansion on the Pacific coast has recently increased dramatically – a movement of over 1000 km in two-three years. It likely that it invaded both Washington State and BC waters in 1997-98, through larval transport on the warm currents of El Niño.

If the crab becomes established in BC, it may have significant effect on the province’s clam, oyster and mussel industries, and possibly the commercially important Dungeness crab fishery. The landed value of native clams and crab in BC was about \$25 million in 2000. Dungeness crab is the most important commercial crab species in BC, with over 200 fishing vessels and crews from over 30 coastal communities dependent on it. There are also an estimated 10-20,000 recreational crabbers.

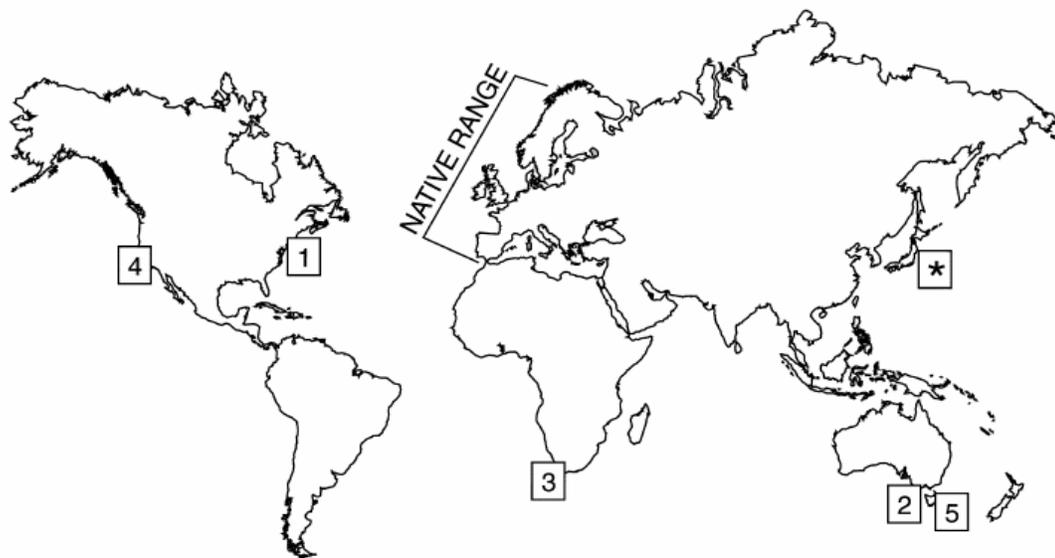
Currently only limited numbers of European green crab have been found in BC and Washington (although over 850 adults have been captured in Willapa Bay and over 250 in Gray’s Harbour) and it is likely that any permanent populations in either jurisdiction are limited in size and scope. This is a critical time for assessing and effectively managing the invasion of the species.

In Washington State, the invasion brought a quick response with the Governor and Legislature in 1998 allocating emergency funds to begin a monitoring program and initiate control actions. A Zebra Mussel and European Green Crab Task Force was established and implemented programs for the outer coast and Puget Sound. Monitoring effort has enlisted the help of aboriginal tribes and partnership groups, and 2 ½ years of trapping effort has resulted in the removal of over 1100 crabs from Willapa Bay and Gray’s Harbour (representing a potential generation of 80-160 million eggs per season).

Information from: Green Crab Case Study by Glen Jamieson in Claudi et al. (pp.179-186); and Washington Department of Fish and Wildlife Aquatic Nuisance Species Bulletin www.wa.gov/wdfw/fish/ans/greencrab.htm

The taskforce concluded that other likely marine invaders could be threatening the country's marine environment and recommended a rapid response strategy for marine organisms. The Australian national Centre for Research on Introduced Marine Pests has completed an extensive literature review of eradication and control approaches to marine invasive alien species as a first component of a "Rapid Response Toolbox" accessible through the World Wide Web and including an interactive hazard analysis.⁴ Another source of information is the US Federal Interagency Committee for the Management of Noxious and Exotic Weeds. The committee has drafted a *National Early Warning and Rapid Response System for Invasive Plants in the United States*.⁵ The Action Plan identifies specific goals, objectives and actions for ten major system elements (e.g., partnerships, rapid assessment, rapid response, information management and research, public outreach and awareness, e-commerce in invasive plants).

Map 4: World map showing the native range of the green crab and regions where it has been introduced



Numbers are in chronological order: 1 – East Coast, USA (early 1800s), 2 – Australia (early 1900s), 3 – South Africa (1983), 4 – West Coast, USA (1989), and 5 – Tasmania (1992).

* Indicates invasion of the very similar Mediterranean species (*C. aestuarii*) to Japan (1984)

Map 5: Known Distribution of Green Crab in British Columbia.

It is thought that the green crab *Carcinus maenas*, first entered the Pacific coast of North America via San Francisco Harbour in 1989-90. By 1998 green crabs were being found in Willapa Bay and Gray's Harbour in Washington State. The first crabs in BC were located on June 17, 1999 head of Barkley Sound in Useless Inlet. Also, in 1999 green crabs were located in Esquimalt Harbour and on May 11, 2000 a male and a female green crab were found in Lemmens Inlet in Clayoquot Sound. Green crabs have now been found as far north on Vancouver Island as Esperanza Inlet.



Pathway Management

Pathway management is the most efficient way to address unintentional introductions. For example, high-risk invasive alien species not yet established can be identified, along with the likely pathways for their entry, and then the pathways can be monitored and/or managed to prevent introduction of invasive alien species.

Quite apart from initial intentional releases or accidental introductions, invasive alien species have differing rates of expansion following introduction. Some species undergo an explosive expansion of their range after natural or human barriers are removed or with changes in environmental conditions. The European green crab, for example, spread very rapidly through Washington State to British Columbia in the late 1990s, most likely due to changes in ocean currents through an exceptional El Niño event (see Figure 13, page 39 and Maps 4 and 5, page 40).

Trading partners, in particular those having common borders with British Columbia, have a shared interest in assessing and monitoring entry pathways and potential vectors of spread for invasive alien species. Significant costs (and trade disruptions) can be avoided through rapid response to initial detection of known “high risk” invasive alien species such as Gypsy moth.

Shared water bodies (freshwater rivers and lakes, and the Pacific coast) are notably “fluid” and provide ready vectors for the dispersal of alien species. Land use practices, changes in agricultural uses or the construction of new linear pathways (e.g., roads, utility corridors) connecting habitats have been linked to “explosions” in numbers and establishment of more pernicious alien invasive species populations.

Section Endnotes:

¹ *Invasive Plant Strategy for British Columbia*, 2004. The strategy identifies the lack of a coordinated means for the early detection and eradication of new invasive species as one of the “top ten challenges” to invasive plant management in the province.

² A draft *National Strategy on Invasive Species* dated March 2004 has been prepared under the leadership of Environment Canada. An accompanying *Operational Plan for Invasive Alien Plants and Plant Pests* provides an assessment of current capacity at a national level and identifies “action items” for strategic priorities such as prevention of introductions. Contact Beth MacNeil of Environment Canada for current status of documents: Beth.MacNeil@ec.gc.ca.

³ National Invasive Species Council. 2001. pp. 34-36.

⁴ The Australian CSIRO Centre for Research on Introduced Marine Pests review of eradication and control approaches noted that much of the literature (especially from failed eradication attempts) has never been published. The review is available at www.marine.csiro.au/CRIMP/Toolbox.html.

⁵ Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW). 2002. *National Early Warning and Rapid Response System for Invasive Plants in the United States: Draft Action Plan* March 15, 2002. Washington D.C. The overall purpose of the US Early Warning and Rapid Response system is “to provide a coordinated framework of public and private partners at the local, state, regional and national levels to more effectively address new invasive plants through:

- Early detection and reporting of suspected new plant species to appropriate officials;
- Identification and vouchering of submitted specimens by designated specialists;
- Verification of suspected new state, regional and national plant records;
- Archival of new records in designated regional and plant databases;
- Rapid assessment of confirmed new records; and
- Rapid response to verified new infestations that are determined to be invasive.”

7. Objective 4: Effective Control and Management

Objective 4: To undertake effective control and management strategies for invasive alien species occurrences in BC, in a manner that does not put native species, natural ecosystems, or the economy at risk.

Priority Activities:

- 4.1 In partnership with other government agencies, industries and communities establish and share clear protocols – utilizing the principles of Integrated Pest Management (IPM)¹ – for the control of invasive alien species that may affect ecosystems and native species. MWLAP will focus control and management effort on provincial protected areas, and work with partners in support of efforts in other areas.
- 4.2 Utilize an appropriate mix of control methods and mitigation measures for the management of invasive alien species on lands under management jurisdiction of the Ministry (e.g., provincial protected areas).

When invasive alien species appear to be permanently established, the most effective action may be to prevent their spread or lessen their effects through control measures. For some invasive alien species, adequate control measures are not available or populations are too widespread for eradication to be feasible. For example, zebra mussel control measures are focused largely on preventing clogging of intake pipes and preventing spread from infested waters to other areas, rather than the eradication of populations within infested waters.

Infestations of invasive alien species do not follow administrative boundaries (e.g., between Regional Districts) and commonly involve both Crown and private lands. Effective control almost always depends on cooperation and effective partnership involving landowners and managers from both public and private sectors. In British Columbia, a provincial coordinating group (such as an “Alien Species Council”), involving all levels of government and provincial interest groups, working with regional committees would enable consistent dissemination of information, with coordinated use of resources for management of alien species. This approach is being advocated for invasive alien plants under the *Invasive Plant Strategy for British Columbia*. The Ministry supports and is participating in this initiative.² In the marine realm, port authorities need to be involved in any coordinated management measures, as well as US agencies in Washington state and Alaska. Monitoring of intentional introductions, and any intentional or unintentional releases, such as salmon species and invertebrates for aquaculture or mariculture, could be needed to encourage continued cooperation of key American agencies and interests in alien species control and cross-boundary trade.

Control and management objectives for invasive alien species may include:

- ◆ Eradication within a localized area;
- ◆ Population suppression;
- ◆ Limiting dispersal; and/or
- ◆ Reducing effects on species and ecosystems at risk, and sensitive habitats.

Integrated Pest Management

Control and management of invasive alien species is best accomplished using an Integrated Pest Management (IPM) approach. This involves considering best available scientific information, updated target population monitoring data and the environmental effects of control methods in selecting appropriate complementary control methods to achieve management objectives. These methods may include:

- ◆ Cultural practices (e.g., crop rotation, revegetation, grazing and water level manipulation);
- ◆ Physical restraints (e.g., fences, equipment sanitation, electric dispersal barriers);
- ◆ Removal (e.g., hand-removal, mechanical harvesting, cultivation, burning, hot foam, mowing);
- ◆ Targeted use of chemical and bio-pesticides;
- ◆ Release of selective biological control agents (such as host-specific predator/herbivore organisms); and
- ◆ Interference with reproduction (e.g., pheromone-baited traps, release of sterile males).

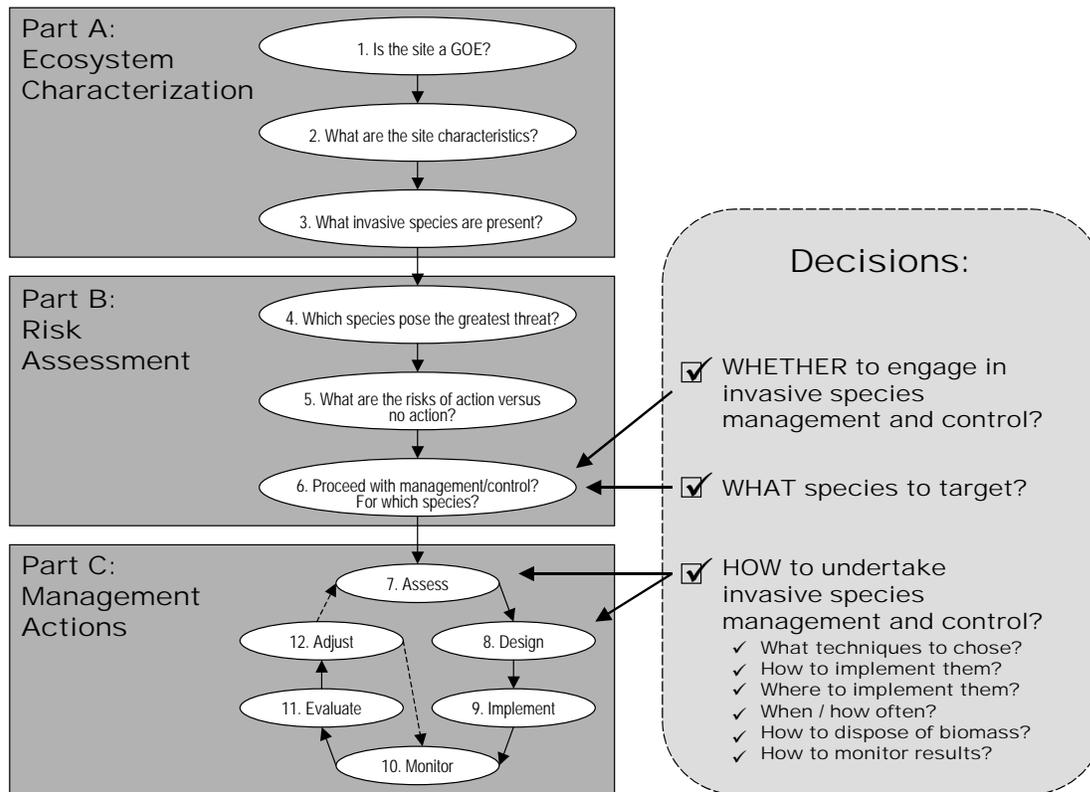
Often several methods of control are used in concert within an overall IPM framework. For example, the control of purple loosestrife may involve biological control, mechanical removal from outlying populations and manipulation of water levels where possible. Use of chemical and bio-pesticides needs to be carefully considered due to their environmental effects, especially in highly vulnerable areas with sensitive or at-risk native species.

It is also important to consider and carefully assess potential ecological side effects of biological control insects prior to their introduction to control an invasive alien species. In a “typical” case of biological control, multiple natural enemies and competitors from the indigenous area are released under the assumption that, in the absence of their own natural enemies and competitors, one or more may limit the density of the invasive plant. An implicit assumption underlying this process is that the information available prior to release is sufficient to predict and prevent significant ecological effects. Recent studies summarized in a February 2003 paper in *Conservation Biology* suggest that this assumption needs to be reexamined, as significant ecological effects on native species of insects have been reported in biological control of both weeds and insects.³

Figure 14 below is an example of a decision support tool for invasive species management in a vulnerable and at risk ecosystem. Additional information on development of the tool and other resources for the management of alien species in the Garry oak ecosystem can be accessed through the website of the Garry Oak Ecosystem Restoration Team (GOERT).⁴

Figure 14: Tools to Support Invasive Alien Species Management and Control Decisions

Determining appropriate actions that can and/or should be taken to control invasive alien species can be a daunting task. The Garry Oak Ecosystem Restoration Team (GOERT) has developed a “Decision Support Tool” for assessing appropriate management actions to maintain Garry oak ecosystems. The tool is targeted for use by those responsible for or interested in management of this rare and threatened ecosystem and provides a list of issues to consider in regards to: ecosystem characterization; impact/risk assessment; and management actions.



Section Endnotes:

¹ British Columbia’s *Integrated Pest Management (IPM) Act* defines IPM as “a process for managing pest populations that includes: a) planning and managing ecosystems to prevent organisms from becoming pests; b) identifying pest problems and potential pest problems; c) monitoring populations of pests and beneficial organisms, damage caused by pests and environmental conditions; d) using injury thresholds in making treatment decisions; e) suppressing pest populations to acceptable levels using strategies based on considerations of: biological, physical, cultural, mechanical, behavioural and chemical controls in appropriate combinations; and environmental and health protection; and f) evaluating the effectiveness of pest management treatments.”

² See endnotes, Section 5. Objective 2: Prevent Introductions of Harmful Invasive Alien Species and Section 6. Objective 3: Early Detection and Rapid Response, for additional details and contact information regarding the *Invasive Plant Strategy for British Columbia*.

³ S.M. Louda *et al.* *Conservation Biology* 17(1):73-82.

⁴ Murray, C. and R.K. Jones, 2002. *Decision Support Tool for Invasive Species in Garry Oak Ecosystems* (http://www.goert.ca/docs/goe_dst.pdf) developed for the Garry Oak Ecosystem Restoration Team (GOERT) by ESSA Technologies Ltd. See also www.goert.ca.

8. Objective 5: Restoration of At-Risk Ecosystems and Native Species

Objective 5: To restore native species and habitat conditions in at-risk ecosystems that have been invaded by alien species, and to encourage use of ecological restoration as a means of invasive alien species control and management.

Priority Activities:

- 5.1 Support partnerships to restore at-risk ecosystems and maintain healthy populations of native species threatened by alien invasions.
- 5.2 Support partnerships to restore at-risk ecosystems and maintain healthy populations of native species as a preventative framework for alien species invasions.
- 5.3 Establish a program to assess and disseminate information regarding the effectiveness of ecological restoration as a means of alien species control in different ecosystems and regions of the province.

Restoration is an integral component of a program to contain the effects of invasive alien species on native species and healthy ecosystems. As well as providing ecological benefits such as increased native biodiversity, increased native forage, improved river flow, sediment and nutrient regimes, and detoxification of polluted areas and increasing human esthetic and recreation values, ecological restoration of degraded areas can decrease vulnerability to future invasions of alien species. Several recent field and experimental studies and reviews have confirmed that restoration that encourages a diverse mix of late successional native species can reduce community susceptibility to alien species invasion and act as an effective method of weed control.¹ From this perspective, restoration is an important part of site-specific invasive alien species prevention and control plans and projects. Due to a lack of native plant sources, in some situations it may be appropriate to use non-invasive alien species for initial restoration effort – with the long-term goal of replacing this temporary cover with local genetic material of native species.

If an invasive alien species is eradicated in an area and the effect on the environment was small, recovery can be rapid. In many cases, however, the disturbances caused by alien species have pervasive effects through an ecosystem, and these alterations are not easily healed. For example, invasive alien species can dramatically reduce biodiversity, alter ecosystem processes, affect surface water quality, or reduce ecosystem productivity. Each invasion area is unique, with such factors as scale, duration and frequency of the invasion, influencing both the nature and effectiveness of restoration efforts. Restoration of aquatic systems, in particular, can be difficult.²

Restoration projects need to be based both on general principles and site-specific considerations and analysis. Resource managers need to have access to specific and current research information on effective and appropriate management strategies and tools, including detailed site assessment methodologies and information on the inter-relationships of the (native and non-native) species involved. As well, monitoring programs are needed to track the effectiveness of management actions in containing and/or eradicating alien invasions and restoring the health of native ecosystems and species.

Section Endnotes:

¹ For a more complete discussion and list of references, see: Blumenthal, D. M., N. R. Jordan, and E. L. Svenson. 2003. *Weed control as a rationale for restoration: the example of tallgrass prairie*. *Conservation Ecology* 7(1): 6. www.consecol.org/vol7/iss1/art6.

² National Invasive Species Council. 2001. p. 40.

9. Action Areas in Support of Objectives

The five objectives described in the previous sections of this document provide an explicit framework to guide the Ministry's activities, and clear target statements against which to assess progress. This section further describes Ministry activities under "action areas" that are commonly shared with other partners involved in preventing and controlling invasive alien species invasions in British Columbia. The Biodiversity Branch of the Ministry – with responsibility for biodiversity science, standards and policy – will most commonly work in a supporting role with partners, providing scientific expertise and information. In its activities, the Ministry will be dedicated to supporting a science-informed approach to the conservation of biodiversity – promoting a strong and vibrant provincial economy, as well as improving environmental performance.

A. Leadership and Cooperation

Priority Activities:

- A.1 Dedicate staff and resources to ensure effective initiation and ongoing success of the proposed Invasive Plant Council of British Columbia (*cf.* Activity 2.4).
- A.2 Investigate interest in establishing "Invasive Alien Species Councils" that address the full spectrum of invasive alien species issues in British Columbia (i.e., terrestrial animal and freshwater and marine aquatic species) among potential government and non-government partners.
- A.3 Develop strategies and action plans to address issues associated with biodiversity in British Columbia, that support provincial, national and international efforts to address the problems of invasive alien species.
- A.4 Working with federal and provincial agencies in nationally coordinated initiatives, participate in the establishment of cooperative certification and/or monitoring programs for high priority industries (such as aquarium and pet trade, aquaculture and agriculture, horticultural and landscaping trade, international transport and import export businesses) that could serve as invasive alien species pathways of entry.

Invasive Alien Species Councils

To effectively manage invasive alien species, British Columbia needs cooperative leadership and organization, addressing province-wide and local interests, with national and international perspectives and connections. "Lead agency" responsibility for addressing invasive alien species concerns in BC has not been explicitly mandated (nor is any single group in the province recognized as a "lead organization" with respect to alien species). MWLAP and Biodiversity Branch have an essential interest and role to play in encouraging partnerships that maintain and restore native species and natural ecosystems. The Ministry will support coordinated efforts to address invasive alien species issues, providing expertise in biodiversity science, policy and standards and other resources as available and feasible.

In the United States, National and State "Invasive Species Councils" have been established under a presidential Executive Order.¹ While such Councils have not yet been explicitly established in Canada or British Columbia, a broad-based group has recently established a province-wide "Invasive Plant Council" as a key element for addressing invasions of alien plants in BC.²

Coordinated attention among partners is also needed to address terrestrial fauna (animals), freshwater ecosystems and the marine realm. As many sensitive and/or important ecosystems (e.g., estuaries, riparian areas) cut across terrestrial, freshwater and marine realms, it may be that the BC Invasive Plant Strategy will be a first step for the partnership group in addressing broader alien species concerns. However, in the meantime, there remains a need for similar concerted and coordinated consideration of alien species in freshwater and marine realms, and for terrestrial non-plant species.

National and Provincial Biodiversity Strategies

The problems posed by invasive alien species extend beyond provincial borders, into national and international spheres. Relevant national and international organizations and international NGOs can be effective partners to government, working with provincial and local agencies to address invasive alien species problems. Local, federal and international public health agencies (including the World Health Organization), for example, are at the forefront of tracking and researching many pathogens (such as the West Nile virus). International trade and travel authorities and industry associations are inherently well-placed to assist in reducing the risks posed by invasive alien species introductions and spread related to trade, travel and tourism. The challenge in this situation is to focus effort on key local priorities and gaps, given the breadth of issues and organizations involved at national and international scales.

The Ministry will support the refinement and implementation of the Canadian Biodiversity Strategy through participation on, and appropriate support for, inter-provincial, national and international committees associated with cross-jurisdictional organizations such as the Canadian Endangered Species Conservation Council (CESCC), the Canadian Wildlife Ministers' Council and the North American Commission for Environmental Cooperation (CEC).³

B. Science-informed Inventories, Risk Assessment and Monitoring

Priority Activities:

- B.1 Work with the provincial Conservation Data Centre (CDC), and other partners, to establish common methodologies for assessing invasive alien species that threaten biodiversity in British Columbia, and to maintain a current and accessible inventory of invasive alien species data (*cf.* Activity 3.1).
- B.2 Participate in the development and utilization of risk assessment processes that review proposals for intentional introductions of invasive alien species to British Columbia (e.g., Committee on Introductions and Transfers of Aquatic Organisms) (*cf.* Activity 2.2).
- B.3. Contribute scientific expertise (e.g., botany, taxonomy, wildlife biology and disease, terrestrial and aquatic ecology, forestry, agrology) to develop and review invasive alien species monitoring and surveillance programs, and conduct regular surveys for alien species on lands and waters under Ministry jurisdiction (*cf.* Activities 1.4 and 2.3).
- B.4 Contribute scientific expertise to the development and implementation of invasive alien species “early detection and rapid response” strategies (*cf.* Activity 3.2).

Assessment and Inventory of Invasive Alien Species that Threaten Biodiversity

Official noxious weed lists generally cover only species that affect agricultural production or have other adverse effects on human economy or health. The non-profit organization NatureServe (associated with The Nature Conservancy and Conservation Data Centers across North America) has over the past decade been

developing a standardized methodology for categorizing and listing non-native invasive plants according to their effects on biodiversity in a large area such as a state, nation, or ecological region.

NatureServe is now using these criteria to create a national (US) list of non-native vascular plant species that threaten biodiversity. Biodiversity Branch has tested this methodology for potential application to a range of species groups (beyond plants) in British Columbia. Preliminary results have been positive and are compiled in a separate report accompanying this Framework.

The inventory and ranking methodology is compatible with existing BC Conservation Data Centre protocols and makes the process of listing alien invasive species transparent, objective and comparable. The resultant assessments are useful to researchers, land managers, regulators, consumers and commercial interests (such as nursery industry, vegetation managers and Integrated Pest Management practitioners).

Figure 15: “Scoresheet” Questions and Categories for Invasive Alien Species Assessment (from NatureServe)

QUALIFYING QUESTIONS	
<input type="checkbox"/>	i. Established outside of cultivation in region of interest?
<input type="checkbox"/>	ii. Occurs in conservation areas?
I. ECOLOGICAL IMPACT	
<input type="checkbox"/>	1. Impact on abiotic ecosystem processes
<input type="checkbox"/>	2. Impact on community structure
<input type="checkbox"/>	3. Impact on community composition
<input type="checkbox"/>	4. Impact on individual native plant or animal species
<input type="checkbox"/>	5. Conservation significance of threatened native species
II. CURRENT DISTRIBUTION AND ABUNDANCE	
<input type="checkbox"/>	6. Current range size in region
<input type="checkbox"/>	7. Proportion of current range negatively impacted
<input type="checkbox"/>	8. Proportion of region's biogeographic units invaded
<input type="checkbox"/>	9. Diversity of habitats or ecological systems
III. TREND IN DISTRIBUTION AND ABUNDANCE	
<input type="checkbox"/>	10. Current trend in total range within the region
<input type="checkbox"/>	11. Proportion of potential range currently occupied
<input type="checkbox"/>	12. Long-distance dispersal potential within region
<input type="checkbox"/>	13. Local range expansion or change in abundance
<input type="checkbox"/>	14. Inherent ability to invade conservation areas
<input type="checkbox"/>	15. Similar habitats invaded elsewhere
<input type="checkbox"/>	16. Reproductive characteristics
IV. MANAGEMENT DIFFICULTY	
<input type="checkbox"/>	17. General management difficulty
<input type="checkbox"/>	18. Minimum time commitment
<input type="checkbox"/>	19. Impacts of management on native species
<input type="checkbox"/>	20. Accessibility of invaded areas

Risk Assessment for Intentional Introductions of Invasive Alien Species

A key tool for preventing the introduction of harmful invasive alien species to British Columbia is the risk analysis and assessment process for screening first-time intentional introductions of non-native species to the province. The Ministry will support development of such risk assessment processes and participate on and/or contribute scientific expertise to existing processes, such as the Committee on Introductions and Transfers of Aquatic Organisms, strengthening the science-base of risk assessment.

Monitoring and Surveillance Programs

The Ministry is committed to monitoring, and reporting on, the health of at-risk ecosystems and native species in British Columbia (*cf.* Activity 1.4). With respect to invasive alien species, the Ministry will also establish a monitoring program utilizing expert surveys to detect and track the presence of invasions on lands under its administration, and of species intentionally introduced for agriculture and aquaculture purposes (*cf.* Activity 2.3). A monitoring program is essential to complement and assess the effectiveness of prevention efforts, as well as an important element of rapid detection and early response strategies. Freshwater and terrestrial ecosystem classifications, part of the provincial response to addressing issues associated with biodiversity, can be used to streamline monitoring and survey efforts.

Rapid Detection and Early Response

While the Ministry has only limited resources available for responding to alien species invasions, it can provide specific scientific expertise and assist in marshalling additional resources as part of coordinated early detection and rapid response strategies. The Royal BC Museum, the Pacific Forestry Centre and academic institutions, among other sources, may also be able to provide specialist expertise in alien species identification and early response efforts. A critical need is to establish authority as to responsibility for taking action (“lead agency or authority”) in an early effort to detect and eradicate invasive alien species.

C. Information and Awareness

Priority Activities:

- C.1 Provide specialist information regarding the vulnerability of high value and at-risk ecosystems and native species to alien species invasions, the current and potential adverse effects of invasive alien species on biodiversity in BC, and actions that can be taken to reduce or prevent such effects for use in information and awareness campaigns.
- C.2. Develop specific and targeted information and awareness programs to support the Ministry’s goal of maintaining biodiversity and protecting high value and at-risk ecosystems and native species (e.g., “British Columbia’s Least Wanted Alien Species”).
- C.3 Support a coordinated review of high priority industries (such as aquarium and pet trade, aquaculture and agriculture, horticultural and landscaping trade, international transport and import export businesses), for subsequent development of targeted information and awareness initiatives. (*cf.* Activity A.4).

Public Awareness and Information

Values and perceptions filter our view of alien species invasions. The prevention and control of harmful invasive alien species will require modifying behaviours, values and beliefs and changing the way in which many decisions are made. Public understanding and acceptance of the actions needed to protect British Columbia's environment and economy from alien species invasions will be critical for any comprehensive plan or framework to succeed. To that end, a wide variety of awareness, outreach and training tools are needed, to help raise awareness of the means by which alien species become established in the province and motivate action to prevent introductions and protect BC's natural resources from invasions.

Partner organizations in British Columbia need to coordinate information and awareness effort for greatest collective benefit – leading to an informed public that supports ongoing actions to reduce the threat of invasive alien species, and the participation of key partners who are actively engaged in implementation of effective solutions. A “strong provincial-level awareness program that will complement and support similar programs for regional districts, municipalities and regional invasive plant programs,” was proposed in the Invasive Plant Strategy for British Columbia. This initiative is strongly supported by the Ministry. The Invasive Plant Strategy also proposes development and maintenance of a central website and establishment of an information clearinghouse for publication distribution. The information gateway www.invasivespecies.gov developed by the United States National Invasive Species Council could serve as a model for British Columbia's efforts.

Targeted Awareness and Information

Effective communication is the cornerstone of effective action. Many individuals and businesses are unaware that their actions can result in the introduction and spread of invasive alien species. Businesses or individuals involved in potentially “high-risk” activities such as transporting living organisms or packaging materials that may contain invasive alien species can form an important line of defense for prevention and control. As well as the major sectors of forestry, aquaculture and agriculture, partnerships need to be cultivated with – and targeted campaigns developed for – such industries as horticulture, seed and feed, pet and aquarium trade, and tourism and travel.

Figure 16: Invasive Alien Species and the Landscape Trade

Soils, seeds, nursery stock and packing materials (especially wood packaging) have been the primary pathways for the introduction of most of the 79 alien tree bug species to Canada. Many of the woody plants that have been introduced to North America through the landscape trade and for agricultural and forestry purposes have become naturalized, although it is unclear how many are considered invasive. Engagement and cooperation of the horticultural sector will be essential to prevent and detect further introductions of alien species.

Source: *The Threat of Alien Invasive Species in Canada*, Environment Canada 2002, p. vi

D. Development, Implementation and Assessment of Management Measures

Priority Activities:

- D.1 Identify priority areas under Ministry jurisdiction (e.g., protected areas) for action to eradicate, contain or control alien species invasions, and work with partner organizations to implement and assess effectiveness of management protocols (*cf.* Activities 4.1 and 4.2).

- D.2. Support partnership efforts to develop and assess invasive alien species management measures that utilize the principles of Integrated Pest Management (IPM) and minimize use of pesticides and herbicides – by providing scientific expertise (at-risk species and ecosystems characteristics, IPM practices) and identifying potential pilot areas for assessment (e.g., sensitive ecosystems facing alien species invasions).

Management Measures – IPM and At-risk Ecosystems and Native Species

When invasive alien species appear to be permanently established, management actions may need to focus on preventing further spread or lessening adverse effects through control measures. However, control measures themselves (e.g., application of herbicides, planting of non-native species, introduction of non-native species for “biocontrol”) can have additional effects on at-risk or sensitive ecosystems and native species.⁴ The Ministry will work with partners to develop, implement and assess management tools that minimize further stress on at-risk ecosystems and native species while achieving control objectives. Opportunities exist for controlled assessment of alien species management actions in areas with a high public profile (e.g., protected areas, such as control of carpet burweed in Ruckle Provincial Park on Salt Spring Island – see Figure 12). Documenting and publicizing such “case studies” could assist in public awareness campaigns, as well as disseminating knowledge about effective management protocols.

E. Policy Direction and Legislation

Priority Activities:

- E.1. Participate in a coordinated (inter-agency) review of provincial legislation, regulations and policy direction (including connections with federal statutes) relevant to the prevention and control of alien species invasions, to establish an efficient and effective framework for coordinated management.
- E.2. Assess need for appropriate amendments to legislation and/or regulations under the Ministry’s authority (e.g., *Wildlife Act*) to enable appropriate and coordinated actions to identify, prevent, eradicate and/or control invasive alien species.
- E.3. Participate, as appropriate, in targeted federal-provincial groups tasked with the development and/or implementation of coordinated invasive alien species legislation and policy (e.g., prevention network, risk assessment protocols and decision-making, rapid response measures).

Review Policy and Legislation for Coherent Direction

The problem of alien species invasion is global in scale, hence British Columbia needs to act in concert with federal, USA and other provincial and territorial legislation and policy initiatives to maintain a coherent approach to prevent and detect harmful introductions, and control invasive alien species. Canada has many long-established laws and regulations to prohibit or restrict the entry of foreign organisms capable of causing economic damage to agricultural crops, livestock or forest trees. Invasive alien species have been the subject of many international conventions, resolutions, agreements, strategies, action plans, guidelines, studies, and codes of conduct and practice. Yet the numbers and adverse effects of invaders in British Columbia have continued to grow in recent decades (See Appendix 1 for summary tables of some of the international and national level agreements and legislation relevant to alien species).

While many of the requirements for an effective and efficient invasive alien species management program can be met through clear and coherent policy direction, legislative measures (e.g., setting out import and release requirements and enforcement penalties) are an essential component. The scope of invasive alien

species management extends beyond the Ministry of Water, Land and Air Protection; hence any review of legislation and policy direction should be undertaken on an inter-agency basis. A comprehensive review would consider:

- ◆ Federal authorities and roles;
- ◆ Prevention measures – threat identification, detection, import risk assessment, quarantine provisions;
- ◆ Regulatory requirements – permits and licenses, bonds and insurance, monitoring protocols, auditing and reporting provisions, transportation and shipping requirements;
- ◆ Control and management authority – general provisions, emergency powers, use of biological control agents and/or pesticides, restoration measures;
- ◆ Enforcement and implementation – authority and funding; and
- ◆ Coordination tools – provincial and/or regional Invasive Species Councils, strategies and plans.

If a comprehensive policy and legislation review is not undertaken, targeted amendments to existing legislation and selected new legislation may address high priority alien species issues. For example, the recent Invasive Plant Strategy for British Columbia recommends a limited number of specific changes to provincial legislation:

- ◆ Revising the wording of Section 9 of the *Weed Control Act* to require the establishment of regional weed committees by regional districts, and Section 10(1) to require the mandatory appointment of weed control inspectors to enforce the Act;
- ◆ Expanding current legislation or providing new legislation for the management of invasive plants not classified as noxious weeds; and
- ◆ Enacting new legislation to prevent the spread of invasive plants by land users, such as recreational users on Crown lands (as distinct from responsibilities of land occupiers).⁵

Revising Legislation Under Ministry Authority

While a comprehensive review of legislation under Ministry of Water, Land and Air Protection has not yet been undertaken, one high priority for legislative amendment is the *Wildlife Act*. British Columbia is presently the only province in Canada that does not have legislative provisions for regulating the import, possession and intra-provincial transport of alien wildlife species. An amendment to the Act could establish powers to restrict the introduction of, monitor, control, or manage sites and/or species affected by live specimens for which it has been established that their introduction into, or presence in, British Columbia presents an ecological and/or economic threat to wild species of fauna and/or flora indigenous to the province.

This provision enables actions to limit adverse effects of alien species posing an “ecological threat” to British Columbia’s biodiversity and provides a basis for provincial Wildlife Officers to implement the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The European Union, for example, has enacted Wildlife Trade Regulations with similar wording and has established import bans under the Regulation for such species as the Red-eared slider (*Trachemys scripta elegans*) and the American bullfrog (*Rana catesbeiana*).⁶

Specific Policy or Legislative Initiatives

The Ministry will participate in, or contribute scientific expertise to, high priority policy or legislative initiatives to prevent, control or manage invasive alien species that threaten British Columbia's biodiversity or economy. Examples of such initiatives could include supporting development and enforcement of ballast water regulations (in cooperation with federal agencies), inter-jurisdictional agreements to limit and control transfer of invasive alien species between water basins, development and participation in invasive alien species introduction or control risk assessment processes, and review of biological control measures and monitoring.

Section Endnotes:

¹ The United States National Invasive Species Council was established in February 1999. The Council is co-chaired by the Secretaries of Agriculture, Commerce and the Interior, and includes eight department members, as well as a non-federal Invasive Species Advisory Committee. The mandate of the Council is to: “provide national leadership on invasive species; see that their Federal efforts are coordinated and effective; promote action at local, State, tribal and ecosystem levels; identify recommendations for international cooperation; facilitate a coordinated network to detect and monitor invasive species; develop a web-based information network; provide guidance on invasive species for Federal agencies to use in implementing the *National Environmental Policy Act*; and prepare a national Invasive Species Management Plan.”

² BC Invasive Plant Strategy Workshop, hosted by the Fraser Basin Council, Richmond BC, Feb. 20, 2003.

³ The Commission on Environmental Cooperation, for example, is developing a Strategic Plan for North American Cooperation in the Conservation of Biodiversity that sets out objective areas and actions emphasizing cooperative effort in such areas as information sharing and management of trans-boundary migratory species. See draft dated March 11, 2003 at www.cec.org/files/PDF/BIODIVERSITY/Biodiversity-strategy-5thDraft-eng.pdf. CEC has another related project: “Closing the Pathways of Aquatic Species Introductions across North America”, see www.cec.org/programs_projects/conserv_biodiv/project/index.cfm?projectID=20&varlan=english.

⁴ S.M. Louda et al. 2003. *Invasiveness of Some Biological Control Insects and Adequacy of Their Ecological Risk Assessment and Regulation*. *Conservation Biology* 17(1):73-82.

⁵ *Invasive Plant Strategy for British Columbia*, March 2004, p. 19.

⁶ Second Report of the European Community to the Convention on Biological Diversity. 2002. *Thematic Report on Alien Invasive Species*. October 2002.

10. Marine and Freshwater Ecosystems: Invasive Alien Species Threats and Priority Actions

Efforts to detect and control invasive alien species in British Columbia are currently focused largely on terrestrial species, for example, the establishment of an Invasive Plant Council for the province, with initial impetus arising from threats posed to grass- and range-lands. Longstanding detection and eradication programs are also in place for some invasive alien species, such as the gypsy moth (*Lymantria dispar*), which poses a threat to commercial agriculture and/or forestry. This working document addressing Invasive Alien Species is intended to support maintenance of a vibrant provincial economy, as well as maintenance of the province's biodiversity, and at-risk species and ecosystems, across all species groups and physical realms, terrestrial, freshwater and marine. While the objectives, action areas and Ministry activities apply to the full spectrum of species groups, and to both terrestrial and aquatic ecosystems, invasive alien species threats and priority actions related to marine and freshwater aquatic ecosystems are recapped in this section in order to highlight their significance. As the issues and expertise sets associated with aquatic invasive alien species differ and are frequently discrete from terrestrial interests, separate initiatives and/or distinct activities may be necessary to address looming and/or persistent concerns.

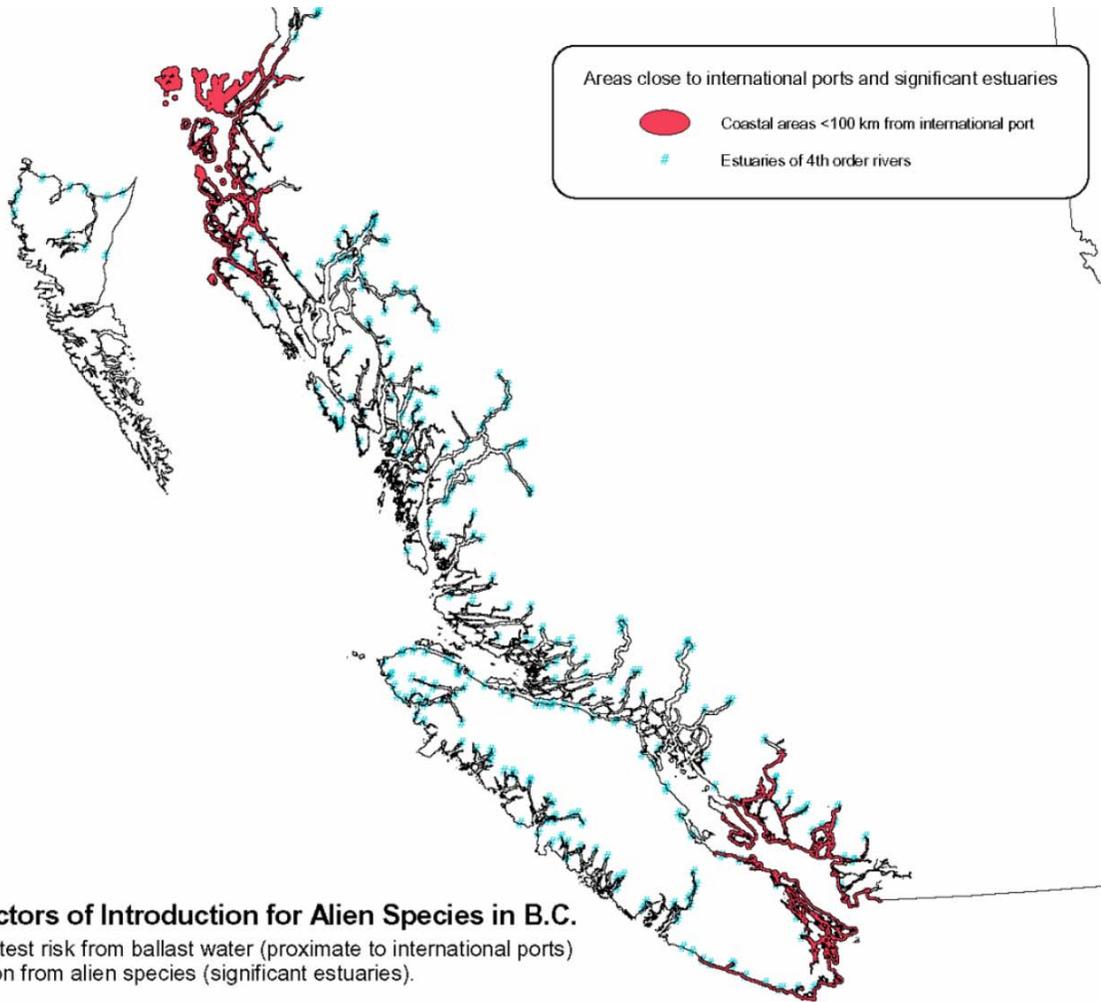
Marine Realm – Threats and Priorities

Threats

The main threats to the marine realm in British Columbia can be summarized by species or by vector. At present the main alien marine species of concern include the European green crab (*Carcinus maenas* Linnaeus), cordgrass (*Spartina anglica*) and Japanese oyster drill (*Ceratostoma inoratum*). There have been too few surveys of marine bacteria, phytoplankton or zooplankton to assess the presence of invasive alien species. A number of invasive alien marine invertebrate species imported for aquaculture have become dominant species in the intertidal areas of much of the BC coast (e.g., Japanese oyster (*Crassostrea gigas*)). Other invasive alien species now commercially exploited include several species unintentionally introduced along with Japanese oyster (e.g., *Tapes philippinarum*), and the Japanese mahogany clam (*Nuttallia obscurata*) (thought to have been introduced via ballast water). There has been considerable concern expressed by some interest groups regarding potential adverse effects on wild stocks of Pacific salmon (*Oncorhynchus spp.*) if Atlantic salmon (*Salmo salar*) become established on the Pacific coast. While there may be short-term beneficial economic effects derived from establishment of this alien species, the full spectrum of effects (including long-term economic effects) has not been thoroughly assessed.

The main pathways for introduction of invasive alien marine species into BC waters have been intentional introductions for aquaculture, accidental introduction along with species brought in for aquaculture, organisms unintentionally introduced and released into BC waters through ballast water, and species that have been introduced in waters in the US Pacific NW and have migrated up the coast into BC (see Map 6: Some Marine Vectors of Introduction for Invasive Alien Species in BC). The areas of the province with the highest potential to be affected by alien species include areas currently under lease to aquaculture, areas most frequented by international shipping (Vancouver, Esquimalt and Prince Rupert), and estuaries and other coastlines closest to Washington State (Southern and west coast Vancouver Island, and southern mainland).

Map 6: Some Marine Vectors of Introduction for Invasive Alien Species in BC



Priority Actions

While most of the regulatory tools in the marine realm belong to the federal government, there are a number of actions that can be undertaken by the Province to reduce risks of alien species to the marine ecosystems of BC. These include:

A: Leadership and Cooperation

- ◆ Together with federal agencies as well as agencies from Washington, Oregon, California and Alaska, establish “Marine Invasive Alien Species Councils” that address the full spectrum of marine invasive alien species issues in British Columbia among potential government and non-government partners.
- ◆ Work with the federal government and other provinces to provide a comprehensive and consistent national framework for the introduction and transfer of aquatic organisms that will ensure a single, standard set of risk assessment and approval procedures covering introductions and transfers of aquatic organisms in Canada, that may be applied across the country.
- ◆ The Province can support federal and international efforts to regulate the import of exotic marine species in ballast water by:
 - ✦ Supporting research into methods to treat ballast water to eliminate exotic organisms. This support could be through grants provided by the BC Science Council or other administrative body.
 - ✦ Contributing to infrastructure costs for required ballast water treatment in the ports of Vancouver Esquimalt, and Prince Rupert as a first priority, as well as other ports.
 - ✦ Supporting federal and international efforts to promote at sea ballast water exchange.
 - ✦ Supporting and actively participating in a coordinated and comprehensive prevention program.

B: Science-informed Inventories, Risk Assessment and Monitoring

- ◆ Contribute scientific expertise to development and implementation of invasive alien species “early detection and rapid response” strategies.
- ◆ Work with the provincial Conservation Data Centre (CDC), and other partners, to establish common methodologies for assessing invasive alien species that threaten biodiversity in British Columbia (e.g. NatureServe assessment methodology for alien species assessment), and to maintain a current and accessible inventory of invasive alien species data (also see second point above under Leadership and Cooperation).
- ◆ Support the development of taxonomic expertise in the identification of marine species, especially invertebrates and plants. This could be facilitated by supporting existing expertise at universities, the Royal BC Museum and government institutions such as the Pacific Biological Station or Institute of Ocean Sciences, as well as by training and employing new scientists.
- ◆ Contribute scientific expertise to development and review of alien species monitoring and survey programs, and conduct regular surveys for alien species in intertidal and marine waters under Ministry jurisdiction.

C: Information and Awareness

- ◆ Provide specialist information regarding the vulnerability of high value and at-risk ecosystems, such as estuaries and harbours, and native species to alien species invasions; the current and potential effects of alien species on biodiversity in BC; and actions that can be taken to reduce or prevent such effects for use in information and awareness campaigns.
- ◆ Develop specific and targeted information and awareness campaigns to make the public aware of the risks of introducing invasive alien species into BC’s marine waters.

- ◆ Support a coordinated review of industry sectors with potential high risk of affecting native species through introduction of invasive alien species. The two industries of highest priority are shipping and aquaculture. The review should consider development of targeted information and awareness initiatives, and potential for cooperative and/or other certification initiatives (e.g., “eco-labeling”).

D: Policy Direction and Legislation

- ◆ Participate in a coordinated (inter-agency) review of provincial legislation and policy direction – and connections with federal statutes – relevant to the prevention and control of alien species invasions, to establish an efficient and effective framework for coordinated management.
- ◆ Assess need for appropriate amendments to legislation under the Ministry’s authority (e.g., *Wildlife Act*) to enable appropriate and coordinated actions to prevent, eradicate and/or control invasive alien species.
- ◆ Participate, as appropriate, in targeted federal-provincial groups tasked with the development and/or implementation of coordinated alien species legislation and policy (e.g., prevention network, risk assessment protocols and decision-making, rapid response measures).

Freshwater Realm – Threats and Priorities

Threats

Freshwater ecosystems (rivers, lakes and wetlands) exist in many different forms, depending upon their underlying climate, geology, vegetation, and other features of the watersheds in which they occur. They are nearly always connected to and dependent upon one another, and as such they form drainage networks that constitute larger ecological systems (i.e., “primary, secondary and tertiary watersheds”). Perhaps the most distinguishing features of freshwater ecosystems from terrestrial ecosystems are their variability in form and their dynamic nature – often changing location (e.g., migrating river channels) and even existence (e.g., seasonal ponds or streams) between seasons or from year-to-year. These attributes make freshwater ecosystems particularly vulnerable to invasive alien species threats.

Freshwater ecosystems are one of the most vulnerable systems to biotic invasion.¹ They face an elevated risk of alien species invasion compared to their terrestrial counterparts due to differences in their species distribution patterns. Organisms on land or in the sea live in or on media that are more or less continuous over extensive regions. Species therefore adjust their ranges to some degree as climate or ecological conditions change. However, freshwater habitats are relatively discrete, and freshwater species do not disperse easily across the land barriers (watersheds) that separate river drainages into discrete units. Freshwater species cannot readily migrate outside their drainage basins to avoid catastrophic climatic and ecological events. Freshwater biodiversity can be highly localized and even small lake or stream systems can harbour unique, locally evolved forms of life. Freshwater lakes are classic examples of “habitat islands” (freshwater islands surrounded by a terrestrial sea). Like islands, the larger, older lakes tend to have high levels of endemism.

Many freshwater ecosystems, notably rivers and large lakes, are trans-boundary in nature. These freshwater ecosystems may be more vulnerable to biotic invasion than other ecosystems that are contained within a single political entity because of their size, interconnection and fragmented management (e.g., with actions taken in the headwaters of the ecosystem having ramifications in distant down stream regions with differing political and/or administrative regimes).

Many freshwater ecosystems have long been and continue to be of immense importance to humankind. Socio-economically, river systems and some lakes are of major importance for transportation, disposal of

effluents, generation of power, provision of water for a range of uses, as a source of food, and as areas for recreation. In contrast, shallow-water ecosystems (wetlands) have traditionally been perceived as having little value. However, wetlands provide many essential services of both economic and environmental “value”, including water purification, fish propagation, flood control and habitat for a wide range of species, including migratory birds, plants, amphibians and reptiles. The effects of humankind’s use have generally been detrimental to the ecological integrity of freshwater ecosystems. The value of wetland ecosystems has been largely neglected. Over 50% of the world’s wetlands have been drained and infilled, and the land converted to other uses. Rivers have been channelized, impounded, polluted and over-fished, and their waters extracted for agricultural, industrial or domestic use. As a result, the decline of freshwater biodiversity has reached alarming rates worldwide. Freshwater species are among the most threatened of all taxa groups. Their extinction rate is predicted to be five times faster than all other groups of species and at a rate equal to that of forest species in the world’s tropics.² Between 20% and 35% of the world’s freshwater fish species have become endangered, threatened, or extinct. Since 1970, the health of the world’s freshwater ecosystems has declined by 50%.³ This crisis will become more devastating in the near future given the effects of global climate change and increasing human demands for freshwater.

Invasive alien species are thought to be the cause of over 70% of this century’s extinctions of native freshwater species; implicated as a contributing factor to 42% of currently endangered freshwater species; and are a significant impediment to recovery of threatened and endangered species.⁴ In the Columbia Basin, introduced fish stocks are a factor in 80% of the documented aquatic extinctions.⁵ Although threats from alien fish species (through both unauthorized public introductions and past intentional stocking programs) are concentrated in the southern half of British Columbia, almost all aquatic habitats in the province are vulnerable. In general, freshwater ecosystems that are of high ecological integrity and function within their natural ranges of variation have a higher resiliency to alien species invasion than those that have been degraded through human alteration for water use.

Priority Actions

A: Leadership and Cooperation

- ◆ Adopt integrated river basin management for the major river systems in British Columbia (e.g., Fraser, Columbia, Peace) – with coordinated communications, technical committees/resources and decision-making processes to identify and address key management concerns (such as introductions and control of invasive alien species). The current Fraser Basin Council and Columbia Basin Trust, among other multi-interest/agency organizations in the province, have some of the elements needed for integrated river basin management, and could be further engaged in invasive alien species/aquatic ecosystems management.
- ◆ Enhance the ecological integrity of freshwater ecosystems through rehabilitation and restoration of degraded ecosystems and the recovery of threatened species to aid in the prevention of introductions and control of invasive alien species.
- ◆ Emphasize, wherever possible, maintenance or restoration of native fisheries stocks in preference to alienation (i.e., loss) of aquatic ecosystems or introduction of alien species.

B: Science-informed Inventories, Risk Assessment and Monitoring

- ◆ Monitor and assess inter-basin water transfers as a prominent pathway for alien species invasion (in coordination with agencies beyond provincial borders, such as Washington State and Alberta). Establish a thorough risk assessment process for any water transfer proposals – encouraging a precautionary approach to probabilities of detecting and controlling introduction of alien invasive species (including fish, invertebrates, plants and microbial species groups).

- ◆ Compile and disseminate studies on the valuation of freshwater ecosystem goods and services, and identify ways to further integrate the use of economic valuation into provincial water related plans, programs and policies. This information should support improved management of aquatic ecosystems – raising public awareness of the values at stake and providing better information for policy development and management decisions.

C: Information and Awareness

- ◆ Promote sound stewardship of freshwater ecosystems – studies have shown that degraded freshwater ecosystems are more prone to alien species invasion than healthy systems.
- ◆ Identify high priority pathways and target audiences (e.g., sports fishers/live bait and sport fish releases), and develop targeted information and awareness campaigns regarding the risks of introducing invasive alien species into BC’s waters.
- ◆ Support a coordinated review of industry sectors with potential high risk of affecting native species through introduction of invasive alien species. The two industries of highest priority are the aquarium trade and aquaculture. The review should consider development of targeted information and awareness initiatives, and potential for cooperative and/or other certification initiatives (e.g., “eco-labeling”).

D: Policy Direction and Legislation

- ◆ Explore the adoption of internationally accepted FAO codes of practices to deal with invasive alien species.
- ◆ Recognize the need for aquaculture industries to be treated as valid users of freshwater resources. For licensing purposes, each type of culture should be assessed on its own merit. Not all aquaculture activities have the same levels of risk for introducing an invasive alien species.
- ◆ Review the effectiveness of current regulations for preventing invasive alien species introductions by the aquarium trade, and promote monitoring and enforcement of regulations.

Section Endnotes:

¹ See, for example, V.H. Heywood, 1995, *Global Biodiversity Assessment*.

² See A. Ricciardi and J.B. Rasmussen, 1999.

³ From J. Loh (ed.), 2000, *Living Planet Report 2000*.

⁴ *ibid*, Heywood 1995.

⁵ Statistic of the American Fisheries Society, quoted by the Columbia Kootenay Fisheries Renewal Partnership, 2003: www.ckfrp.com/issues.htm .

11. Mapping the Threat of Invasive Alien Species to Biodiversity in British Columbia

In a companion project to development of this framework, Biodiversity Branch of the Ministry of Water, Land and Air Protection commissioned preparation of GIS-maps and a database of threats posed by invasive alien species to biodiversity in British Columbia. The maps are, in turn, a component of a comprehensive summary of “threats to biodiversity” (including such factors as climate change and land use practices) prepared by the Ministry to address issues associated with biodiversity in the province. This section provides a brief synopsis of the methodology and tabular results of the mapping project. Some of the resultant maps have also been used to illustrate portions of the framework (see Index of Maps).

The mapping project addressed threats to terrestrial, freshwater aquatic and marine ecosystems (or “realms”). Madrone Environmental Services Ltd. (led by Jeff Bertoia) addressed terrestrial and freshwater realms, while Jacqueline Booth & Associates prepared information related to the marine realm. The methodology used for terrestrial and aquatic species is the primary focus of this summary.

Marine Realm

Due to the fluid and interconnected nature of British Columbia’s marine environment, the methodology chosen to map the threats to biodiversity posed by invasive alien species focused on vectors for introduction, rather than physically discrete ecological units. The main vectors for introduction of invasive alien marine species into BC waters have been:

- ◆ Intentional introductions for aquaculture;
- ◆ Accidental introduction, accompanying species brought in for aquaculture (i.e., “hitchhikers”);
- ◆ Organisms unintentionally introduced and released into BC waters through ballast water; and
- ◆ Species that have been introduced in waters in the US Pacific NW and migrated up the coast into BC.

Identifying the species and locations of alien species invasions is presently speculative at best, due to the very limited surveys and assessments that have been undertaken in BC to date. For example, there have been too few surveys of marine bacteria, phytoplankton or zooplankton to assess the presence of invasive alien species. However, some of invasive alien species of concern to biodiversity in BC identified by experts in the field to date include:

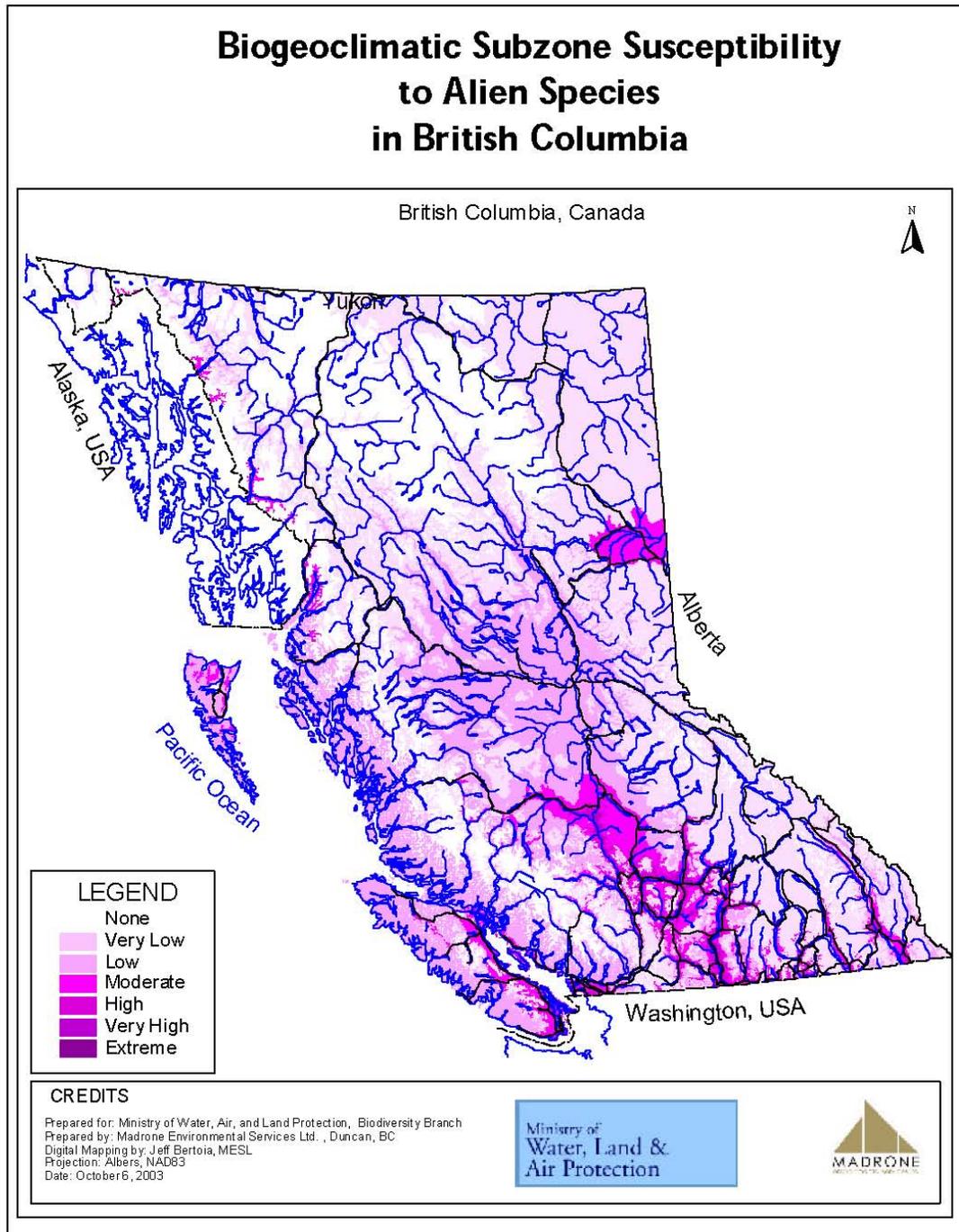
- ◆ European green crab (*Carcinus maenas* Linnaeus);
- ◆ Cordgrass (*Spartina anglica*);
- ◆ Japanese oyster drill (*Ceratostoma inoratum*);
- ◆ Japanese mahogany clam (*Nuttallia obscurata*) (thought to have been introduced via ballast water);
- and

The map products for the marine realm identify vulnerable marine areas in relation to vectors of invasive alien species introduction (e.g., southern areas proximal to Washington State, international shipping transportation lanes and ports associated with Prince Rupert and Vancouver), “significant” (i.e., fourth order river) coastal estuaries (of high biological productivity and importance to biodiversity). No attempt was made to further assess vulnerability of particular habitat types (e.g., rocky shoreline, pebble or sand beach) due to limited data available, the provincial scale of the project and the ease by which invasive alien species can generally be transported in the marine environment.

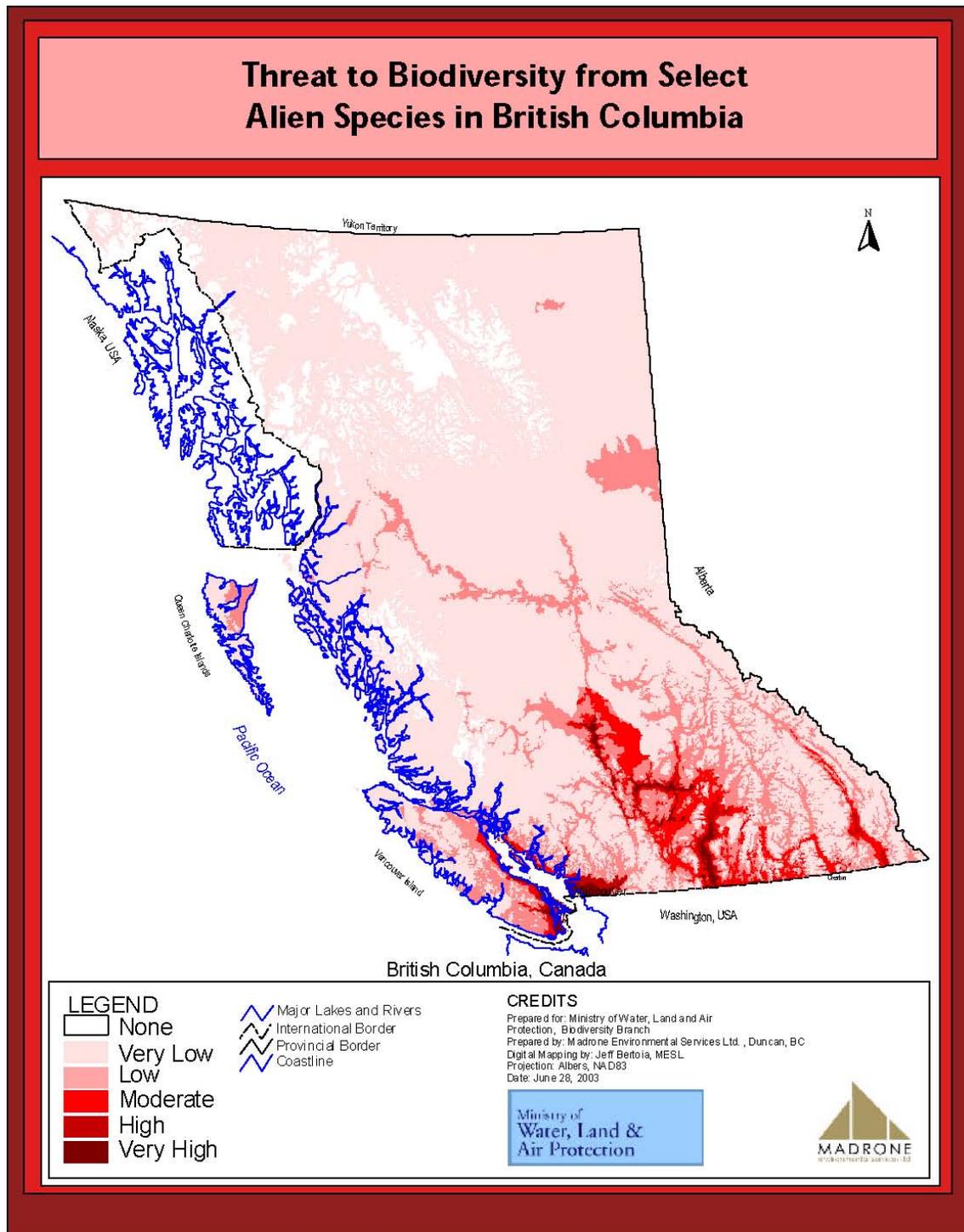
Terrestrial and Freshwater Realms

The project team faced a number of methodological challenges in attempting to map the susceptibility (or vulnerability) of terrestrial and freshwater ecosystems in British Columbia to alien species invasions. First, the limited budget and provincial scale of the project limited detailed (i.e., BGC subzone level) identification of invasive alien species occurrences, estimation of extent or intensity of invasions (e.g., % of habitat affected by invasive alien species) and ecosystem assessment (i.e., linking occurrence data to ecosystem characteristics (e.g., disturbed soils, openings or edges)). Second, the small pool of experts on various species groups in the province had only limited time and resources available for input to the project team during the data collection and draft review phases of the project. Third, the project team wished to establish a methodology that could be replicated and further refined in future mapping efforts. As expert knowledge is an essential element of assessing both the susceptibility of ecosystems to invasions, and the threat posed by known and potential invasive alien species, documenting the rationale behind comments and opinions and/or establishing clear methodological categories and guidelines for assessing threat were important criteria in determining the approaches used in the project.

Two complementary approaches were used to develop summary maps of threats of invasive alien species to biodiversity in British Columbia. The first involved establishing a relative rating of the “susceptibility” of ecosystems to alien species invasions (by biogeoclimatic (BGC) subzone) through identification of key invasive alien species and ecosystem characteristics by knowledgeable ecologists (i.e., “expert opinion”). The second involved mapping the distribution of selected invasive alien species (and developing a “short-list” of most significant species by species group, selected by relevant experts) using published range information, and with each species rated (and weighted in the mapping product) for degree of “invasiveness” using a methodology developed by NatureServe¹ for categorizing and listing non-native invasive plants according to their overall effects on biodiversity. Both approaches, and the resulting map products, should be considered as pilot efforts – utilizing rough scale and accessible preliminary data and adapting methods for application across a broad range of species groups and at a provincial scale.



Map 1: Biogeoclimatic Subzone Susceptibility to Invasive Alien Plant Species in British Columbia, and



Map 2: Summary Map of Threats of Invasive Alien Species in British Columbia).

a. Biogeoclimatic Subzone Susceptibility to Invasive Alien Plant Species

Biogeoclimatic subzones in British Columbia were assigned weighting for “susceptibility to invasive alien species” based on ecosystem characteristics and human factors influencing invasion by ecologists with Madrone Environmental Services Ltd. and in the Biodiversity Branch. Ecosystem characteristics that increased weighting included:

- ◆ Large expanses of non-forested areas (abundant light and easy dispersal of seeds);
- ◆ Frequent exposed soil (suitable seed bed); and
- ◆ Warm growing season temperatures.

Factors that increased weighting were primarily linked to proximity to human habitation and activities, including:

- ◆ Cities and rural (human) populations (source for unintentional introductions (e.g., garden escapees), as well as habitat and ecosystem disturbances);
- ◆ Agricultural activity (e.g., grazing, forage crops) (soil exposure and introduction of invasive species in seed mixes and imports);
- ◆ Forestry (openings and disturbed soils in environmentally conducive (i.e., warm) BGC subzones); and
- ◆ Potential linear corridors (i.e., valley bottoms) that often act as dispersal pathways.

The following table lists the derived weightings by biogeoclimatic (BGC) subzone.

Table 1: Susceptibility to Invasive Alien Plant Species by Biogeoclimatic Subzone

BGC subzone	Susceptibility Weighting	Location	Comments
CDFmm, CWHxm	15	Southern BC coast, east side of Vancouver Island and lower mainland.	These two subzones are very susceptible to introduced species, for ecological reasons, but also due to a high potential for dispersal in urban and rural areas, through: transportation, garden escapees, agriculture, international trade, etc.
CWHmm1, dm, ds1	5	Southern, drier areas close to Vancouver; low to mid elevations on eastern side of Vancouver Island	Close to urban and rural areas, with the associated potential for dispersal, but many forested areas slow down seed dispersal for invasive plants and movement of other invasive alien species.
ICHdw, mw, xw	6	Low elevation valleys in south east BC	Close to rural populations, many open areas favour dispersal. Factors include agriculture (grazing, farming), mining, logging, and transportation.
IDFxm, xw, xm	15	Kamloops Forest Region, Okanagan area	Summer hot, dry areas. Open forest types lend themselves to rapid dispersal of invasive species due to abundant light, warm temperatures in the growing season, and frequent exposed soil. This area is close to urban areas in the Okanagan. Alien invasive species pose serious threats to biodiversity in the S Okanagan due to the high number of rare elements present.

BGC subzone	Susceptibility Weighting	Location	Comments
PPdh, xh	15	Kamloops Forest Region, major valleys: Nicola, Fraser, Thompson, Okanagan	The PP and BG zones are extremely susceptible to invasive alien species because of: large expanses of non-forested areas (abundant light and easy dispersal of seeds); frequent exposed soil (suitable seed bed); and warm growing season temperatures. Present day factors include: agriculture (grazing, forage crops); transportation corridors; and rural populations. With the introduction of cattle grazing and forage crops in the 1800's, these were the first parts of the province to have problems from invasive plants (grasses such as <i>Phleum pratense</i> , <i>Poa pratensis</i>). Invasive alien plants threaten the biodiversity of these open, dry ecosystems.
BGxh, xw	20	Kamloops Forest Region, major valleys, Nicola, Fraser, Thompson, Okanagan	
IDFdm, mw, dk, ww, dw	7	Kamloops and Cariboo Forest Regions, low to mid-elevations.	Open forest ecosystems, widespread in the area. Exposed mineral soil is common. Warm growing season temperatures. The most important dispersal vector is (cattle) grazing, followed by forest harvesting (and associated road construction), and other agriculture.
CWHvm, wh, vh	6	Southern coastal BC (mainland inlets, west coast VI)	Coastal ecosystems intrinsically have a low susceptibility to alien species establishment due to the almost continuous forest, which does not favour rapid dispersal of plants. However logging, road building, and rural areas have been responsible for many introductions.
ICHdk, MSxk, xv	3	Southern BC, drier areas at mid-elevation	These mid-elevation subzones historically had closed forest except for areas that were burnt. Open forest situations are common on warm aspects. Logging and agriculture are the main dispersal vectors. Roadsides have abundant exposed soil, which make ideal seedbeds, and seed dispersal by wind in logging cut-blocks is facilitated by the lack of trees.
SBSdh, dw, mh, mm, dk; SBPSmk, xc, dc	4	Cariboo plateau, southern sub-boreal areas	Historical forests covered these areas although forest fires were common. Widespread road construction and cattle grazing have allowed the rapid dispersal of invasive alien species.
ICHmc, mk, mm, wk, vk	3	Kispiox, Skeena R., Col-umbia Mtns. Rocky Mtn. Trench (McBride area)	These are moist areas in central BC. Agriculture, logging and transportation corridors are important dispersal vectors.
MSdk, dm, dv, dc	5	Mid-elevations across Southern BC, fairly dry climate	These mid-elevations historically had closed forest except for areas that were burnt. Open forest situations are possible on warm aspects. Logging and the associated road building are the main dispersal vectors.

BGC subzone	Susceptibility Weighting	Location	Comments
BWBSmw, dk, vk, wk	Mw =6 rest= 3	North-east BC east of the Rocky Mountains. Extension of the Great Plains.	These subzones cover a large area in the NE of BC east of the Rocky Mtns. The southern areas (Ft. St. John, Dawson Creek) are much more susceptible to invasive alien species than northern areas (Fort Nelson), due to increased agriculture, transportation and road corridors, rural populations, and milder climate. The abundance of oil and gas exploration roads allows invasive species to expand their ranges.
ICHmc, vc, wc	4	Nass, Meziadan, Iskut, Stikine area	A cool summer area, with short growing season, and long winters. These areas historically had continuous forest cover with a low susceptibility to alien species invasion. Logging and transportation corridors have allowed some invasive species to become established.
SBSmc, mk, mw, vk, wk; SBPSmc	5	Northern Cariboo plateau, S. portion of Prince George Forest Region, sub-boreal areas at mid-elevations	These are cool, sub-boreal climates. Logging and road building are the main dispersal corridors in these areas (road building is made easier in this area due to subdued topography).
CWHds2, mm2, ms, vm, wh, wm, ws	3	Northern and mid-coast areas	Cool temperatures, high precipitation and almost continuous forest limit establishment of invasive alien species in these areas.
ESSFxcp, dk, dv, xc, xv, xvp, dc	4	Drier, southern zones, high elevation areas in the BC interior	These are high elevation mountainous areas, with a fairly dry climate and a short but mild growing season. The almost continuous forest discourages establishment and rapid dispersal of invasive species. Logging and associated road building may allow invasive species tolerant of cool climates to become established.
ESSFdcp, dkp, dvp, mcp, mkp, mmp, mvp, mwp, vcp, vvp, wcp, wmp, wvp, mc,mk, mm, mv, mw, vc, wc, wk, wm, wv	2	Wetter, colder sub-alpine areas in central and northern BC	These are high elevation mountainous areas, with cool climates. The almost continuous forest discourages establishment and dispersal of invasive species. Logging and associated road building may allow invasive species tolerant of cool climates to establish here.
AT coastal, interior	1	Alpine areas throughout BC	Cold, high-elevation alpine climates don't favour the establishment of invasive species.
MHmm, mmp, wh, whp	1	Coastal sub-alpine areas (BC coast), maritime and hyper-maritime climates	The high amount of precipitation, heavy winter snow loads, and cool summertime temperatures do not favour the establishment of invasive species.

BGC subzone	Susceptibility Weighting	Location	Comments
SWBdk, dks, mk, mks, vk, vks	1	Subalpine areas in northern BC south of the Yukon border	Cold, northern sub-alpine climates don't favour the establishment of invasive species.

b. Threats of Invasive Alien Species to Biodiversity

This approach involved mapping the cumulative (and weighted) numbers of significant and known invasive alien species by biogeoclimatic subzone across British Columbia. The assumption underlying the approach is that the ecosystems most vulnerable to current and future alien species invasions will be those where invasive alien species are known to occur (given common dispersal and establishment characteristics of invasive alien species by group, and the length of time over which invasive alien species have had the opportunity to become established in the province).

As well as a cumulative map of “threat of invasive alien species to biodiversity in British Columbia”, the Ministry commissioned map-based estimates of threat to biodiversity posed by invasive aliens for the following species groups:

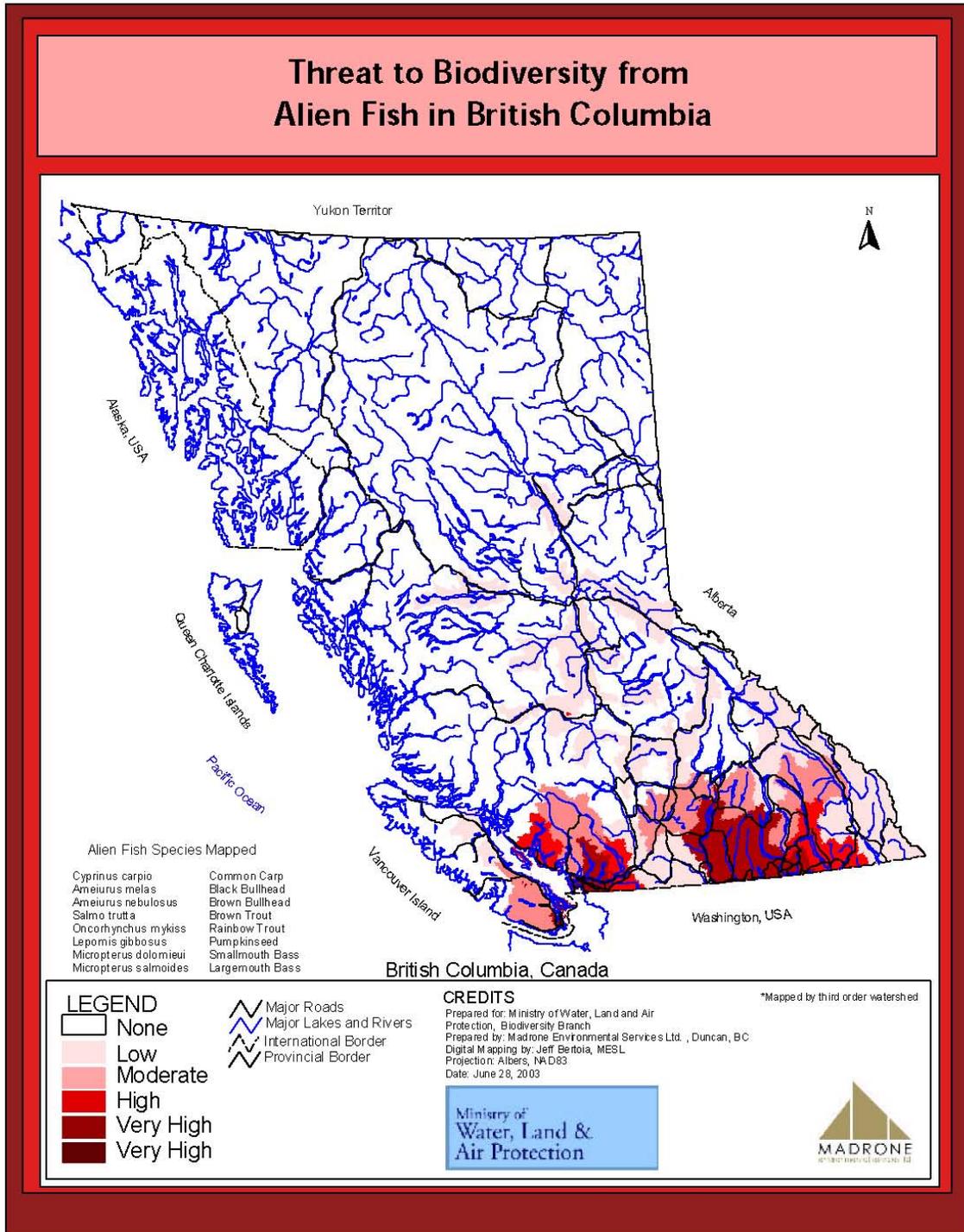
- ◆ Terrestrial (vascular) plants;
- ◆ Aquatic (vascular) plants;
- ◆ Vertebrates (including amphibians and reptiles);
- ◆ Fish;
- ◆ Marine plants, invertebrates and vertebrates;² and
- ◆ Invertebrates, non-vascular plants and fungi.³

The project team established individual invasive alien species rankings, and cumulative weightings by:

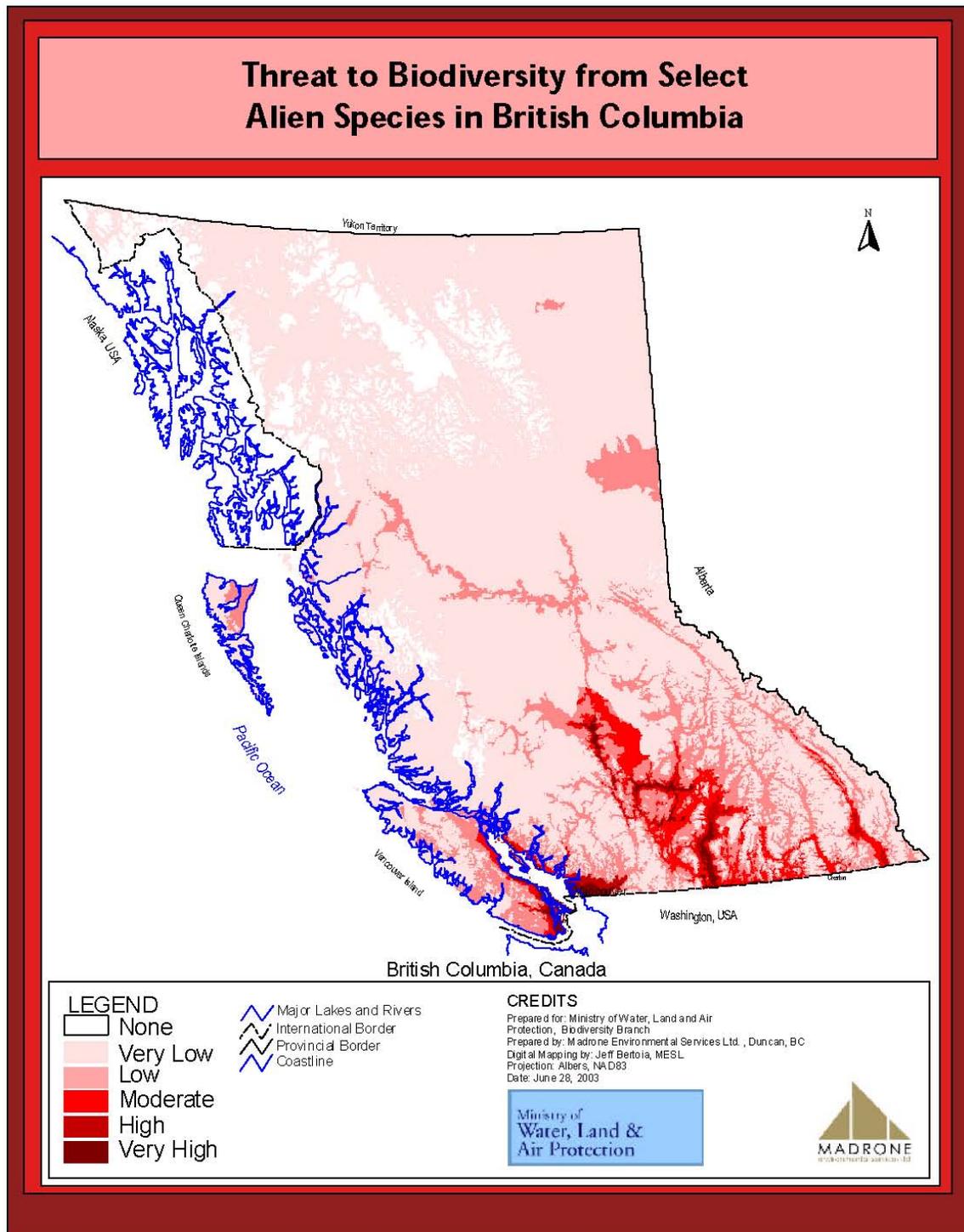
- 1) Utilizing a “long list” of known invasive alien plants in British Columbia⁴ (including over 200 of the nearly 700 known introduced species in the province) as a starting point for the assessment, with supplemental information on other species groups provided by experts on the project team, with the assistance of species group experts;
- 2) Establishing a “short-list” of the most significant known invasive alien species for the various species groups utilizing project team and species group expertise (the short-list included 36 terrestrial vascular plants, 14 terrestrial vertebrates, 7 freshwater vascular plants, 13 freshwater vertebrates, 18 invertebrates and 1 terrestrial fungus); and
- 3) Assessing each species for degree of “invasiveness” and effect on biodiversity by adapting a recently developed (NatureServe) standardized methodology for categorizing and listing alien invasive plants (See Figure 15, page 48: “Scoresheet” Questions and Categories for Invasive Alien Species Assessment (from NatureServe) and Appendix 3).⁵

The “short-list” of invasive alien species was chosen on the basis of: a review of “top species of concern” lists from other jurisdictions; current and past documented experience in BC; and recommendations of species group experts consulted through the development of the Framework.

Following assessment for “invasiveness”, individual species occurrence records and range distribution maps from published sources were then used to identify the biogeoclimatic subzones (and in some cases variants) where each invasive alien species is found. Individual species group maps, as well as a cumulative map for the 70 species on the “short-list” were produced in ArcView shapefile and database format. Themes were created using queries and specific GIS software tools, which populated the tables with each species “ranking points.” Note that the summary map does not include occurrence information for the terrestrial invertebrates.



Map 3: Threat of Invasive Alien Fish Species to Biodiversity in British Columbia.



Map 2: Summary Map of Threats of Invasive Alien Species in British Columbia).

The following table lists the scientific and common names, as well as the cumulative “I-Rank” rating, for each of the short-listed alien invasive species identified in this assessment (See Appendix 3 for the full scoring of each of the short-listed species, as well as a more detailed description of the assessment categories, and Figure 15, page 48 for a list of the questions in each assessment category.)

Species - Scientific Name	Common Name	Rating
TERRESTRIAL SPECIES		
Vascular Plants		
<i>Bromus tectorum L.</i>	Downy brome grass (or cheat grass)	A
<i>Centaurea diffusa Lam.</i>	Diffuse knapweed	A
<i>Centaurea maculosa Lam.</i>	Spotted knapweed	A
<i>Euphorbia esula</i>	Leafy spurge	A
<i>Anchusa officinalis</i>	Common bugloss (Anchusa)	A
<i>Chondrilla juncea</i>	Rush skeleton weed	A
<i>Hieracium aurantiacum</i>	Orange hawkweed	A
<i>Potentilla recta</i>	Sulphur cinquefoil	A
<i>Lepidium latifolium</i>	Perennial pepperweed	A
<i>Tribulus terrestris</i>	Puncturevine	A
<i>Linaria vulgaris</i>	Yellow (common) toadflax	B
<i>Knautia arvensis</i>	Field scabious	B
<i>Echium vulgare</i>	Blueweed	B
<i>Matricaria maritima</i>	Scentless chamomile	B
<i>Sonchus arvensis</i>	Perennial sowthistle	B
<i>Bromus inermis</i>	Smooth brome grass	B
<i>Cirsium arvense (L.) Scop. var. horridum</i>	Canada thistle	B
<i>Cirsium palustre</i>	Marsh thistle	B
<i>Cytisus scoparius (L.) Link.</i>	Scotch broom	B
<i>Daphne laureola</i>	Spurge laurel	B
<i>Hedera helix L.</i>	English ivy	B
<i>Linaria genistifolia ssP. dalmatica (L.)</i>	Dalmatian toadflax	B
<i>Poa pratensis</i>	Kentucky bluegrass	B
<i>Rubus procerus</i>	Himalayan blackberry	B
<i>Cynoglossum officinale L.</i>	Hound's tongue	C
<i>Echinochloa crusgalli (L.) Beauv.</i>	Common barnyard grass	C
<i>Elymus repens (L.) Gould</i>	Quackgrass	C
<i>Eleagnus angustifolia</i>	Russian olive	C
<i>Hypericum perforatum L.</i>	St. John's-wort	C

Species - Scientific Name	Common Name	Rating
<i>Leucanthemum vulgare</i> Lam.	Ox-eye daisy	C
<i>Lupinus arboreus</i>	Yellow bush lupine	C
<i>Polygonum cuspidatum</i>	Japanese knotweed	C
<i>Tanacetum vulgare</i> L.	Common tansy	C
<i>Tragopogon dubius</i> Scop.	Yellow salsify	C
<i>Trifolium subterraneum</i>	Subterranean clover	C
<i>Ulex europaeus</i>	Gorse	C
Fungi		
<i>Cronartium ribicola</i>	White pine blister rust	B
Vertebrates		
<i>Odocoileus hemionus sitkensis</i>	Mule Deer subsp. sitkensis (QCI)	B
<i>Cygnus olor</i>	Mute Swan	B
<i>Sturnus vulgaris</i>	European Starling	B
<i>Procyon lotor</i>	Raccoon (QCI)	C
<i>Rattus norvegicus</i>	Norway Rat	C
<i>Sciurus carolinensis</i>	Grey Squirrel	C
<i>Podarcus muralis</i>	European Wall Lizard	D
<i>Didelphis virginiana</i>	North American Opossum	D
<i>Rattus rattus</i>	Black Rat	D
<i>Sylvilagus floridanus</i>	Eastern Cottontail	D
<i>Branta c. canadensis</i>	Canada Goose (S. coast)	D
<i>Callipepla californica</i>	California Quail	D
<i>Alectoris chukar</i>	Chukar	D
<i>Perdix perdix</i>	Gray Partridge	D
<i>Passer domesticus</i>	House Sparrow	D
Invertebrates⁶		
<i>Armadillidium vulgare</i>	Pill bug	-
<i>Carabus nemoralis</i>	Ground beetle	-
<i>Coleophora laricella</i>	Larch casebearer	-
<i>Cryptorhynchus lapathi</i>	Poplar and willow borer	-
<i>Fenusa pusilla</i>	Birch leafminer	-
<i>Forficula auricularia</i>	European earwig	-
<i>Leucoma salicis</i>	Satin moth	-
<i>Operophtera brumata</i>	Winter moth	-
<i>Pieris rapae</i>	Cabbage White	-

Species - Scientific Name	Common Name	Rating
<i>Porcellio scaber</i>	Sow bug	-
<i>Pristiphora erichsonii</i>	Larch sawfly	-
<i>Profenusa thomsoni</i>	Ambermarked birch leafminer	-
<i>Thymelicus lineola</i>	European Skipper	-
<i>Adelges piceae</i>	Balsam woolly aphid	C
<i>Harmonia axyridis</i>	Asian ladybird beetle	C
<i>Arion rufus</i> [often reported as <i>A. ater</i>]	Chocolate arion	D
FRESH WATER SPECIES		
Vascular Plants		
<i>Lythrum salicaria L.</i>	Purple loosestrife	A
<i>Myriophyllum spicatum L.</i>	Eurasian watermilfoil	A
<i>Phragmites australis</i>	Common reed	B
<i>Butomus umbellatus L.</i>	Flowering rush	C
<i>Potamogeton crispus</i>	Curly pondweed	C
<i>Iris pseudacorus</i>	Yellow flag	D
Vertebrates (Fish)		
<i>Cyprinus carpio Linnaeus</i>	Common Carp	B
<i>Salmo trutta L.</i>	Brown Trout	B
<i>Oncorhynchus mykiss (Walbaum)</i>	Rainbow Trout (many plateau lakes)	C
<i>Salvelinus fontinalis</i>	Brook Trout	C
<i>Rana catesbeiana</i>	Bull frog	C
<i>Castor canadensis</i>	Beaver (Graham Is.)	C
<i>Micropterus dolomieu Lacepede</i>	Smallmouth Bass	D
<i>Micropterus salmoides (Lacepede)</i>	Largemouth Bass	D
<i>Ameiurus melas (Rafinesque)</i>	Black Bullhead	D
<i>Ameiurus nebulosus (Lesueur)</i>	Brown Bullhead	D
<i>Lepomis gibbosus (Linnaeus)</i>	Pumpkinseed	D

Section Endnotes:

¹ Associated with The Nature Conservancy and Conservation Data Centers across North America. See: www.natureserve.org and www.natureserve.org/conservation/invasivespecies.jsp.

² Maps of threats posed by invasive alien species in the marine realm utilized vectors and pathways of introduction, rather than species-based data (See sub-section a) above and Section 10 above.).

³ Maps for invertebrates, non-vascular plants and fungi were not produced due to limitations in budget and the ability to collect data within the project timeframe.

⁴ The long list focuses on plant species and was developed by Dave Polster under contract to the Ministry of Water, Land and Air Protection. The list represents species that were identified as invasive within the range of “potentially invasive” to “highly invasive” from a literature review and from telephone conversations with various key persons interviewed across British Columbia during the fall of 2001. It “covers 221 species of the 675 introduced vascular plant species in British Columbia as of November 26, 2001.” See: Polster, D. March, 2002. *The Role of Invasive Species Management in Terrestrial Ecosystem Restoration*. Ministry of Water, Land and Air Protection. Victoria, BC.

⁵ Only minor adaptations at a gross level were required to utilize the methodology for species groups beyond plants (e.g., considering “non-seed” dispersal mechanisms and species characteristics). The rigour of this “all species group” approach, however, was not assessed in a systematic manner within this project and inherent biases or difficulties in translating the approach to differing species groups may be significant.

⁶ Invertebrate species were not systematically assessed using the NatureServe methodology, nor mapped, due to budget and data constraints.

12. Definitions of Important Terms

The following list of definitions is drawn from work of the Global Invasive Species Program (GISP), the National Invasive Species Council (United States) and Canadian federal documents (Environment Canada and Office of the Auditor General). Organizations and governments are currently working toward adopting consistent terminology in this field; however, many fundamental terms (e.g., “Invasive Alien Species”) are not consistently used or widely understood in the public realm. The working document follows this list of definitions and descriptions for the identified terms.

Term	Definition and Description
Accidental introduction	Introduction of an aquatic organism, including “fellow travelers” (or “hitchhikers”), by chance, not by design. For example, the release of an organism transported in ship’s ballast water (synonym: unintentional introduction)
Alien species	A species, subspecies or lower taxon introduced outside its normal past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce. (Synonyms: non-native, non-indigenous, foreign, exotic.)
Aquarium fish	All species of fish and aquatic plants for ornamental use imported or transferred into strict confinement.
Aquatic organisms	All organisms (finfish, molluscs, crustaceans, echinoderms, and other invertebrates and their lifestages defined as “Fish” in the <i>Fisheries Act</i> , as well as marine and fresh water plants.
Baitfish	Live fish (or other aquatic organisms) placed on a hook or in a trap in order to lure fish.
Benefits	Advantages or profits derived as a result of an action (e.g., social or economic benefits from a proposed introduction).
Biodiversity	The diversity of plants, animals and other living organisms in all their forms and levels of organization, including the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them. (Synonym: biological diversity.)
Bioinvasions	Human-assisted introductions or “natural” range expansions of invasive species.
Biosecurity	The management of risks posed by organisms to the economy, environment and people’s health through exclusion, mitigation, adaptation, control and eradication.
Casual Alien Species	Alien species that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations, and which rely on repeated introductions for their persistence.
Containment	Keeping invasive alien species within regional barriers or preventing the escape of an organism (from a facility such as a research lab or public zoo or aquarium).
Containment facility	A facility that has been specially modified to prevent the release of aquatic organisms to waters outside the facility (includes quarantine facility with treated effluent). Some jurisdictions assign level of containment status to facilities based on defined standards.
Control	As appropriate, eradicating, suppressing, reducing, or managing invasive species populations, preventing the spread of invasive species from areas where they are present, and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.
Ecology	A branch of science concerned with the inter-relationships of organisms and their environment.
Ecosystem	The complex of a community of organisms and its environment. An ecosystem consists of all the biotic (living) organisms in a given area, as well as the abiotic (non-living) components (physical and chemical factors) of their environment, linked through nutrient cycling and energy flow. An ecosystem can be of any size or scale (e.g., log, pond, grassland, forest, watershed, or even the earth’s biosphere in its entirety).

Term	Definition and Description
Enhancement	The release of a species (e.g., fish) to augment the public resource. This can be accomplished through culture techniques or the introduction or transfer of wild organisms.
Eradication	The extirpation of the entire population of an alien species in a managed area; eliminating an alien invasive species completely.
Establishment	The process of a species in a new habitat/location successfully reproducing at a level sufficient to ensure continued survival without infusion of new genetic material from outside the system.
Exotic species	Synonym for introduced species.
Extirpated species	A species that is no longer present in the wild in an area of its known historic range; often described in terms of jurisdiction (e.g., country, province), or geographic or ecological region (e.g., Vancouver Island, northern Rocky Mountains).
Facility	A location where alien species are cultivated, held or transferred. For example, in the context of fish, all locations holding fish or from which come cultured or wild fish or eggs from wild or cultured fish.
Fellow traveler	An organism that inadvertently accompanies the shipment of a species intended for introduction/transfer.
Fish	As defined in the <i>Fisheries Act</i> includes a) parts of fish, b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals; and c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.
Genetic containment	Prevent escape to the wild of organisms that can propagate, or allow only the release of organisms that are reproductively sterile.
Genetic diversity	All of the genetic variation in an individual, population or species.
Genetically-modified organism /Living modified organism	An organism in which genetic material has been purposefully altered by human technology in a way that does not occur naturally by mating and or natural recombination (excludes hybrids and polyploids; includes transgenics). These are addressed under Article 8(h) of the CBD. (See also Transgenic organisms.) (Acronyms: GMO/LMO)
Hazard	A thing or action that can cause adverse effects.
Hybrid	Offspring of two animals or plants that are of different species.
Import	Movement of aquatic organisms across national or inter-provincial boundaries.
Intentional introduction	The purposeful movement by humans of a species outside its natural range and dispersal potential (such introductions may be authorized or unauthorized). (See also unintentional introduction.)
Introduced species	Any species intentionally or accidentally transported and released by humans into a region (either directly into the environment or through indirect means such as facilities with potential for dispersal) in which they did not occur in historical time. (Synonyms: exotic, foreign, non-indigenous species.)
Introduction	The movement, by human agency, of a species, subspecies, or lower taxon (including any part, gametes, seeds, eggs, or propagule that might survive and subsequently reproduce) outside its natural range (past or present). This movement can be either within a country (e.g., inter-provincial, inter-regional) or between countries.
Invasional meltdown	The process by which a group of non-indigenous species facilitates one another's invasion in various ways, increasing the likelihood of survival, ecological impact, and possibly the magnitude of effect.

Term	Definition and Description
Invasive alien species	An alien species (a species, subspecies, or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce), whose introduction and/or spread threaten biological diversity (Global Invasive Species Program – Decision VI/23/COP6). Only a small fraction of aliens become invasive but these few can do enormous damage. (Often referred to as, but not necessarily synonymous with: weeds, pests, exotics, noxious species.) (Acronym: IAS.)
Live fish for the food trade	Fish destined strictly for consumption. Imported live fish are held in containment facilities or containment units such as those in restaurants or fish stores.
Minimal impact or risk	A change in an environmental attribute that will have, or is predicted to have, little or no consequence to the environment.
Native species	A species, subspecies, or lower taxon living within its natural range (past or present), including the area which it can reach and occupy using its own legs, wings, wind/water-borne or other dispersal systems, even if it is seldom found there. (Synonym: indigenous species.)
Natural range	The geographic area a species inhabits or would inhabit in the absence of significant human influence.
Natural zone of potential dispersal	The area a species would disperse to in the absence of significant human influence.
Naturalized species	Alien species that reproduce consistently and sustain populations over more than one life cycle without direct intervention by humans (or in spite of human intervention). They often reproduce freely, but do not necessarily invade natural, semi-natural or human-made ecosystems. (See also: casual alien species.)
Niche	The attribute of an organism which defines the boundaries within which it can carry out its life processes. The potential niche of an organism is constrained by the physical environment and interactions with other species producing a realized niche in a particular ecosystem.
Non-native species	A species living beyond its natural range or natural zone of potential dispersal, including all domesticated and feral species, and all hybrids except for naturally occurring crosses between indigenous species. (Synonym: non-indigenous species)
Noxious weed	A harmful invasive plant species, designated under the <i>British Columbia Weed Control Act</i> .
Organism	A living thing – includes pathogens and parasites, as well as plants and animals
Pathways	The means and routes by which alien species are introduced to an area or jurisdiction.
Pest	“Any species, strain or bio-type of plant, animal or pathogenic agent injurious to plants or plant products.” (International Plant Protection Convention)
Precautionary Approach	Measures to implement the Precautionary Principle. A set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resources, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the consequences of being wrong (FAO 1995, 1996).
Quarantine	The facility and/or process by which live organisms and any of their associated organisms can be held/or reared in complete isolation from the surrounding environment.
Range extension	The enlargement of a geographic area that is occupied by a species, usually through intentional human action; the extension is usually incremental, over short distances and contiguous.
Re-introduction	Release of a species to waters from which the species had been previously extirpated (i.e., no longer existing in Canada). (Synonym: introduction.)

Term	Definition and Description
Release	The liberation of aquatic organisms to the natural environment. Release can be unintentional, as in the escape of organisms from aquaculture facilities or during use as live bait.
Risk	The probability of a negative or undesirable event occurring; the likelihood of the occurrence and the magnitude of the consequences of an adverse event; a measure of the probability of harm and the severity of effect of a hazard.
Risk analysis	The process that includes risk identification, risk assessment, risk management and risk communication.
Risk assessment	The process of identifying and describing the risks of introductions or transfers of alien species having an effect on native species, habitat or economically important species and activities (e.g., agriculture, aquaculture) in the receiving lands or waters before such introductions or transfers take place; the process of identifying a hazard and estimating the risk presented by the hazard, in either qualitative or quantitative terms.
Risk communication	The open exchange of information and opinion, leading to a better understanding of risk and related decisions; the processes by which the results of the risk assessment and proposed risk management measures are communicated to the decision-making authority and interested parties.
Risk management	The process of selection and implementation of options to reduce, to an acceptably low level, the risk of negative effect of introductions or transfers of aquatic organisms; the process of identifying, evaluating, selecting and implementing alternative measures for reducing risk.
Sanitary and phytosanitary measures	Any measure applied a) to protect human, animal or plant life or health from the entry, establishment or spread of pests, diseases or disease carrying organisms; or b) to prevent or limit other damage from the entry, establishment or spread of “pests” (or invasive alien species).
Significant impact	A predicted or measured change in an environmental attribute that should be considered in project decisions, depending on the reliability and accuracy of the prediction and the magnitude of the change within specific time and space boundaries.
Species	A group of organisms all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves, and show persistent differences from members of allied groups of organisms.
Stock	A population of organisms that, sharing a common gene pool, is sufficiently discrete to warrant consideration as a self-perpetuating system which can be managed.
Strain	A group of individuals with common ancestry that exhibits genetic, physiological or morphological differences from other groups of the same species as a result of husbandry practices.
Suppression	Reducing population levels of an invasive alien species to an acceptable threshold.
Taxon	A basic category within the scientific classification system of living organisms, based on natural relationships such as genetics, structure and patterns of change (e.g., kingdom, phylum (or for plants, division), class, order, family, genus, species, sub-species, variety).
Transfer	The movement of individuals of a species or population of an aquatic organism from one location to another within its present range.
Transgenic organisms	Organisms bearing within their DNA, copies of novel genetic constructs introduced through recombinant DNA technology. This includes novel genetic constructs within species as well as interspecies transfers. Such organisms are usually (but not always) produced by micro-injection of DNA into newly fertilized eggs. (See also: GMO/LMO.)
Vector	Physical means or agent by which a species is transported. Ballast water, ships’ hulls, and the movement of commercial oysters are examples of vectors. Synonyms include pathway, dispersal mechanism, and mode.

Term	Definition and Description
Weeds	Plants (not necessarily alien) that grow in sites where they are not wanted and have detectable negative economic or environmental effects; alien weeds are invasive alien species. (Synonyms: plant pests, harmful species, noxious plants, problem plants.)

13. References

- Blumenthal, D. M., N. R. Jordan, and E. L. Svenson. 2003. *Weed control as a rationale for restoration: the example of tallgrass prairie*. Conservation Ecology 7(1):6. www.consecol.org/vol7/iss1/art6.
- British Columbia. 2003. Budget 2003 Ministry of Water, Land and Air Protection Service Plan 2003/04 – 2005/06, Victoria, p. 14. See: <http://www.bcbudget.gov.bc.ca/sp2003/wlap/>.
- British Columbia Ministry of Environment, Lands and Parks. 2002. *State of Environment Reporting* website: www.wlapwww.gov.bc.ca/soerpt/2risk/importance.html
- British Columbia Ministry of Environment, Lands and Parks and Environment Canada. 1993. *State of the Environment Report for British Columbia*, Victoria.
- Canada's Aquatic Environments. 2002. Website hosted by University of Guelph. *Invading Species*. www.aquatic.uoguelph.ca/Human/exotics/frame.htm
- Canadian Council of Ministers of Fisheries. 2002. *National Code on Introductions and Transfers of Aquatic Organisms*. Task Group on Introductions and Transfers. January 2002. www.dfo-mpo.gc.ca/science/OAS/aquaculture/nationalcode/codedefault_e.htm
- Canadian Endangered Species Conservation Council (CESCC). 2001. *Wild Species 2000: The General Status of Species in Canada*. Ottawa: Minister of Public Works and Government Services Canada.
- Canadian Wildlife Service. 2003. *Impacts on Canadian Species at Risk from Invasive Alien Species*. Draft Report. Prepared by Astrid Vik Stronen, June 12th, 2003, Ottawa.
- Cannings, R.J. and E. Durance. 1998. *Human use of natural resources in the South Okanagan and Lower Similkameen valleys* in Smith, I.M., and G.G.E. Scudder, eds. *Assessment of species diversity in the Montane Cordillera Ecozone*. Burlington: Ecological Monitoring and Assessment Network, 1998.
- Carleton, J. T. 2001. *Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities*. Pew Oceans Commission, p. 36.
- Carleton, J. T., D. Reid and H. van Leeuwen. 1995. *The Role of Shipping in the Introduction of Non-indigenous Aquatic Organisms to the Coastal Waters of the United States (other than the Great Lakes) and an Analysis of Control Options*. US Coast Guard and US Department of Transportation, National Sea Grant College Program/Connecticut Sea Grant. USCG Rep. No. CG-D-11-95. Natl. Tech. Inf. Serv. (NTIS) Rep. AD-A294809, Washington, DC.
- Ciruna, K.A., L.A. Meyerson and A. Gutierrez. 2003. *The Ecological and Socio-economic Impacts of Invasive Alien Species in Inland Water Ecosystems*. Report to the Conservation on Biological Biodiversity Commission on behalf of the Global Invasive Species Programme, Washington, D.C. *in prep.*
- Claudi, Renate, P. Nantel and E. Muckle-Jeffs, eds. 2002. *Alien Invaders in Canada's Waters, Wetlands, and Forests*. Natural Resources Canada, Canadian Forest Service, Science Branch, Ottawa
- Enserink, M. 1999. Biological invaders sweep in. Science 285:1834-1836.
- Commissioner of the Environment and Sustainable Development. 2002. *Report of the Commissioner of the Environment and Sustainable Development to the House of Commons*, Chapter 4: Invasive Species. Office of the Auditor General of Canada, Ottawa/Hull.
- Environment Canada. 2002. *The Threat of Alien Invasive Species in Canada: Reporting on the State of Canada's Environment*. Draft 11 September 2002. Environment Canada SOE Reporting Program, Ottawa/Hull.

- European Union. 2002. *Second Report of the European Community to the Convention on Biological Diversity: Thematic Report on Alien Invasive Species*. October 2002.
- Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW). 2002. *National Early Warning and Rapid Response System for Invasive Plants in the United States: Draft Action Plan March 15, 2002*. Washington D.C.
- Haber, E. 2002a. *Impact of Invasive Plants on Species and Habitats at Risk in Canada*. National Botanical Services of Canada and Canadian Wildlife Service, Ottawa.
<http://24.43.24.85/nbs/ipcan/impact.html>.
- Haber, E. 2002b. *Invasive Species of Canada: An Assessment of Resources and Needs*. National Botanical Services of Canada and Canadian Wildlife Service, Ottawa.
<http://24.43.24.85/nbs/ipcan/impact.html>.
- Heywood, V.H. 1995. *Global Biodiversity Assessment*. Cambridge University Press. 1140 pp.
- Hill, Barry, 2003. Testimony before the Subcommittee on Fisheries, Wildlife, and Water, Committee on Environment and Public Works, United States Senate. *Invasive Species: Federal Efforts and State Perspectives on Challenges and National Leadership*. United States General Accounting Office, June 17, 2003. www.gao.gov/cgi-bin/getrpt?GAO-030916T.
- Keddy, C.A., M. Smith, and B. Tegler, 1999. *The Role of Importation Control In Protecting Native Canadian Biodiversity*. Canadian Wildlife Service.
- Kling, G.W., et al. 2003. *Confronting Climate Change in the Great Lakes Region: Impacts on our Communities and Ecosystems*. Union of Concerned Scientists, Cambridge Massachusetts, and Ecological Society of America, Washington, D.C.
www.davidsuzuki.org/files/Climate/BC/GLReportFinal.pdf or www.ucsusa.org/greatlakes.
- Loh, J. (ed.). 2000. *Living Planet Report 2000*. UNEP-WCMC, World Wide Fund for Nature (WWF). Gland, Switzerland.
- Louda, S.M., A.E. Arnett, T.A. Rand and F.L. Russell. 2003. *Invasiveness of Some Biological Control Insects and Adequacy of Their Ecological Risk Assessment and Regulation*. *Conservation Biology* 17(1):73-82.
- McNeely, J.A., H. Mooney, L. Neville, P. Schei, and J. Waage, eds. 2001. *A Global Strategy on Invasive Alien Species*. IUCN Gland, Switzerland and Cambridge UK, in collaboration with the Global Invasive Species Programme (GISP).
- Murray, C. and R.K. Jones, 2002. *Decision Support Tool for Invasive Species in Garry Oak Ecosystems* (http://www.goert.ca/docs/goe_dst.pdf) developed for the Garry Oak Ecosystem Restoration Team (GOERT) by ESSA Technologies Ltd. See also www.goert.ca
- National Invasive Species Council. 2001. *Meeting the Invasive Species Challenge: National Invasive Species Management Plan*.
- Office of the Auditor General of Canada. 2002. *Report of the Commissioner of the Environment and Sustainable Development to the House of Commons*, Chapter 4: Invasive Species.
- Perrings, C., M. Williamson, E. B. Barbier, D. Delfino, S. Dalmazzone, J. Shogren, P. Simmons, and A. Watkinson. 2002. *Biological invasion risks and the public good: an economic perspective*. *Conservation Ecology* 6(1): 1. www.consecol.org/vol6/iss1/art1.
- Pimentel, David, ed. 2002. *Biological Invasions: Economic and Environmental Costs of Alien Plant, Animal and Microbe Species*. CRC Press, Boca Raton Florida.

- Polster, Dave. March, 2002. *The Role of Invasive Species Management in Terrestrial Ecosystem Restoration*. Ministry of Water, Land and Air Protection. Victoria, BC.
- Ricciardi A. and J.B. Rasmussen. 1999. *Extinction Rates of North American Freshwater Fauna*. *Conservation Biology* 13 (5): 1220-1222.
- Sala, O.E., F.S. Chapin III, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker, D.H. Hall. 2000. *Global Biodiversity Scenarios for the Year 2100*. *Science* 287: 1770- 1774
- Simberloff, Daniel. 2003. *How Much Information on Population Biology is Needed to Manage Introduced Species?* *Conservation Biology* 17(1):83-92.
- Simberloff, Daniel. 2002. *Ecological and Economic Impacts of Alien Species: A Phenomenal Global Change*. Pages 29-39, in Claudi, Renate, et al. 2002. *Alien Invaders in Canada's Waters, Wetlands, and Forests*. Natural Resources Canada, Canadian Forest Service, Science Branch, Ottawa.
- Simberloff, Daniel. 1996. *Impacts of Introduced Species in the United States*. *Consequences* 2(2):13-23.
- Svenson, E. L. 2003. *Weed control as a rationale for restoration: the example of tallgrass prairie*. *Conservation Ecology* 7(1): 6. www.consecol.org/vol7/iss1/art6.
- The Nature Conservancy. 2003. *Freshwater Initiative*. Freshwater Biodiversity. www.freshwaters.org/bio/decline.shtml.
- The Nature Conservancy. 2003. Wildland Invasive Species Team: Invasives on the web. <http://tncweeds.ucdavis.edu/esadocs.html>.
- Washington Department of Fish and Wildlife. 2003. *Aquatic Nuisance Species: European Green Crab (Carcinus maenas)*. Bulletin: www.wa.gov/wdfw/fish/ans/greencrab.htm.
- Wilcove, D.S., D. Rothstein, J. Dubrow, A. Phillips and E. Losos. 1998. *Quantifying threats to imperiled species in the United States*. *BioScience* 48:607-615.
- Wilcove, D.S., D. Rothstein, J. Dubrow, A. Phillips and E. Losos. 2000. *Leading Threats to Biodiversity*. Pages 239-254 in B.A. Stein, L.S. Kutner and J.S. Adams, eds. *Precious Heritage: The Status of Biodiversity in the United States*. Oxford University Press, Oxford.
- Wittenberg, Rudiger and M.J.W. Cock, eds. 2001. *Invasive Aliens: A Toolkit of Best Prevention and Management Practices*. CAB International, Wallingford, Oxon UK.

Appendix 1: International and National Agreements, Legislation and Policy with Provisions Pertaining to Invasive Alien Species

A. International Agreements

Provisions, commitments and resolutions to address the threats posed by alien species are a component of many international agreements, including:

- ◆ *Cartegena Protocol on Biosafety* to the CBD (Montreal 2000);
- ◆ *United Nations Convention on the Law of the Sea* (Montego Bay 1982);
- ◆ *Convention on Wetlands of International Importance*, especially as Waterfowl Habitat (Ramsar 1971);
- ◆ *Convention on Migratory Species of Wild Animals* (Bonn 1979);
- ◆ *Convention on the Law of Non-navigational Uses of International Watercourses* (New York 1997);
- ◆ *International Plant Protection Convention* (Rome 1951, as amended 1997);
- ◆ *Agreement on the Application of Sanitary and Phytosanitary Measures* (Marakesh 1995);
- ◆ *International Health Regulations* (Geneva 1982);
- ◆ *North American Free Trade Agreement* (1982);
- ◆ *North American Agreement on Environmental Cooperation* (1993);
- ◆ *Guidelines for the Control and Management of Ships' Ballast Water* to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens (International Maritime Organisation 1997);
- ◆ *Code of Conduct for Responsible Fisheries* (FAO 1995);
- ◆ *Code of Conduct for the import and release of exotic biological control agents* (FAO 1995); and
- ◆ *Preventing the Introduction of Invasive Alien Species* (International Civil Aviation Organisation 1998).

The following table, providing additional information regarding these agreements, is excerpted from the Global Strategy on Invasive Alien Species (2001).¹

Table 2: Selected International and Continental Agreements with Provisions Pertaining to Invasive Alien Species

International Agreement	Relevant Provisions
UN Convention on Biological Diversity (CBD) (1992) www.biodiv.org	Article 8 (h). Parties to “prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.”
Cartegena Protocol on Biosafety to the CBD (Montreal 2000) www.biodiv.org	Protocol’s objective is to contribute to ensuring adequate level of protection in the safe transfer, handling and use of living modified organisms resulting form modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity.

International Agreement	Relevant Provisions
United Nations Convention on the Law of the Sea (Montego Bay 1982) www.un.org/Depts/los/losconv1.html	Article 196. States to take all measures necessary to prevent, reduce and control the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes.
Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar 1971) www.ramsar.org	COP 7 – Resolution VII.14 on Invasive Species and Wetlands
Convention on Migratory Species of Wild Animals (Bonn 1979) www.wcmc.org.uk/cms/	Range State Parties of Endangered Migratory Species (Annex 1) to prevent, reduce or control factors that are endangering or likely to further endanger the species, including exotic species. (Article III (4) (c)). Agreements for Annex II Migratory Species to provide for strict control of the introduction of, or control of already introduced exotic species detrimental to the migratory species (Article V (5) (e)).
Convention on the Law of Non-navigational Uses of International Watercourses (New York 1997) www.un.org	Watercourse States take all necessary measures to prevent the introduction of species, alien or new, into an international watercourse. (Article 22).
International Plant Protection Convention (Rome 1951, as amended 1997) www.fao.org/legal/treaties	Creates an international regime to prevent spread and introduction of pests of plants and plant products through the use of sanitary and phytosanitary measures by Contracting Parties. Parties establish national plant protection organizations and agree to cooperate on information exchange and on the development of International Standards for Phytosanitary Measures.
World Trade Organisation (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (Marakesh 1995) www.wto.org/english/tratop_e/sps_e/spagr.htm	A supplementary agreement to the WTO Agreement. Applicable to all sanitary and phytosanitary measures directly or indirectly affecting international trade.
International Health Regulations (Geneva 1982) www.who.int/emc/IHR/int_regs.html	To ensure maximum security against the international spread of diseases with a minimum of interference with world traffic. Regulations strengthen the use of epidemiological principles as applied internationally, to detect, reduce or eliminate the sources from which infection spreads, to improve sanitation in and around ports and airports, to prevent the dissemination of vectors and to encourage epidemiological activities on the national level.
North American Free Trade Agreement (1982) www.sice.oas.org/tradee.asp#NAFTA	Each Party may adopt, maintain or apply any sanitary or phytosanitary measure necessary for the protection of human, animal, plant life or health in its territory. (Article 712(1)). Each Party shall adapt any of its sanitary or phytosanitary measures relating to the introduction, establishment or spread of an animal or plant pest or disease taking into account conditions relating to transportation and handling, between those areas. (Article 716).
North American Agreement on Environmental Cooperation (1993) www.cec.org	The Council of the Commission on Environmental Cooperation may develop recommendations regarding exotic species which may be harmful. (Article 10 (2)(h)).

International Agreement	Relevant Provisions
<p>IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species (2000) www.iucn.org/themes/ssc/pubs/policy/invsiveseng.html</p>	<p>Guidelines designed to increase awareness and understanding of the effect of alien species. Provides guidance for the prevention of introduction, re-introduction, and control and eradication of alien invasive species.</p>
<p>Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens (International Maritime Organisation 1997) www.imo.org</p>	<p>Provides guidance and strategies to minimize the risk of unwanted organisms and pathogens from ballast water and sediment discharge. (Resolution A.868 (29)).</p>
<p>Code of Conduct for Responsible Fisheries (FAO 1995) www.fao.org/fi/agreem/codecond/ficonde.asp</p>	<p>Encourages legal and administrative frameworks to facilitate responsible aquaculture. Including pre-introduction discussion with neighbouring states when non-indigenous stocks are to be introduced into transboundary aquatic ecosystems. Harmful effects of non-indigenous and genetically altered stocks to be minimized, especially where significant potential exists for spread into other states or country of origin. Adverse genetic and disease effects to wild stock from genetic improvement and non-indigenous species to be minimized.</p>
<p>Code of Conduct for the import and release of exotic biological control agents (FAO 1995) www.fao.org</p>	<p>Aims to facilitate the safe import, export and release of such agents by introducing procedures of an internationally acceptable level for all public and private entities involved, particularly where national legislation to regulate their use does not exist or is inadequate. Outlines specific responsibilities for authorities of an exporting country, who should ensure that relevant regulations of the importing country are followed in exports of biological control agents.</p>
<p>Preventing the Introduction of Invasive Alien Species (International Civil Aviation Organisation 1998) www.icao.int/icao/end/res/a32_9.htm</p>	<p>Resolution A-32-9. Urges all Contracting States to use their civil aviation authorities to assist in reducing the risk of introducing, through civil air transportation, potentially invasive species to areas outside their natural range. Requests the ICAO Council to work with other United Nations organizations to identify approaches that the ICAO might take in assisting to reduce the risk of introducing potential invasive species.</p>

B. Selected Federal Legislation, Policies and Guidelines

The following table of selected federal legislation, policies, and guidelines for the prevention/control of alien species introductions in Canada is excerpted from the September 2002 Draft report *The Threat of Alien Invasive Species in Canada*, by Environment Canada.²

Table 3: Selected Federal Legislation and Policies with Provisions Pertaining to Alien Species

Legislation/Policies/Strategies	Responsible Organization	Provisions that Prevent/Control Alien Species Introductions in Canada
<p>Canada Shipping Act http://www3.ec.gc.ca/EnviroRegs/EN/NG/SearchDetail.cfm?intAct=1026</p> <p>Canadian Ballast Water Management Guidelines http://www.shipfed.ca/Library/BallastWater/BallastWaterCanadianGuidelines.html</p>	<p>Transport Canada</p> <p>Transport Canada and Fisheries and Oceans Canada</p>	<p>Act amended in 1998 to allow regulations to be enacted. Voluntary national guidelines went into effect in September 2001. Proposed regulations could go into effect next year.</p> <p>Introduced under the <i>Canada Shipping Act</i>, these guidelines are intended to minimize the probability of future introductions of harmful aquatic organisms and pathogens from ships' ballast water while protecting the safety of ships.</p>
<p>Canadian Agricultural Products Act http://laws.justice.gc.ca/en/C-0.4/text.html</p>	<p>Canadian Food Inspection Agency</p>	<p>Provisions are included with respect to the illegal import of agricultural products.</p>
<p>Canadian Biodiversity Strategy http://www.ec.gc.ca/press/conserv_b_e.htm</p>	<p>Environment Canada</p>	<p>Strategy calls for federal and provincial governments to take all necessary steps to prevent the introduction of harmful alien organisms and to eliminate their adverse effects.</p>
<p>Canadian Environmental Protection Act http://www.ec.gc.ca/CEPARegistry/the_act</p>	<p>Environment Canada</p>	<p>Can prevent the intentional introduction of potentially invasive alien species. New Substances Notification Regulations can be applied to the proposed importation of an alien species (e.g., subject to environmental and human health risk assessment) if it is new to Canada and its importation is not addressed under another federal Act.</p>
<p>Feeds Act http://laws.justice.gc.ca/en/F-9/53426.html</p>	<p>Canadian Food Inspection Agency</p>	<p>Prohibits import into Canada of any feed that may adversely affect animal or human health and any that does not meet certain criteria, such as being registered as prescribed and conforming to prescribed standards.</p>
<p>Fisheries Act http://lois.justice.gc.ca/en/F-14/index.html</p>	<p>Fisheries and Oceans Canada</p>	<p>Release or transfer of live fish requires a licence, and the fish must be free of disease. The intent is to minimize adverse effects on stock size or genetic characteristics.</p>
<p>Fish Inspection Act http://laws.justice.gc.ca/en/F-12/54942.html</p>	<p>Canadian Food Inspection Agency</p>	<p>The Fish Inspection Regulations prohibit the importation of live freshwater mitten crab (genus <i>Eriocheir</i>).</p>

Legislation/Policies/Strategies	Responsible Organization	Provisions that Prevent/Control Alien Species Introductions in Canada
<p>Health of Animals Act http://laws.justice.gc.ca/en/H-3.3/index.html</p>	<p>Canadian Food Inspection Agency</p>	<p>A specific regulation is the Honeybee Importation Prohibition Regulations, 1999 prohibit importation of any bee of the genus <i>Apis</i> (honeybees) into Canada or any Canadian port from the United States, except from the State of Hawaii.</p>
<p>Migratory Birds Convention Act http://www.cws-scf.ec.gc.ca/legislations/laws1_e.cfm</p>	<p>Environment Canada</p>	<p>Conserve the diversity of migratory birds in Canada.</p>
<p>National Code on Introductions and Transfers of Aquatic Organisms http://www.dfo-mpo.gc.ca/science/OAS/aquaculture/nationalcode/codedefault_e.htm</p>	<p>Canadian Council of Fisheries and Aquaculture Ministers</p>	<p>The Code is intended to ensure that decisions to transfer aquatic organisms from one body of water to another are based on consistent and rigorous scientific criteria across Canada. The Code contains provisions for a national database for risk assessment and a national registry on invasive aquatic species.</p>
<p>Pest Control Products Act and Regulations http://www3.ec.gc.ca/EnviroRegs/EN/NG/SearchDetail.cfm?intReg=116</p>	<p>Pest Management Regulatory Agency</p>	<p>Any organisms used for controlling pests and organic functions of plants or animals must be registered for importation and use.</p>
<p>Plant Protection Act http://lois.justice.gc.ca/en/P-14.8</p>	<p>Canadian Food Inspection Agency</p>	<p>Movement, growth, culture, or production of pests is prohibited, except by permit.</p>
<p>Seeds Act http://www.inspection.gc.ca/english/plaveg/pbo/96004e.shtml Weed Seeds Order http://laws.justice.gc.ca/en/S-8/SOR-86-836/index.html</p>	<p>Canadian Food Inspection Agency</p>	<p>Species of prohibited noxious weeds are not permitted in seed.</p> <p>An order determining the species of plants the seeds of which are deemed to be <i>weed seeds</i>: the seeds of the species of plants set out in the schedule are deemed to be weed seeds for the purpose of establishing grades under the <i>Seeds Act</i>.</p>
<p>Transportation of Dangerous Goods Act http://www.tc.gc.ca/actsregs/tdg/english/tdg.htm</p>	<p>Transport Canada</p>	<p>Standards are specified for mode of transportation, packaging, labelling, etc. to promote safety in organism transportation into, from, or within Canada by Canadian vehicles.</p>
<p>Wildlife Policy for Canada http://www.cws-scf.ec.gc.ca/Trends/wild.html</p>	<p>Wildlife Ministers Council of Canada</p>	<p>Introduction of non-indigenous or genetically engineered species from outside Canada is bounded by certain conditions.</p>
<p>Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (WAPPRIITA) http://www.cites.ec.gc.ca/wappa/policies/bengal.html</p>	<p>Environment Canada</p>	<p>Protects Canadian animals and plants from risk of overexploitation and safeguards them from species designated as harmful through import regulations.</p>

Appendix 1 Endnotes:

¹ Annex 1. McNeely, J.A.; Mooney, H.; Neville, L.; Schei, P.; and Waage, J. (eds.) 2001. *A Global Strategy on Invasive Alien Species*. IUCN Gland, Switzerland and Cambridge UK, in collaboration with the Global Invasive Species Programme (GISP).

² Environment Canada. 2002. *The Threat of Invasive Alien Species in Canada's Terrestrial and Freshwater Ecosystems: Reporting on the State of Canada's Environment*. Draft 11, September 2002.

Appendix 2: Selected Web Sites Pertaining to Invasive Alien Species¹

A. Aquatics/Fishes

Great Lakes Fishery Commission: Exotic Species

<http://www.glfc.org/fishmgmt/exotic.htm>

FishBase (extensive and global in scope)

<http://www.fishbase.org/search.cfm>

USGS Non-indigenous Aquatic Species

<http://nas.er.usgs.gov/>

Baltic Sea Alien Species Database (“The Baltic Sea Alien Species Database is seen as a regional node in the future Global Information System for Invasive Species”)

<http://www.ku.lt/nemo/mainnemo.htm>

B. Plants/Weeds/Diseases

Invasive Plants of Canada (illustrated plant fact sheets with maps; surveys; links; provincial alert reports)

<http://infoweb.magi.com/~ehaber/ipcan.html>

Invasive Plants of Natural Habitats in Canada (out of print publication by Canadian Wildlife Service, Environment Canada: on-line version)

http://www.cws-scf.ec.gc.ca/publications/inv/index_e.cfm

Field Guide to Noxious and other Selected Weeds of British Columbia (illustrated fact sheets)

<http://www.agf.gov.bc.ca/croplive/cropprot/weedguid/weedguid.htm>

Weed Control Program, Ministry of Forests, BC

<http://www.for.gov.bc.ca/hfp/noxious/introduc.htm>

Canadian Forest Service, Forest Health, NRCAN (forest diseases)

http://www.glfc.cfs.nrcan.gc.ca/index-en/research-e/forest_health-e/forest_health-e.html

Weeds BC: identification and management (Fact sheets/ profiles on 80 BC weeds)

<http://www.weedsbc.ca/>

TNC: Invasives on the Web (excellent “Element Stewardship Abstracts” with detailed text-only fact sheets on invasive plants, their biology and control; site also has photo library)

<http://tncweeds.ucdavis.edu/esadocs.html>

North American Weed Management Association <http://www.nawma.org/>

Center for Invasive Plant Management <http://weedcenter.org/warnings/warningshome.html>

Database of Invasive Plant Management Resources (extensive links to sites)

<http://www.ippc.orst.edu/cicp/gateway/weed.htm>

INVADERS Database System, University of Montana (“The INVADERS Database is a comprehensive database of exotic plant names and weed distribution records for five states in the northwestern United States.”) <http://invader.dbs.umt.edu/>

C. “Pest” Species

Canadian Food Inspection Agency (pest fact sheets)
<http://www.inspection.gc.ca/english/index/sitee.shtml>

Alberta Agriculture Food and Rural Development (facts on pests, plant diseases and weeds)
<http://www.agric.gov.ab.ca/>

Manitoba Agriculture (weeds, insects and disease; extensive and well illustrated pest management fact sheets) <http://www.gov.mb.ca/agriculture/index.shtml>

National Agricultural Pest Information System (NAPIS), Purdue University
<http://www.ceris.purdue.edu/napis/>

D. Taxonomic/Biological Resources

NatureServe Explorer (“a source for authoritative conservation information on more than 50,000 plants, animals, and ecological communities of the United States and Canada”)
<http://www.natureserve.org/explorer/>

Integrated Taxonomic Information System (ITIS) – a taxon based information system for North America
http://sis.agr.gc.ca/pls/itisca/taxaget?p_ifx=plgl

USDA PLANTS Database <http://plants.usda.gov/>

GRIN taxonomic data provide the structure and nomenclature for the accessions of the National Plant Germplasm System (NPGS). <http://www.ars-grin.gov/npgs/tax/>

E. General

Global Invasive Species Programme <http://jasper.stanford.edu/gisp/home.htm>

CABI Bioscience (biocontrol information; biodiversity projects and services)
<http://www.cabi-bioscience.org/>

Pacific Northwest Economic Region, Regional Invasive Species Taskforce – Priority Threat List
www.pnwer.org/Working_Group/Agriculture/InvasivePriorityList.htm

Appendix 2 Endnotes:

¹ Excerpted and adapted from Erich Haber, 2002b.

Appendix 3: Rating a Sample Short-list of Invasive Alien Species for Threat to Biodiversity in British Columbia

The non-profit organization NatureServe (associated with The Nature Conservancy and Conservation Data Centers across North America) has over the past decade been developing a standardized methodology for categorizing and listing non-native invasive plants according to their overall effects on biodiversity in a large area such as a state, nation, or ecological region. NatureServe is now using these criteria to create a national (US) list of non-native vascular plant species that threaten biodiversity.

Criteria are designed to distinguish between species that cause “high”, “medium”, “low” or “insignificant” negative effects to native biodiversity within a specified geographical region. The method addresses twenty factors as multiple-choice questions (see Figure 15, page 48). These questions are grouped into four sections that address four major aspects of a species’ total impact: I) Ecological Impact: Impact on Ecosystem Processes, Communities, and Native Species (five questions); II) Current Distribution and Abundance within the area under consideration (four questions); III) Trend in Distribution and Abundance in the area (seven questions); and IV) Management Difficulty (four questions). For each question, evaluators must select one of four defined answers (A-D), or specify “unknown”. Each answer is assigned points from a scoring table, with the points for each section tallied separately to yield four individual sub-ranks. Points are then assigned to each sub-rank according to another scoring table and tallied to yield an “*Invasive Non-native Plant Biodiversity Impact Rank*” or “I-Rank” (High, Medium, Low, or Insignificant). Scores for different questions are weighted differently, as are the four different sub-ranks, with the Ecological Impacts section having greater weight than the other three.

The project team utilized this methodology to assess a sample short-list of invasive alien species in British Columbia covering a wide range of species groups (i.e., beyond plants) for threat to biodiversity. This “sample short-list” was not intended to be exhaustive or indicative of all species of concern, rather a range of known invasive alien species was selected by species group experts in order to assess the utility of the NatureServe methodology across taxonomic groups. Preliminary impressions of the experts who used the system were positive. The users felt that the methodology would need only minor revisions and review to be able to systematically address the differing characteristics of various species groups and that the methodology forced careful and relatively “objective” consideration of the various factors involved in assessing invasiveness of alien species. One suggestion for improvement made by the users was to distinguish “management difficulty” from the other criteria used to determine invasiveness (as “invasiveness” should reflect strictly the characteristics and ecological effects of the species). Management difficulty, while an important consideration in determining eradication and/or control strategies, is a distinct issue and could be incorporated in the “I-Rank” as a secondary signifier or notation.

The inventory and ranking methodology is compatible with existing BC Conservation Data Centre protocols and makes the process of listing alien invasive species transparent, objective and comparable. The resultant assessments are useful to researchers, land managers, regulators, consumers and commercial interests (such as the nursery industry, vegetation managers and Integrated Pest Management practitioners).

Detailed results are compiled in a separate report describing the methodology used to prepare the map-based products associated with this Invasive Alien Species Framework.

The following table provides individual and cumulative scores, with the associated rating for “invasiveness” for each short-listed alien invasive species.

Table 4: Invasiveness Rating for Short-listed Invasive Alien Species in British Columbia (using NatureServe Methodology)

Scientific name	Common Name	Eco-invasive	Current invasive	Trend invasive	Management invasive	Invasive Score	Rating Letter	Invasiveness
<i>Euphorbia esula</i>	Leafy spurge	50	25	10	10	95	A	High
<i>Lythrum salicaria</i> L.	Purple loosestrife	50	17	15	10	92	A	High
<i>Crassostrea gigas</i>	Pacific (Japanese) oyster	50	25	10	3	88	A	High
<i>Myriophyllum spicatum</i> L.	Eurasian watermilfoil	50	17	10	10	87	A	High
<i>Centaurea diffusa</i> Lam.	Diffuse knapweed	33	25	15	10	83	A	High
<i>Centaurea maculosa</i> Lam.	Spotted knapweed	33	25	15	10	83	A	High
<i>Bromus tectorum</i> L.	Downy brome grass, Cheat grass	33	25	10	10	78	A	High
<i>Linaria genistifolia</i> ssp. <i>dalmatica</i> (L.) Maire & Petitm.	Dalmatian toadflax	33	25	10	7	75	B	Medium
<i>Cytisus scoparius</i> (L.) Link.	Scotch broom	50	8	10	3	71	B	Medium
<i>Cygnus olor</i> (Gmelin)	Mute swan	33	17	15	7	72	B	Medium
<i>Phalaris arundinacea</i>	Reed canary grass	33	17	10	3	63	B	Medium
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	Common reed	33	17	10	3	63	B	Medium
<i>Odocoileus hemionus sitkensis</i>	Mule Deer subsp. sitkensis (QCI)	33	17	5	7	62	B	Medium
<i>Cronartium ribicola</i>	White pine blister rust	17	25	10	7	59	B	Medium
<i>Sturnus vulgaris</i>	European Starling	17	25	10	7	59	B	Medium
<i>Daphne laureola</i>	Spurge laurel	33	8	10	7	58	B	Medium
<i>Hedera helix</i> L.	English ivy	33	17	5	0	55	B	Medium

Scientific name	Common Name	Eco-invasive	Current invasive	Trend invasive	Management invasive	Invasive Score	Rating Letter	Invasiveness
<i>Cirsium palustre</i>	Marsh Thistle	33	8	10	3	54	B	Medium
<i>Rubus discolor</i> <i>Weihe and Nees</i>	Himalayan blackberry	33	8	10	3	54	B	Medium
<i>Cyprinus carpio</i> <i>Linnaeus</i>	Common Carp	33	8	5	7	53	B	Medium
<i>Bromus inermis</i>	Smooth brome grass	17	17	10	7	51	B	Medium
<i>Carcinus maenas</i>	Green crab	33	0	15	3	51	B	Medium
<i>Cirsium arvense</i> (L.) <i>Scop. var. horridum</i> <i>Wimm. & Grab.</i>	Canada thistle	17	17	10	7	51	B	Medium
<i>Nuttallia obscurata</i>	Varnish clam	33	8	10	0	51	B	Medium
<i>Poa pratensis</i>	Kentucky bluegrass	17	17	10	7	51	B	Medium
<i>Trifolium subterraneum</i>	Subterranean clover	33	8	5	3	49	C	Low
<i>Hypericum perforatum</i> L.	St. John's-wort	17	17	10	3	47	C	Low
<i>Leucanthemum vulgare</i> Lam.	Ox-eye daisy	17	17	10	3	47	C	Low
<i>Rana catesbeiana</i>	Bull frog	17	17	10	3	47	C	Low
<i>Tanacetum vulgare</i> L.	Common tansy	17	17	10	3	47	C	Low
<i>Castor canadensis</i>	Beaver (Graham Is.)	33	8	5	0	46	C	Low
<i>Elymus repens</i> (L.) <i>Gould</i>	Quackgrass	17	17	5	7	46	C	Low
<i>Procyon lotor</i>	Raccoon (QCI)	17	17	5	7	46	C	Low
<i>Harmonia axyridis</i>	Asian ladybird beetle	0	25	10	10	45	C	Low
<i>Cynoglossum officinale</i> L.	Hound's tongue	17	8	10	7	42	C	Low
<i>Sciurus carolinensis</i>	Grey Squirrel	17	8	10	7	42	C	Low
<i>Tragopogon dubius</i> Scop.	Yellow salsify	17	17	5	3	42	C	Low
<i>Ulex europaeus</i>	Gorse	33	0	5	3	41	C	Low
<i>Polygonum cuspidatum</i>	Japanese knotweed	17	8	10	3	38	C	Low

Scientific name	Common Name	Eco-invasive	Current invasive	Trend invasive	Management invasive	Invasive Score	Rating Letter	Invasiveness
<i>Potamogeton crispus</i>	Curly pondweed	17	8	10	3	38	C	Low
<i>Adelges piceae</i>	Balsam woolly aphid	0	17	10	10	37	C	Low
<i>Cerastostoma inornatum</i>	Japanese oyster drill	0	25	5	7	37	C	Low
<i>Ondatra zibethicus</i>	Muskrat (QCI)	17	8	5	7	37	C	Low
<i>Eleagnus angustifolia</i>	Russian Olive	17	8	10	0	35	C	Low
<i>Echinochloa crusgalli</i> (L.) Beauv.	Common barnyard grass	17	8	5	3	33	C	Low
<i>Butomus umbellatus</i> L.	Flowering rush	17	0	10	3	30	C	Low
<i>Rattus norvegicus</i>	Norway Rat	0	17	5	7	29	C	Low
<i>Branta c. canadensis</i>	Canada Goose (S. coast)	0	8	10	7	25	D	Insignificant
<i>Iris pseudacorus</i>	Yellow flag	17	0	5	3	25	D	Insignificant
<i>Sylvilagus floridanus</i>	Eastern Cottontail	0	8	10	7	25	D	Insignificant
<i>Arion rufus</i>	Chocolate Arion	0	8	5	10	23	D	Insignificant
<i>Podarcus muralis</i>	European Wall Lizard	17	0	5	0	22	D	Insignificant
<i>Passer domesticus</i>	House Sparrow	0	8	5	7	20	D	Insignificant
<i>Rattus rattus</i>	Black Rat	0	8	5	7	20	D	Insignificant
<i>Tapes philippinarum</i>	Manila clam	0	8	10	0	18	D	Insignificant
<i>Perdix perdix</i>	Gray Partridge	0	8	0	7	15	D	Insignificant
<i>Alectoris chukar</i>	Chukar	0	8	0	0	8	D	Insignificant
<i>Didelphis virginiana</i>	North American Opossum	0	0	0	7	7	D	Insignificant
<i>Callipepla californica</i>	California Quail	0	0	5	0	5	D	Insignificant