Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 9
Alien Invasive Species

Contents

Chapter 9

Alien Invasive Species

by Michelle Gorman, in collaboration with Aimée Pelletier, Dave Polster, and Raj Prasad

Dave Polster demonstrates cutting invasive Spurge-laurel (*Daphne laureola*) below ground. Photo: Chris Junck

9.1 Introduction to Alien Invasive Species

After habitat destruction, conservation biologists have ranked alien invasive species as the second most serious threat to species at risk globally. About a quarter of Canada's species at risk are adversely affected in some way by alien species. Alien species introductions are one of the most important threats to Red-listed plants and animals in B.C. (BC MLAP 2004).

The management of alien invasive species in Garry Oak ecosystems (or other ecosystems) is frequently a significant activity that requires extensive resources and can have a sizeable impact on the landscape. It is important to have a solid understanding of the restoration objectives of the area before undertaking invasive species management. This chapter aims to provide the

practitioner with a good basis on which to begin dealing with alien invasive species in restoration situations.

9.1.1 What Are Alien Invasive Species?

Indigenous (or native) species are species that occur naturally in an area. Alien or exotic species are those that have been moved outside of their natural home range (i.e., non-indigenous species). Introduced species have been brought intentionally or unintentionally from another geographic area. Many invasive species reproduce rapidly, dominating habitats to the detriment of other species. Good definitions, examples of alien invasive species, and their threats to Canadian ecosystems can be found on the Garry Oak Ecosystem Recovery Team (GOERT) website (www.goert.ca/about_invasive_species.php) and the Environment Canada website (www.ec.gc.ca/eee-ias/default.asp?lang=En&n=986EC44D-1).

Alien or exotic species are those that have been moved outside of their natural home range (non-indigenous species).

Alien invasive species are those harmful alien species whose introduction or spread threatens the environment, the economy, or society; the harm to society includes harm to human health (United States National Invasive Species Council 2001).

9.1.2 Indigenous Species that Become Invasive

Through the absence of predation and through natural successional processes that occur in the absence of fire, native species such as Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*) and Douglas-fir (*Pseudotsuga mensiesii*) can become very abundant and take on invasive characteristics in Garry Oak ecosystems. Restoration strategies for managing such native invaders are discussed in Chapter 8: Restoration Strategies.

9.1.3 How Do Alien Invasive Species Harm Ecosystems?

Invasive species, including plants, animals, and micro-organisms, pose a significant threat to native ecosystems (Vitousek 1990). After habitat conversion caused by urban development and agriculture, invasive species pose the second greatest threat to native ecosystems (Murray and Pinkham 2002). The impacts of alien invasive species vary in scale and scope and may include one or more of the following:

- hybridization with native species, potentially causing reduced genetic integrity and diversity
- parasitism, predation, grazing, and/or browsing of native species
- competition with native species for limited resources
- carrying parasites and diseases
- degradation of habitat by altering vegetation structure and/or ecosystem processes such as fire and nutrient cycling
- alteration of ecosystems in such a way that further invasion by other invasive species is promoted

9.1.4 Invasive Species of Garry Oak and Related Ecosystems

All Garry Oak ecosystems have been invaded to some extent by alien invasive species, and the ecosystems continue to be at risk of further invasions. Alien invasive species can produce major ecological effects on Garry Oak ecosystems through habitat change, competition, predation, disease, and hybridization. These species may have multiple effects and may interact to amplify these effects, which may worsen through time and other factors of change. It may be difficult to determine if an alien species is invasive prior to its introduction to new locations and ecosystems. While only a minority of alien species become invasive, it is not currently possible to effectively predict all of the species that will have substantial adverse effects (BC MLAP 2004).

At least 174 alien species (not including invertebrates or micro-organisms) have been identified in Garry Oak ecosystems, including 4 tree, 14 shrub, 142 herb, 1 reptile, 6 bird, and 7 mammal species (GOERT 2003). Many of these alien species have become invasive in Garry Oak and associated ecosystems; there is a list of exotic invaders on the GOERT website, along with a field manual on invasive species of greatest concern titled, *Invasive Species in Garry Oak and Associated Ecosystems in BC* (www.goert.ca/pubs_invasive.php#Field_Manual).

Lists of alien invasive species found in an ecosystem are useful when determining what to look for on-site, but the alien invasive species present on site need to be considered dynamic and subject to change over time. The GOERT (2003) list of exotic and potentially invasive species represents only a snapshot of a collection of alien species known to exist in Garry Oak ecosystems at the time of compilation of this publication.

Dense English Ivy (*Hedera helix*) and other species carpeting the forest floor and climbing trees at Pemberton Park, Victoria, B.C. Alien invasive species pose significant threats to native ecosystems. English Ivy is an aggressive invader in our area, and can carpet natural areas, blocking sunlight and crowding out low-growing plants. It can weaken and even kill trees. Land managers face a serious long-term challenge in developing and conducting effective programs to deal with existing populations of alien invasive species. Preventing introduction and controlling spread once introduced saves substantial investment in resources and funds in the long run. Photo: City of Victoria

The consequences of invasions can be particularly severe for species at risk. See Chapter 4: Species and Ecosystems at Risk and Appendix 9.1 for more information regarding species and ecosystems at risk.

9.1.5 Chapter Overview

The objectives of strategies that address alien invasive species focus on **prevention** of the species' entering an area and becoming established, **early detection** of newly introduced alien invasive species and **rapid response** to eliminate the species, and **management** of those species that do establish. In this chapter, we discuss the prevention of alien invasive species introductions (Section 9.2), early detection and rapid response (Section 9.3), and management of established alien invasive species (Section 9.4). We also discuss a full range of control measures for alien invasive species (Section 9.5), and conclude by discussing management of alien invasive species in the context of restoration (Section 9.6).

Prevention is the most efficient and economical approach to reducing the introduction, establishment, and spread of alien invasive species.

9.2 Preventing the Introduction of Alien Invasive Species

Prevention is the most efficient and economical approach to reducing the introduction, establishment, and spread of alien invasive species. As an alien invasive species becomes established and begins to spread, there are progressive increases in financial and environmental losses due to the invasion, and corresponding increases in the cost to eradicate, contain, and control it. Prevention should be a high priority in any strategy that addresses alien invasive species. The ways in which alien invasive species are introduced or spread are called pathways. The many pathways of introduction include ballast water, recreational boating, aquarium trade, pet trade, horticulture trade, hitchhikers on commodities, stowaways in various modes of transportation, and diseases in wildlife. These introductions can be intentional (purposeful) or unintentional (accidental), and they can be authorized or unauthorized (illegal) (Environment Canada 2004). Increased international trade and travel has brought a corresponding increase in the number of alien invasive pests intercepted in North America (CFIA 2004). Although legislation (Section 9.2.1) and regulations (Section 9.2.2) exist, anyone working in Garry Oak ecosystems should be diligent about not allowing potential new invasive species to gain a foothold.

The ways in which alien invasive species are introduced or spread are called pathways.

9.2.1 Closing the Pathways of Introduction – Legislation

International Context

The introduction of plants and plant pests from one geographical area to another is a worldwide concern and is governed principally by the International Plant Protection Convention (IPPC). The purpose of this treaty is to protect plants (including natural flora) and plant products from the introduction of invasive plants or plant pests and to promote appropriate measures for their control. Canada has been a signatory since 1951, and its plant quarantine programs are consistent with the convention and its

standards. Canada also signed the Convention on Biological Diversity (CBD) in 1992, a global agreement on the conservation and sustainable use of biological diversity with a Memorandum of Cooperation between the CBD and the IPPC.

Federal Context

Many departments and agencies from various jurisdictions in Canada have a mandate to protect agriculture, forestry, and natural environments, and already undertake activities related to alien invasive species, either directly or indirectly (Environment Canada 2005).

The **Canadian Food Inspection Agency** (CFIA) has a mandate to protect Canada's plant resources by preventing the entry or establishment of plant pests that are not already present in Canada, or pests that are present and of limited distribution. The Plant Health Program of the CFIA includes activities such as **pest risk analysis** and policy setting, surveillance and monitoring, pest detection, and pest eradication or management. The list of pests regulated by Canada includes insects, mites, mollusks, nematodes, fungi, bacteria, viruses, phytoplasmas, and plants. This list can be found on the CFIA website (www.inspection.gc.ca/english/plaveg/protect/listpespare.shtml).

Observations of any of the pests on this list should be reported to the CFIA at 1-800-442-2342. You may be directed to the nearest office to make your report or submit a sample of the suspicious insect, plant, or plant pest.

Samples of suspected alien species can also be brought or sent to the local BC Ministry of Agriculture and Lands (BCMAL) office. The office will forward any suspicious samples to selected experts to determine if they are alien species. The BCMAL Plant Diagnostic Lab will accept suspect alien species samples free of charge.

Many other federal, provincial, and local government agencies have regulatory responsibilities for helping to close the pathways of alien invasive species entry. A summary of some of these agencies and their area of expertise is provided in Appendix 9.2.

9.2.2 Closing the Pathways of Introduction – Regulation

An integrated legislative framework is required to facilitate the comprehensive regulation of alien invasive plants and plant pests in Canada. The *Plant Protection Act* (1990) administered by the CFIA is a key legal tool in the regulation of the importation and domestic movement of plants, plant products, and plant pests (CFIA 2004). Other federal acts and regulations such as the *Canadian Environmental Protection Act* (1999), the *Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act* (1992), and others contribute to the protection of plants and habitats in Canada. The CFIA responsibility is aligned with that of the U.S. Department of Agriculture, Animal and Plant Health Inspection Service. The CFIA can:

- restrict entry of "economically harmful" species through quarantine/inspections for "Regulated species" (222 species listed in Canada),
- eradicate or suppress introduced species to prevent establishment, and
- limit movement of exotic species between counties or provinces to prevent the spread.

Regulatory control actions such as quarantine or restricted movement of commodities are preceded by a risk analysis and assessment process.

Table 9.1 Pathways of invasion (from CFIA 2004)

Alien Species	Intentional Introductions[1]	Unintentional Introductions
Aquatic Invasive Species	• Live food fish • Aquarium and horticultural pond trade • Live bait fish • Authorized stocking • Unauthorized transfer or stocking	• Commercial shipping (ballast water management, hull fouling) • Recreation/tourism—boating, float planes • Garbage • Water diversions, canals, and dams • Natural transboundary spread
Invasive Animals and Animal Pests	• Wildlife/pet trade • Game or fur farming/ranching of livestock, poultry, apiculture • Research and development • Zoos • Malicious introductions	• Animal products (meat, dairy, eggs, pet food) • Packing/packaging materials (containers, etc.) • Commercial transport—containers, airplanes, boats, trains, trucks, cars • Recreation/tourism (baggage) • Natural transboundary spread

1 Intentional introduced species can also be associated with unintentional introduced species (pests/hitchhiker). Intentional introductions may be both authorized and unauthorized.

Pest Risk Assessment of Potential Invaders

Risk assessment of potential invaders is a key tool for preventing the introduction of harmful species to British Columbia. The CFIA conducts risk assessments for alien invasive species in the context of animal and plant health and is highly regarded by the global community for its risk assessment approach. In fact, in order to regulate for a potential alien invasive species, the CFIA must conduct the pest risk assessment.

Pathways analysis involves identifying the main pathways that facilitate a pest's movement and dispersal (Table 9.1). Literature on invasive plants introduced in Canada documents the intentional introduction of plants for agricultural, ornamental, or medicinal uses as potential sources of alien invasive species (CFIA 2004). Pathways analysis is the tool used to identify and assess the different means by which species may be introduced to new areas and the relative likelihood of successful establishment occurring. This allows subsequent pest risk assessments, research, and policy development to focus on priority high-risk pathways.

Risk assessment is the process by which potential alien invasive plants and plant pests are identified and evaluated. It includes pathways analysis and pest risk assessment.

Pest risk assessment is the process of evaluating the relative risks posed by particular pests or alien invasive species. International standards for pest risk assessments have been established by the IPPC and provide the framework in which the CFIA conducts pest risk assessments. The IPPC standards for pest risk assessment include commodity-based pest risk assessments and pest-specific pest risk assessments. Commodity-based pest risk assessments focus on a particular commodity, and identify all potential pests that may be associated with that pathway. Pest-specific pest risk assessments provide more detailed information on particular pest species, and assign them risk

ratings based on their likelihood of introduction and potential impacts. Pest risk assessments are based on the best scientific information available. An example of a pest risk assessment can be found on the California Oak Mortality Task Force website: www.suddenoakdeath.org/pdf/RevisedPRA.8.03.pdf (Kliejunas 2003).

Potential Invasive Species Risk Communication and Garry Oak Ecosystems

Identifying and making note of alien species that are potentially detrimental to Garry Oak ecosystems prior to their entry should be done by those familiar with the ecosystems and the risk of new species to harm them. Those experts should communicate the risk to those government organizations charged with assessing risk and regulating their entry.

In order to expedite the regulation of a potential alien species from entering Canada or British Columbia, a pest risk assessment of the species should be conducted according to the IPPC standards. While the CFIA and the Canada Border Services Agency have principal roles in the prevention of new introductions of alien invasive plants and plant pests, departments with land management responsibilities, such as Environment Canada, Agriculture and Agri-Food Canada, Natural Resources Canada-Canadian Forest Service, and Parks Canada have critical functions in the management of alien invasive species within their land management responsibilities. Environment Canada, for example, contributes to the development of legislation, policies, and programs to protect biodiversity from alien invasive plants and other pests. A risk assessment conducted to the IPPC standards by a not-for-profit society such as GOERT could flag a potential alien invasive species for consideration by Environment Canada, which may then be passed up to the CFIA to create regulation to tighten the pathways of entry. The consideration of commodities, pathways, and vectors responsible for the introduction of alien invasive species is vital for designing an effective prevention plan.

Early identification of alien invasive species, followed by a rapid response to eradicate or contain the pest, saves substantial investment in resources and funds in the long run.

9.3 Early Detection and Rapid Response

When alien invasive species circumvent prevention measures and enter Canada, it is essential to detect and identify them before or immediately after they become established. Early identification of alien invasive species, followed by a rapid response to eradicate or contain the pest, saves substantial investment in resources and funds in the long run (Figure 9.1).

It is essential to respond to new introductions rapidly before they establish or spread and cause serious harm to the environment.

Steps involved in an early detection rapid response program:

- Identifying the introduced pest
- Conducting a risk assessment, including a pathway assessment
- Conducting site mapping of the pests in the area
- Providing containment of the area
- Evaluating successful management techniques used for the species in other areas
- Identifying and mapping species at risk in the area

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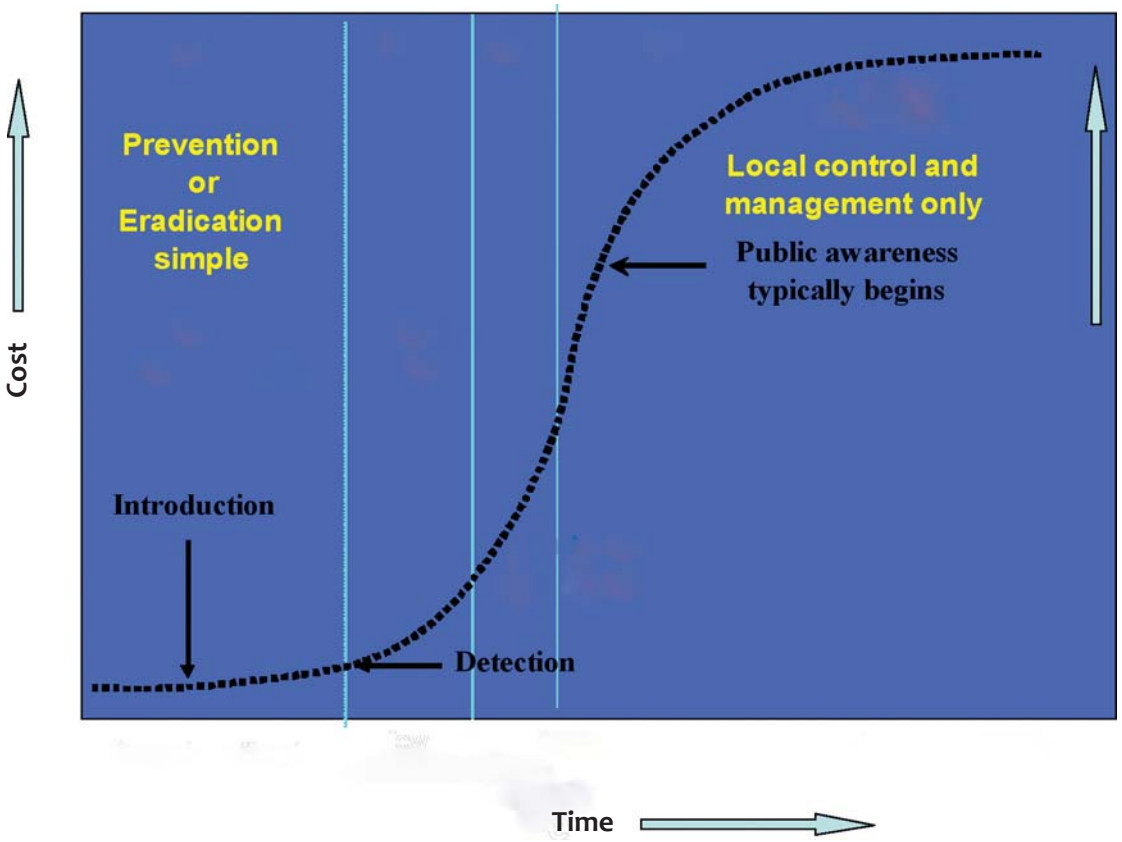

Figure 9.1 Typical invasion sequence for alien invasive species (after Hobbs and Humphries 1995).

- Communicating the program elements to stakeholders and other land managers
- Implementing management techniques
- Evaluating the success of the management response program
- Revising the program to increase subsequent success

In 2006, the Invasive Plant Council of BC developed an Early Detection Rapid Response Plan (www.invasiveplantcouncilbc.ca/publications/EDRR%20for%20Review.pdf) to respond rapidly to invasive plant species. Many of the steps of an Early Detection Rapid Response Plan were followed in an attempt to contain or eradicate Carpet Burweed (*Soliva sessilis*), a weed that potentially impacts Garry Oak ecosystems (see Case Study 1).

CASE STUDY

Case Study 1. Early Detection, Rapid Response in the Case of Carpet Burweed (*Soliva sessilis*)

by Dave Polster

Carpet Burweed (*Soliva sessilis*). Photo: City of Victoria

Awareness of the Alien Invasive Species

- First introduction to Ruckle Park , Salt Spring Island, B.C. in 1996
- By 2005 found in 3 other provincial parks, 1 municipal park and 1 federal park
- Two forums held by Invasive Plant Council of British Columbia (IPC) to communicate the findings and concern lead to an initial economic assessment
- Alien invasive species pest risk potential leads to funding aimed at the eradication of Carpet Burweed in B.C.

Spotting, Identifying, and Locating the New Introductions

- Two botanists were hired to search for the plant at likely locations on southern Vancouver Island and the associated Gulf Islands
- An additional search crew was hired to visit all of the private campgrounds and recreational vehicle parks on southern Vancouver Island
- Carpet Burweed was found at 23 of the over 175 sites searched

Communications to Stakeholders

- The IPC was founded in 2003 to provide coordination of invasive plant issues in the province
- IPC coordinated the stakeholder communications and eradication efforts
- Two workshops held with affected stakeholders
- Coastal Invasive Plant Council (CIPC) added Carpet Burweed to their priority invasive species list and completed a fact sheet about it: www.coastalinvasiveplants.com/carpet-burweed
- Follow-up presentations regarding Carpet Burweed status made at IPC AGM
- Site crews conducted information sessions prior to offering/conducting eradication measures

Incursion Management—Management Tools, Pooling of Resources, Rapid Response Management Team

- Organized by the IPC ground efforts and consisted of two phases: 1) searching for sites with Carpet Burweed present; and 2) treating the populations that were found
- Management methods used by the Rapid Management Team:

  -Site manager or owner was notified and treatment was arranged

  -At some sites, the infested areas were fenced to prevent movement of Carpet Burweed seeds to other areas from plants that had been missed in the burning

CASE STUDY

Left: Searching for Carpet Burweed. Right: Burning with a torch. Photos: City of Victoria

-2006 treatments consisted of hand-pulling if plants were few or burning patches with more than a few plants using propane fired hand torches

-Small pin flags were used to identify locations of patches in larger lawn areas. This allowed one person to search for Carpet Burweed while another person followed with the torch

-A total infested area of slightly over 8 ha was treated

Monitoring the Outcome—Success in Some Areas, Not Others

- Analysis of the data collected during the study suggested pathways of spread and estimated success of Carpet Burweed eradication
- Continued annual monitoring and treatment was encouraged
- In areas where resources were applied to do so, such as at Beacon Hill Park, results have shown continued reduction over the last 4 years; the remaining burweed population is less than 5% of the original population size
- Areas such as Ruckle Park where treatment is reduced to hand-picking in a sizable area due to the presence of a species at risk, Macoun's Meadowfoam (*Limnanthes macounii*), makes eradication unlikely but management possible

Prevention (Ongoing)

- Entails reviewing the pathways of spread of this alien invasive plant (on hiking boots, shoes, tent pads, dogs' paws), reducing the impact where possible, and monitoring the most likely sites of introduction
- Continued education and awareness for land managers and other stakeholders
- Avoiding contamination from a known infested area to a non-infested area where possible through exclusion/containment measures

Reference

Polster, D.F. 2007. Eradicating Carpet Burweed (*Soliva sessilis* Ruiz & Pavón) in Canada. Topics in Canadian Weed Science. Canadian Weed Science Society 5:71-81.

Dave Polster *is a consulting plant ecologist with more than 30 years of experience in vegetation studies, reclamation and invasive species management.*

Even if an alien invasive species is already established in a given region, it may be treated as a new invader in more outlying areas. For example, Spurge-laurel (*Daphne laureola*) is well-established at Fort Rodd Hill but is considered to be a new invader in Victoria. In Victoria, this species has been treated as an early detection invasive and given a high priority for removal in order to try to eradicate it and save valuable management resources in the long-term.

9.3.1 Emergency Response Plans

An emergency response plan provides guidance on actions that should be taken and how decisions are made following the declaration that a new alien invasive species incursion has taken place. In cases where invasions of insects, such as the Asian Longhorned Beetle (*Anoplophora glabripennis*), would represent an emergency in urban and natural forests, a government body may be able to provide the landowner with an emergency response plan. An example of such a plan is coordinated through the U.S. Department of Agriculture Animal and Plant Health Inspection Service (www.uvm.edu/albeetle/management/actionplans.html).

9.3.2 Risk Communication, Education, and Public Awareness

The public plays a large role in addressing the problem of alien invasive species. Public awareness and understanding of the risk and pathways of spread of potential or newly introduced alien invasive species is the cornerstone to controlling such species and preventing their introduction.

Figure 9.2 Carpet Burweed public alert sign (City of Victoria). Public awareness is a key component of successful invasive species management, particularly in controlling pathways and preventing spread to new sites.

Raising public awareness is key to the successful management of alien invasive species, particularly those that are newly introduced to a site. For example, Carpet Burweed management signs have been posted in containment areas to alert the public to the presence of the alien invasive species, its potential harm, and risk of spread (Figure 9.2).

Chapter 6: Outreach and Public Involvement discusses many innovative ways of working with the public in Garry Oak restoration.

9.4 Management of Established Alien Invasive Species

Land managers face a serious long-term challenge in developing and conducting effective programs to deal with existing populations of alien invasive species. The first steps in managing an invasive species include recognizing the species, mapping the extent of its introduction, and learning about its biology in order to understand how best to manage it.

The prevalence of alien invasive plants in Garry Oak and associated ecosystems in British Columbia has been documented in a number of studies. In the 1960s, Roemer (1972) found that 25% of the species within the core of the Garry Oak (*Quercus garryana*) range in British Columbia were introductions from the Mediterranean and other parts of Europe. McCune (2010) re-monitored a portion of Roemer's plots in 2009. She found that while many Garry Oak plots had had no exotics 30 years earlier, they all had exotic plants when re-monitored in 2009. In the Coastal Douglas-fir plots, 76 out of 114 plots had no exotic plants in the 1960s but only 3 out of 114 had no exotic plants by 2009 (McCune 2010).

The first steps in managing an invasive species include recognizing the species, mapping the extent of its introduction, and learning about its biology in order to understand how best to manage it.

Not all of these non-native plant species established in Garry Oak and associated ecosystems are invasive, but many are, including shrubs such as Scotch Broom (*Cytisus scoparius*), Spurge-laurel, Gorse (*Ulex europaeus*), and Himalayan Blackberry (*Rubus armeniacus*); grasses such as Kentucky Bluegrass (*Poa pratensis*), Colonial Bentgrass (*Agrostis capillaries*), and Creeping Bentgrass (*A. stolonifera*); and forbs such as Tiny Vetch (*Vicia hirsuta*), Common Vetch (*V. sativa*), and Hairy Cat's-ear (*Hypochaeris radicata*). A list of invasive, non-native species of Garry Oak ecosystems can be found in Appendix 9.1.

In a 2009 butterfly and moth survey of four City of Victoria parks that contain Garry Oak and associated ecosystems, the most abundant butterflies and moths were non-native species. Fifty-two percent of the butterflies observed were exotic, and consisted of the Cabbage White (*Pieris rapae*) and the European Skipper (*Thymelicus lineola*); 56% of the macromoths captured, Large Yellow Underwing (*Noctua pronuba*) and Lesser Yellow Underwing (*N. comes*), were non-native (Page et al. 2009). The Large Yellow Underwing and Lesser Yellow Underwing moths were recently introduced to B.C. and are considered to be pest species (Copley and Cannings 2005). Other alien insects that have become invasive in Garry Oak ecosystems include the Jumping Gall Wasp (*Neuroterous saltitrius*), Oak Leaf Phyloxera (*Phylloxera glabra*), and Winter Moth (*Operophtera brumata*) (GOERT 2009).

Alien species are regularly intercepted upon entry into B.C. by the federal government (CFIA); however, with the vast movement of people and products, introductions still occur and some result in established populations.

In dealing with established alien invasive species, land managers must be prepared for a long-term investment of resources and develop goals for removing the invasive species in a context of restoration management.

The Invasive Plant Council of BC has developed a number of tools to assist with invasive plant management in this province. One such tool has been developed in collaboration with the B.C. Ministry of Forests and Range: Invasive Alien Plant Program (IAPP). The IAPP is "a web-based database that stores information on comprehensive invasive plant data in B.C." (Invasive Plant Council of BC). Regional committees across B.C. have offered 1-day IAPP workshops that have featured the new IAPP Version 1.6 and include training on the "Report-A-Weed" functionality. Information on IAPP training is available on the B.C. Ministry of Forests and Range website (www.for.gov.bc.ca/hra/Plants/IAPPtraining.htm).

9.4.1 Adaptive Management

Adaptive management is a problem-solving approach to environmental management which takes existing knowledge, explores alternatives, makes predictions of their outcomes, selects one or more actions to implement, and monitors to determine if the outcomes match the predictions. Results obtained from this management practice are then used as a learning exercise and a basis to adjust future management plans and policy. See the GOERT website for a description of how an adaptive management strategy works (www.goert.ca/documents/goe_dst_ams.pdf).

Our understanding of how these dynamic and complex ecosystems work and respond to disturbances is limited. This makes ecosystem management and restoration challenging, but an adaptive management approach is useful for proceeding with restoration activities in the face of uncertainties. See Chapter 8: Restoration Strategies for more information on adaptive management, and Chapter 3: Natural Processes and Disturbance for a discussion of what is known about disturbance in these ecosystems.

9.4.2 Site Management

It is important to investigate the ecosystem and the conditions on site that have encouraged the establishment of alien invasive species. For example, it is important to ask what species at risk occur on site (see Table 4.1), find their locations, and measure their populations (e.g., map and set up a way to monitor these species, see Section 5.2.2 in Chapter 5: Restoration Planning, Inspection and Inventory, and Chapter 7: Inventory and Monitoring). It is also critical to identify the particular invasive species concerns on site, the locations of such species, and the extent of infestation (e.g., map and set up a way to monitor the site). More information on site management is available on the GOERT website: *General Decision Process for Managing Invasive Plant Species in Garry Oak and Associated Ecosystems (GOEs)* (www.goert.ca/documents/General_Decision_Process_revised.pdf) (GOERT 2007).

9.4.3 Management Plan

Management plans should reflect the goals for the site and consider the management of targeted alien invasive species while preserving the native species on site (see GOERT resources: www.goert.ca/invasive) such as best practices documents and a field manual on invasive species). Management plans should also consider the biology of targeted alien invasive species, their known impacts on Garry Oak ecosystems, and management techniques for the species. Decisions need to be made about which alien invasive species are of the highest priority on the site given the resources available for management. The GOERT website has resources to help in the decision process (www.goert.ca/documents/General_Decision_Process_revised.pdf) of developing such priorities (GOERT 2007).

Likewise, plans should consider the biology of plants at risk (refer to GOERT's field manual: *Species at Risk in Garry Oak and Associated Ecosystems in B.C.*: www.goert.ca/pubs_at_risk.php). An excellent example of a management plan that contains these elements is Parks Canada (2008), in their Anniversary Island restoration plan (see Case Study 2 following, and Appendix 5.1 in Chapter 5: Restoration Planning).

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CASE STUDY

Case Study 2. Alien Invasive Species Management on Anniversary Island, Gulf Islands National Park Reserve

by Aimée Pelletier

Established Alien Invasive Species Being Managed

a. Himalayan Blackberry (*Rubus armeniacus*)
b. Bur Chervil (*Anthriscus caucalis*)
c. Bull Thistle (*Cirsium vulgare*)
d. Agronomic grasses, including:
   -Common Velvetgrass (*Holcus lanatus*)
   -Sweet Vernal-grass (*Anthoxantham odoratum*)
   -Kentucky Bluegrass (*Poa pratensis*)
   -Orchard-grass (*Dactylis glomerata*)

Planting Blue Wildrye (*Elymus glaucus*) plugs. Photo: Nicole Kroeker, Parks Canada

Groups Involved

Parks Canada Agency staff, co-op students, and volunteers

Location of Restoration/Management Project

Anniversary Island is a 1.8 hectare islet located in Gulf Islands National Park Reserve about one kilometre northwest of Saturna Island, within the Belle Chain Islets, in the Strait of Georgia. It is primarily a coastal bluff ecosystem dominated by dense shrubby Garry Oak (*Quercus garryana*), Common Snowberry (*Symphoricarpos albus*), Nootka Rose (*Rosa nutkana*), and mature Seaside Juniper (*Juniperus maritima*) (Blackwell 2007). Coastal bluff ecosystems are naturally rare throughout eastern Vancouver Island and the southern Gulf Islands. These ecosystems are of increasing conservation concern due to development pressure, increased recreational use, and alien invasive species infestations. Anniversary Island is designated as Zone 1 (Special Preservation), meaning that only authorized access is permitted to afford protection to its rare and sensitive ecosystems.

Restoration Goals and Objectives

The overall restoration goal for this project is to improve the ecological integrity of Anniversary Island. At the beginning of the restoration project, native plant communities were estimated through informal survey to comprise at least 75% of the total cover (C. Webb, pers. comm. 2008); however, advancing infestations of agronomic invasive grasses and Himalayan Blackberry were threatening the native communities and establishing a new steady state in the vegetation (Polster 2007). Achieving the restoration goal therefore involves removing the key threats to ecological integrity so that existing native plant communities can persist with a minimum of human intervention. To provide project direction and guidance, a restoration plan was written for the island that outlines the objectives, targets, methods, and monitoring protocols (see Appendix 5.1 in Chapter 5 for the full restoration plan). The approach adopted is not to modify all of the island's ecosystems. Rather, activities are focused on repairing specific degraded areas using an integrated

pest management approach and methods that are sensitive to the presence of native flora and fauna, and cultural features. The restoration plan has three objectives:

a. Replace infestations of agronomic grasses in specific treatment polygons with native shrubs
b. Permanently remove large Himalayan Blackberry thickets
c. Permanently remove smaller Himalayan Blackberry occurrences and other priority alien invasive species (AIS) that occur incidentally throughout the island

The restoration plan for Anniversary Island follows an ecosystem-based adaptive management approach (*sensu* Johnson 1999). Adaptations to the plan are made as we apply treatments, monitor using ecologically sound methods, and learn.

Management Methods Used Prior to AIS Removal

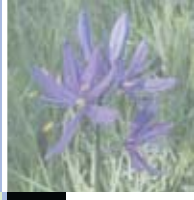
a. Site inventory for species at risk as well as the AIS

A site inventory was conducted at the beginning of the restoration project to identify species at risk as well as all alien invasive plant species on Anniversary Island. Each year the island is resurveyed to detect any new occurrences of alien invasive plant species.

b. Prioritization of AIS for removal

Not all alien plant species demonstrate invasive tendencies in all situations. This makes it neither necessary nor effective to treat all alien species equally. Prioritizing which species to treat and when facilitates effective treatment and allocation of resources. Species identified as top priority for treatment were selected based on each species' degree of infestation, relative ease of treatment, and significance of impact on the ecosystem, using past experience and the *General Decision Process for Managing Invasive Plant Species in Garry Oak and Associated Ecosystems* (GOERT 2007) as guides. This list is revised as new data are collected and treatments applied.

Left: Planting a snowberry plug. Right: Planting shrubs and grasses on Anniversary Island. Photos: Aimée Pelletier, Parks Canada



Management Methods Used to Remove AIS and Restore Native Plant Communities

a. Seasonal Consideration

The advice developed by GOERT on the best months to remove alien invasive species in this region is followed in deciding when to remove each AIS. Priority is placed on removing AIS prior to seed set such that further dispersal and spread can be avoided.

b. Protection of Species at Risk

Species at risk in the vicinity of the treatment areas are clearly flagged (e.g., flagging tape, pins) prior to AIS removals in order to avoid disturbance.

c. Agronomic Grass Control

Although Common Velvet grass, Sweet Vernal-grass and Orchard-grass are identified as top priority species in the restoration plan for the island, their predominance and the difficulty in controlling them precludes them from being treated outside the treatment polygons. Within specific treatment areas, grasses are repeatedly cut to deplete their energy reserves, mulched, and left to decay *in situ* to suppress re-infestation until native shrub cuttings and live stakes are planted to out-compete them, as recommended by Polster (2007). A variety of removal tools are employed, including hand shears, carpet knives and a gas-powered weed whip. The first cutting occurs at the time of anthesis[1] (typically early June depending on seasonal weather). A second cutting occurs in mid-late summer at the time of maximum re-growth.

d. Woody Shrub Control

Himalayan Blackberry is the main woody shrub of concern on Anniversary Island. Between 2003 and 2006, volunteers removed patches of Himalayan Blackberry by hand-cutting using loppers and root ball removal. With the removal of the Himalayan Blackberry infestations, agronomic grasses that were present around and among the blackberry expanded to dominate the areas where blackberry was removed. In addition, these physical control methods did not prevent the blackberry thickets from re-growing and continuing to expand. In 2008 and 2009, blackberry thickets were first cut with a gas-powered brush saw, or manually with hand loppers and then spot-treated with a selective herbicide (Garlon). After two years of herbicide treatment, the blackberry infestations appear to be shrinking, but the method has not proved 100% effective in killing the canes. Monitoring of the blackberry treatment areas in early December 2009 detected re-sprouting canes in all of the treatment areas. Re-application of herbicide was therefore planned for 2010. Due to the difficult and dangerous access, Himalayan Blackberry growing on the island's steep cliff faces has not yet been treated. As long as these patches remain, they can continue to act as a source of seed for new infestations on the island. Consideration is being given to training staff in the use of ropes and harnesses in order to remove these patches.

e. Forb Control

Infestations of priority alien invasive forbs are removed by hand, by either cutting or careful hand-pulling. Attention is given to the timing of removal. Bur Chervil (*Anthriscus caucalis*) must be hand-pulled in early spring before seeds mature (10–12 weeks after flowering). Bull Thistle

1 The period during which a flower is fully open and functional.

(*Cirsium vulgare*) is another target species that is present on Anniversary Island. Once plants bolt but before they flower, they are pulled if possible to get the taproot, or cut ~ 3 cm below the soil surface to prevent the plant from re-sprouting. Small rosettes are carefully dug up and the tap-root removed if possible without significantly disturbing the soil.

f. Re-vegetation of Treatment Areas

As described above, removal of Himalayan Blackberry infestations enabled agronomic grasses that were present around and among the blackberry to expand and dominate the treatment area. One problem alien invasive species was replaced with another! Where the bare patches left by alien invasive species removal are relatively small (e.g., ≤20 cm x 20 cm), native shrubs or forbs from adjacent habitat can be expected to expand and naturally re-vegetate the area. For larger bare patches, and those where agronomic grasses now dominate, a restoration strategy was developed to expedite succession to a native plant community through re-vegetation with native species that can outcompete the agronomic grasses.

The choice of species used to re-vegetate the treatment areas depends on the native plant community present. Treatment areas located in areas naturally dominated by shrubs (e.g., Snowberry association, Juniper-Oak association) are re-vegetated with native shrubs, while treatment areas located in more open meadow plant communities (e.g., camas-herb association) are re-vegetated with native grasses and forbs.

Because Common Snowberry (*Symphoricarpos albus*) and Nootka Rose (*Rosa nutkana*) tend to form dense layers beneath which agronomic grasses do not dominate, and because they are most easily propagated from cuttings, these species are used for re-vegetation of treatment areas located in shrub habitat. In June 2008, several hundred snowberry and rose cuttings were collected from Anniversary Island and sent to a professional nursery for propagation into plugs. These cuttings were to be the primary source of re-vegetation material, but yielded far fewer viable plants than anticipated. For this reason, and so that we do not rely on only one method, a combination of native shrub plugs, live stakes, and layering is used to re-vegetate the treatment areas.

In January 2009, layering of snowberry and live staking of rose and snowberry was tested for effectiveness in some of the treatment areas. Given the apparent success of these methods (~75% survival rate), as well as their cost-effectiveness and efficiency, a larger effort will be undertaken in January 2010. In December 2009, approximately 400 snowberry and 100 rose plugs were planted into two of the treatment areas. The success of these plugs will be monitored and compared to the success of the live staking and layering trials in order to determine the most efficient and cost-effective re-vegetation strategy. In order to reduce competition of the agronomic grasses with the newly planted plugs, live stakes, and layered shrubs, grass cutting will continue in the treatment areas. Cutting will be done by hand, however, to avoid damage to the shrubs.

For treatment areas located in open meadow communities, fast-growing/early seral stage native forbs such as Sea Blush (*Plectritis congesta*) and native grass species such as Blue Wildrye (*Elymus glaucus*) are preferred. In December 2008, Blue Wildrye plugs propagated from seed collected on the island were used to re-vegetate one of the treatment areas. Additional Blue Wildrye plugs are currently being propagated to re-vegetate additional treatment areas and will be planted in early 2010. Collection of seed for propagating a greater diversity of native forbs and grasses was planned for 2010.

CASE STUDY

Live staking of rose and snowberry on Anniversary Island. Photo: Nicole Kroeker, Parks Canada

Monitoring

Island-wide systematic surveys for target alien invasive species are carried out annually in May and October to search for and remove alien invasive species. Formal monitoring of the restoration efforts on Anniversary Island focus on the treatment polygons. The extent of any Himalayan Blackberry infestation is determined annually by defining the boundary using a GPS unit, whereas a crude estimate of percent cover is recorded to determine intensity. Photos are captured before and after treatments as a qualitative record of change in each treatment polygon over time. Belt transects through the polygons are used to assess percent cover of native species. The general health and survival of plugs, live stakes, and layered stems is monitored in the re-vegetation areas. A survival rate ≥ 75% is considered a success.

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Left: English Ivy prior to removal in Pemberton Park. Right: English Ivy removal in Summit Park. When invasive species occupy large areas, a targeted management approach is best. In the case of English Ivy, targeted management focuses on immediately reducing its spread by removing the climbing stage (ivy on trees), thus eliminating seed production. An understanding of the biology of the species involved is important in determining the best management strategies. Photos: City of Victoria

Where Should Action be Taken on Targeted Invasive Species?

In many cases it is hard to know where to begin if the invasive species occupies large areas of the site. An example of this is a site with English Ivy (*Hedera helix*), which can occupy many hectares (photo above). With invasive species such as this, a targeted approach works well. Because ivy produces seeds when it reaches a climbing stage, removing it from the trees will immediately reduce its spread. The ivy can be cut at 1 metre above the ground all the way around the tree, and the upper vines can be left to decay on the tree. After cutting the ivy on the trees, a manageable area can be chosen to hand pull the vines on the ground (e.g., based on what volunteers and staff could remove in less than a day). The ivy can be removed by using hand trowels to pry the root system up and roll it back like a carpet, followed by appropriate disposal.

9.4.4 Disposal

Garden waste can be dropped off at municipal public works yards. Check the website of the municipality to find out the rules for proper garden waste drop off. City of Victoria guidelines can be found at www.victoria.ca/cityhall/departments_engcivicwaste.shtml#garden. The Capital Regional District lists yard waste options and rules to follow when disposing of yard wastes

including invasive species (CRD: www.crd.bc.ca/waste/organics/yardwasteoptions.htm). A current option is to place all plant parts in garbage bags labelled "invasive species", and take them to Hartland Landfill in Victoria, B.C.

9.5 Alien Invasive Species Control Methods

9.5.1 Seasonal Considerations

Alien invasive species should be removed at a time of year when native species would be least affected. Because seasons differ from one location to another within regions, removal timetables will vary. Sample timetables are included here for reference. Practitioners should keep in mind that seasonal patterns vary annually, even within the same area of larger sites.

Example 1. Timing of invasive species removal developed for volunteers of Government House by Pat Boyle (available on the GOERT website: www.goert.ca/documents/best_time_to_remove_invasive_species.pdf).

Example 2. *Best Management Practices for invasive species removal from sensitive ecosystems* (Table 9.2), compiled by Nathalie Dechaine with the intention of educating community volunteers about the environmental and social sensitivities associated with invasive plant removal (drafted November 2008).

9.5.2 Competition and Shading

Alien invasive species are often shade intolerant, and this attribute can be used against them in various ways. For example, a Scotch Broom control program can use shade to prevent re-sprouting of this shade-intolerant plant. Young broom plants (the width of a pencil or smaller) may be pulled without causing much soil disturbance. Removal of larger, older plants in the same way would cause significant soil disturbance on-site and would bring up seeds from the soil bank, which would cause more harm than good. However, older broom plants can be cut low when the plant is stressed (after flower production, when starch reserves are low in the plant, and prior to seed release) and then covered over with mulch or leaf litter to mimic shading, which reduces the amount of re-sprouting from the stalk.

All ecosystems have successional stages, and the early stages tend to be most susceptible to weedy species that are programmed to occupy bare ground, when competition and shade are at their lowest. Some weeds of prairies and grasslands, such as Russian Thistle (*Salsola kali*), can be reduced or eliminated by the establishment of a healthy cover of native perennial grasses and forbs, which outcompete and shade out the weedy species (Polster et al. 2006).

9.5.3 Biological Control

Biological control uses a wide variety of organisms, including grazing animals, fungi, microbes, and insects to control targeted alien invasive species. Biological control agents are selected based on their ability to manage targeted invasive species without impacting natural ecosystems. The Winter Moth, for example, native to northern Europe and northern Asia, was introduced to Vancouver Island in the 1970s without the natural checks and balances that keep

Table 9.2 Best management practices for invasive species removal in sensitive ecosystems. These timeframes mimic typical seasonal timeframes. Some years may vary; therefore, removal should be in accordance with actual events (e.g., the onset of fall rains) as opposed to the calendar (from Dechaine 2008; used with permission).

Species*	Form	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Rationale
Ivy	creeping	√√√	√√√	OOO	OOX	XXX	XXO	OOO	OOO	XXO	√√√	√√√	√√√	ev, ds
	climbing	√√√	√√√	√√O	OOO	OOO	OO√	√√√	√√√	√√√	√√√	√√√	√√√	ev, ns
Broom	pulling*	√√√	√OX	XXX	XXX	XXX	XXX	XXX	XXX	XXO	√√√	√√√	√√√	ev, ds
	cutting	√√√	OOX	XXX	XXX	XXX	OOO	O√√	√√√	√√√	√√√	√√√	√√√	ev, ns, ds
Blackberry	stems	√√√	OOO	OOX	XXX	XXX	OOO	OXX	XXX	√√√	√√√	√√√	√√√	ev, ns, fs
	roots	√√√	OOO	OOO	XXX	XXX	OOO	XXX	XXX	√√√	√√√	√√√	√√√	ev, ns, fs
Daphne	pulling*	√√√	√√O	OOO	OOO	OOO	OOO	OOX	XXX	XXO	√√√	√√√	√√√	ev
	cutting	√√√	√√O	OOO	OOO	OOO	OOO	√√√	√√√	√√√	√√√	√√√	√√√	ev
Holly	pulling**	√√√	√√√	√OO	OOO	OOO	OOO	OOX	XXX	XXO	√√√	√√√	√√√	ev, ds
E. Hawthorn	pulling**	√√√	√√√	√√O	OOO	OOO	OOO	OOX	XXX	XXO	√√√	√√√	√√√	ev, ds

*NOTE: It is imperative to know the health hazards associated with handling invasive plant species before commencing work. Toxic Plant Warning information is found on the WorkSafeBC website. (www.worksafebc.com/publications/health_and_safety/bulletins/toxic_plants/default.asp)

TIMING
*Pulling should occur only if seedlings are a pencil width or smaller
**Pulling requires the use of a tool (Weed-wrench© or Pullerbear ©) and should occur only if the shrub is 3.5 cm or less in diameter

KEY
√√√ Ideal season
OOO Extreme care must be taken (removal from certain areas may be inappropriate)
XXX Refrain from any removal (see rationale)

RATIONALE
ds = dry season, pulling causes severe soil disruption
ev = emergent vegetation
fs = fruiting season (can create public backlash)
ns = nesting season (birds nesting and sensitive to disturbance)

it to a manageable level in its native locations. Winter Moth is an alien invasive species and a detrimental defoliator of several host trees including Garry Oak, aspen, birch, poplar, and Bigleaf Maple (*Acer macrophyllum*) as well as many ornamental trees, shrubs, and native species such as snowberry (*Symphoricarpus* spp.). A joint federal-provincial biological control program, involving the importation and release of two European parasites on Vancouver Island, was initiated in 1978 following the example of a similar program in Nova Scotia which brought the Winter Moth populations down to manageable levels within 6 years in the release sites. The two parasitoids

released were *Cyzenis albicans*, a tachinid fly, and *Agrypon flaveolatum,* a parasitic wasp (Roland and Embree 1995).

In greenhouse trials, a bioherbicide derived from the fungus *Chondrostereum purpureum* was found to be effective at preventing re-sprouting of 2-year-old broom plants (Prasad and Kushwaha, 2001). The development of biological control agents to manage alien invasive species requires time for research of the appropriate agent, testing in the safety of the laboratory and greenhouse to assess both efficacy and range of target, and then ground-truthing of the agent in the field for management of the alien invasive species. An eight to ten year timeframe is not uncommon for the development and registration of biological agents prior to use in the field. Health Canada's Pest Management Regulatory Agency, under the authority of the *Pest Control Products Act* (2002) and the Pest Control Products Regulations, reviews all products, including biological pest control products for registration in Canada (Health Canada's Pest Management Regulatory Agency, www.hc-sc.gc.ca/ahc-asc/branch-dirgen/pmra-arla/index-eng.php). In the case of an alien invasive species like the Winter Moth, the development and release of biological agents can prove to be an invaluable management tool (see invasive species field manual found on the GOERT website: www.goert.ca/invasive). The BC Ministry of Agriculture's *Integrated Weed Management Introductory Manual* (2010) (www.agf.gov.bc.ca/cropprot/weedman.htm#BIOLOGICAL) contains a section on the use of biocontrol for managing invasive species. Another resource can be found on the Ministry of Forests, Lands and Natural Resource Operations, Biocontrol Development website which includes biocontrol research, and publications on biocontrol of weeds in British Columbia (www.for.gov.bc.ca/hra/Plants/biocontrol/index.htm).

9.5.4 Mowing

Mowing knocks plants back to ground level but does not disturb the root systems. It can kill rhizomatous invasives by depleting energy reserves, which deprives the roots of the energy derived from photosynthesis. Repeated cutting at the right time of year can reduce vigour

Mowing around Deltoid Balsamroot (*Balsamorhiza deltoidea*), an Endangered plant in Garry Oak ecosystems. GOERT is creating a document about Best Management Practices (BMPs) for mowing in Garry Oak ecosystems which will be available on the GOERT website in late 2011.

or completely kill offending plants. The key to success is understanding the physiology and phenology of the invasive organism so it can be mowed at the weakest point in its life cycle. Scotch Broom and some alien perennial grasses can be managed with well-timed mowing. Mowing has been used to mimic fire in Beacon Hill Park.

The Mill Hill Regional Park Restoration Plan contains a section on the Best Practices for Control of Scotch Broom that lists technical guidelines to consider when removing this invasive species, including mowing (CRD Parks 2003, pp. 36-38). This plan can be found on the CRD website (www.crd.bc.ca/parks/documents/mill_hill_restoration_plan.pdf).

9.5.5 Tilling

Multiple tilling is used to deplete soil seed banks where the terrain, soil, and seed bank extent is favourable to this method. Due to the extensive seed banks of some alien invasive plant species in infested Garry Oak ecosystems and to the presence of native forbs at most sites, tilling has limited use in most Garry Oak ecosystems.

9.5.6 Thermal

On sites where all existing vegetation is considered undesirable, solarization and sheet mulching have been used to kill the existing vegetation and prepare the bed for the planting of desirable species. Solarization involves the use of clear or black plastic sheets to raise soil temperatures enough to kill unwanted seeds and vegetation cover. Various types of mulch can be used to eliminate light to unwanted vegetation. The Urban Restoration Project at the Kings Road Native Plant Garden conducted by Pat Johnston and friends from the Native Plant Study Group employed the sheet mulching technique as a way to suppress weed growth and to prepare the ground for a meadow (see photos below). A story about this project can be found on the GOERT website: www.goert.ca/news/2009/07/kings-road-native-plant-garden.

"Before" photo: in the foreground, natural leaf fall at the site of a future thicket, and in the background, deep sheet mulch prepares the ground for the Garry Oak meadow. Photo: Pat Johnston

"After" photo: a few years later, the meadow is full of camas lilies (not in flower) and Red-flowering Currant (*Ribes sanguineum*) (see also pink variety in foreground). A few daffodils remain. Photo: Pat Johnston

9.5.7 Management of Hydrology

Substantial changes to local hydrology due to urban development, land filling of streams, and placing streams underground have caused large-scale ecological degradation and weed invasions in B.C. Mimicking historical flows on flood controlled rivers may be a means of controlling invasives. Increasing spring water release from the Columbia and Snake River dams to aid fish migration may also help restore willow bars by flooding out broom and blackberry patches that have occupied former floodplains (Polster et al. 2006). With the renewed interest in "day-lighting" urban creeks, it may be possible to re-establish willow and other riparian species in these areas.

In other cases, it may be possible to remove drainage from a site as part of a restoration project. For example, over the last 60 years the northeast side of the Garry Oak meadow in Beacon Hill Park had three drains placed in the interior of the meadow and one just outside the meadow, with an accompanying drainage ditch. The drainage on this section of the meadow changed its hydrology: the area went from being a relatively wet meadow with vernal seeps in the winter and early spring that dried slowly over the summer season, to a much drier meadow with occasional winter seeps. Nuttall's Quillwort (*Isoetes nuttallii*) and Golden Paintbrush (*Castilleja levisecta*) are extirpated species that used to live in the moist areas of this meadow, and suites of moisture-fond native plants such as the Jeffrey's Shootingstar (*Dodecatheon jeffreyi*) have dwindled in numbers and have been replaced by their drier-habitat cousins, Broad-leaved Shootingstar (*Dodecatheon hendersonii*). Invasive species such as Orchard-grass (*Dactylis glomerata*) and Scotch Broom, favoured by the dryer conditions, have moved into the meadow, with the nitrogen-fixing Scotch Broom feeding the nitrogen-loving Orchard-grass. A recent restoration of a portion of this area entailed reclaiming a former meadow from a parking area of 1000 m^2, removing the drainage ditch and drain to put back some of the former hydrology, and planting a suitable suite of plants. In addition to encouraging the moist-loving plant species formerly found on this meadow, it is hoped that the change in hydrology will be sufficient to discourage drier-loving invasives such as Scotch Broom and Orchard-grass.

9.5.8 Prescribed Burning

In oak and pine woodlands and savannahs, in the absence of frequent, low-intensity fires, both native tree and shrub species such as Douglas-fir (*Pseudotsuga menziesii*) and Common Snowberry (*Symphoricarpos albus*) and non-native species invade, changing open grassy areas into densely-treed or shrubbed areas (see Chapter 3: Natural Process and Disturbance). Restoring the natural fire regime would theoretically help manage some of these invaders. In most cases, initial site preparation would be required. This could include activities such as cutting the invasive species, or raking needles or duff away from old trees, to lower the fuel load prior to engaging in a controlled prescribed burn (see Case Study 2 in Chapter 8: Restoration Strategies).

9.5.9 Chemical

Various types of chemicals, such as herbicides, insecticides, and fungicides, may be used in pest management. Herbicides are particularly useful for controlling deep-rooted and rhizomatous plant species (Polster et al. 2006). When used as part of an integrated pest management program and with careful selection, timing, and application method, chemical herbicides can provide excellent control of some invasive species. An example is stem application of glyphosate to Japanese Knotweed (*Fallopia japonica*). Care must be taken to minimize effects on non-target

A prescribed burn at the Cowichan Garry Oak Preserve, near Duncan, B.C. In the absence of fire, certain native and non-native species can invade open, grassy areas and change them into more densely vegetated ones. Restoring the natural fire regime would theoretically help manage some of these invaders (for more information, see Case Study 2 in Chapter 8). Photo: Tim Ennis, Nature Conservancy of Canada

species; chemical use should be avoided on sites with species at risk (SAR). There are many alternatives to chemical use: new technology exists such as the use of hot water-based weed control applicators that provide non-chemical choices in the area of vegetation management (Murray and Pinkman 2002).

9.5.10 Physical

Manual removal of invasive plant species is practiced in many restoration projects, particularly where volunteer labour is available and on sites where other management techniques are not appropriate, such as sites with rare or endangered species.

A variety of approaches and tools are used in physical weed control, ranging from hand-pulling to the use of spades, hoes, specially-designed weed pullers like weed wrenches, flamers, weed-eaters, brush saws, and in already highly disturbed areas, backhoes and bulldozers. It is important to choose the tools appropriate to the site and species being managed. Scotch Broom, for example, produces large amounts of seed per plant which can remain in the seed bank for numerous years. Methods that minimize soil disturbance, such as cutting with loppers or brush saws as close to the ground as possible, should be used for broom plants with stems larger than a pencil width. Young broom plants that are smaller than pencil width can be manually pulled by standing on either side of the plant and pulling straight up to minimize bringing large potions of the seed bank to the surface. Targeting broom prior to flowering, where possible, also avoids seed banking. With heavy broom growth in highly disturbed areas with very little of the original habitat remaining, it may be appropriate to take in larger wheeled machinery to slash the broom prior to a large-scale restoration project. Best management practices for removing several types of invasive species can be found on the GOERT website (www.goert.ca/pubs_invasive.php#GDP).

9.5.11 Grazing

Domestic grazing animals, primarily goats and sheep, have been used with varying degrees of success to reduce invasive species such as Scotch Broom, English Ivy, and Himalayan Blackberry. Although grazing may not eliminate invasive species, when combined with other methods it can reduce the occurrence of such species and help with site preparation. Care must be taken to choose the type of animal that has the appropriate grazing habits for the job to be done. For example, goats prefer browsing woody species to eating grasses and forbs; therefore, the animals can be useful in oak savannahs if they are confined to the target area and then moved when appropriate (Soll 2004). On the other hand, over-grazing can cause excessive disturbance of grassland sites (Douglas 2011); (see Case Study 1 in Chapter 8: Restoration Strategies).

9.6 Summary

Management of alien invasive species focuses on strategies to prevent the species from entering an area and becoming established, strategies for the early detection of newly introduced alien species that may become invasive, a rapid response to their elimination, and strategies to manage those alien invasive species that do become established.

Although much of the management of invasive species in Garry Oak ecosystems tends to focus on alien invasive plants, alien species include a wide variety of organisms such as birds, squirrels, rabbits, insects, mites, slugs, and diseases (such as Sudden Oak Death) whose ecological impacts may be less obvious at first but more devastating in the long run.

The early detection of an alien species, accompanied by a rapid response to control that species, saves a major investment of resources over an extended period of time. Managing established alien invasive species on a site, on the other hand, requires a long-term management commitment and is much more costly.

In some areas, removal of the alien invasive species may be all that is required to re-establish a healthy, functioning ecosystem. In other cases, management of invasive species should be done in conjunction with other strategies, such as the planting of native species. The development of management techniques is dynamic and changes as ecologists and land managers learn what does and does not work on their sites, and how they communicate their knowledge and adapt it into the next set of management plans.

With the increase in international trade, world travel, and the relatively temperate climate in southern British Columbia, new alien species will continue to enter Garry Oak ecosystems. By creating a pest alert system, many of these species may be managed before they become established. Through the sharing of knowledge among a variety of groups and individuals involved in Garry Oak ecosystem restoration, more and more sites are being restored despite the presence of well-established alien invasive species.

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Appendix 9.1

Invasive Alien Species Listed by Restoration Ecosystem Unit

Restoration Ecosystem Unit Number and Name	**Invasive Alien Species** (from Erickson and Meidinger 2007 and Parks Canada Agency 2006a, 2006b)
Restoration Ecosystem Unit #1: Deep Soil, Average Moisture Garry Oak Communities	Shrubs Common Hawthorn (*Crataegus monogyna*) English Ivy (*Hedera helix*) Himalayan Blackberry (*Rubus armeniacus*) Scotch Broom (*Cytisus scoparius*) Spurge-laurel (*Daphne laureola*) Tree Lupine (*Lupinus arboreus*) Forbs Bur Chervil (*Anthriscus caucalis*) Carpet Burweed (*Soliva sessilis*) Common Chickweed (*Stellaria media*) Common Vetch (*Vicia sativa*) Grass Peavine (*Lathyrus sphaericus*) Hairy Cat's-ear (*Hypochaeris radicata*) Little Hop-clover (*Trifolium dubium*) Ribwort Plantain (*Plantago lanceolata*) Sheep Sorrel (*Rumex acetosella*) Tiny Vetch (*Vicia hirsuta*) Graminoids Barren Brome (*Bromus sterilis*) Barren Fescue (*Vulpia bromoides*) Hedgehog Dogtail (*Cynosurus echinatus*) Kentucky Bluegrass (*Poa pratensis*) Orchard-grass (*Dactylis glomerata*) Rip-gut Brome (*Bromus rigidus*) Silver Hairgrass (*Aira caryophyllea*) Soft Brome (*Bromus hordeaceus**) Sweet Vernalgrass (*Anthoxanthum odoratum*)
Restoration Ecosystem Unit #2: Deep Soil, Wetter Garry Oak Communities	Shrubs Common Hawthorn (*Crataegus monogyna*) English Ivy (*Hedera helix*) Himalayan Blackberry (*Rubus armeniacus*) Scotch Broom (*Cytisus scoparius*) Spurge-laurel (*Daphne laureola*) Forbs Carpet Burweed (*Soliva sessilis*) Common Chickweed (*Stellaria media*) Common Vetch (*Vicia sativa*) Graminoids Kentucky bluegrass (*Poa pratensis*) Orchard-grass (*Dactylis glomerata*)

Restoration Ecosystem Unit #3: Shallow Soil Garry Oak Communities	Shrubs Scotch Broom (*Cytisus scoparius*) Forbs Bur Chervil (*Anthriscus caucalis*) Carpet Burweed (*Soliva sessilis*) Common Chickweed (*Stellaria media*) Common Vetch (*Vicia sativa*) Dovefoot Geranium (*Geranium molle*) Hawksbeard (*Crepis* spp.) Sheep Sorrel (*Rumex acetosella*) Tiny Vetch (*Vicia hirsuta*) Graminoids Barren Brome (*Bromus sterilis*) Barren Fescue (*Vulpia bromoides*) Cheatgrass (*Bromus tectorum*) Early Hairgrass (*Aira praecox*) Hedgehog Dogtail (*Cynosurus echinatus*) Kentucky Bluegrass (*Poa pratensis*) Orchard-grass (*Dactylis glomerata*) Soft brome (*Bromus hordeaceus*) Sweet Vernalgrass (*Anthoxanthum odoratum*)
Restoration Ecosystem Unit #4: Shallow Soil Seepage Communities	Shrubs Scotch Broom (*Cytisus scoparius*) Forbs Carpet Burweed (*Soliva sessilis*) Small-flowered Catchfly (*Silene gallica*) Small-fruited Parsley-piert (*Aphanes australis*) Wall Speedwell (*Veronica arvensis*) Graminoids Early Hairgrass (*Aira praecox*) Hedgehog Dogtail (*Cynosurus echinatus*). Soft Brome (*Bromus hordeaceus*)
Restoration Ecosystem Unit #5: Maritime Meadow Communities	Shrubs Scotch Broom (*Cytisus scoparius*) Spurge-laurel (*Daphne laureola*) Forbs Carpet Burweed (*Soliva sessilis*) Common Chickweed (*Stellaria media*) Common Vetch (*Vicia sativa*) Carpet Burweed (*Soliva sessilis*) Hairy Cat's-ear (*Hypochaeris radicata*) Little Hop-clover (*Trifolium dubium*) Ribwort (*Plantago lanceolata*) Sheep Sorrel (*Rumex acetosella*) Tiny Vetch (*Vicia hirsuta*) Graminoids Barren Fescue (*Vulpia bromoides*)

	Common Velvet-grass (*Holcus lanatus*) Early Hairgrass (*Aira praecox*) Hedgehog Dogtail (*Cynosurus echinatus*) Kentucky Bluegrass (*Poa pratensis*) Orchard-grass (*Dactylis glomerata*) Rip-gut Brome (*Bromus rigidus*) Silver Hairgrass (*Aira caryophyllea*) Soft Brome (*Bromus hordeaceus*) Sweet Vernalgrass (*Anthoxanthum odoratum*)
Restoration Ecosystem Unit #6: Vernal Pool Communities	Forbs Carpet Burweed (*Soliva sessilis*) Creeping Buttercup (*Ranunculus repens*) English Daisy (*Bellis perennis*) Hairy Cat's-ear (*Hypochaeris radicata*) Hairy Hawk-bit (*Leontodon saxatilis*) Little Chickweed (*Cerastium glomeratum*) Ribwort (*Plantago lanceolata*) Small-flowered Catchfly (*Silene gallica*) Graminoids Barren Fescue (*Vulpia bromoides*) Creeping Bentgrass (*Agrostis stolonifera*) Early Hairgrass (*Aira praecox*) Hedgehog Dogtail (*Cynosurus echinatus*) Common Velvet-grass (*Holcus lanatus*) Kentucky Bluegrass (*Poa pratensis*) Perennial Ryegrass (*Lolium perenne*) Soft Brome (*Bromus hordeaceus*)
Restoration Ecosystem Unit # 7: Coastal Bluff Communities	Shrubs Chinese Elm (*Ulmus parvifolia*) English Hawthorn* (*Crataegus monogyna*) English Ivy* (*Hedera helix*) Gorse* (*Ulex europaeus*) Himalayan Blackberry (*Rubus armeniacus*) Morning Glory* (*Convolvulus sepium*) Spurge-laurel* (*Daphne laureola*) Tree Lupine* (*Lupinus arboreus*) Forbs Broad-leaved Peavine* (*Lathyrus latifolius*) Bull Thistle* (*Cirsium vulgare*) Carpet Burweed (*Soliva sessilis*) Ribwort Plantain* (*Plantago lanceolata*) Wall Lettuce* (*Lactuca muralis*) Graminoids Brome species*(*Bromus* spp.) Hedgehog Dogtail* (*Cynosurus echinata*) Orchard-grass* (*Dactylis glomerata*) Sweet Vernalgrass* (*Anthoxanthum odoratum*) Tickle-grass* (*Agrostis* spp.)

Restoration Ecosystem Unit #8: Douglas-fir Communities	Shrubs Spurge-laurel (*Daphne laureola*) English Holly (*Ilex aquifolium*) English Ivy (*Hedera helix*) Forbs Carpet Burweed (*Soliva sessilis*) For early successional stages, many of the species listed for Restoration Ecosystem Units #1, #2, and #6 will occur

Plants with the * included in Ecosystem Unit 7: Coastal Bluff Communities, were listed in the draft *Dallas Bluffs Conservation Plan* commissioned by the City of Victoria as requiring priority management. City of Victoria, Draft Dallas Bluffs Conservation Management Plan (unpublished draft; has not been formally adopted). May 2011. Kerrwood Leidal Associates Ltd. Appendix E. Invasive Species Management Prescriptions.

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Appendix 9.2

Regulatory Responsibilities of Agencies with Respect to Alien Species

FEDERAL AGENCIES

Agriculture and Agri-Food Canada (AAFC) addresses issues of national interest related to agriculture. AAFC maintains the Canadian National Collections containing the most comprehensive collections of plants, fungi, arthropods, and nematodes in Canada and **implements research programs to develop management strategies (including biological control) for invasive alien species significant to agriculture.**

Environment Canada (EC) coordinates the development of **the Invasive Alien Species Strategy for Canada under the Canadian Biodiversity Strategy**. EC conducts and supports research, monitoring, and management activities for invasive alien plants that pose a risk to Canada's species at risk, migratory birds, wetland habitats and National Wildlife Areas and Migratory Bird Sanctuaries. EC contributes to the development of legislation, policies, and programs to protect biodiversity from invasive alien plants and other pests.

Natural Resources Canada's Canadian Forest Service (NRCan-CFS) promotes the sustainable development of Canada's forests and competitiveness of the Canadian forest sector. Through a Memorandum of Understanding, **NRCan-CFS provides scientific interpretation, advice, and research support pertaining to pest impacts, life histories, control, taxonomy, diagnostics and control methodologies for invasive alien species to the CFIA**. NRCan-CFS has performed research on established invasive alien species such as Dutch Elm disease, White Pine blister rust, Gypsy Moth, beech bark disease, balsam Woolly Adelgid, and many others.

Parks Canada Agency (PCA) is the largest federal land management agency in Canada, representing about 2% of Canada's total land mass. Within national parks, efforts are directed at **maintaining intact ecosystems of native species**. Individual park management plans provide guidelines for the management of all non-native species on federal lands in national parks and historic sites following a strategy of prevention and control.

The **Canada Border Service Agency (CBSA)** facilitates legitimate cross-border traffic while preventing the movement of people and goods that pose a risk to Canada. **CBSA carries out border control/interception programs for invasive alien species based on instructions from other government departments**, often providing ground-level implementation of regulations regarding invasive alien species such as those developed by the Canadian Food Inspection Agency.

PROVINCIAL CONTEXT

Most provinces and territories have some legislative capacity to address issues pertaining to invasive alien species, but gaps exist in one or more areas for most jurisdictions and the capacity for enforcement is often limited. Relevant ministries in most provincial/territorial jurisdictions include agriculture, forestry, and natural resources.

LOCAL GOVERNMENTS – REGIONAL DISTRICTS AND MUNICIPALITIES

Local governments are empowered under provincial legislation to enact bylaws pertinent to matters of local importance. Most municipalities are responsible for the enforcement of provincial weed and pest legislation, and many have enacted bylaws pertaining to noxious weeds, specifically requiring property owners to ensure that certain species are not growing on their property. Local governments are also significant land managers within their jurisdiction, with responsibilities for local parks, roadsides, and other publicly owned properties.

FIRST NATIONS

First Nations enact bylaws either under the authority of the *Indian Act* or develop their own legal regimes under a self-governing agreement. First Nations own and manage a significant amount of land in Canada, with reserves covering over 3 million ha in 2002/03.The *Indian Act* allows Band Councils to develop bylaws controlling noxious weeds. First Nations operating under the *First Nations Land Management Act* or under self-government agreements develop their own land management and environmental regimes in accordance to their needs. Provincial legislation rarely applies on First Nations lands. Traditional ecological knowledge should not be overlooked in its capacity to help with ecosystem restoration.

VOLUNTARY SECTOR

The role of non-governmental environmental organizations such as World Wildlife Fund, Sierra Club, and Ducks Unlimited, as well as local naturalists and interested community groups, in addressing issues related to invasive alien species can be valuable in invasive alien species detection and removal.

BRITISH COLUMBIA

The *Invasive Alien Species Framework* is a background document on invasive alien species issues that affect biodiversity in British Columbia[1]. The Biodiversity Branch of the BC Ministry of Water, Land and Air Protection (BC Ministry of the Environment) emphasized the following five areas of participation (February 2005):

- The development of an Invasive Plant Strategy for British Columbia, led by the Fraser Basin Council, which included the formation of the BC Invasive Plant Council
- Participation on an Inter-ministry Invasive Plant Committee to coordinate invasive plant initiatives across the province
- Development of a Federal/Provincial/Territorial Invasive Species Strategy which includes action plans for managing 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 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

1 This strategy lists four B.C. ecosystems considered to be particularly vulnerable to alien species invasions: Southern Interior Valleys Grassland Ecosystems; Pacific Coastal Islands; Eastern Vancouver Island Garry Oak Meadow Ecosystems; and Freshwater Ecosystems: River and Lake Systems, Wetland Habitats and Coastal Estuaries.