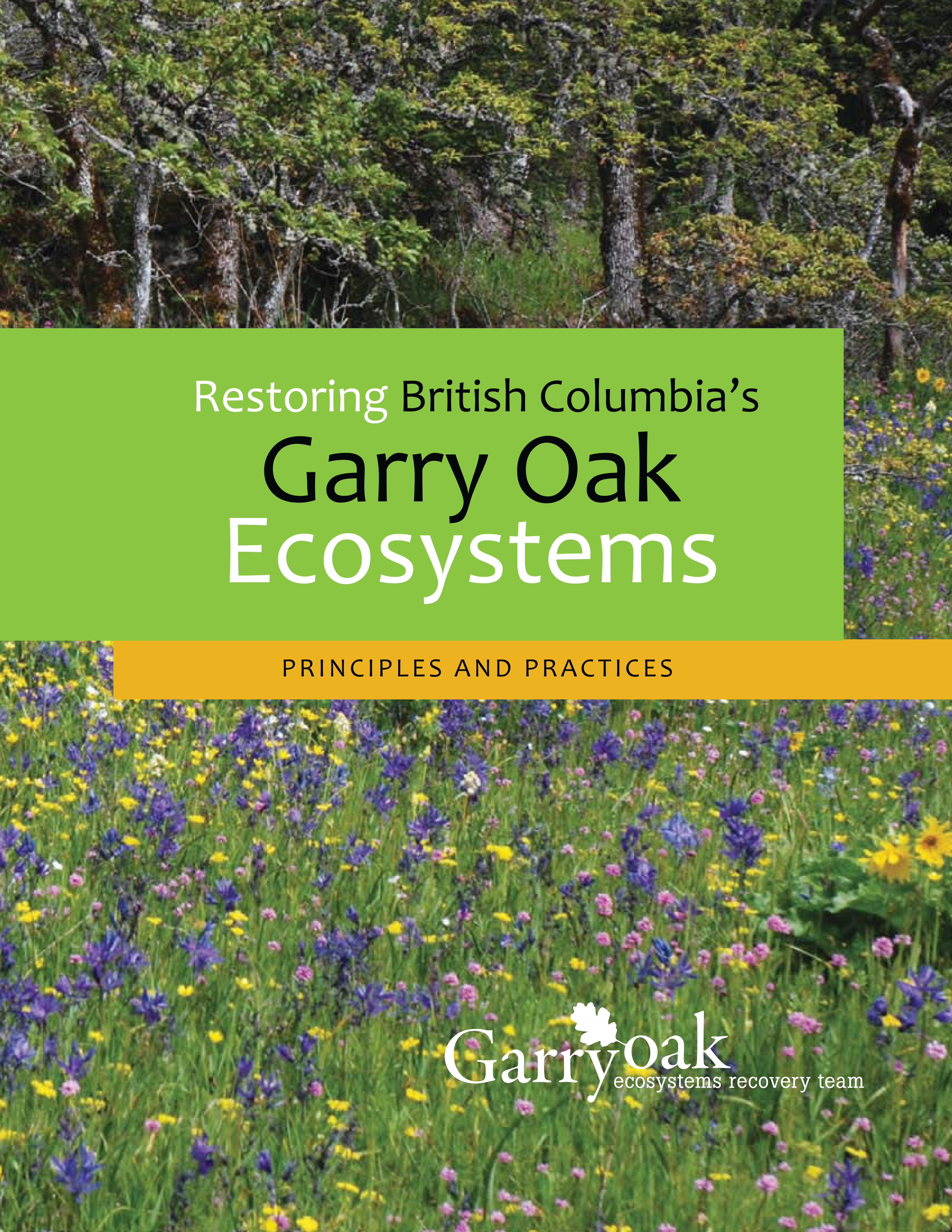
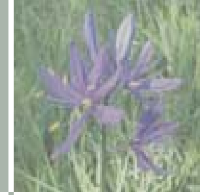


Restoring British Columbia's Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Garry oak ecosystems recovery team

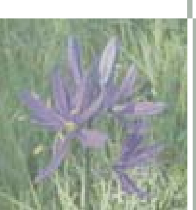


Restoring British Columbia's Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

A Lifeline for Our Rarest Species

Garry oak ecosystems recovery team



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Project Team

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We appreciate the suggestions and ideas that came from those who participated in the development workshop for this publication in November 2009. Thank you!

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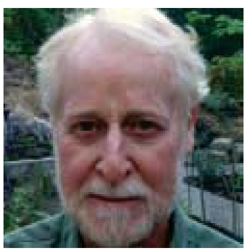

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Don is a (mostly retired) wildlife biologist with more than 35 years experience in wildlife research and conservation. He graduated with a Master's degree in Natural History from the University of Aberdeen in 1964, and received a doctorate in Plant Science from the University of British Columbia in 1977. For most of his career (1965-1997), Don worked at the BC Ministry of Environment as a wildlife research biologist, studying the ecology and conservation of a wide range of vertebrates across B.C., with particular reference to impacts of land use activities. Also during this period he represented B.C. on the national committee that developed the Canadian Biodiversity Strategy. After retiring from the provincial government, he worked for five years as the Faculty Coordinator of the Restoration of Natural Systems Program at the University of Victoria. Don is an Adjunct Associate Professor at the university and has taught courses on wildlife conservation and ecological restoration; he continues his university involvement through graduate students. Since his second retirement, he has remained engaged in a variety of conservation and ecological restoration activities, especially in those dealing with species and ecosystems at risk.

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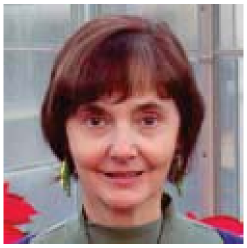

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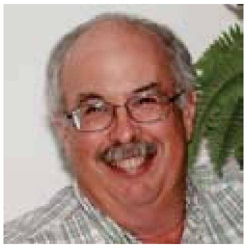
Carolyn MacDonald

Carolyn is an Environmental Education Officer with the District of Saanich. Her work with Saanich includes leading public invasive species programs, ecological restoration projects and other education and outreach programs. She chaired and coordinated the Garry Oak Restoration Project (GORP), www.saanich.ca/gorp, for almost ten years and has served on the GOERT Restoration and Management RIG since 2007. Carolyn is on the Board of GOERT and the Invasive Plant Council of BC. She enjoys writing and has worked on a number of manuals, including co-authoring and leading the partnership project for *Garry Oak Ecosystems of BC: An Educator's Guide* (2006). Carolyn's background is in education, environmental education, and ecological restoration.



Dave Polster, M.Sc., R.P. Bio.

Dave is a plant ecologist with over 30 years of experience in vegetation studies, reclamation and invasive species management. He has developed a wide variety of reclamation techniques for mines, industrial developments and steep/unstable slopes, as well as techniques for the re-establishment of riparian and aquatic habitats. Dave has provided on-site design and direction in the development of reclamation and bioengineering systems for restoration of severely damaged ecosystems. He pioneered the concept of successional reclamation where the aim of the reclamation program is the re-integration of the disturbed site into the natural processes of vegetation succession. He has applied his knowledge of ecology to solving problems of unwanted and invasive vegetation. He has authored numerous papers and teaches graduate level courses on these topics.

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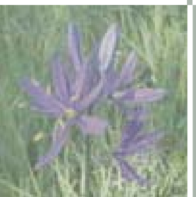
Shyanne has more than 9 years' experience working on species and ecosystems at risk recovery and conservation in Canada. She has worked closely with a variety of stakeholder groups as a team or project lead, and has authored or co-authored several species at risk recovery planning documents. An ecologist with a background in biogeography, species at risk inventory, recovery planning and field botany, Shyanne completed her M.Sc. on historical stand dynamics in Garry Oak ecosystems in 2007. Shyanne was the RIG Coordinator with GOERT for three years before taking on the roles of Program Manager and recovery team co-chair in December 2008. She currently oversees the Garry Oak ecosystems recovery program (see www.goert.ca) supported by six core staff. Key project areas include species at risk landholder contact, recovery planning, local government and First Nations outreach, recovery project implementation and support, and public communications.

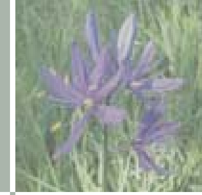
Kersti Vaino, B.Sc.-E.S.

Kersti specializes in terrestrial biology and has experience in species at risk biology, vegetation and habitat ecology, and invasive species management. In 2001, she completed a degree in environmental science at Royal Roads University. She spent the following years working in a number of positions in the environmental field where she gained a range of experience in field biology, including inventory of species at risk, assessing habitat use by grizzly bears, and studying the effects of salmon farming on sea lice infestations in wild salmon populations. Kersti spent two years working with GOERT where she helped coordinate the recovery of plant species at risk in these sensitive ecosystems. Her work involved mapping of species at risk occurrences and their habitat, coordinating restoration projects, preparing documents for recovery planning, and preparing resources for restoration practitioners and land managers. Kersti also has an interest in GIS and has developed geodatabases to track the occurrence of species and ecosystems at risk. In 2010, she relocated to Squamish, B.C. where she works with Cascade Environmental Resource Group.

Conan Webb, B.Sc.

Conan has been working on the conservation of rare species and ecosystems since 2002. His work has been focused primarily on Garry Oak ecosystems and rare plants found therein; however, he has also worked with other species in various capacities. Conan has spent the last few years working for the Species at Risk program at Parks Canada focusing on Garry Oak restoration at Fort Rodd Hill National Historic Site and Gulf Islands National Park Reserve, including species at risk and invasive species research and management. He is a member of GOERT and chairs the Restoration and Management RIG. His current position with Parks Canada is focused on recovery planning for species at risk in Garry Oak ecosystems.

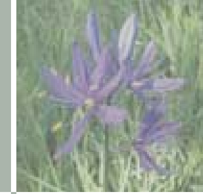


Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES



Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 1 Introduction

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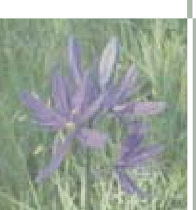

Chapter 1

Introduction

by Don Eastman, in collaboration with Brenda Costanzo, Richard Hebda, Ted Lea, Carolyn MacDonald, Mike Meagher, Brian Nyberg, Hans Roemer, and Kersti Vaino

Restored Garry Oak ecosystem at Mt. Tzuhalem Ecological Reserve, Duncan, B.C. Photo: Dawn Fizzard

1.1 The Need To Restore Garry Oak Ecosystems

Over recent decades, individuals, organizations, and governments around the world have recognized the decline in our natural heritage, what these days we call "biological diversity" or "biodiversity" (Wilson 1992). The concern is not only that we are losing the diversity of life, which has value in its own right, but also that we are losing the many services biodiversity provides us (Millennium Ecosystem Assessment 2005). The status of British Columbia's biodiversity was summarized comprehensively in a recent report, *Taking Nature's Pulse* (Austin et al. 2008). Among many topics, the report assessed the conservation status of provincial ecosystems, and determined that the Coastal Douglas-fir biogeoclimatic zone, which includes Garry Oak and associated ecosystems, was one of the most imperilled. The impacts of urban and agricultural development on this zone were particularly noted.

Garry Oak ecosystems are among the rarest ecosystems in Canada, and the area that they occupy continues to decline (Fuchs 2001). Their precarious situation was convincingly demonstrated by Lea (2006), who showed that the range of Garry Oak ecosystems has shrunk by more than 95% since the time of European contact. Losing these ecosystems has had an adverse impact on many animal and plant species—more than 100 species associated with Garry Oak ecosystems are considered at risk provincially, and 55 of these species are federally listed under the *Species at Risk Act* (SARA) (GOERT 2009).

Garry Oak ecosystems are defined as those ecosystems with naturally occurring Garry Oak (*Quercus garryana*) trees, plus a complex of the following closely related ecosystems: coastal bluff, maritime meadow, vernal pool, grassland, and rock outcrop.

For the purposes of this guide, Garry Oak ecosystems are defined as those ecosystems with naturally occurring Garry Oak (*Quercus garryana*) trees, plus a complex of the following closely related ecosystems: coastal bluff, maritime meadow, vernal pool, grassland, and rock outcrop. These latter habitats may not necessarily contain Garry Oak trees, however, they have the assemblages of plants and animals normally associated with Garry Oak ecosystems. Also included are transitional forest ecosystems containing Douglas-fir (*Pseudotsuga menziesii*), Arbutus (*Arbutus menziesii*), and Garry Oak trees. All of these habitats contain some semblance of the ecological processes and communities that prevailed before European settlement.

The endangered status of Garry Oak ecosystems in Canada results from three main causes:

Habitat loss due to conversion of land for urban, industrial, and agricultural purposes. These losses are largely irreversible.

Habitat fragmentation, whereby once-connected habitat patches have become isolated and reduced in size. This partitioning has negative impacts on species persistence and ecosystem integrity. Fragmentation of habitats prevents dispersal and genetic interchange among populations of plants and animals, and reduces the size of habitat patches so much that they can no longer support the full complement of Garry Oak ecosystem species.

Habitat degradation results mostly from the spread of invasive species and the loss of natural disturbance regimes, such as fire. Consequently, even the small remnants of Garry Oak ecosystems are compromised and continue to be degraded by a variety of human activities.

The dire status of Garry Oak ecosystems in Canada is now widely recognized by all levels of government, by not-for-profit environmental organizations, and by the general public. In response to the endangered status of these ecosystems, the Garry Oak Ecosystems Recovery Team (GOERT) was established. GOERT coordinates efforts to protect and restore endangered Garry Oak and associated ecosystems and the species at risk that inhabit them. GOERT is a collaborative partnership of all levels of government, non-governmental organizations, academic institutions, First Nations, volunteers, and consultants. It is the primary organization leading and coordinating efforts to protect and recover Garry Oak and associated ecosystems in Canada.

Since its founding in 1999, GOERT has spearheaded development of a recovery strategy for

Garry Oak ecosystems (www.goert.ca/documents/RSDr_Feb02.pdf). The strategy has two major components: protection and recovery (Fuchs 2001). The need for protection has been emphasized by educating the public and by providing sound scientific data. More and more lands have been safeguarded, either through outright purchase or through other mechanisms such as conservation covenants. The second focus, restoration, involves undertaking activities that enable damaged sites and threatened species to recover, or at least to move along pathways to recovery.

Restoring British Columbia's Garry Oak Ecosystems: Principles and Practices addresses the second focus of the strategy. Its purpose is to provide the best available information about approaches, strategies, and methods for restoration. To achieve this purpose, this guide summarizes the principles and concepts of restoration, reviews the ecology of Garry Oak and associated ecosystems, and provides a wealth of practical information on restoration techniques.

Ecological restoration is the process of assisting the recovery of ecosystems that are damaged, degraded, or destroyed (Society for Ecological Restoration International, 2004). Considerable efforts, both by government and non-government organizations, often acting in concert, have gone into restoring Garry Oak ecosystems. Restoration efforts have ranged from private individuals converting their backyards into Garry Oak habitat, to community-based removal of invasive species, such as Scotch Broom *(Cytisus scoparius)*, from parklands, to studies of ecological processes and practical techniques. Some lessons learned from these activities have been recorded, but not always in readily accessible sources; other lessons have not been written down but reside in the minds of seasoned practitioners.

This guide is meant to be a comprehensive, straightforward, and reliable source of knowledge that will assist the reader in the practice of ecological restoration of Garry Oak ecosystems.

Thus, the knowledge of how to restore Garry Oak ecosystems is widely scattered and not readily accessible. This guide is meant to be a comprehensive, straightforward, and reliable source of knowledge that will assist the reader in the practice of ecological restoration of Garry Oak ecosystems. It is not intended to be a scientific treatise, although sound science is fundamental to good ecological restoration. Instead, it is a technically-oriented user's guide on how best to approach restoration. It is intended to provide a synthesis of current knowledge and practice that will contribute to successful restoration of these endangered ecosystems.

1.2 Organization of This Guide

Restoring British Columbia's Garry Oak Ecosystems: Principles and Practices consists of eleven chapters grouped into five parts.

Part I introduces the publication and presents key principles used to guide restoration (Chapter 1).

Part II provides the background understanding of Garry Oak ecosystems that is needed to undertake restoration. Chapter 2 sketches the geographic scope of Garry Oak ecosystems in Canada and describes the ecological units that make up Garry Oak ecosystems. The next two chapters provide important ecological perspectives: the natural disturbance processes that historically shaped these ecosystems (Chapter 3) and the endangered species and ecosystems that are associated with Garry Oaks (Chapter 4).

Part III focuses on how to undertake a restoration project. Chapter 5 addresses project initiation and planning by specifically explaining the organizational structure of a restoration project. Then, Chapter 6 addresses the importance of outreach and how to engage the public. The final chapter in this part, Chapter 7, provides principles and practices for inventory and monitoring, and key elements of an adaptive management approach to restoration.

Part IV explores ways of implementing restoration projects. Chapter 8 outlines various strategies and approaches that can be used in restoration. The thorny issue of dealing with invasive species forms the content of Chapter 9. The propagation and supply of native species for use in restoration is the subject of Chapter 10.

Part V summarizes key points made throughout the publication in the concluding Chapter 11.

1.3 Strategic Working Principles

The authors adopted six principles to guide the scope and content of the publication, and the team encourages all practitioners to consider following them in their restoration projects. The six principles are:

1. Put protection before restoration
2. Adopt an eco-cultural approach
3. Apply the best available knowledge
4. Apply adaptive management
5. Set clear objectives
6. Document all phases of all restoration projects

Restoration, no matter how well executed, will never re-create what has been damaged, degraded, or destroyed.

Protection is the first priority in the conservation of Garry Oak and associated ecosystems. Whenever possible, current Garry Oak and associated ecosystems must be protected, whether by outright purchase, by conservation covenant, or by some similar means that ensures their long-term security. The reason for highlighting this principle is that restoration, no matter how well executed, will never re-create what has been damaged, degraded, or destroyed. The focus on protection serves to emphasize that restoration is not an acceptable excuse for the loss of these ecosystems in the past and certainly not in the future.

The second principle encourages restoration practitioners to adopt a definition of ecological restoration that includes both human culture and the conventional biophysical elements or dimensions. Good ecological restoration requires the application of the best available ecological knowledge in a human context, where humans are considered to be part of ecosystems and are meaningfully involved in all stages of the restoration process from planning to after-care. Experience demonstrates repeatedly that unless as many people as possible are consulted and involved at the start of the process, restoration projects are likely to fail. Given the tremendous amount of effort that usually goes into restoration projects, it is critical to involve people in order to ensure long-term success (Sauer 1998).

The third principle emphasizes the importance of using the best available knowledge. In this publication, knowledge includes understanding gained from scientific research, as well as traditional and local ecological knowledge and practice. As part of this approach, we recognize that our understanding of ecological restoration techniques and methods continually improves; users of this guide should view its content as a starting point. This publication is intended as a living document and will be updated periodically. Please check the GOERT website for updates (www.goert.ca/restoration).

The fourth principle—the application of adaptive management—could be described as "learning by doing". However, "learning by doing" oversimplifies the real meaning of the concept and overlooks the important features and benefits that make up adaptive management (Holling 1978; Walters 1986). The concept of adaptive management arose from the realization that land management activities, including ecological restoration, are often experimental because their outcomes cannot be predicted with certainty; their results will be known only after ecosystems have responded to treatments. This uncertainty is a common feature of Garry Oak restoration projects. For example, mowing and mulching are being used to replace fire as a disturbance agent in projects like the ongoing restoration at the Somenos Garry Oak Protected Area near Duncan, B.C. The long-term outcome of these techniques in terms of how well they replicate burning has yet to be seen.

> The vital role of monitoring in restoration projects cannot be over-emphasized; all Garry Oak restoration initiatives must include a well-designed monitoring component.

To learn as much as possible from management experiments, adaptive management practitioners use a systematic process to plan, conduct, and learn from their activities. Nyberg (1998) summarized adaptive management as a series of steps:

i. problem assessment
ii. project design
iii. implementation
iv. monitoring
v. evaluation
vi. adjustment of future decisions

By identifying knowledge gaps and uncertainties during problem assessment, then deliberately designing the management treatment or program to address these gaps, practitioners can achieve both on-the-ground results and—just as importantly—gain new knowledge about how and why the ecosystem responded the way it did. Note that careful monitoring of field results is a critical step in the adaptive management process because it ensures that reliable information is gathered to address the knowledge gaps and uncertainties identified at the outset. The vital role of monitoring cannot be overstated, and all Garry Oak restoration initiatives must include a well-designed monitoring component.

The fifth principle of setting clear objectives is closely related to adaptive management and is central to successful restoration (Hebda 2010). Project objectives drive the actions of a project, set criteria for evaluating success, and directly shape budgets. A project with unclear objectives may generate confusion among the participants, can lead to selecting incorrect methods, and may lead to conflicts when making decisions. It is hard to communicate to the public and to project supporters if the project's desired outcomes and targets are not clear. The importance of establishing clear, shared objectives cannot be overstated, for it can determine the success or failure of a restoration project. Furthermore, adaptive management decisions cannot be made without clear objectives for the management actions taken.

The sixth principle of documenting project activities may seem obvious. Yet for so many projects there are only brief or scattered records of what was attempted and what actually happened. Restoration is a recent field of activity, and the literature is only beginning to accumulate. Thus, even the most basic observations are critical to advancing our understanding, and it is especially important to document failures so that unsuccessful approaches are not repeated. All new knowledge needs to be compiled and passed on to future restoration projects and practitioners.

1.4 Experience Beyond the Canadian Region

Restoration work does not exist in a vacuum, and there is much useful information available in other regions, including those with Garry Oaks and other oak species. There is considerable interest in oak ecosystems in the various Mediterranean climatic zones around the world, as demonstrated by the recent publication *Cork Oak Woodlands on the Edge: Ecology, Adaptive Management, and Restoration* (Aronson et al. 2009). In this publication, the editors state that "cork oak woodlands can be viewed as a system on the edge of radical change and at clear risk of collapse" (p. 5), a statement that sounds all too familiar to those working on Garry Oak ecosystems.

While there is much we can learn from work in these other ecosystems, it is important to realize that there are unique aspects to be considered closer to home within the context of southern British Columbia. Considerable work has been completed and continues to be done in similar oak-meadow-dominated ecosystems in Washington and Oregon (e.g., Vesely et al. 2004). Much can be gained by continued (and enhanced) communication and collaboration with Garry Oak restoration efforts in these neighbouring states. An excellent example of this collaboration is the "Cascadia Prairie-Oaks Partnership" that was highlighted at a recent conference (March 24–27, 2010) in Washington state, and which spans both Canada and the United States. The *Prairie Landowner Guide for Western Washington* (The Nature Conservancy 2011) has recently become available at www.southsoundprairies.org, and *Restoring the Pacific Northwest*: *The Art and Science of Ecological Restoration in Cascadia* (Apostol and Sinclair 2006) provides another good example of integration of restoration work across the region, and includes a chapter on oak woodlands and savannahs.

1.5 Restoration for All Concerned

There is a clear need to restore Garry Oak ecosystems because many serious issues threaten their existence. In addition to providing ecological and biological benefits, restoration activities and projects provide participating individuals, communities, and organizations with opportunities to gain a remarkable sense of accomplishment and to reconnect in a meaningful way with the natural world around us. Even though restoration seems to be a never-ending process, it creates a long-term connection between participants and their natural surroundings. It is our hope that this guide will be a valuable aid both to restoring Garry Oak ecosystems and to building human and natural communities in our special places. We encourage you to apply what we offer here to your restoration efforts, and to add your knowledge and experience to the growing body of knowledge on successful restoration. We wish you well in all you do for restoration!

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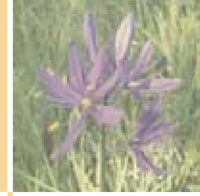

Restoring British Columbia’s
Garry Oak Ecosystems
PRINCIPLES AND PRACTICES

Chapter 2
Distribution and Description

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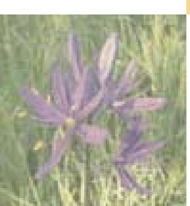

Chapter 2

Garry Oak and Associated Ecosystems: Distribution and Description

by Ted Lea

Figure 2.1 Looking west toward Fort Victoria in the late 1840s. Plants shown include camas (*Camassia* spp.), Woolly Sunflower (*Eriophyllum lanatum*), Barestem Desert-parsley (*Lomatium nudicaule*), and Spring Gold (*Lomatium utriculatum*). Painting by Michael Kluckner (Kluckner 1986; used with permission).

2.1 Introduction

When Europeans first arrived in Victoria in the early 1840s they found a landscape and vegetation that was quite different than it is today (Figure 2.1). James Douglas noted that more than two-thirds of the land between the Inner Harbour and Gonzales Point was "Prairie Land" (Kluckner 1986). For centuries, First Nations people had set fires throughout the range of Garry Oak (*Quercus garryana*) ecosystems to burn off trees and shrubs and promote the growth of edible root crops, such as camas (*Camassia* spp.) and Bracken Fern (*Pteridium aquilinum*), and to create openings for hunting ungulates, such as deer and Roosevelt Elk (*Cervus canadensis roosevelti*) (Turner 1999). This created the areas of prairie land noted by

Douglas. The oldest detailed map of the Victoria region was drawn in 1842 by Adolphus Lee Lewis, who accompanied James Douglas (Figure 2.2). It shows the extent of cleared areas, forests, Garry Oak trees, and riparian areas. European settlers eventually halted the burning by the Aboriginal people. Shrub-sized Garry Oaks, then larger oak trees, rapidly became established (B. Beckwith, pers. comm. 2010). Photographs and maps made 20 to 40 years after Lewis's map showed a far more extensive distribution of Garry Oak trees. Further succession resulted in Douglas-fir-dominated communities on many sites (see Chapter 3).

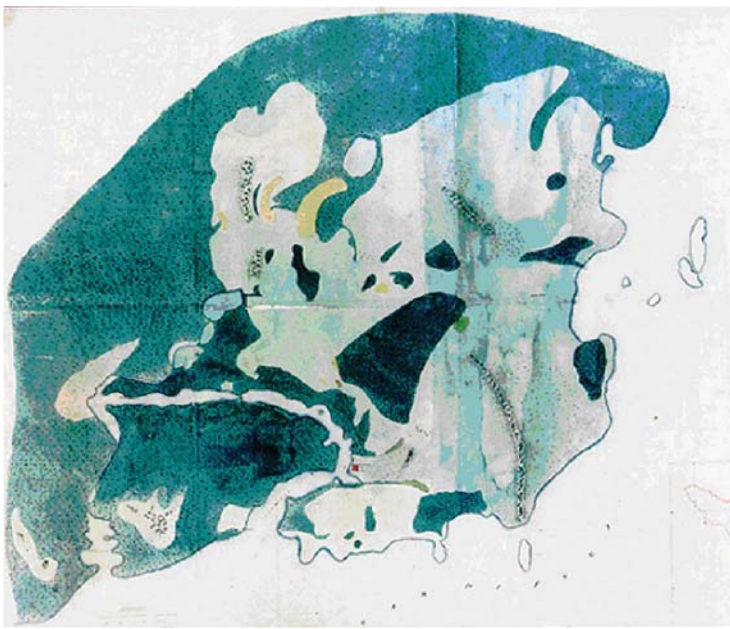

Figure 2.2 Ground plan of the portion of Vancouver Island selected for new establishment by James Douglas Esqr. 1842. Hudson's Bay Company Archives, Archives of Manitoba; used with permission.

LEGEND

- dark areas: woods and forests
- lighter areas: 'plains' or open parkland
- dots within light areas: Garry Oak trees
- enclosed darkest areas: riparian areas such as Bowker Creek

This chapter describes where Garry Oak and associated ecosystems currently exist, where they occurred in the past and where they could exist based on current climatic conditions. Chapter 3 (Natural Processes and Disturbance) describes where these ecosystems could occur in the future with global climate change.

This chapter also provides a general introduction to the classification of plant communities within Garry Oak and associated ecosystems, and it presents a classification system of **Restoration Ecosystem Units** that is used throughout this guide to help restoration practitioners determine what plant communities can be returned to which sites (see Section 2.5.7).

2.1.1 The Setting

The Garry Oak landscape lies within a rain shadow zone in the lee of the Olympic and Vancouver Island Mountains, and has a mild, winter-wet, summer-dry modified Mediterranean climate. This area is comprised of inner coast and islands with elevations ranging from sea level to 550 m on ridge tops and mountains. Geologically, this region is complex. It is composed of a folded and faulted sedimentary basin, metamorphic contact zones with exotic terranes, granitic intrusions, and both glacial and colluvial surface overlays. Soils have been organically enriched with Ah horizons and are often shallowly underlain by bedrock. Persistent exposure to insolation, wind, or sea spray is common. Periodic fire is thought to have typified the natural disturbance regime, as in other oak woodlands of the Pacific Northwest. At a landscape scale, plant communities are most strongly influenced by site-level moisture regime, elevation, and amount of surface bedrock (exposed or with shallow humus). At the plant community scale, the most important distinguishing variables are site mineral soil exposure, soil coarse fragments, and geographic area, followed by topographic drainage, soil texture, depth to bedrock, percent downed wood, and elevation (Erickson and Meidinger 2007).

2.2 Current Distribution

The distribution of Garry Oak (Oregon White Oak) is restricted to the western portion of North America, mainly close to the Pacific Ocean. In British Columbia, Garry Oak and associated ecosystems occur primarily on southeastern Vancouver Island, the adjacent Gulf Islands, and a couple of locations on the mainland, namely Sumas Mountain and Yale (Figure 2.3). The locations on the mainland are related to the distribution of Garry Oak in Washington State, which approaches the British Columbia border. The North American distribution of Garry Oak extends through Washington and Oregon State into northern California (Figure 2.4). Unlike in British Columbia, a fair amount of Garry Oak occurs in the interior portions of these states.

The current distribution of Garry Oak ecosystems in Canada is centered mainly around Victoria, Duncan, Nanaimo, and Comox (Lea 2006; Appendix 2.1). These ecosystems also occur on most of the southern Gulf Islands, although only their distribution on Salt Spring, Denman, and Hornby Islands has been mapped. On most other surrounding Gulf Islands, Garry Oak occurs on warm, steeper, south-facing slopes or on rock outcrops. For example, significant areas of Garry Oak occur along the coastlines of Gabriola and Pender Islands.

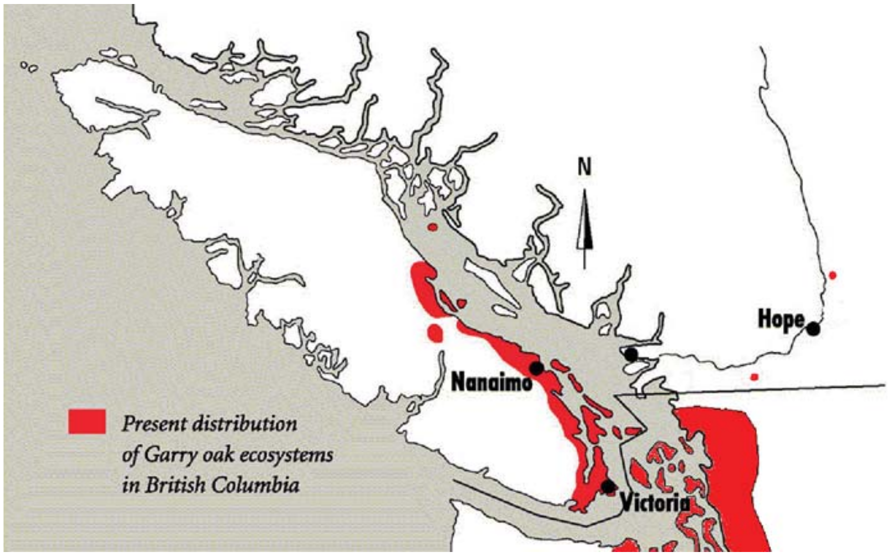

Figure 2.3 Current distribution of Garry Oak ecosystems in British Columbia. Map © Province of British Columbia

Figure 2.4 Current global distribution of Garry Oak ecosystems. Map © Province of British Columbia

2.3 Historical and Present Day Distribution

Pollen in soil cores sampled on southern Vancouver Island and the adjacent mainland suggests that the range of Garry Oak woodlands in Canada was more extensive several thousand years ago than it is today (R. Hebda, pers. comm. 2010; Brown and Hebda 2002; Pellat et al. 2001; Walker and Pellatt 2001). According to pollen analysis, Garry Oak first occurred in British Columbia around 9500 ybp[1] and was most common from about 8000 ybp to 6000 ybp. After that, the distribution of Garry Oak was similar to present day (Pellatt et al. 2001).

The distribution of Garry Oak ecosystems, including prairies, prior to European settlement and for the present day has been mapped (Lea 2006; Appendix 2.1). The maps cover most of the distribution of Garry Oak ecosystems on Vancouver Island, and include minor occurrences on many of the Gulf Islands (see Section 2.2). Significant losses of deep soil ecosystems have occurred within these areas due to agricultural and urban development, as is reflected in the present day distribution. Shallow soil ecosystems have been less impacted by development.

2.4 Current Suitability of Climate for Garry Oak Ecosystems

Figure 2. 5 shows where planting of Garry Oak could be successful based on current climatic conditions, if appropriate sites are chosen. These sites include areas with deep soils on average to

1 ybp - years before present

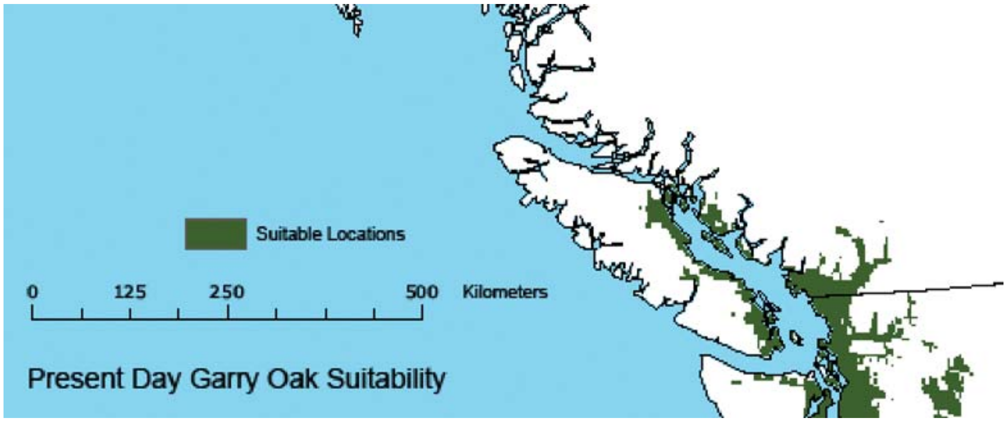

Figure 2.5 Areas that currently have suitable climate for supporting Garry Oak ecosystems. Royal BC Museum n.d.

drier sites with gentle slopes or warm aspects, and shallow soils. This indicates that Garry Oak and associated ecosystems could be established beyond their current range, in areas such as the Sunshine Coast and the lower Fraser Valley, which are believed to have supported Garry Oak in the past (R. Hebda, pers. comm. 2010).

Terrestrial Ecosystem Mapping (TEM) has been done for the entire Coastal Douglas-fir biogeoclimatic zone (Madrone 2008), which corresponds with much of the area where current climatic conditions could support Garry Oak. This mapping will allow restoration practitioners to determine where connectivity between existing Garry Oak communities could be developed so that these communities can expand as climate warming occurs. Many areas, such as the Sunshine Coast, already support many of the species that occur in Garry Oak and its associated ecosystems.

The results of this Terrestrial Ecosystem Mapping for the Coastal Douglas-fir biogeoclimatic zone (CDFmm) and the Coastal Western Hemlock portion that is surrounded by CDFmm (CWHxm) indicate that the following mapped ecosystem units have the potential to support Garry Oak and its associated species or could be maintained as associated ecosystems (Table 2.1).

The Terrestrial Ecosystem Mapping for these zones is available on the provincial government EcoCat website (www.env.gov.bc.ca/ecocat).

Garry Oak and associated ecosystems could be established beyond their current range, in areas such as the Sunshine Coast and the lower Fraser Valley, which are believed to have supported Garry Oak in the past.

Table 2.1 Ecosystem map units that could support Garry Oak and associated ecosystems (from Madrone 2008).

TEM Map Code	Site Series Number	Name
CDFmm[1]		
FC	00	Fescue – Camas
OR	00	Oceanspray – Rose
SC	00	Cladina – Wallace's Selaginella
GO	00	Garry Oak – Oceanspray
OM	00	Garry Oak – Moss
QB	00	Garry Oak – Brome/mixed grasses
DS	01	Douglas-fir – Salal (officially known as Douglas fir/Dull Oregon-grape; gentle slopes and warm aspects only, not cool aspects)
DA	02	Douglas-fir – Shore Pine – Arbutus
DO	03	Douglas-fir – Oniongrass
CWHxm[2]		
AM	00	Arbutus – Hairy Manzanita
FC	00	Fescue – Camas
QB	00	Garry Oak – Brome/mixed grasses
SC	00	Cladina – Wallace's Selaginella

1 Coastal Douglas-fir moist maritime biogeoclimatic subzone
2 Coastal Western Hemlock very dry maritime subzone

2.5 Ecosystem Classification and Uses in Restoration

This section briefly describes the plant communities that are found in Garry Oak and associated ecosystems. It is intended to provide enough information for restoration practitioners to determine which plant communities could be developed on sites that are being restored. These communities are described in detail in Erickson and Meidinger (2007), Erickson (1995), and Parks Canada Agency (2006a, b, c; 2008). The information provided in this section is particularly relevant to creating new plant communities on sites that no longer have significant cover of native flora. The more detailed descriptions provided in Erickson and Meidinger (2007) can be used when working on relatively natural sites with Garry Oak woodlands. There is no similar plant community classification for associated ecosystems, such as maritime meadows or vernal pools; therefore, it is recommended that a knowledgeable local botanist be involved in determining appropriate activities when creating or restoring fairly natural areas, especially if species at risk could be present. Refer to Chapter 4: Species and Ecosystems at Risk, for further information about special considerations at a site that may contain at-risk species.

Communities often occur in mosaics across the landscape, and site conditions can change over very short distances and time periods. Site conditions will determine what plant communities can be supported on a piece of land, so they are the first attributes that should be determined before restoration begins. The key below provides a means to determine which plant communities may be appropriate for a particular property based on site conditions.

KEY TO RESTORATION ECOSYSTEM UNITS

1a. Forests dominated by coniferous species, such as Douglas-fir. **Restoration Ecosystem Unit #8: Douglas-fir Communities.**

1b. Not forests dominated by coniferous species. Go to step 2.

2a. Steep slopes (greater than 30% slope) along the coastline dominated by small trees, shrubs, and herbs. **Restoration Ecosystem Unit # 7: Coastal Bluff Communities**.

2b. Gentle slopes or steeper slopes dominated by open stands of Garry Oak. Go to step 3.

3a. Depressional areas where water accumulates in the winter and early spring; variety of soils conditions, which prevent percolation of water. **Restoration Ecosystem #6: Vernal Pool Communities.**

3b. Generally well-drained soils, either on deep or shallow soils. Go to step 4.

4a. Low-elevation, treeless areas along the coastline; soils are often shallow, frequently 10–20 cm deep, but usually less than 50 cm of soil over bedrock; parent material may consist of till or glaciomarine clay, silt, or loam. **Restoration Unit #5: Maritime Meadow Communities.**

4b. Other conditions. Go to step 5.

5a. Areas of shallow soil over bedrock. Go to step 6.

5b. Areas with deeper soil. Go to step 8.

6a. Sites (often microsites) with significant seepage throughout the growing season. **Restoration Unit #4: Shallow Soil Seepage Communities.**

6b. Well to rapidly drained soils with limited seepage during the growing season. Go to step 7.

7. **Restoration Unit #3: Shallow Soil Garry Oak Communities.** Steps for 7a, 7b, and 7c are taken directly from Erickson and Meidinger (2007) for bedrock or other rocky, xeric landscapes, usually dominated by bryophytes or sparse, deep-rooted shrubs.

7a. Primarily uniform bedrock, usually dominated by bryophytes. Warm aspects, exposed sites on rapidly drained topography, high site mineral soil exposure, trees if present may include Douglas-fir and Arbutus at relatively high cover. **Garry Oak – *Racomitrium elongatum* – Wallace's Selaginella plant association.**

7b. Cool aspects, topographically protected sites but with high mineral soil exposure and high percent soil coarse fragments. **Garry Oak – *Dicranum scoparium* plant association.**

7c. Dry colluvial sites primarily underlain by fractured rock talus; if bedrock present, then cracked and fissured, not uniform; usually dominated by sparse, deep-rooted shrubs. **Garry Oak – Hairy Honeysuckle plant association.**

8a. Deep soil; average moisture conditions; gentle to steep slope. Go to step 9.

8b. Deep soil; wetter than average moisture conditions; receiving moisture from upslope. Often subhygric sites. Go to step 11.

9. **Restoration Unit #1: Deep Soil, Average Moisture Garry Oak Communities.** Steps 9a, 10a, and 10b are taken directly from Erickson and Meidinger (2007) for less xeric landscapes with a surface soil mantle.

9a. Usually dominated by grassy herbaceous species; high percentage of soil coarse fragments. **Garry Oak – Roemer's Fescue plant association.**

9b. Gentle to steep slopes with soil mantle, usually dominated by native herbaceous vegetation. Go to step 10.

10a. Less xeric, often submesic gentle to moderate mid-slopes, sometimes with high mineral soil exposure cover; light to moderate native shrub understorey, usually dominated in early season by herbaceous forb species or later by herbaceous grasses. **Garry Oak – Common Camas – Blue Wildrye plant association.**

10b. Mesic to submesic gentle lower slopes, sometimes cool, protected, or wetter topographic sites including basins and gentle topography; soils relatively deep, medium-textured with low or moderate percent coarse fragments; light to moderate native shrub understorey; usually dominated in early season by herbaceous forb species or later by herbaceous grasses. **Garry Oak – Great Camas – Blue Wildrye plant association.**

11. **Restoration Unit #2: Deep Soil, Wetter Garry Oak Communities.** Step 11 is taken directly from Erickson and Meidinger (2007) for wetter topographic sites; cool sites receiving moisture additions off bedrock, and wet, mesic to subhygric, deep-soil sites usually dominated by dense cover of native shrubs, including dense, multi-layered native shrub thickets. **Garry Oak – Oceanspray – Common Snowberry plant association.**

2.5.1 Garry Oak Woodlands

Garry Oak ecosystems have been described in general by Parks Canada Agency (2006a), and in detail by Roemer (1972), Erickson (1995), and Erickson and Meidinger (2007). Originally, two major types were recognized within the Garry Oak ecosystem: *parkland* and *scrub oak*.

The parkland community type, which occurs on deep soils (Pojar 1980a, 1980b), supported common understorey plants, including Common Snowberry (*Symphoricarpos albus*), Common Camas (*Camassia quamash*), Great Camas (*Camassia leichtlinii*), Fawn Lily (*Erythronium oregonum*), various graminoid species (grasses, sedges, and rushes), and Bracken Fern (*Pteridium aquilinum*). Almost all of this community type has disappeared because it occupied areas that were most suitable for growing crops. Those areas started being cleared for agriculture and urban development in the 1840s. While many large Garry Oak trees remain, the original plant communities beneath them have been replaced by lawns, roads, agricultural fields, or concrete. A few examples of this community type remain in the Nature Conservancy of Canada's Cowichan

Garry Oak Preserve, in a stand in Beacon Hill Park in Victoria, and in the Department of National Defence lands at Rocky Point in the District of Metchosin.

The scrub oak community type occurs on shallow soils and rock outcrops. The oak trees are often of lower stature than those growing on deep soils. The understories of these rock outcrop communities were originally dominated by many spring-flowering perennial forbs, grasses, and mosses, but now they often contain extensive cover of invasive alien species such as Scotch Broom (*Cytisus scoparius*), agronomic grasses, and other weeds. More of this community type remains, probably because many of the rocky habitats that support it were difficult to develop. Many scrub oak sites are now in protected areas such as Mount Tzuhalem Ecological Reserve, Mount Tolmie Park, and Mount Douglas Park.

These deep soil and shallow soil Garry Oak woodlands occur as patches within the Coastal Douglas-fir biogeoclimatic zone as a result of climatic, edaphic, and cultural factors (see Fuchs 2001). Recent classification of these two community types is described in detail in Erickson and Meidinger (2007). The authors defined seven Garry Oak plant associations, which are subdivided into 16 plant community types and six sub-communities. These plant communities are combined in Section 2.5.7.

2.5.2 Maritime Meadows

Maritime meadow plant communities in British Columbia have not been formally recognized or described. They are typically low-elevation, herb-dominated communities that occur within 3 km of the coastline (Parks Canada Agency 2006b). Much of the original area occupied by these ecosystems has been developed for housing, and it is believed that less than 200 ha remain (Parks Canada Agency 2006b). Environmental conditions of these ecosystems have been well described in the recovery strategy for maritime meadow species at risk (Parks Canada Agency 2006b, 2008).

Tree species are mostly or completely absent. The shrub layer is typically sparse and composed of combinations of Tall Oregon-grape (*Mahonia aquifolium*), Nootka Rose (*Rosa nutkana*), Common Snowberry, and Trailing Blackberry (*Rubus ursinus*), and may include sparse trees such as Garry Oak or Douglas-fir (*Pseudotsuga menziesii*). Under natural conditions, the well-developed herb layer tends to be dominated by a mix of forbs and graminoids. Forbs that may dominate the community include Common Camas, Great Camas, Wild Strawberry (*Fragaria virginiana*), Field Chickweed (*Cerastium arvense*), Pacific Sanicle (*Sanicula crassicaulis*), Barestem Desert-parsley (*Lomatium nudicaule*), Woolly Sunflower (*Eriophyllum lanatum*), Puget Sound Gumweed (*Grindelia stricta*), and Bracken Fern. Other less common forbs include Common Yarrow (*Achillea millefolium*), Hooker's Onion (*Allium acuminatum*), Slimleaf Onion (*Allium amplectens*), Chocolate Lily (*Fritillaria affinis*), Fool's Onion (*Triteleia hyacinthina*, White Triteleia), Spring Gold (*Lomatium utriculatum*), Cleavers (*Galium aparine*), Thrift (*Armeria maritima*), and Western Buttercup (*Ranunculus occidentalis*). The most commonly occurring native graminoids are California Oatgrass (*Danthonia californica*), Tufted Hairgrass (*Deschampsia cespitosa*), Red Fescue[2] (*Festuca rubra*), Blue Wildrye (*Elymus glaucus*), and Pacific Woodrush (*Luzula comosa*).

2 Red Fescue is a species complex with both native and non-native elements, sometimes described as sub-species, and with confused taxonomy.

Cover of the moss layer is often quite limited. Many invasive alien plant species dominate these sites (Parks Canada Agency 2008). These species are discussed in Chapter 9 (Alien Invasive Species).

Soil depth, parent material, and the percent of coarse fragments vary considerably among sites. Soils are often shallow, from 10–20 cm deep, but occasionally there is 30 cm or more of soil over bedrock. The parent material may consist of till or glaciomarine clay, silt, or loam. Coarse fragments are often abundant in the soil but may be almost absent. The soil tends to be well to rapidly drained. In the early growing season (October to March), the soil tends to remain moist. Soil moisture levels diminish as the growing season progresses, and by mid-summer significant water deficits occur for prolonged periods. Sites usually occur between 1 and 15 m above sea level (Parks Canada Agency 2008).

Maritime meadow ecosystems with more than 5% cover of California Oatgrass, Roemer's Fescue (*Festuca roemeri*), and/or native elements of Red Fescue have been described for the Puget Trough in Washington State, but other maritime meadow ecosystems in this area have not been classified (Chappell 2006).

2.5.3 Vernal Pools

Vernal pools are spatially discrete, seasonally flooded depressions that form on top of impermeable layers such as hardpan, claypan, or bedrock.

Vernal pool plant communities in British Columbia have not been formally recognized or described. Vernal pools are spatially discrete, seasonally flooded depressions that form on top of impermeable layers such as hardpan, claypan, or bedrock (Parks Canada Agency 2006c). The pools on Vancouver Island tend to be of two types: those formed by rock depressions and those forming on clay soils (Parks Canada Agency 2006c). They occur under Mediterranean-type climatic conditions that include relatively high levels of precipitation in winter and early spring, followed by complete or partial drying in summer. Environmental conditions have been well described in the recovery strategy for maritime meadow species at risk (Parks Canada Agency 2006c) and by the Parks Canada Agency (2008). Today, most of the remaining vernal pool/vernal seep habitat on Vancouver Island is confined to isolated coastal bluffs on the southeast side of the island, and to small undeveloped islands adjacent to the coast (Parks Canada Agency 2006c). Vernal pools, swales, and seeps are scattered throughout the Gulf Islands and along the Vancouver Island coast as far north as Campbell River and Mitlenatch Island. Harewood Plains, near the City of Nanaimo, is an important vernal pool and seepage area (Parks Canada Agency 2006c).

Trees and shrubs are absent. The herb layer is dominated by forbs with a lesser component of graminoids. Vernal pools have a variety of dominant plants, with annual plants being the most common. Some of the plants species found on Vancouver Island and the Gulf Islands include Scouler's Popcornflower (*Plagiobothrys scouleri*), Blinks (*Montia fontana*), Water-starwort (*Callitriche* spp.), Nuttall's Quillwort (*Isoetes nuttallii*), Macoun's Meadowfoam (*Limnanthes macounii*), Puget Sound Gumweed, Lowland Cudweed (*Gnaphalium palustre*), Tiny Mousetail (*Myosurus minimus*), Dwarf Owl-clover (*Triphysaria pusilla*), Erect Pygmyweed (*Crassula connata* var. *connata*), Yellow Monkey-flower (*Mimulus guttatus*), Toad Rush (*Juncus bufonius*), White-tipped Clover (*Trifolium variegatum*), and Long-spurred Plectritis (*Plectritis macrocera*). Perennial native forbs are not common but can include Thrift and Hooded Ladies' Tresses

(*Spiranthes romanzoffiana*). The moss layer may be present and common on some sites. Many alien invasive plant species dominate these sites (Parks Canada Agency 2006c, 2008).

Soils are imperfectly drained. In the early growing season (December to February), the water table is at or near the soil surface. Seepage diminishes as the growing season progresses. Winter seepage waterlogs the soil, creating conditions that are unsuitable for most woody or tall herbaceous species. Summer drought creates conditions that are unsuitable for those woody and tall herbaceous species that tolerate winter flooding. Parent material usually consists of glacio-marine clay-loam. The soils commonly consist of thin (1–20 cm deep) deposits over level bedrock. Coarse fragments are scarce in the soil and absent at the surface (Parks Canada Agency 2008).

2.5.4 Vernal Seeps

Vernal seep plant communities in British Columbia have not been formally recognized or described. Vernal seeps have shallow groundwater flow that emerges on sloping terrain, usually on the lower slopes of shallow soil and rock dominated hillsides (Parks Canada Agency 2006c). Seeps differ from vernal pools in that they are not usually associated with prolonged inundation; however, like vernal pools, they tend to dry up by late spring or early summer and thus present plants with similar challenges (Parks Canada Agency 2006c).

The ground cover is dominated by bryophytes and low annual herbs. The most abundant native species are bryophytes, particularly the Grey Rock-moss (*Racomitrium elongatum*) and *Bryum miniatum*. A number of native annual herbs may be present, most notably Yellow Monkey-flower, Fool's Onion, Small-leaved Montia (*Montia parvifolia*), Sea Blush (*Plectritis congesta*), Large-flowered Blue-eyed Mary (*Collinsia grandiflora*), Cup Clover (*Trifolium cyathiferum*), Smooth Fringecup (*Lithophragma glabrum*), Blinks, Narrow-leaved Montia (*Montia linearis*), Grassland Saxifrage (*Saxifraga integrifolia*), and Tomcat Clover (*Trifolium willdenowii*). Three bulb-forming species—Common Camas, Fool's Onion, and Harvest Brodiaea (*Brodiaea coronaria*)—are often present, as is Wallace's Selaginella (*Selaginella wallacei*), which may be abundant. Native graminoids are uncommon or absent. Most of the native plant species found in vernal seeps are habitat specialists and are not generally found in drier habitats (Parks Canada Agency 2006c, 2008).

The slope of vernal seep sites is usually greater than 35%; however, plants tend to occur on small, nearly level to moderately sloping benches. Soils tend to be very shallow, from 0.5 to 10 cm thick. Parent material tends to consist of weathered bedrock and slope-wash, and is generally rich in organic matter and often has a significant component of sand and/or fine gravel. Rock outcrops are generally present within or immediately adjacent to vernal seeps. The soil tends to be well- to rapidly-drained. In the early growing season (January to March), the soil tends to remain moist or wet as a result of near constant seepage. The soil moisture level diminishes as the growing season progresses, and by late spring, the soil experiences significant water deficits for prolonged periods. The soil surface is characterized by relatively small amounts of exposed mineral soil and fine litter (Parks Canada Agency 2008).

2.5.5 Coastal Bluffs

Coastal bluff plant communities in British Columbia have not been formally recognized or described. Two categories of the coastal bluff ecosystem have been identified: vegetated rocky islets and shorelines, and vegetated coastal cliffs and bluffs (Ward et al. 1998). These areas are subjected to harsh environmental conditions such as crashing waves, winds, heat, storms, and salt spray. Coastal bluff ecosystems are often intermixed with other ecosystems such as Garry Oak woodlands, maritime meadows, and vernal pools.

Trees, when present, are sparse and may be stunted or windblown. Species include Arbutus (*Arbutus menziesii*), Garry Oak, Douglas-fir, and occasionally Seaside Juniper (*Juniperus maritima*). Shrub cover is usually limited but may include Tall Oregon-grape, Saskatoon (*Amelanchier alnifolia*), Oceanspray (*Holodiscus discolor*), and Common Snowberry. The herb layer consists mainly of graminoids, including Roemer's Fescue, Alaska Brome (*Bromus sitchensis*), Long-Stoloned Sedge (*Carex inops*), and Red Fescue, with a few herb species such as Stonecrops (*Sedum* spp.), Small-flowered Alumroot (*Heuchera micrantha*), strawberries (*Fragaria* spp.), Nodding Onion (*Allium cernuum*), Death-camas (*Zigadenus venenosus*), Sea Blush, Wallace's Selaginella, and Puget Sound Gumweed. Harvest Brodiaea and Menzies' Larkspur (*Delphinium menziesii*) occur less often. The moss and lichen layer is diverse and typically includes *Racomitrium elongatum*, *Syntrichia ruralis*, and on exposed rock, *Polytrichum piliferum* (Ward et al. 1998).

Coastal bluffs are usually rock-dominated and lack soils or have a shallow veneer of soil in rock crevices and depressions that allows vegetation to grow. Soils are usually very dry and nutrient poor and may have high salinity due to salt spray. Due to the surrounding harsh environment, it takes many years for organic matter to accumulate and distinct soil horizons to develop. Soils are usually sand to sandy-loams. Steep slopes limit the accumulation of organic matter to bedrock fissures on cliffs and bluffs (Ward et al. 1998).

2.5.6 Douglas-fir Plant Communities

Many of the deep soil sites that currently support Garry Oak can also support Douglas-fir communities. Within the Coastal Douglas-fir biogeoclimatic zone, many of the Douglas-fir communities are red- or blue-listed by the BC Conservation Data Center (see Chapter 4: Species and Ecosystems at Risk). The Douglas-fir communities are considered the end point in succession for these sites (see Section 2.6), and ecologically are acceptable to restore to on these sites. Douglas-fir communities have been described by Roemer (1972), McMinn et al. (1976), Green and Klinka (1994), and Madrone (2008). Tree species commonly found on these sites include Douglas-fir, Western Redcedar (*Thuja plicata*), and Grand Fir (*Abies grandis*). Common shrubs are Salal (*Gaultheria shallon*), Red Huckleberry (*Vaccinium parvifolium*), and Dull Oregon-grape (*Mahonia nervosa*). Sword Fern (*Polystichum munitum*) and Bracken Fern occur in the herb layer. Mosses are common and include *Hylocomium splendens*, *Kindbergia oregana*, *Plagiothecium undulatum*, and *Rhytidiadelphus loreus*. The plant communities where restoration of Garry Oak and associated species would be successful include Douglas-fir/Dull Oregon-grape (CDFmm/01), but only on gentle slopes and steeper warm aspects, not cool aspects; Douglas-fir/Arbutus (CDFmm/02); and Douglas-fir/Alaska Oniongrass (CDFmm/03).

Restoration Ecosystem Units, developed for this publication, provide restoration practitioners of Garry Oak and associated ecosystems with information that can be used at a broad scale.

2.5.7 Restoration Ecosystem Units

To aid the restoration of Garry Oak and associated ecosystems, the authors of this publication have developed broad ecological units called Restoration Ecosystem Units (REUs). These units are used throughout this publication to provide restoration practitioners with information that can be used at a broad scale. If practitioners require vegetation classification information for a site, they can refer to Erickson and Meidinger (2007).

Table 2.2 Restoration ecosystem units and their plant associations.

Restoration Ecosystems Unit No. and Name	Restoration Ecosystem Unit Description	Common Native Plant Species	Plant Associations[1]
REU #1: Deep Soil, Average Moisture Garry Oak Communities	Deep soil; variety of soil conditions; average or mesic moisture; low elevations; gentle slopes to moderate and steep south- facing slopes; usually over deeper bedrock	Tree layer Garry Oak, Douglas-fir Shrub layer Common Snowberry, Tall Oregon-grape Herb layer Common Camas, Great Camas, White Fawn Lily, Western Buttercup, Broad-leaved Shootingstar (*Dodecatheon hendersonii*), Sea Blush, Pacific Sanicle, Cleavers, Harvest Brodiaea, Spring Gold, Miner's-lettuce (*Claytonia* spp.), Blue Wildrye, California Brome (*Bromus carinatus*), Alaska Oniongrass (*Melica subulata*), Long-Stoloned Sedge Moss layer *Racomitrium elongatum*	Garry Oak – Common Camas – Blue Wildrye Garry Oak – Great Camas – Blue Wildrye
REU #2: Deep Soil, Wetter Garry Oak Communities	Deep soil; wetter than average moisture; lower slopes that receive moisture from above; wetter subhygric	Tree layer Garry Oak, Oregon Ash (*Fraxinus latifolia*), Douglas-fir Shrub layer Common Snowberry, Oceanspray, Nootka Rose, Indian-plum (*Oemleria cerasiformis*), Western Trumpet (*Lonicera ciliosa*), Tall Oregon-grape Herb layer Cleavers, Great Camas, White Fawn Lily, Chocolate Lily, American Vetch (*Vicia americana*), Blue Wildrye, California Brome, Long-stoloned Sedge Moss layer *Rhytidiadelphus triquetrus*	Garry Oak – Oceanspray – Common Snowberry

1 From Erickson and Meidinger (2007) and Green and Klinka (1994)

Restoration Ecosystems Unit No. and Name	Restoration Ecosystem Unit Description	Common Native Plant Species	Plant Associations[1]
REU #3: Shallow Soil Garry Oak Communities	Primarily underlain by bedrock or fractured rock; if bedrock, then cracked and fissured, not uniform; also found on talus or coarse colluvial material and at the margins of bedrock or other rocky xeric landscapes; occupies a variety of slope positions—usually moisture-shedding, gentle upper slope positions or steeper south- facing slopes	Tree layer Garry Oak, Arbutus, Douglas-fir Shrub layer Common Snowberry, Oceanspray Herb layer Common Camas, Hairy Honeysuckle (*Lonicera hispidula*), Common Yarrow, Small-flowered Birds-foot trefoil (*Lotus micranthus*), Small-flowered Blue-eyed Mary (*Collinsia parviflora*), Woolly Sunflower, Broad-leaved Stonecrop (*Sedum spathulifolium*), Cleavers, Pacific Sanicle, Sea Blush, Satinflower (*Olsynium douglasii*), Wallace's Selaginella, California Brome, Blue Wildrye, Licorice Fern (*Polypodium glycyrrhiza*), Roemer's Fescue Moss layer Abundant with *Racomitrium elongatum, Dicranum scoparium, Polytrichum juniperinum*	Garry Oak – Roemer's Fescue Garry Oak – Hairy Honeysuckle Garry oak – Grey Rock-moss – Wallace's Selaginella Garry Oak – Broom-moss Garry Oak – Hairy Honeysuckle
REU #4: Shallow Soil Seepage Communities	Shallow soil seepage areas where water slowly flows in the winter and early spring; very dry in summer	Tree layer: absent Shrub layer: absent Herb layer Blue-eyed Mary (*Collinsia* sp.), Smooth Fringecup, Blinks, Narrow-leaved Montia, Grassland Saxifrage, Tomcat Clover, Common Camas, Fool's Onion, Harvest Brodiaea, Wallace's Selaginella Moss layer Usually abundant with *Racomitrium elongatum* and *Bryum miniatum*, and significant lichen growth, mainly on rock outcrops or very shallow soil	None defined

1 From Erickson and Meidinger (2007) and Green and Klinka (1994)

Restoration Ecosystems Unit No. and Name	Restoration Ecosystem Unit Description	Common Native Plant Species	Plant Associations[1]
REU #5: Maritime Meadow Communities	Low-elevation, treeless areas along the coastline; soils are less than 50 cm deep and are over bedrock; parent material may consist of till or glaciomarine clay, silt, or loam	Tree layer Sparse, usually Garry Oak or Douglas-fir Shrub layer Sparse and composed of Tall Oregon-grape, Nootka Rose, Common Snowberry, and Trailing Blackberry Herb layer Common Camas, Great Camas, Wild Strawberry, Field Chickweed, Pacific Sanicle, Barestem Desert-parsley, Woolly Sunflower, Puget Sound Gumweed, Bracken Fern, Common Yarrow, Hooker's Onion, Slimleaf Onion, Chocolate Lily, Fool's Onion, Spring Gold, Cleavers, Thrift, Western Buttercup, California Oatgrass, Tufted Hairgrass, Red Fescue, Blue Wildrye, Pacific Woodrush Moss layer: typically sparse	Non-defined
REU #6: Vernal Pool Communities	Depressional areas where standing water accumulates in the winter and early spring; soil conditions prevent percolation of water; dry in summer	Tree layer: absent Shrub layer: absent Herb layer Variety of species including Scouler's Popcornflower, Water Chickweed (*Myosoton aquaticum*), Water-starwort, Nuttall's Quillwort, Macoun's Meadowfoam, Puget Sound Gumweed, Lowland Cudweed, Tiny Mousetail, Dwarf Owl-clover, Erect Pygmyweed, Yellow Monkey-flower, Toad Rush, White-tipped Clover, Long-spurred Plectritis, Blinks, Thrift, Hooded Ladies' Tresses Moss layer May be present and common on some sites	Non-defined

1 From Erickson and Meidinger (2007) and Green and Klinka (1994)

Restoration Ecosystems Unit No. and Name	Restoration Ecosystem Unit Description	Common Native Plant Species	Plant Associations[1]
REU #7: Coastal Bluff Communities	Steep slopes (over 30% slope) along the ocean; dominated by shrubs and herbs	Tree layer Arbutus, Garry Oak, Douglas-fir, Seaside Juniper Shrub layer Tall Oregon-grape, Saskatoon, Oceanspray, and Common Snowberry Herb layer Roemer's Fescue, Alaska Brome, Long-stoloned Sedge, Red Fescue, stonecrops, Small-flowered Alumroot, strawberries, Nodding Onion, Death-camas, Sea Blush, Wallace's Selaginella, Puget Sound Gumweed Moss layer: sparse	Non-defined
REU #8: Douglas-fir communities	Variety of site conditions, but mostly deep, moist soils, gently sloping over bedrock	Tree layer Douglas-fir, Western Redcedar, Grand Fir Shrub layer Salal, Red Huckleberry, Dull Oregon-grape Herb layer Sword Fern, Bracken Fern, Alaska Oniongrass Moss layer *Hylocomium splendens, Kindbergia oregana, Plagiothecium undulatum,* and *Rhytidiadelphus loreus*	Douglas-fir / Dull Oregon-grape (also known as Douglas-fir – Salal) Douglas-fir – Shore Pine – Arbutus Douglas-fir – Oniongrass

1 From Erickson and Meidinger (2007) and Green and Klinka (1994)

2.6 Successional Perspective and Implications for Restoration

As the beginning of this chapter indicates, changes to Garry Oak ecosystems can occur quite quickly. Areas that originally supported prairie quickly succeeded to stands of Garry Oak when burning ceased. Over time, stands dominated by coniferous trees, such as Douglas-fir, developed mainly on sites with deep soil. On sites with shallow soil, Garry Oak communities may never be replaced by Douglas-fir.

Restoration workers often seem to select a particular successional community and try to manage their area to that "ideal state." In the case of Garry Oak stands, this is often an oak savannah or oak woodland with a meadow-like understorey of camas, Fawn Lily, and other attractive flowers, but many other stages could also be appropriate (see Peter and Harrington 2004). Restoration practitioners can use successional information to determine which vegetation communities or stages could occur on the site they wish to restore, and what may happen to a particular community over time if it is not actively managed. For example, many deep soil areas that support Garry Oak communities can also support dense shrubby communities or coniferous forest (Roemer 1972). Therefore, shrubby species, such as snowberry or Indian-plum, or coniferous species, such as Douglas-fir, may establish on sites where restoration practitioners are attempting to maintain a Garry Oak woodland with a forb/graminoid understorey.

> Restoration practitioners can use sucessional information to determine which vegetation communities or stages could occur on the site they wish to restore, and what may happen to a particular community over time if it is not actively managed.

A variety of successional pathways can occur in deep soil sites in the Puget Sound area (Figure 2.6; Peter and Harrington 2004). These sites can support open prairie dominated by forbs and graminoids; parkland or woodland Garry Oak communities; dense shrub-dominated communities; or Douglas-fir communities all on the same site depending on disturbance history and intensity. Successional stages often existed in mosaics across the landscape depending on disturbance history (Lea 2006). Much of the area that historically supported Garry Oak ecosystems included sites where a Douglas-fir/Salal/Dull Oregon-grape community would be the climax plant community (McMinn et al. 1976).

In the past, the First Nations people regularly burned much of southeastern Vancouver Island to maintain important wildlife habitat and plant resources such as camas, and other root crops such as Bracken Fern (Roemer 1972; Turner 1999). Paleoecological evidence indicates that this burning allowed Garry Oak woodlands to persist over the last several thousand years by preventing succession to coniferous forest (Pellatt et al. 2001). Historical records indicate that the resulting landscape was a matrix of open prairies, rich meadows, and shrub thickets (MacDougall et al. 2004). Many Garry Oak woodland ecosystems (particularly the more mesic, deeper soil sites) depend on fire to maintain an open canopy and understorey, and remove thatch accumulation. Fire suppression also changes hydrological and nutrient regimes, which could negatively affect the species within these ecosystems. The expansion of shrubs is evident in portions of the Garry Oak woodlands at the Cowichan Garry Oak Preserve and at Somenos Lake, where Common Snowberry dominates the understorey vegetation. Snowberry appears to effectively shade out and eliminate most herbaceous species (Parks Canada Agency 2006a). Detailed successional relationships are also defined within each plant community described by Erickson and Meidinger (2007) and

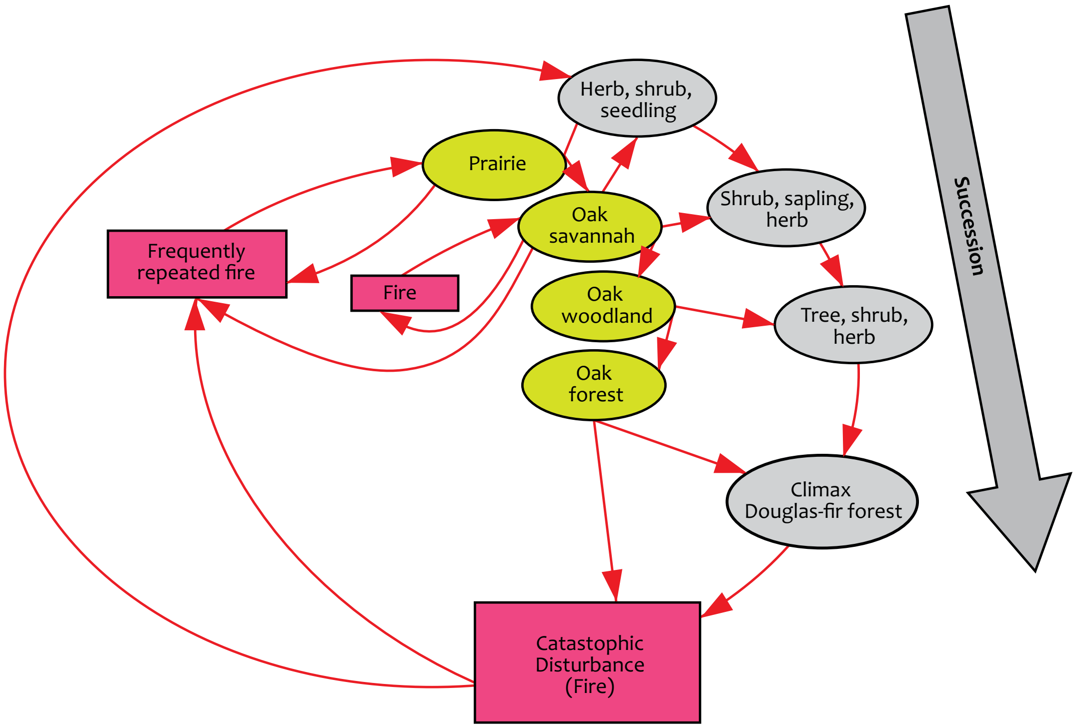

Figure 2.6 Successional pathways in deep soil sites in the Puget Sound area (modified from Peter and Harrington 2004).

Erickson (1995). These considerations of succession shed much light on the restoration process, since restoration must take into consideration the dynamic nature of Garry Oak communities. Chapter 3 (Natural Processes and Disturbance) provides a more in-depth look at fire and succession in relation to restoration.

2.7 Acknowledgements

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Appendix 2.1

Historical (pre-European settlement) and Present Day Distribution of Garry Oak Ecosystems

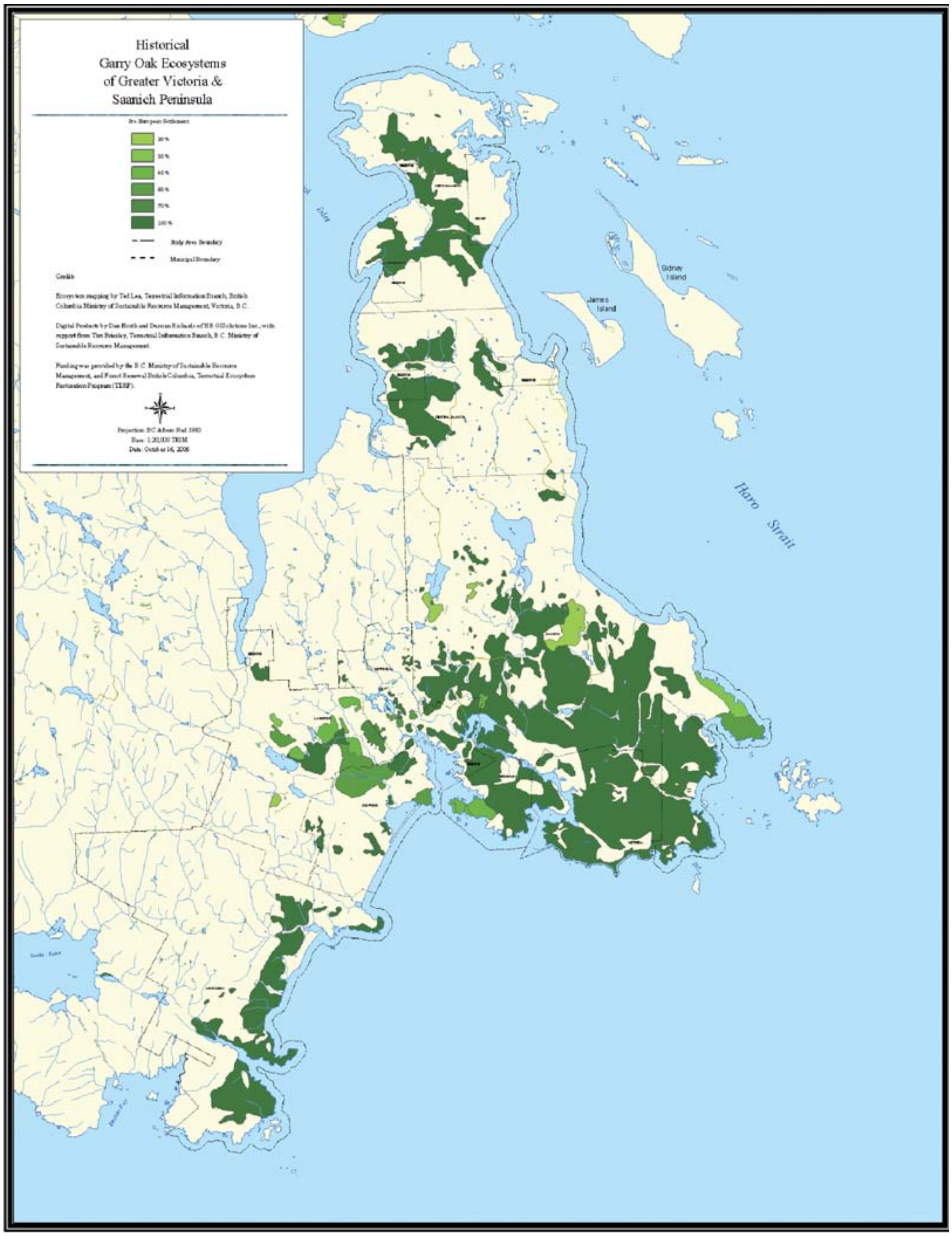

Figure A2.1 Historical Garry Oak Ecosystems of Greater Victoria and Saanich Peninsula (pre-European settlement).

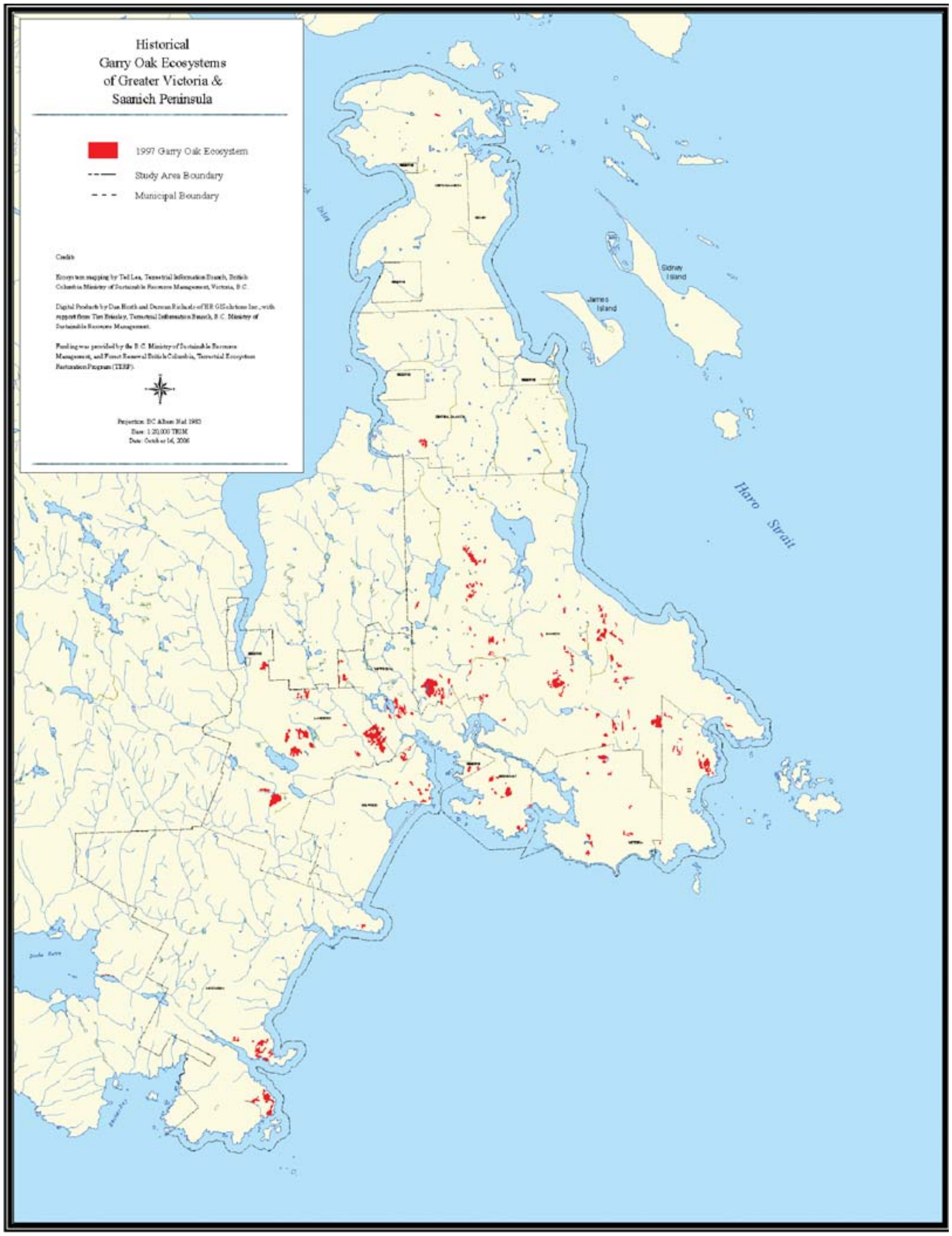

Figure A2.2 Present day (1997) Garry Oak Ecosystems of Greater Victoria and Saanich Peninsula.

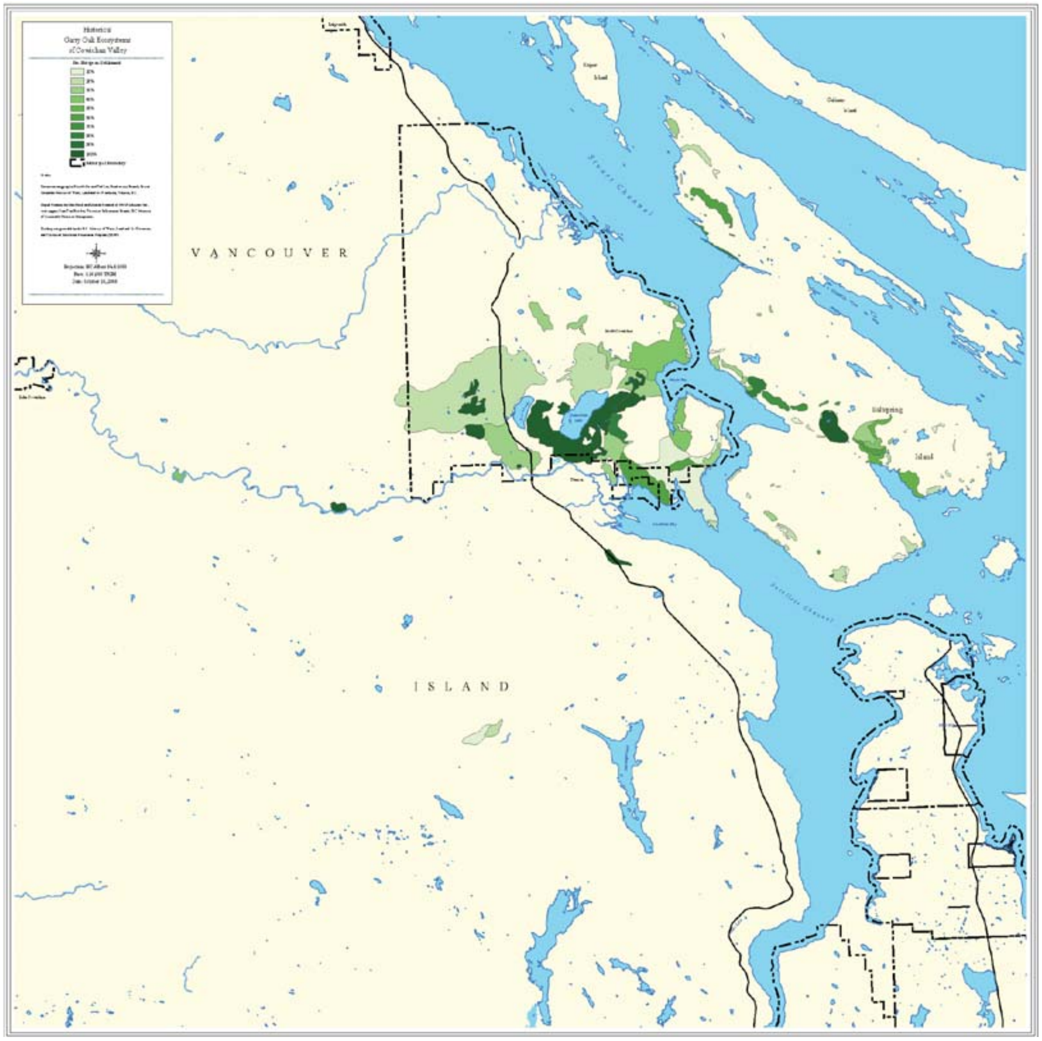

Figure A2.3 Historical Garry Oak Ecosystems of Cowichan Valley (pre-European settlement).

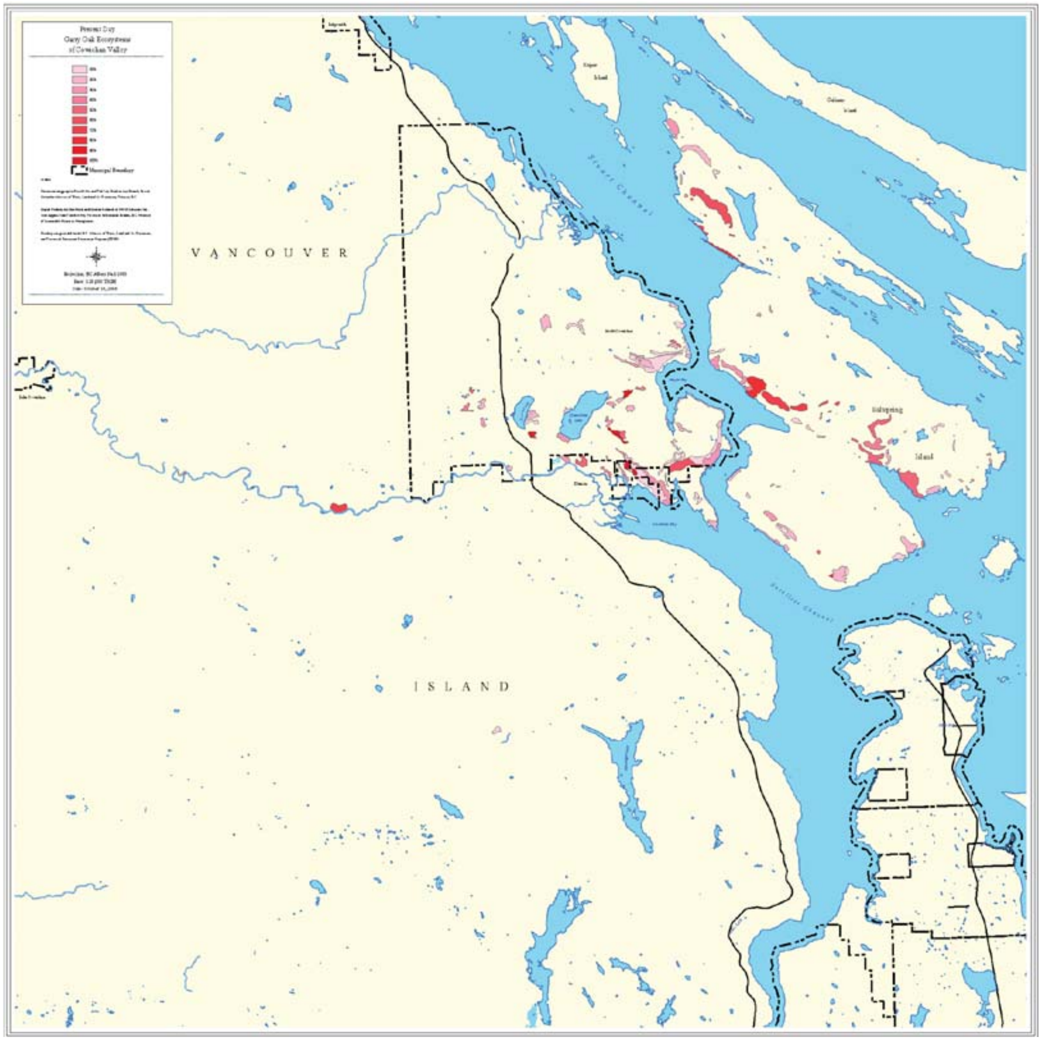

Figure A2.4 Present day (2006) Garry Oak Ecosystems of Cowichan Valley.

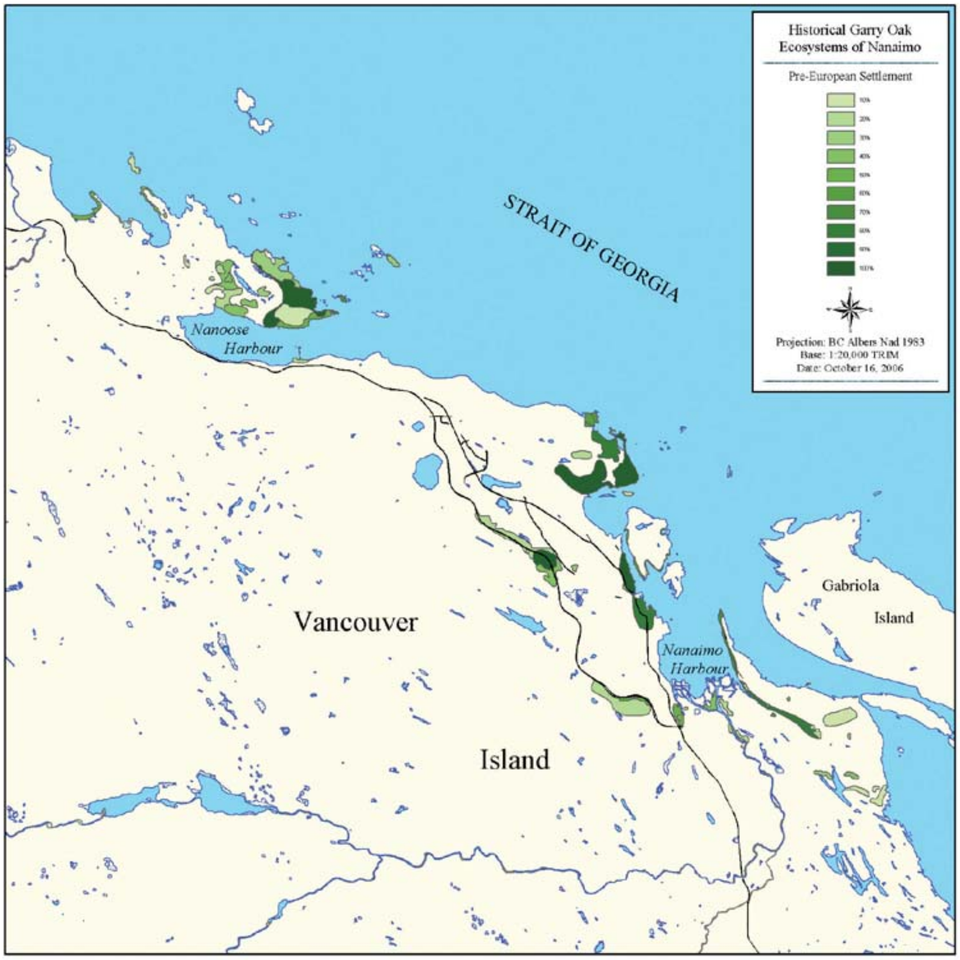

Figure A2.5 Historical Garry Oak Ecosystems of Nanaimo (pre-European settlement).

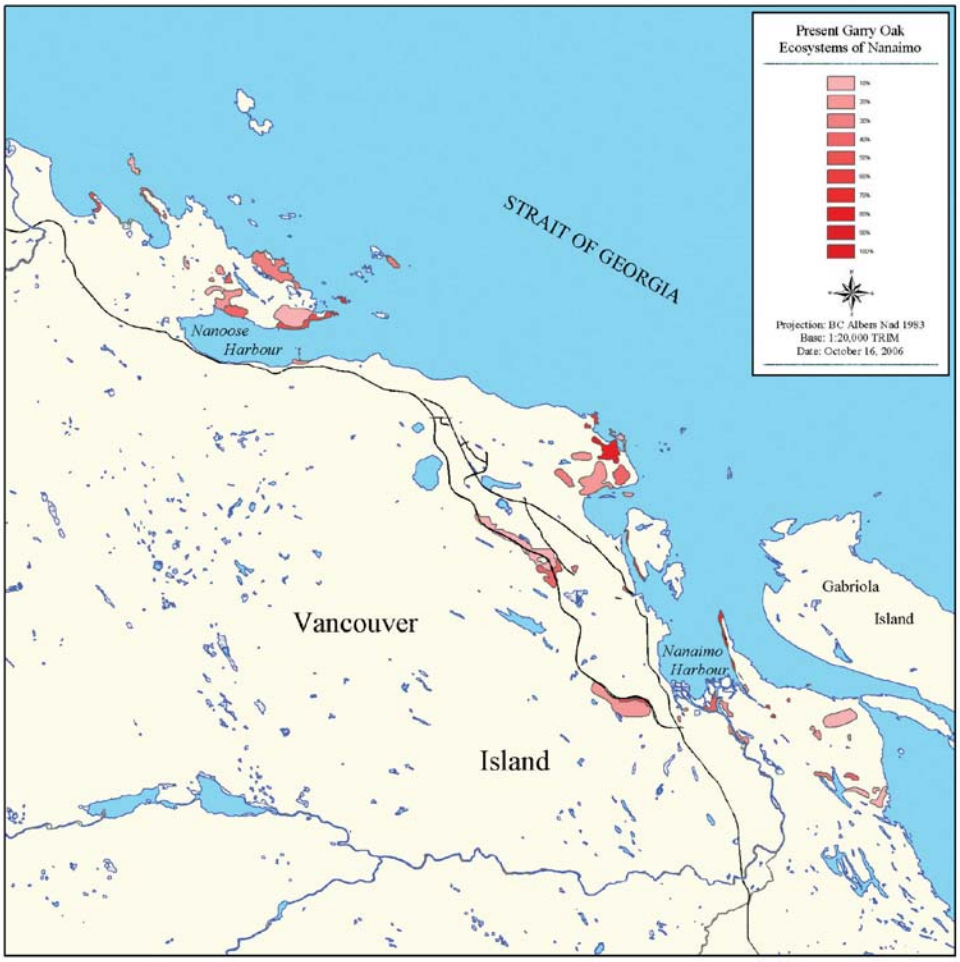

Figure A2.6 Present day (2006) Garry Oak Ecosystems of Nanaimo.

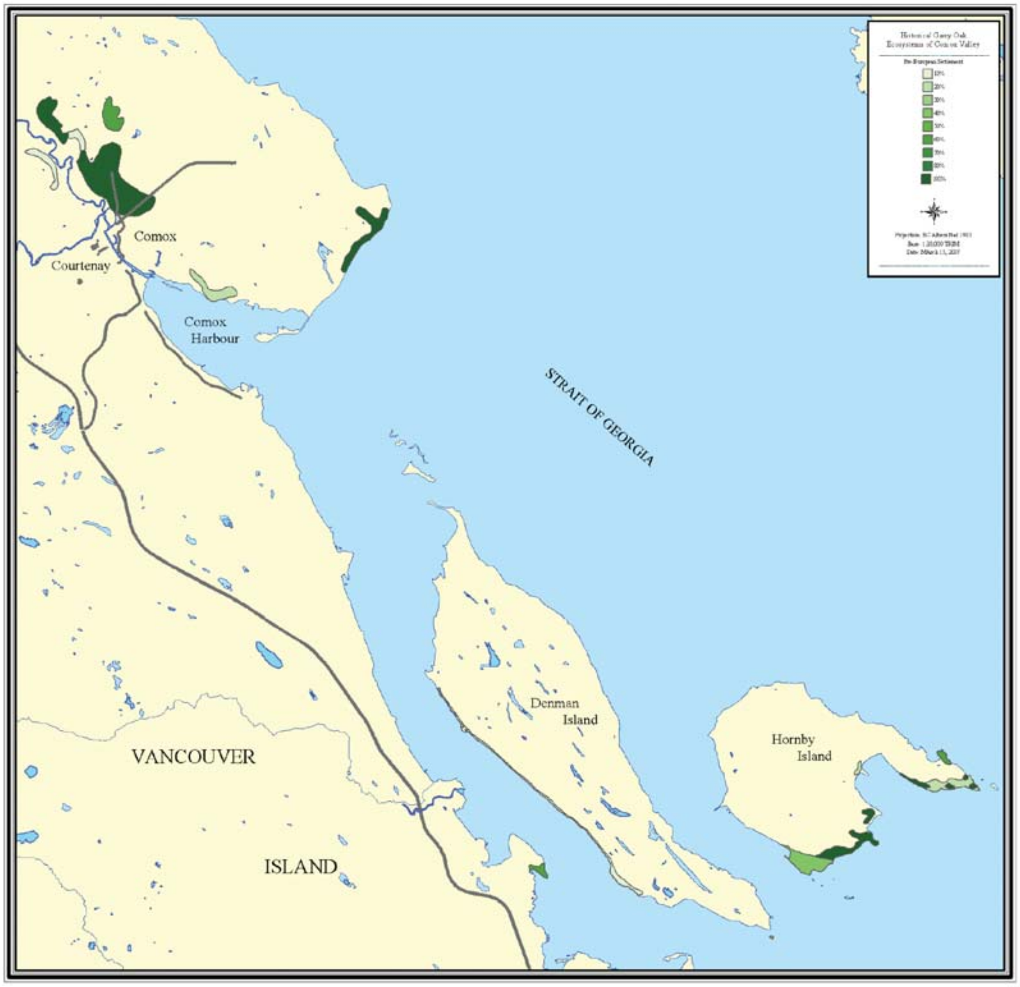

Figure A2.7 Historical Garry Oak Ecosystems of Comox Valley (pre-European settlement).

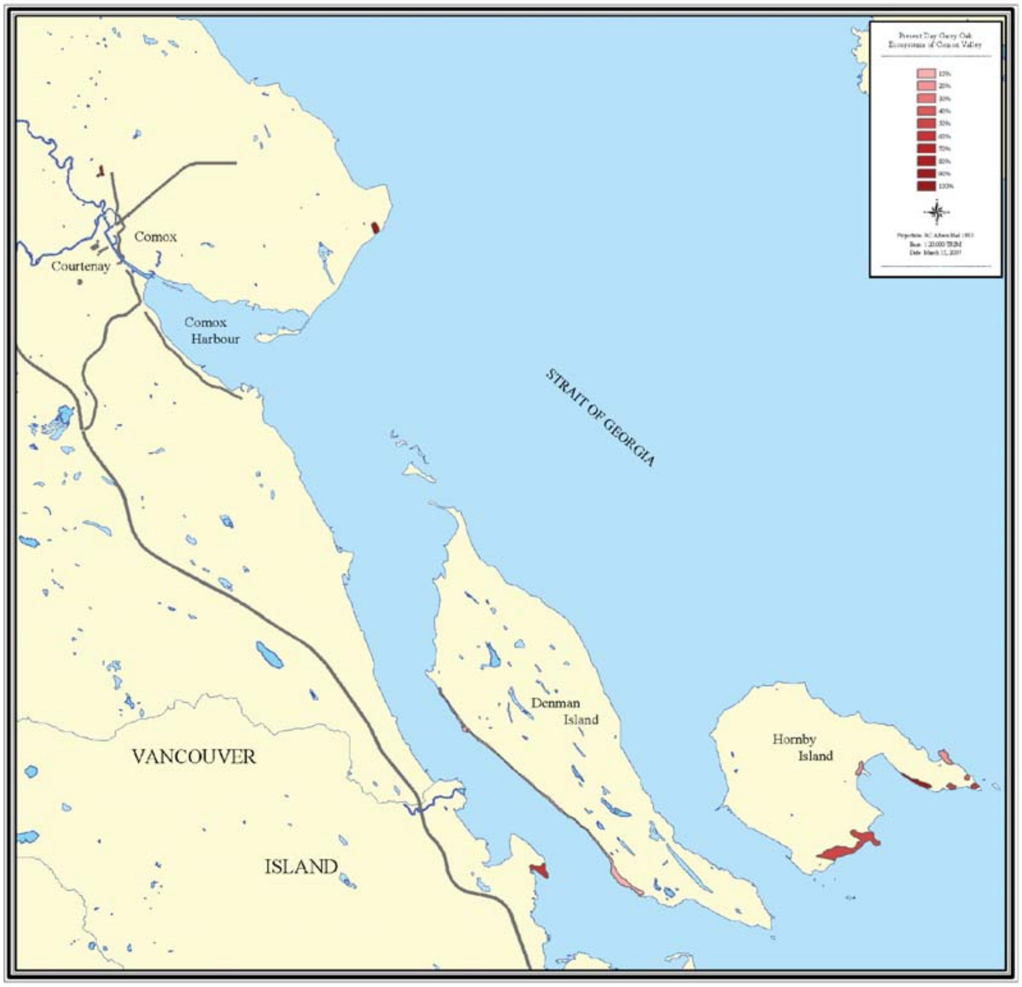

Figure A2.8 Present day Garry Oak Ecosystems of Comox Valley.

Restoring British Columbia's Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 3
Natural Processes and Disturbance

Contents

Chapter 3

Natural Processes and Disturbance

by Shyanne Smith in collaboration with Duncan Morrison, Richard Hebda, Matt Fairbarns, and Christian Engelstoft

Figure 3.1 Intact deep soil woodland at Cowichan Garry Oak Preserve. Photo: Shyanne Smith

3.1 Introduction

What is the goal of your site restoration? This should be one of your first questions as you design a restoration project. Given that we cannot predict community change and often do not even know what an ecosystem might have been like prior to human influence (Parks Canada Agency 2000; Samways 2000; Choi 2004), how do we determine what to restore to? Restoration need not attempt to predict what a particular ecosystem would be without human interference, but rather should attempt to restore processes and attributes (Hebda 1999). For example, prescribed[1] burning, livestock grazing, or mowing and native plant seeding may be used as restoration

1 Prescribed fires are fires deliberately set by managers to produce disturbances or conditions that are beneficial to an ecosystem or that achieve management objectives.

surrogates to replace the lighting of frequent fires and bulb digging by First Nations (Anderson and Barbour 2003) that would have historically maintained some Garry Oak (*Quercus garryana*) savannahs. Given the impacts of climate change, land use practices including fire suppression, and introduction of invasive alien species, we are unlikely to be able to restore to a specific historical condition and introduction of such a state is also not likely desirable due to the current stressors and changing climate (Harris et al. 2006). Understanding historical composition, structure, and processes, however, is the first step toward restoring a degraded site to a functional, resilient ecosystem.

> Understanding historical composition, structure, and processes is the first step toward restoring a degraded site to a functional, resilient ecosystem.

A basic understanding of prairie, savannah, and woodland systems and their maintenance is an important foundation for interpreting site conditions and determining appropriate methods for implementing restoration. This chapter outlines principles of stand dynamics, some of the natural processes (dynamic interactions between living and non-living elements), and historical disturbances to consider when designing a restoration plan for Garry Oak and associated ecosystems.

We first generally discuss ecosystem function and role of disturbance (Section 3.1.1. and Section 3.1.2). We then discuss the concept of stand dynamics (Section 3.2), and apply this to our local systems and explain the roles of fire, alien invasive species, herbivory, plant disease, and climate change in the dynamics of Garry Oak and associated ecosystems (Section 3.3). We conclude (Section 3.4) by summarizing key restoration considerations that relate to natural processes and disturbances.

3.1.1 Ecosystem Function

Four fundamental processes govern ecosystems: water cycling, nutrient cycling, energy flow, and succession. Water cycling involves the capture, storage, and release of water from precipitation, surface flow, and subsurface flow, as well as water uptake and release by organisms. Plans for restoration should consider how each action will affect water cycling. Physical disturbances, such as ditches, irrigation channels, water bars, or even removal of vegetation or trail blazing, may disrupt the supply of water to a site. The loss of wetlands, which serve as sponges, reduces the ability of a site to store and gradually release water. Changes in vegetation structure, such as tree in-growth into a meadow, may increase rainfall interception water uptake from the soil and thus reduce the availability of water to other species. The capacity of soil to absorb and store water may be significantly reduced by even seemingly minor changes, such as the replacement of perennial species by annual grasses or by trampling which reduces soil porosity.

Changes in nutrient cycling may also have profound effects on ecosystem structure and function. For instance, nitrogen[2] often limits plant growth in natural ecosystems in our region. Much of our native flora is well-adapted to nitrogen-poor conditions. An increase in the amount of nitrogen available for plant growth may benefit numerous alien species that are profligate nitrogen users and give them a competitive edge over native plants. Soil nitrogen levels may be

2 The key component of proteins that constitute much of biological tissue.

boosted by inputs from nearby agricultural and urban activities. Some alien invasive species may even increase the availability of nitrogen; for instance, Scotch Broom (*Cytisus scoparius*) has a symbiotic relationship with nitrogen-fixing bacteria that are attached to their roots. The extra boost of nitrogen helps broom plants grow vigorously and may increase the amount of soil nitrogen available to other invasive plants. Micro-organisms and soil fauna (such as earthworms) break down decaying vegetation and release nutrients that are then recycled in the ecosystem. Rainwater could flush many of these nutrients deep into the soil, but plant roots can intercept and recycle many nutrients. Changes in plant community composition may alter the rooting zone structure enough to reduce the recycling of nutrients within the soil.

Energy cycling is driven by the ability of plants to capture energy from sunlight, carbon from the atmosphere, and water from the soil to create sugars which fuel ecosystems. Plants, animals, fungi, and bacteria use these fuels to drive their life processes, and as the fuels are used up, the carbon they contain is released back into the atmosphere in the form of carbon dioxide. Rapid and effective carbon cycling may be blocked in some ecosystems, resulting in a buildup of plant litter, wood, and soil organic matter. An increase in plant litter may reduce the ability of light rainfalls to replenish soil moisture and may prevent some plants from successfully seeding into some areas. Low levels of soil organic matter, on the other hand, tend to reduce the ability of the soil to act as a sponge and store water for plant growth. Herbaceous plants, particularly grasses, "pump" large amounts of carbon into the upper soil as their old roots die and decay. Trees and shrubs, in contrast, release a greater proportion of their dead tissue onto the soil surface as litter.

Ecological succession is an ongoing process that follows a more or less predictable sequence of changes, that at times causes lakes to be overgrown and eventually end up in the current climax forest ecosystem. The successional trajectory is influenced by local circumstances such as weather, stochastic events, and seed sources. This is also a "force" many management objectives aim to keep at bay. For example, Douglas-fir (*Pseudotsuga menziesii*) or Grand Fir (*Abies grandis*) in-growth is driven by natural succession. At times, ecosystems stabilize at intermediate succession stages until circumstances change. The lessons from considering these general processes are:

1) Successful restoration may involve preliminary assessment of more than stand composition and structure
2) Barriers to successful restoration may not be apparent immediately and their detection may require a strategy that considers principles of ecological function such as those described by Harwell et al. (1999) as Essential Ecosystem Characteristics

3.1.2 Role of Disturbance

The current widespread decrease in species diversity in prairies and increasing encroachment of prairies and open savannahs are examples of the need for active management of disturbance-based ecosystems[3]. Such early- to mid-successional ecosystems, such as deep soil Garry Oak communities, depend on disturbance to prevent succession into conifer forest. Ecological disturbance can be defined broadly as "any relatively discrete event in time that disrupts

3 Most ecosystems are "disturbance-based" to some degree, meaning that they are occasionally impacted by disturbance, but savannah or grassland systems like the Garry Oak ecosystems discussed exhibit high levels of disturbance.

Ecological disturbance can be defined broadly as “any relatively discrete event in time that disrupts ecosystem, community or population structure and changes resource, substrate availability, or the physical environment”.

ecosystem, community or population structure and changes resource, substrate availability, or the physical environment” (White and Pickett 1985). Thus, disturbance includes processes that historically operated in Garry Oak ecosystems, such as fires and bulb digging, or simulations of such disturbances, such as mowing or weeding.

If the integrity of ecosystems that have historically been maintained by First Nations is to be protected, management must implement actions that simulate First Nations management activities (Anderson and Barbour 2003). Re-introducing disturbance, however, does not necessarily mean that plant communities will respond the same way as they did historically.
There are three potential difficulties with re-introducing disturbances:

1) Historical dynamics are not fully understood because they functioned in ways that are not apparent today
2) Historical disturbances do not function as before due to factors such as habitat loss, population decline, and community change due to invasive species
3) There are high costs and risks associated with re-introducing disturbance in the modern (settled) landscape (MacDougall and Turkington 2006, 2007)

Because present conditions and species composition differ from the historical state, the same disturbance will not necessarily have the same effect as it did historically (Hobbs and Huenneke 1992) and our understanding of how plant communities respond to disturbance is still limited due to the complexity of the process. Disturbances interact with other ecosystem-level processes such as production, biomass accumulation, energetics, and nutrient cycling, and change the structure and dynamics of natural communities. Because historical disturbances have largely been suppressed in our natural areas, plant communities have tended to become dominated by a few competitive, often invasive, species (Wilsey and Polley 2006).

In addition, different anthropogenically driven disturbances, such as increased herbivore pressure, eutrophication (i.e., excess nutrients in aquatic systems), and soil disruption have facilitated the establishment of alien invasive species worldwide (Jenkins and Pimm 2003).

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The suppression of historical disturbances may also be maintaining the dominance of alien invasive species in many cases (MacDougall and Turkington 2005). Because disturbance plays an important role in influencing the structure and composition of ecosystems, it is imperative to understand the historical disturbance patterns at a particular restoration site, as well as the current disturbances, and their influence on ecosystem composition and structure and ultimately on restoration goals.

A basic understanding of prairie, savannah, and woodland systems and their maintenance is an important foundation for interpreting site conditions and determining appropriate methods for implementing restoration.

3.2 Stand Dynamics in Savannah Systems: General Principles

The term "stand dynamics" generally refers to changes in forest stand structure[4] over time, including stand behaviour, during and following disturbances. Stand dynamics, therefore, encompasses natural processes and disturbances that affect the species and structure of an ecosystem that has a tree component.

Savannahs are broadly defined as tree-grass or woody-herbaceous communities and are characterized by the co-dominance of tree and herbaceous layers (Scholes and Archer 1997). These communities typically experience a drought season, which limits tree growth. Savannahs are generally classified as a state between open prairie or meadow and closed-canopy[5] woodland.

Savannahs are not simply prairies with trees. Pavlovic et al. (2006) found that the species composition in oak woodlands in Indiana was most strongly influenced by the amount of canopy cover rather than by other environmental factors, at least at a fine scale (at a broader level, soil productivity was the primary variable). Similar findings were obtained for oak woodlands and savannahs in California: vegetation in the understorey of oak savannahs and woodlands was different and more productive than vegetation in open grasslands. The oak understorey also reacted differently than vegetation in open grasslands to both the presence and removal of grazing pressure (Frost et al. 1997).

Savannahs are not simply prairies with trees.

A number of studies describe the encroachment of trees into savannahs, but the conditions that maintain savannah communities vary and are poorly understood (Sankaran et al. 2004); therefore, questions remain about how savannahs develop, how trees and the ground layer of vegetation interact, and how savannahs are maintained (Scholes and Archer 1997; Jeltsch et al. 2000). Descriptions of savannahs worldwide (including temperate North American savannahs) reveal a general pattern of transition into forest over the last 50–300 years (Archer 1989; Scholes and Archer 1997; Foster and Shaff 2003; Moore and Huffman 2004).

4 Stand structure refers to forest structure in terms of tree species and/or sizes of trees.

5 A closed canopy is created by sufficient shading by trees that have grown enough to fill any gaps that allow light to penetrate to the ground surface.

It is important to consider disturbance in light of your restoration goals, the current state of your restoration site, and potential effects of disturbance given the changed conditions.

Climatic and soil characteristics, fire, herbivory, biotic interactions, and human activity have all been identified as factors involved in this transitional process. Although there have been many attempts to create comprehensive models of savannah dynamics, the variability among sites means that a careful assessment of site-specific conditions is necessary before beginning restoration.

The process of forest encroachment has become an important management concern for North American savannahs (Arno and Gruell 1986; McPherson 1997). Encroachment can be divided into two categories: clump coalescence and gradual progression. Clump coalescence occurs when individual trees or shrubs establish in patches within openings, leading to further encroachment, whereas gradual progression occurs when woody vegetation slowly expands from the perimeter of openings. These two modes of forest encroachment have been described in field studies but have rarely been related to fire regimes and anthropogenic factors. For example, a study of forest progression in Africa indicates that increased anthropogenic fire frequency produces a shift from more rapid climate-driven clump coalescence to more gradual progression from the edges (Favier et al. 2004).

The configuration of a habitat patch in relation to adjoining habitat patches and the site's grazing history and topography have also been found to affect plant community composition (Foster and Tilman 2003; Hersperger and Forman 2003). Thus, when you look at a given savannah site to decide how stable it is, it may be important to look at the adjacent forested habitats for clues. The successional state of habitat patches and the level of contrast between patches and their surrounding landscape will typically result in unique patch dynamics and life forms, making generalizations difficult and potentially misleading (Watson 2002). When savannahs are fragmented and occur as patches within a matrix of forested and developed land, this increased patchiness may also result in an elevated rate of forest encroachment. Patterns of forest encroachment can also vary between nearby habitats due to local differences, including unique human land use history.

In general, evidence indicates that virtually all savannah ecosystems have had a long history of relatively frequent, low-intensity fires. In the past, many fires were started by lightning, but the landscape management activities of First Nations peoples were responsible for much of the regularity of the fire regime[6] across North America. European settlement has disrupted the fire regime in most locations. The predominant post-settlement pattern has been one of fire suppression[7] or complete fire exclusion. These changes in the disturbance regime have resulted in dramatic changes to the composition, structure, and function of savannah ecosystems. As

6 The term fire regime refers to the pattern of fire that occurs over time (e.g., the average interval between fires and/or fire severity when fires occur).

7 Fire suppression refers to active human intervention to prevent fires from occurring or at least restricting them to small areas through fire fighting activities.

expected, the precise role of fire, and the changes that have accompanied fire exclusion, vary among vegetation types.

Re-introduction of fire or simple introduction of another disturbance is not always an easy or effective solution to restoring savannahs. Savannahs that have historically been maintained by fire or other disturbance may experience increased invasion by alien species if disturbance is returned to the system, creating additional restoration difficulties. Re-introduction of fire in temperate grasslands often benefits many alien species, to the detriment of native ones (Agee 1993; Grace et al. 2001). It is important to remember that fire regimes within a given system may also vary between patches of similar habitat (Wardle 2002), thereby making it necessary to determine site-specific fire prescriptions. It is important to consider disturbance in light of your restoration goals, the current state of your restoration site, and potential effects of disturbance given the changed conditions (see Case Study 1 in Chapter 8).

3.3 Stand Dynamics in Oak Savannahs and Prairies in the Pacific Northwest

Savannah ecosystems are some of the most altered ecosystems worldwide, and much of North America's oak (*Quercus* spp.) savannah ecosystems have been lost to development. The encroachment of woody species into oak savannahs presents additional complications, since a current lack of adult oak recruitment has been observed in a number of different oak savannah and forest types (Russell and Fowler 2002; Brudvig and Asbjornsen 2005; Gedalof et al. 2006). Throughout North America, the observed decline in oak has been attributed to various factors, such as selective logging of oaks, catastrophic fires, fire suppression, poor seed production, seedling damage, shading and competition from other tree species and alien grasses, and chestnut blight in the eastern United States (Abrams 1992; Lorimer et al. 1994; McEwan et al. 2006). However, dendrochronological analyses of Garry Oak and Douglas-fir stand structures in British Columbia indicate that both tree species increased in abundance in coastal savannahs and prairies following European settlement (Gedalof et al. 2006; Smith 2007).

Factors involved in encroachment of conifers into savannahs are not well understood but links have been identified among fire suppression, increased deer browsing, and lack of oak recruitment in many oak forests and savannahs in North America. In some oak savannahs, conifers appear to be recruiting successfully, possibly as a result of increased oak establishment immediately following European settlement and the suppression of fire (Agee and Dunwiddie 1984; Peter and Harrington 2002; Gedalof et al. 2006; Smith 2007). In order to restore an oak savannah effectively, restoration practitioners need to understand both the processes that historically maintained the savannah and the processes and conditions that affect the current stand structure and regeneration.

In order to restore an oak savannah effectively, restoration practitioners need to understand both the processes that historically maintained the savannah and the processes and conditions that affect the current stand structure and regeneration.

Historically, fire was instrumental in inhibiting shrub and tree encroachment (including oak) into open prairies. It also maintained the open vegetation structure of oak savannahs and parklands.

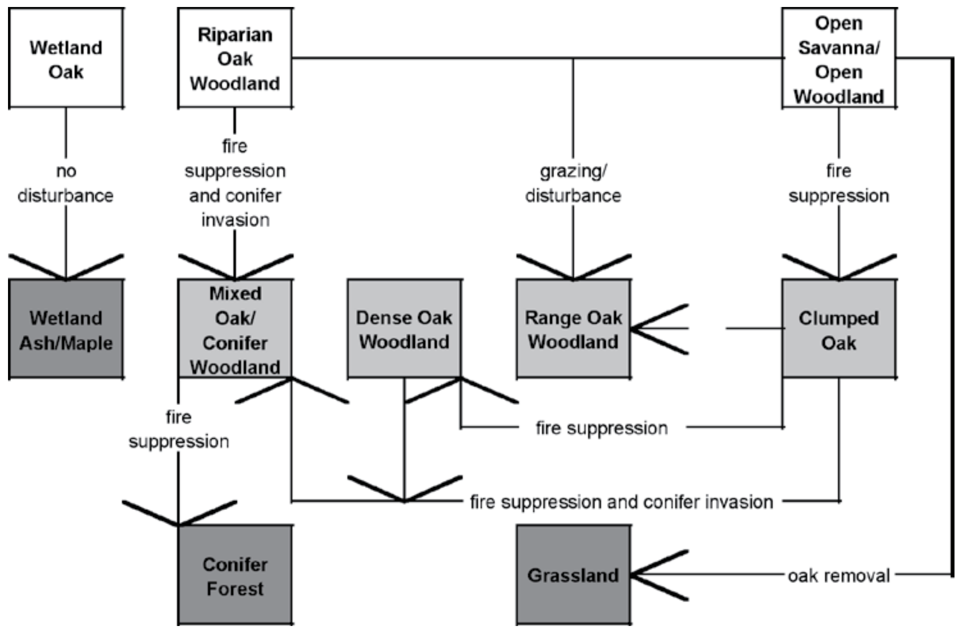

Figure 3.1 Stand development model of the impacts of different disturbance regimes, particularly fire suppression, on different types of Garry Oak woodland in the South Puget Sound area of Washington. Disturbance regimes are representative of those that have dominated the landscape since European settlement. Progression from white to light gray to dark grey boxes indicates a transition from historical oak to altered oak to non-oak habitats. Redrawn with permission from Hanna and Dunn (1996).

McCoy et al. (2006) studied historical Garry Oak ecosystems by examining charcoal and fossil pollen from lake sediments on Pender Island and Vancouver Island. Their work shows low fire activity prior to 1780 AD, increased fires between 1780 and 1860, and little fire activity after about 1940. Hanna and Dunn (1996) proposed a stand-development model that illustrates the impacts of post-European settlement disturbance regimes, particularly fire suppression, on different types of Garry Oak stands in the South Puget Sound area of Washington (Figure 3.1). This model shows changes occurring in many Garry Oak stands throughout the species' range.

Current stem densities within the stands are as much as an order of magnitude higher than they were at the time of European settlement (Hanna and Dunn 1996; Gedalof et al. 2006; Smith 2007). Fire stimulates oak sprouting but causes high seedling mortality; therefore, in the absence of fire, oak (and possibly conifer/maple) density increases, conifers establish in the understorey, and savannahs convert to conifer forests (Sugihara et al. 1987; Smith 2007).

Smith (2007) and Gedalof et al. (2006) studied tree ring chronologies, stand structure and recruitment, and understorey composition at representative Garry Oak ecosystem sites on Vancouver Island and the southern Gulf Islands. One common factor observed at B.C. sites was an increase in stand recruitment at the time of European settlement. This recruitment was most likely related to increased disturbance and/or disruption of land use and fire regimes at that time. Increased site disturbance resulted in increased opportunities for tree seedling establishment, and in the absence of repeated disturbance, these pulses of regeneration established dense woodlands and forests. Rates of forest encroachment varied considerably between sites depending on environmental conditions, land use history, fire history, or other natural disturbances at the site. All sites exhibited a high degree of conifer encroachment as a result of disturbance and land clearing activity concurrent with European settlement (except for those sites where encroachment was environmentally controlled, such as on exposed islets or steep slopes). Grazing/browsing pressure, exposure and/or salt spray, adjacent forest, slope, and soil type/depth influence encroachment patterns and rates in oak savannahs in B.C. For example, on Tumbo Island in the southern Gulf Islands, there is a clump coalescence pattern of encroachment, as well as heavy browsing by deer. Forest progression is slower than at sites with gradual forest progression because browsing pressure restricts conifer establishment. Otherwise, gradual forest progression is the typical form of encroachment that can be expected to occur in these Garry Oak sites, and the rate of encroachment is linked to browsing pressure, site disturbance, adjacent forest cover (and seed source), understorey vegetation type and density, and degree of canopy closure. Fire-maintained savannahs are much more likely to be more mesic, less steep, and have a deeper, more organic soil than environmentally maintained (e.g., shallow soil rocky environment) savannahs which are more likely to have harsher site conditions, and readily show impacts from herbivores (e.g., presence of alien invasive grasses, disturbed soil, and clipped vegetation).

Grazing/browsing pressure, exposure and/or salt spray, adjacent forest, slope, and soil type/depth influence encroachment patterns and rates in oak savannahs in B.C.

3.3.1 Role of Fire and other Environmental Controls and Site Conditions

What do we Know about the Historical Role of Climate, Fire, and First Nations Management?

Burning by aboriginal peoples is widely thought to have had an important influence on the composition and structure of Garry Oak communities (Tveten and Fonda 1999; Thysell and Carey 2001). Fire history, dynamics, and effects within Garry Oak and associated prairie and mixed forest ecosystems have been studied throughout the Pacific Northwest from California to British Columbia. These studies have documented the ubiquitous use of fire by First Nations peoples prior to European settlement.

Charcoal in sediment cores taken on southeastern Vancouver Island indicates that fire activity gradually increased between 11,500 and 10,000 ybp[8], presumably as a result of warming, high-intensity storms and lightning strikes. The sediment cores further indicate that between 10,000 and 7000 ybp, fires were more frequent and not stand-replacing, and were most likely the result of drier conditions at that time. Charcoal levels dropped between 7000 and 4000 ybp at lowland sites as the climate again grew moister. However, at about 2000 ybp, fire activity increased at several sites, even though the climate continued to moisten and cool. This increase in fire activity is attributed to burning by First Nations peoples (Brown and Hebda 2002).

The functions of First Nations management activities varied from place to place, but for the most

8 ypb = years before present.

part were associated with directly enhancing important food resources such as camas, berries, and Bracken Fern (*Pteridium aquilinium*), improving the ease of capture or collection of game or other resources (such as deer), or making travel across land easier (Agee 1993; Anderson 2007). It has also been reported that burning was done to reduce the prevalence of insect pests and disease (Anderson 2007). The precise characteristics of the fires are largely unknown, but historical accounts and tree ring analyses indicate that they were ignited in late summer and fall, burned frequently, perhaps annually in some places, and covered large expanses of the landscape. This regular fire regime prevented the build up of fuels; consequently, fires were generally flashy and of low intensity, and were carried quickly through the landscape by the dry herbaceous understorey. Tree ring analyses at several Garry Oak savannah sites in B.C. indicate that, historically, the landscape had less tree cover and regular low-intensity fires (Smith 2007). Historical descriptions of B.C.'s Garry Oak ecosystems during and after European settlement support these findings and suggest that the landscape was a mosaic of vegetation types, determined mainly by topography, soil depth, and fire (see Chapter 2). This mosaic would have consisted of varying patch sizes from small rocky outcrops to large, deep-soil savannahs (MacDougall et al. 2004). Pollen analysis of soil profiles confirms the mosaic nature of the vegetation (McDadi and Hebda 2008).

Tree ring analyses at several Garry Oak savannah sites in B.C. indicate that, historically, the landscape had less tree cover and regular low-intensity fires.

First Nations peoples also introduced other disturbances to savannahs and prairies. In particular, the cultivation of camas and other bulbs is believed to have played an important role in maintaining an abundance of forbs in Garry Oak and associated ecosystems. First Nations peoples actively dug and sowed bulbs and corms, thereby practicing a form of tillage that aerated the soil and encouraged forb growth (Turner 1999; Anderson 2007).

Fire exclusion has been described as the most serious ecological problem facing remnant Garry Oak stands that are protected from development.

The effects of fire exclusion, which began after European settlement around 1850, are important to consider. Fire exclusion has been described as the most serious ecological problem facing remnant Garry Oak stands that are protected from development (Sugihara and Reed 1987; Agee 1993; Hanna and Dunn 1996). Disturbance by fire allows Garry Oak woodlands to persist in deeper

Pellow Islet is an example of a small islet where shallow soils, wind, and salt spray restrict vegetative growth. Photo: Emily Gonzales soil sites that would otherwise succeed to conifer forest. Large-scale conversions of prairie and oak savannah to forest have been documented in California, Oregon, Washington, and British Columbia. Estimates indicate that up to 50% of all Garry Oak woodlands that are suitable for conifer establishment might be lost within 30 years (Agee 1993).

Some Garry Oak communities are maintained through a combination of abiotic conditions, such as precipitation and soil characteristics, rather than through disturbance such as fire.

Aboriginal burning, however, may not have been a factor in maintaining all oak savannahs. Agee and Dunwiddie (1984) identified a fire rotation of approximately 80 years on Yellow Island in the San Juan Islands. Shrub and tree invasion on this island is thought to be linked to above-average summer precipitation rather than to a change in the fire regime. Conifer encroachment was also not an issue at some sites in Canada's Gulf Islands, where forest development was restricted by environmental controls such as extremely well-drained or thin soils, steep slopes, and exposure to wind or salt spray (Figure 3.2 and 3.3) (Smith 2007). Soils in Garry Oak ecosystems in B.C. are often shallow or have excessive drainage (Roemer 1972, 1993), and are often nitrogen poor, which reduces competition from other native species. It is important to note that some Garry Oak communities are maintained through a combination of abiotic conditions, such as precipitation and soil characteristics, rather than through disturbance such as fire.

Effects of Prescribed Fire and Fire Surrogates on Garry Oak Ecosystems

Prescribed fire is in use as a restoration tool in Garry Oak and associated prairie ecosystems at a number of locations in California, Oregon, and Washington. The use of prescribed burning is only at an early, experimental stage in Garry Oak ecosystems in B.C. Most often, prescribed fire requires the prior manual removal of ladder fuels, such as shrubs, and may require the removal of woody debris and thatch, depending on site conditions. Additionally, individual trees may need to be manually removed to achieve the desired stand density. *A Practical Guide to Oak*

Figure 3.2 Krummholtz oaks on an islet in the southern Gulf Islands, subject to salt spray and wind. Photo: Brian Reader

Figure 3.3 Extremely steep slopes can be environmentally maintained as open savannah or prairie. Photos: Shyanne Smith

Release (Harrington and Devine 2006; www.fs.fed.us/pnw/pubs/pnw_gtr666.pdf) provides an introduction to the release of oak stands.

Fire surrogates are also used when the use of fire is not practical or desirable. Surrogates include mowing and raking or other manual removal of vegetation or woody material. A study in a savannah dominated by alien perennial grasses (Kentucky Bluegrass, (*Poa pratensis*) and Orchard-grass, (*Dactylis glomerata*)) in B.C. indicates that annual prescribed fire and fire surrogates were similarly effective in controlling the alien invasive grass species and encouraging perennial forb species over a five year period (MacDougall and Turkington 2007) (See Case Study 2 in Chapter 8). However, assessment of manual disturbance (thinning) of oak woodlands in Oregon after four to seven years found that the single treatment resulted in increased annual species cover, including a doubling of alien annual grass cover, and a decrease in native perennial species (Perchemlides et al 2008). These findings illustrate the need for ongoing management and site-specific research and monitoring.

Once a savannah converts to forest, it becomes increasingly difficult to successfully implement prescribed fire, or otherwise restore the ecosystem to a savannah state. The benefits of using fire as a restoration tool also vary due to complications such as the responses of invasive species to fire and altered species composition (see Section 3.3.2 below, and Chapter 9: Alien Invasive Species). In addition, prescribed fire alone, even over multiple years, can result in increased woody understorey cover due to widespread sprouting from tree bases and stumps (Chiang et al. 2005). Prescribed fire should be considered as a potential restoration tool, to be used in conjunction with other restoration techniques, including invasive species removal, re-introduction or enhancement of native species, litter removal, and stand and/or soil modification.

Once a savannah converts to forest, it becomes increasingly difficult to successfully implement prescribed fire, or otherwise restore the ecosystem to a savannah state.

Experimental prescribed fire at Cowichan Garry Oak Preserve (see Case Study 2 in Chapter 8). Photo: Tim Ennis

Timing

The frequency and timing of burns or surrogate management activities are important considerations for restoration and management. High-frequency burning (three or more times per decade) can prevent development of an oak sapling layer and canopy infilling, while low-frequency burning (less than two fires per decade) can produce stands with dense thickets of saplings (Peterson and Reich 2001); however, the optimal timing and frequency of prescribed burning of Garry Oak stands in B.C. are largely unknown. Given the summer drought period that Garry Oak ecosystems in B.C. experience, fires would likely have historically occurred between July and October, and would have been set after camas harvesting was completed and most vegetation had senesced. Fires likely occurred patchily across the landscape, creating a mosaic of different communities and stand structures.

Timing prescribed burns or similar treatments (cutting and raking or weeding) for mid-summer, when alien invasive grasses are at their reproductive peak, was found to be dramatically more effective in controlling alien invasive grass abundance.

Effects on Plant Species

The effects of fire on herbaceous vegetation are not limited to the inhibition of woody shrubs and trees. Different species of plants respond differently to the changes in temperature, litter, soil moisture, soil chemistry, microclimate, and soil biota that are caused by fire, and they exhibit varying levels of vulnerability to direct damage (Daubenmire 1968). Fire-adapted forbs and grasses that evolved and persisted in these ecosystems possess various structural adaptations (e.g., they are capable of dying back to living tissues near or below the ground surface) and life history strategies (e.g., late summer die-back of above-ground parts) that enable them to tolerate frequent, low-intensity fires. Bulb and rhizome-forming species, and species with fire-adapted seed strategies, tend to be favoured by fire (Sugihara and Reed 1987). Timing prescribed burns or similar treatments (cutting and raking or weeding) for mid-summer, when alien invasive grasses are at their reproductive peak, was found to be dramatically more effective in controlling alien invasive grass abundance, compared to late season burns at the Cowichan Garry Oak Preserve (MacDougall and Turkington (2007).

A study in Oregon found that four to seven years after fuel-reduction thinning treatment (cutting and chipping or cutting and pile-burning), native annual species had expanded more than other functional groups, particularly when a seed source was available (Perchemlides et al. 2008). These native annuals included species of *Clarkia*, *Epilobium*, *Lotus*, and *Plagiobothrys*. Several species in these genera are rare in our B.C. Garry Oak ecosystems. The results of this study demonstrate the need for careful restoration plan design. If your goal is to restore, for instance, a population of a rare annual, you may decide to implement manual fuel-reduction treatments that open the canopy and create soil disturbance. If your goal is to restore native perennials, you would instead likely choose methods which would create less soil disturbance, while still removing canopy or thatch, such as cutting and raking and/or low-intensity prescribed burning during the dormant season of the target perennial.

Effects on Plant Communities

Plant community responses to fire and fire surrogates are complex due to competitive interactions among resident species, and many other factors, including microhabitat, weather, seasonality

SOIL DISTURBANCE AND RARE ANNUALS


Photos: Shyanne Smith

GOERT members discuss the role of disturbance in creating a carpet of a Threatened annual, Macoun's Meadowfoam (*Limnanthes macounii*), that appeared after plowing of a firebreak (Left photo). A surprising find, it is thought that individuals of this species had persisted at low, undetected numbers in a small vernal seep area. When the firebreak was cleared, the disturbance created conditions needed for the population to expand. Soil disturbance has also been observed to be important for several other rare annual forbs. Soil disturbance by feral goats at the site of the largest population of another rare annual, Slender Popcornflower (*Plagiobothrys tenellus*), is also thought to have played a key role in the persistence of the species (Right photo).

and frequency of burning or disturbance, and fire or other disturbance intensity. A compilation of responses of numerous species to fire is available in the Fire Effects Information System (www.fs.fed.us/database/feis). There are also several resources available from the USDA Forest Service that summarize the effects of wildland fire on flora, fauna, soils, water, air, and alien invasive plant species. The effects of re-introducing fire or other disturbance in the presence of alien invasive plants, particularly grasses, is a concern because many of these species are well-adapted to disturbance and are able to establish in disturbed areas more rapidly than native species. See Section 3.3.2 for more information on alien invasive plants. Care must be taken to ensure that fire, or similar disturbance is applied during the reproductive peak of these grasses and after native vegetation has senesced. Fire, or other disturbance, as a restoration tool was found to most effective where native flora was already present (MacDougall and Turkington 2007; Perchemlides et al. 2008). Native seed addition following burning may be beneficial, or even necessary, in more degraded sites.

Effects on Animals

Faunal responses to fire and other disturbance have received considerably less attention than has plant responses. The Fire Effects Information System (2011) provides some information about responses of a number of vertebrate species to fire, including some species found in Garry Oak and associated ecosystems in B.C. The responses of vertebrates to a given frequency of burning depend largely on how fire impacts vegetation structure. For example, animals that are associated with grasslands and other open ecosystems tend to benefit from a frequent fire regime. Many species, in fact, rely on fire or other disturbances for the maintenance of their habitats. However, some grassland species are favoured by conditions that immediately follow a burn, while others do better under conditions that occur a few years later (Clark and Kaufman 1990; Johnson 1997). Fire also creates standing dead and downed wood, which favours species that depend on these habitat elements (e.g., Western Bluebird [*Sialia mexicana*] and Lewis's Woodpecker [*Melanerpes lewis*]). These and other birds that rely on coastal prairie and oak savannahs have declined or become extirpated from the region (Huff et al. 2005; GOERT 2002). Temporal factors, such as the seasonality of burning, are also important in determining the effects of fire on animals. For example, direct mortality or disruption of breeding may occur if burning happens during critical periods in an animal's life cycle (Cavitt 2000).

> A compilation of responses of numerous species to fire is available in the Fire Effects Information System (www.fs.fed.us/database/feis).

Like vertebrates, invertebrate species vary in their response to fire. Some invertebrates are favoured by conditions that immediately follow a burn, whereas others do better a few years later. In contrast to highly mobile vertebrates, invertebrates are more vulnerable to direct fire-caused mortality (Nicolai 1991; Swengel 1996; Siemann et al. 1997). Because fire suppression has caused increased fuel loads in most places, fires tend to burn hotter than they did historically, thus increasing mortality risk. Maintaining populations of invertebrates that are vulnerable to fire-caused mortality but depend on fire-maintained ecosystems requires a staggered burning strategy, such as rotating burns among portions of the site (U.S. Fish and Wildlife Service 1984; Schultz and Crone 1998). Thus, management must incorporate not only the disturbance process itself, but variation in time and space to support a complex of species over time. Habitat patches in fragmented landscapes must be large enough to accommodate such complex disturbance patterns.

Research and Monitoring

Experimental work is currently being undertaken to learn more about fire, including the use of prescribed fire, in Garry Oak and associated ecosystems in B.C. The Nature Conservancy of Canada and Andrew MacDougall of the University of Guelph have led this research at the Cowichan Garry Oak Preserve near Duncan B.C. (see Prescribed Fire case study (2) in Chapter 8). The Fire and Stand Dynamics Steering Committee (www.goert.ca/about_fire_stand_dynamics.php), operating under the Restoration and Management Recovery Implementation Group of GOERT, is also working to design and implement the use of techniques to manage stand structure, promote awareness about woody encroachment and management by land managers, and further fire and stand dynamics research.

In general, the use of prescribed fire has been found to reduce the cover of alien invasive herbs in California (Sugihara and Reed 1987; Hastings and Barry 1997) and to suppress C3 grasses[9] (including native species) and increase growth and reproduction of some native forbs here in B.C. There have been mixed results, however, at Fort Lewis (Tveten 1997; Tveten and Fonda 1999), Mima Mounds (Schuller 1997), and Yellow Island (Dunwiddie 1997) in Washington. These results underscore the need for caution in applying prescribed fire. Potential sites must be carefully assessed, and burning or other disturbance should be used within an adaptive management framework, in which management actions are applied experimentally, results are monitored, and management is refined according to the results obtained. See Chapter 7 (Inventory and Monitoring) for further information on adaptive management methods.

Potential sites must be carefully assessed, and burning or other disturbance should be used within an adaptive management framework, in which management actions are applied experimentally, results are monitored, and management is refined according to the results obtained.

3.3.2 Disturbance and Alien Invasive Species

Controlling Invasive Species with Fire or Other Disturbance

Fire can be effective in controlling some invasive alien species, such as Scotch Broom, if repeated over a number of years (Dunn 1998). However, other invasive species in Garry Oak ecosystems in British Columbia can be favoured by fire. MacDougall has been studying the effects of fire and invasive grasses on plant diversity in a deep-soil Garry Oak savannah for a number of years. His research indicates that most annuals and other species that have rapid seed production and high seedling growth rates, and that quickly colonize disturbed areas, are favoured by disturbance, but some invasive alien grasses (such as some bluegrass species) actually fare best in the absence of disturbance in this system (MacDougall and Turkington 2004). Exotic bluegrass species are able to dominate in undisturbed systems due to their ability to tolerate reduced resource availability under intense competition. MacDougall's research has also demonstrated that native species are recruitment-limited in invaded Garry Oak ecosystems, meaning that their scarcity, compared to non-native species, may be a result of fewer available native plant seeds (MacDougall and Turkington 2006). In addition, available light appears to be the primary limiting factor for native forb growth. Removing biomass (including thatch and leaf litter) before alien grasses set seed has been shown to effectively increase growth of several native perennial forbs (MacDougall and Turkington 2007).

Invasive Plants

Little is known about the relationships among different understorey plant species and communities and the forms and rates of forest encroachment in savannahs. However, alien invasive plants can be considered a disturbance or something that changes the "ecosystem, community or population structure and changes resource, substrate availability, or the physical

9 C3 grasses: Grasses are divided into two groups, C3 and C4, based on their photosynthetic pathways for carbon fixation. C3 grasses are referred to as "cool season grasses" while C4 plants are considered "warm season grasses".

An example of an often-overlooked alien invasive that affects Garry Oak and associated ecosystems is the earthworm.

environment" (White and Pickett 1985). Research has demonstrated that savannahs are not simply "prairies with trees" (Leach and Givnish 1999), and that replacement of dominant native perennial grasses with alien annuals is associated with decreased oak recruitment (D'Antonio and Vitousek 1992; Gordon and Rice 2000). Other studies have shown that alien invasive grasses can alter nitrogen dynamics in the soil (Sperry et al. 2006). Scotch Broom, a nitrogen-fixer, has the potential to change ecosystem-wide resource supply and facilitate the growth of nitrogen-loving plants. It also generates large amounts of woody fuel that can support high-intensity fires, and in this way alters the natural disturbance regime. Gorse (*Ulex europaeus*) has similar characteristics and destructive potential as Scotch Broom, but to date is not as widespread in B.C. (Clements et al. 2001).

A strong link between invasion of alien species and rates and forms of tree recruitment or other ecosystem change has not been established. MacDougall and Turkington (2005) illustrate the importance of considering the presence and removal of alien invasive species in a functional ecosystem context. They examined whether alien invasive grasses could be considered the drivers or passengers of ecosystem change, and found at their study site that invasion by the dominant non-native grasses was likely a side effect of fire suppression rather than a result of superior competitive ability.

Invasive Animals

Plants are not the only invasive species that can affect stand structure and drive ecosystem change. Non-native Eastern Grey Squirrels (*Sciurus carolinensis*)consume acorns, and thus pose a threat as a competitor for this valued resource. Although they may help disperse oaks by caching acorns, they do not tend to transport acorns very far, and their habit of biting out the apical meristem at the tip of the acorn prior to caching it likely limits their role as dispersers (Fox 1982; Pigott et al. 1991; Fuchs 1998). Herbivores can also have a significant impact on stand regeneration and ecosystem composition (see Section 3.3.3).

An example of an often-overlooked alien invasive that affects Garry Oak and associated ecosystems is the earthworm. Most earthworms in B.C. are European introductions and are considered ecosystem engineers (Jouquet et al. 2006). On southeastern Vancouver Island and the Gulf Islands, native earthworms are generally absent (Marshall and Fender 1998); however, it is unknown whether they have always been sparse or absent, or if they have been displaced. Earthworms play an important role in ecosystem function as decomposers and in structuring and aerating soils (Speirs et al. 1986; Koss 1999). Changes in the nature or extent of earthworm activity can affect nutrient regimes, ecosystem productivity, and other ecosystem functions (Fuchs 2001).

3.3.3 Herbivory

Research conducted on the Gulf Islands and San Juan Islands shows that herbivory by deer limited the establishment, growth, survival, and reproduction of both seedlings and transplanted native forbs and shrubs, and that competition from alien plant species had relatively less impact (Gonzales and Arcese 2008; Gonzales and Clements 2010). It should be noted that this research was conducted on shallow soil sites, so the results may not be applicable to deep soil sites. Alien annual grasses were rarely browsed and increased with increasing ungulate density (deer

Exclosures around oak seedlings or other vegetation may be needed to control herbivory by deer. Photo: Shyanne Smith

and sheep). The volume of alien perennial grasses declined with herbivory, but their overall presence was unaffected by ungulate density (despite being preferentially foraged). An important implication from this research is that reducing ungulates, such as deer, which is necessary for the recovery of many native forbs, may also benefit alien perennial grasses (see also Chapter 8, Case Study 1).

Present densities of deer exceed historical levels (Gonzales and Arcese 2008). As a result of increased herbivory, less palatable species (e.g., alien grasses) have a competitive advantage. Reducing deer numbers alone may not result in an increase in native grasses and forbs, since alien perennial grasses may replace the alien annuals. Gonzales and Arcese (2008) found that deer prefer native forbs over most alien annual and perennial grasses, and they suggest that

Figure 3.4 Feral goats in steep open savannah on Saturna Island. Photo: Shyanne Smith

restoration practitioners will improve their success by controlling herbivore density. Where deer are abundant, herbivore pressure can be reduced through fencing, culling, or increasing deer alertness[10]. Fertility control, repellents, and habitat modification are alternatives to hunting in suburban communities, but the success of these approaches as long-term solutions remains uncertain (Gonzales and Arcese 2008).

> Herbivory can be used to reduce cover of alien perennial grasses by fencing restoration sites from fall to spring, when most native forbs are germinating and growing, then opening the sites to grazing during summer.

In addition to the abundant native Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*), introduced mammalian herbivores, such as goats (*Capra hircus*), sheep (*Ovis aries*), Eastern Cottontail rabbits (*Sylvilagus floridanus*), and domestic European rabbits (*Oryctolagus cuniculus*) also occur in Garry Oak and associated ecosystems throughout their range in B.C. Like other perturbations, these abundant herbivores can shift plant communities to new ecosystem states. Research has shown that in general, in the presence of increased herbivory, plant communities become homogenized, and change in structure and composition (Gonzales and Arcese 2008; Gonzales and Clements 2010). In this way, herbivory tends to encourage dominance by alien annual grasses, whereas protection from herbivory favours alien perennial grasses. Their research also suggests that herbivory can be used to reduce cover of alien perennial grasses by fencing restoration sites from fall to spring, when most native forbs are germinating and growing, then opening the sites to grazing during

10 Deer alertness is increased by hunting, noise-makers, predator presence, etc. Increased deer alertness results in more sporadic browsing, diluting the impact of deer on the site.

summer, after the native forbs have senesced. Grazing by sheep or goats can not only reduce biomass, but can also create bare soil sites for native annual species establishment (Smith, pers. observ.) (Figure 3.4).

It is important to note that cover of invasive alien flora does not necessarily increase with increased levels of herbivory, and protection from herbivory once alien invasive species have established will not automatically reduce the invasive vegetation. However, herbivory does tend to encourage dominance by alien annual grasses, whereas protection from herbivory favours alien perennial grasses. With the widespread abundance of deer and other herbivores throughout Garry Oak and associated ecosystems, isolated, small islets or other locations with low densities of herbivores may provide important reference sites for historical Garry Oak and associated plant community composition and structure (Gonzales 2008).

Other forms of herbivory that may occur on a site-specific basis should also be considered, such as herbivory by insects or other invertebrates. For example, Winter Moth (*Operophtera brumata*) and particularly Gypsy Moth (*Lymantria dispar*), can seriously defoliate oaks. The introduced European Black Slug (*Arion ater*) can also destroy seedlings, and has been reported to impact a number of rare plant populations, particularly those of Yellow Montane Violet (*Viola praemorsa* ssp. *praemorsa*) and Deltoid Balsamroot (*Balsamorhiza deltoidea*) (Fuchs 2001).

Diseases cause disturbance and facilitate plant succession by debilitating or killing a plant, thereby creating space or favourable conditions for other plant species.

3.3.4 Plant Disease

Plant disease has been defined as any interference with the normal functioning of a plant that results in disturbed or abnormal physiological action or the deterioration of any of its parts (after Hubert 1931). Disease is the result of the interaction of a disease agent, a host, and environmental factors. Diseases cause disturbance and facilitate plant succession by debilitating or killing a plant, thereby creating space or favourable conditions for other plant species. When planning an ecosystem restoration project, it is advisable to know about occurrence and incidence of diseases that are capable of causing major disturbance so that the risk of future damage can be assessed and appropriate measures can be taken to minimize risk.

Fungi, including those that cause disease, are normal components of ecosystems. Information on the classification and biology of fungi is provided on the Tree of Life website (www.tolweb.org/fungi).

The lists of fungi mentioned below (Table 3.1) which occur on native grasses, forbs, shrubs, and trees in Garry Oak ecosystems, were compiled from the Herbarium Collections Database and host-fungus index at the Pacific Forestry Centre (www.pfc.cfs.nrcan.gc.ca/biodiversity/herbarium/index_e.html) and the Pacific Northwest Fungi Database (http://pnwfungi.wsu.edu/programs/aboutDatabase.asp). Many of the native graminoids and shrubs, and most of the native forbs referred to in this publication, lack disease records in the databases. For example, no fungi are recorded on onion (*Allium* spp.) in Garry Oak ecosystems. In contrast, in the Pacific Forestry Centre herbarium there are 91 collections of 49 fungi on Garry Oak trees. Thus, it is evident that a systematic survey of disease has not been conducted in these ecosystems.

Table 3.1 Some frequently recorded or damaging diseases on graminoids, forbs, shrubs, and trees in Garry Oak ecosystems.

DISEASES OF GRAMINOIDS			
Host	**Plant part**	**Fungus**	**Type of damage**
Blue Wildrye (*Elymus glaucus*)	foliage	*Puccinia striiformis*	rust
	foliage	*Puccinia recondita*	rust
Alaska Oniongrass (*Melica subulata)*	foliage	*Erysiphe graminis*	mildew
DISEASES OF FORBS			
Host	**Plant part**	**Fungus**	**Type of damage**
Common Camas (*Camassia quamash)*	foliage	*Urocystis colchici*	smut
White Fawn Lily (*Erythronium oregonum)*	foliage	*Uromyces heterodermus*	rust
	foliage	*Ustilago heufleuri*	smut
DISEASES OF SHRUBS			
Host	**Plant part**	**Fungus**	**Type of damage**
Oceanspray (*Holodiscus discolor)*	stem	*Phellinus ferreus*	decay
	stem	*Hymenochaete tabacina*	decay
Hairy Honeysuckle (*Lonicera hispidula)*	foliage	*Microsphaera penicillata*	mildew
	foliage	*Hyponectria lonicerae*	leaf blight
Tall Oregon-grape (*Mahonia aquifolium)*	foliage	*Microsphaera berberidis*	mildew
Nootka Rose (*Rosa nutkana)*	foliage, fruit	*Phragmidium fusiforme*	rust
	foliage	*Phragmidium rosae-californicae*	rust
Common Snowberry (*Symphoricarpos albus)*	foliage	*Puccinia crandellii*	rust
	foliage	*Puccinia symphoricarpi*	rust
Red Huckleberry (*Vaccinium parvifolium)*	foliage	*Lophodermium cladophylum*	leaf spot
	stem	*Pucciniastrum goeppertianum*	witches broom
DISEASES OF TREES	**Plant part**	**Fungus**	**Type of damage**
Host	foliage	*Pucciniastrum sparsum*	rust
Arbutus (*Arbutus menziesii)*	foliage	*Coccomyces arbutifolius*	leaf spot
	foliage	*Coccomyces quadratus*	leaf spot
	foliage	*Diplodia maculata*	leaf spot
	branch/stem	*Fusicoccum arbuti*	canker
	stem	*Phellinus ferreus*	decay
	branch/stem	*Hymenochaete tabacina*	decay
Oregon ash (*Fraxinus latifolia)*	branch	*Cytospora* sp.	canker on twigs
Garry Oak (*Quercus garryana)*	foliage	*Taphrina caerulescens*	leaf blister
	roots/butt	*Armillaria gallica*	killing of roots, decay
	roots/butt	*Ganoderma* spp.	decay
	roots/butt	*Inonotus dryadeus*	decay
	stem	*Phellinus ferreus*	decay
	stem	*Hericium erinaceus*	decay
	stem	*Laetiporus gilbertsonii*	decay

Not all host-fungus records in the databases have been listed in Table 3.1. For shrubs and trees, host-fungus combinations that were recorded frequently or that are especially damaging are listed. For graminoids and forbs, the host-fungus combinations were the only ones recorded in the databases; they are included in the table to indicate the types of diseases that occur on these plant types.

Pathogens, Parasites, and Saprophytes

A pathogen is a biotic agent that causes disease. A parasite lives its whole life (obligate parasite) or part of its life cycle (facultative parasite) on living tissue, whereas a saprophyte lives on dead organic material. For example, in the Garry Oak ecosystem, rusts are obligate parasites on the foliage of several plants, *Armillaria gallica* is a facultative parasite on the roots of oak, and *Hymenochaete tabacina* is a saprophyte on decaying dead branches.

Detection, Diagnosis, and Assessment of Fungal Disease

DETECTION

Fungal diseases are recognized by the symptoms they cause in their hosts. Symptoms include declining amount of foliage, necrotic spots on leaves, cankers on stems, and decay in woody tissue.

DIAGNOSIS

Mycologists use symptoms and signs to determine the cause of a disease. The reproductive structures of fungi are used to identify the cause of the infestation; these vary from microscopic dots on leaves to mushrooms and large conks on the stem of trees. Knowing the cause helps determine the type and amount of damage that can be expected and the kind of remedial treatment that might be applied.

ASSESSMENT OF DAMAGE

The amount of damage caused by foliage pathogens can be estimated by determining the proportion of leaf area affected, and the proportion of leaves and plants affected. Damage to woody tissue by canker-causing fungi can be similarly estimated. Bole- and root-decaying fungi are difficult to detect unless there are external signs or symptoms. Fungal fruiting bodies

Figure 3.5 Whole tree failure of a 280-year-old Garry Oak caused by decay of its roots by *Armillaria gallica* and *Inonotus dryadeus*. Photo: Duncan Morrison

Figure 3.6 *Armillaria gallica* rhizomorphs on the surface of a Garry Oak root. The rhizomorphs are attached to the bark and are associated with small infections in the bark that will eventually coalesce into a large lesion. Photo: Duncan Morrison

Figure 3.7 A lesion at the soil line on a Garry Oak stem caused by *Armillaria gallica*. Wood behind the lesion was decayed by the fungus. The host has produced callus tissue at the margin of the lesion and a reaction zone (black line) in the wood adjacent to the *A. gallica* decay. Photo: Duncan Morrison

(mushrooms and conks) on the bole or at the soil line, and suspect characteristics, such as lesions and wounds, are indicators of internal decay in the bole or roots. The diameter and length of a decay column in the bole or the proportion of structural roots decayed can be determined with an increment borer or resistograph instrument. Removal of soil by hand or with an air spade by trained personnel permits examination of the major roots for lesions and signs of fungi, such as rhizomorphs or decay.

Diseases of Graminoids

The diseases recorded for the two graminoid species in the Pacific Forestry Centre database were caused by rusts and a mildew (Table 3.1). These fungi require specific environmental conditions for infection to occur. It is unlikely that these conditions will occur every year, so although plants may be stressed, it is unlikely that they will be killed.

Diseases of Forbs

Two smuts and a rust have been recorded on species of Liliaceae (Table 3.1). As with the grasses, the risk of mortality is low.

Diseases of Shrubs

Most of the diseases of important shrub species are caused by rusts and mildews (Table 3.1). The risk of mortality is low.

Diseases of Trees

A number of wood decay fungi have been reported on both Arbutus (*Arbutus menziesii*) and Garry Oak (Table 3.1). Several of these, especially *Armillaria gallica, Inonotus dryadeus* and *Ganoderma* spp. are responsible for whole tree failure (Figure 3.5) and *Laetiporus gilbertsonii* for

Figure 3.8 Mushroom of *Armillaria gallica* attached to the base of a Garry Oak tree. Photo: Duncan Morrison

failure of large branches. It is common to find more than one of these fungi in trees that have failed. Characteristics of the diseases they cause are described below. Fungi that cause brown rot decay preferentially remove cellulose and hemicellulose from wood, leaving a brittle matrix of modified lignin. In contrast, fungi that cause white rot decompose lignin and cellulose. Some of the diseases that cause significant disturbance to Garry Oak and Arbutus are described below.

DISEASES THAT CAUSE SIGNIFICANT DISTURBANCE TO GARRY OAK TREES

Armillaria root disease

Four species of *Armillaria* are known from the range of Garry Oak in southwestern B.C.: *A. ostoyae, A. sinapina, A. nabsnona*, and *A. gallica* (Morrison et al. 1985). All four species could occur in Garry Oak ecosystems, especially in moist ecosystem classification units. *Armillaria ostoyae* is a virulent primary pathogen, mainly of conifers. *Armillaria sinapina* and *A. nabsnona* are pathogens of low virulence that are usually found on stressed, woody angiosperms.

Armillaria gallica has a circumpolar distribution, and in southwestern B.C., *A. gallica* is associated primarily with broad-leaved tree species, including Bigleaf Maple (*Acer macrophyllum*), Garry

Figure 3.9 Sporophore of *Inonotus dryadeus* at the base of a Garry Oak stem. The current year sporophore is above that of the previous year. Photo: Conan Webb, Parks Canada

Figure 3.10 Sporophore of *Ganoderma* sp. at the soil line on a Garry Oak stem. Photo: Chris Paul

Figure 3.11. Sporophores of *Laetiporus gilbertsonii* on a Garry Oak stem. Photo: Dave Gilbert

Figure 3.12. Stem canker caused by *Fusicoccum arbuti* on arbutus. Photo: Brenda Callan, NRCan

Oak, Paper Birch (*Betula papyrifera*), Red Alder (*Alnus rubra*), and hawthorn (*Crataegus* spp.). This fungus is common in Garry Oak ecosystems, especially in moist ecosystem classification units, and is often associated with whole tree failure of oak. The fungus spreads from colonized wood through soil by root-like strands called rhizomorphs (Figure 3.6), or at contacts between a healthy root and colonized wood. The fungus invades, decays and kills bark tissue and root wood (Figure 3.7). Rhizomorphs spread the fungus throughout a root system, and over many years most structural roots can become decayed and can be killed. From mid-October to mid-November, diseased trees can be recognized by the presence of mushrooms at the base of the stem or on the ground around the tree (Figure 3.8).

Inonotus dryadeus

Inonotus dryadeus is found throughout much of North America, primarily on oaks and other hardwoods. This species causes a mottled white rot of the roots and root crown of both living and dead trees. Infections reportedly begin in the roots and spread into the root crown, but decay does not extend much above ground level. Fruiting bodies are annual, but old basidiocarps may persist for several years. They develop near the base of the trunk or from roots below the soil surface (Figure 3.9). Basidiocarps vary in size, but can be large, up to 50 cm wide. Fresh basidiocarps are yellowish to brownish above and may be covered with drops of amber liquid; hence, the common name "weeping conk". The lower surface is buff with fine circular to angular pores (4–6 per mm). Basidiocarps eventually become brown to black and cracked. Trees with *I. dryadeus* fruiting bodies have substantial amounts of root decay and an elevated risk of wind-throw (Swiecki and Bernhardt 2006). This fungus is implicated in whole tree failure of Garry Oak.

Ganoderma spp.

One or more species of *Ganoderma* cause decay of Garry Oak in southwestern B.C. Sporophores occur on the stem at or near the soil surface (Figure 3.10); there is often an old basal wound associated with fruit bodies. Extensive decay in the lower bole and roots of mature trees has resulted in whole tree failure. Work is needed on the taxonomy of the species on Garry Oak, their biology, and the hazard associated with the presence of conks on trees.

Laetiporus gilbertsonii (syn. *L. sulphureus*)

Laetiporus gilbertsonii causes brown cubical decay of *Quercus* spp., including Garry Oak, along the Pacific coast of the United States from California to Washington, and probably into southern B.C. Recently, molecular techniques and mating incompatibility were used to examine collections of *L. sulphureus sensu lato* from North America (Burdsall and Banik 2001). Based on those results, two new species were described from western North American collections: *L. conifericola* from conifers and *L. gilbertsonii* (Figure 3.11) from oak and eucalyptus. The fungus causes brown rot in stems and branches, having entered the tree through pruning wounds or broken branches.

The fungi that cause diseases are native components of the ecosystem.

DISEASES THAT CAUSE SIGNIFICANT DISTURBANCE TO ARBUTUS

Fusicoccum arbuti (syn. *Natrassia mangifera* and *Hendersonula toruloidea*) has a broad geographic and host range and causes stem canker (Figure 3.12), but in B.C. it has only been recorded on Arbutus (Hunt et al. 1992). Weakened or stressed trees, especially those near the ocean, appear to be susceptible to the disease. Infection of Arbutus bark by spores likely occurs through tissue damaged by winter injury, sunscald, or mechanical wounds. The first symptoms are areas of discoloured and killed bark, which become sunken, and later slough off. A perennial canker is formed with callus tissue surrounding the areas of dead bark. Small branches may be killed by girdling.

Cultural Practices and Remedial Measures

Should we consider modifying cultural practices or introducing remedial measures to reduce the effects of diseases on plants in Garry Oak ecosystems? The fungi that cause diseases are native components of the ecosystem, so for most of the diseases listed above, the answer is “no”. Foliage diseases caused by rusts, smuts, and mildew have little or no long-term impact on the plants because foliage is deciduous, and incidence of disease varies from year to year. Similarly, saprophytes such as *Hymenochaete tabacina* and *Fuscoporia ferrea*, which decay stems and branches that are dead due to suppression (shading), are of little consequence.

In contrast, fungi that decay the wood of roots, stems, or large branches of Garry Oak rarely kill trees but can predispose branches, stems, or whole trees to failure. Usually, these fungi cause detectable disease and failure in trees older than 100 years, although younger trees can become diseased. Except for *A. gallica*, which can colonize and kill root tissue, most fungi require a wound through which their spores can colonize the wood. Wounds are created by pruning branches and mowing machines, and possibly by ground fires. For sites where protection of existing trees is desirable, managers should avoid creating wounds (wound dressings do not prevent colonization by decay fungi). Diseased trees should be monitored, hazardous ones should be removed, and new trees should be planted if required.

3.3.5 Climate Change and Garry Oak Ecosystems

Ecological restoration must address the effects of climate change. Broadly speaking, we can expect changes in weather patterns, including more extreme climatic events, higher temperatures, and changes in precipitation patterns, along with increases in sea level (Harris et al. 2006).

Restoration practitioners need to consider how species ranges may shift under climate change, what new plant communities may form given the unprecedented changes, and how genetic variability should be incorporated into restoration design.

Given the current fragmented and degraded state of most Garry Oak ecosystems, we need to be aware of the potential for climate change to impact these ecosystems over time.

In the context of Garry Oak ecosystems and their restoration, climate change could be seen as a mixed blessing. On one hand, an ecosystem that is generally favoured by warmer and drier conditions than today would seem to be favoured by predicted changed conditions (many of the Garry Oak and associated ecosystems described in this publication may be favoured by warmer and drier conditions). On the other hand, rapid and dramatic climatic change is intensely disruptive to established ecosystems and will most likely result in extirpation (or extinction) of some species. In addition, atmospheric CO_2 concentrations may have a role in maintaining savannah systems. This may be contributing to in-growth of woody vegetation in savannah openings and can be expected to increase with ongoing climate change (Bond and Midgley 2000).

Looking to the Future—Clues from the Past

Historical conditions should not be regarded as a blueprint for our restoration designs, but rather as a reference or guide to be used to help us set restoration goals or targets (see Section 8.2). Our understanding of historical conditions also highlights the importance of restoring Garry Oak ecosystems in Canada. Two lines of evidence strongly suggest that Garry Oak and associated ecosystems, in general, are likely to expand their range in Canada as the climate warms. Studies of fossil pollen from a Saanich Inlet core (Pellatt et al. 2001) reveal that dry meadow ecosystems in the area (with *Camas* spp. as an element) were much more widespread than today under warm, dry climates about 8000 years ago. Once Garry Oaks arrived in our region 8000-7000 ybp, they became widespread and abundant along the southeast side of Vancouver Island. For example, extensive stands likely occurred in the Cowichan Valley at that time. They seem to have become particularly common about 6000 years ago as the climate remained warm but moisture increased. Cooling and moistening climate reduced the range of the species and associated ecosystems after 4000 ybp, despite the use of burning practices by First Nations peoples (Brown and Hebda 2002).

Restoration efforts must consider the effects of climate change on ecosystem dynamics, and we must consider how our restoration sites fit into the broader regional landscape.

It is notable that some species that are exceedingly uncommon today in our region, such as Oregon Ash (*Fraxinus latifolia*), were much more common under the warmer climates of the past. This suggests that even rare species may have a more positive future as climatic conditions change, provided that they can survive in the region until the climate becomes more favourable to them. Keeping species at risk from extinction in the meantime will be a challenge because ecosystem changes due to climate change can be rapid and catastrophic, allowing little opportunity for migration and dispersal (Hebda 2004). Given the current fragmented and degraded state of most Garry Oak ecosystems, we need to be aware of the potential for climate change to impact these ecosystems over time.

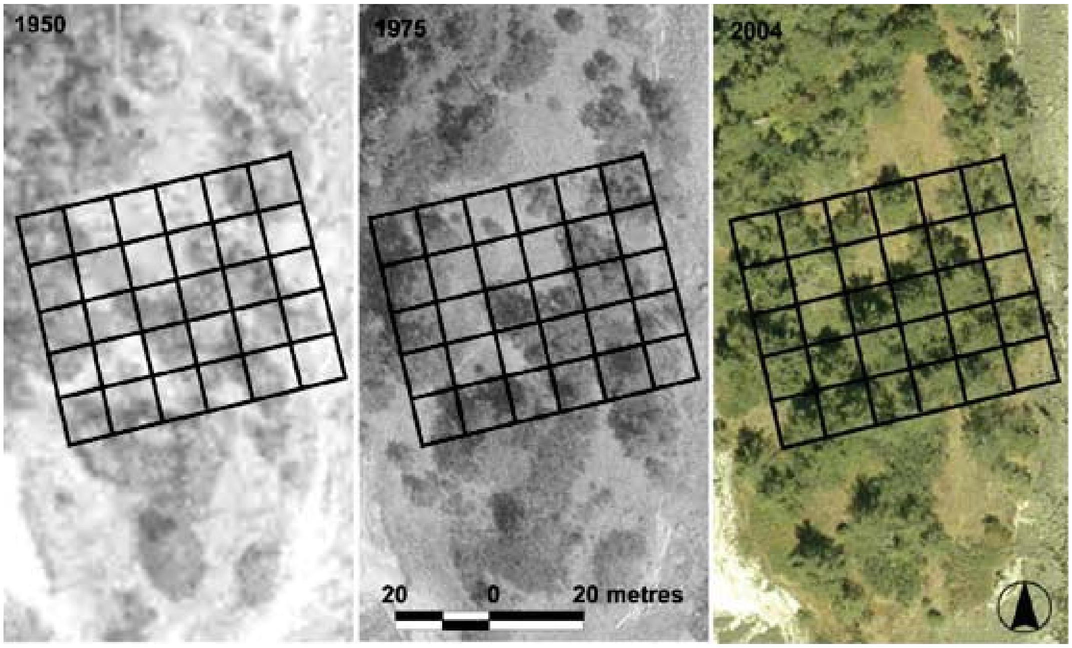

Figure 3.13 Using air photos to understand change in recent history. This series of images show a study plot (60x50 m) superimposed on air photos from 1950, 1975, and 2004 to show change in tree cover over time. Image: Shyanne Smith

Climate models that project the future extent of suitable climate for a species provide a strong second line of evidence that Garry Oaks and their associated species will have an opportunity to expand their range markedly. It has generally been accepted that the range of Garry Oak and associated ecosystems will begin expanding in B.C. under a warmer climate. However, recent bioclimatic modelling, based on a spatial model of climatic suitability for Garry Oak ecosystems and forecasted distribution of climate regions based on global climate models, indicates suitability for the current Garry Oak range will actually decrease in the near future (Bodtker et al. 2009). However, this modelling also indicates that the climate suitability will improve again later in the century. These results reinforce the need for active restoration and management of Garry Oak and associated ecosystems, and the need to take an experimental, adaptive management approach to restoration. Restoration efforts must consider the effects of climate change on ecosystem dynamics, and we must consider how our restoration sites fit into the broader regional landscape. By integrating model results with our understanding of past and current ecosystems, we can assess possible climate change impacts on, and adaptations of, species within Garry Oak and associated ecosystems, and prepare for change.

Collecting site-specific reference information is an important first step in restoration because it helps to define restoration goals and allows restoration efforts to be effectively evaluated.

Figure 3.14 Tree ring cores can be used to assess disturbance and changed conditions at a site over the life of the tree. Cores can be taken with an increment borer, mounted, sanded, and viewed with a microscope. Software that measures each annual tree ring is useful for accurately recording small variations in growth and creating site chronologies. Photo: Shyanne Smith

3.4 Summary of Restoration Considerations

3.4.1 Understanding Site History

Collecting site-specific reference information is an important first step in restoration because it helps to define restoration goals and allows restoration efforts to be effectively evaluated (see Chapter 7: Ecological Inventory and Monitoring). From a practical perspective, an understanding of the historical reference state can result in a restoration that is more likely to be self-sustaining and therefore easier and less costly to maintain (White and Walker 1997). Reference information includes not only baseline current conditions (climate, topography, soil, vegetative composition, and successional trends) but also any available historical data, ranging from historical accounts and photos (Figure 3.13) to legacies remaining on the landscape, such as woody debris and dendrochronological (tree ring) records (White and Walker 1997) and pollen profiles of soils (McDadi and Hebda 2008).

Understanding the ecological history of a site is important to its management and restoration, particularly when little is known about the historical stand structure, typical regeneration patterns, importance of environmental controls, and historical fire regimes. Given the widespread changes to vegetation and disturbance regimes in North American open-land habitats, it is unlikely that many present species assemblages closely resemble those that occurred prior to European settlement (Motzkin and Foster 2002). Using available methods of understanding site history (such as soil cores, tree ring study, weather instrument and historical accounts, photographs, long-term ecological monitoring, air photos, and even packrat middens), historical conditions can be reconstructed and used to provide context to inform management and restoration (Figure 3.13 and 3.14) (Swetnam et al. 1999; Kettle et al. 2000).

RESTORATION DESIGN TIPS

• Consider what impacts your restoration activities might have on the four fundamental processes governing ecosystems: water cycling, nutrient cycling, energy flow, and succession.

• What is the goal of your restoration? Are you restoring for a specific purpose such as for native annual forbs, or for grassland birds? What does current research suggest? For example, soil disturbance has been found to benefit several native annuals but not native perennials. Weigh the costs and benefits of restoration activities and identify specific objectives (see Chapter 5).

• Check into research already done (ask GOERT) and look for clues about your site's history in historical photos, writings or maps, old air photos, or tree rings. Look for cohorts (many trees of similar age), stumps indicating logging, fire scars on trees, or charcoal in the soil. Determine when any cohorts established, and when any logging, fire or other disturbance occurred.

• Check for environmental controls (filters): are shallow or extremely wet soils or exposure to wind or salt maintaining open prairie or savannah conditions? (See also Section 8.3.)

• Consider the three potential problems with re-introducing disturbances: the need to understand historical dynamics, that disturbances will not likely have the same results today as historically, and the high costs and risks of introducing disturbance into the modern landscape.

• Consider the effect of your timing of disturbance activities, as well as the effects on native and invasive plants and animals, and on plant communities.

• Assess deer abundance: is there an evident browse line (trees and shrubs heavily "pruned" within reach of deer)? Deer prefer native forbs over alien grasses—controlling herbivores will increase success toward achieving most restoration goals. Are there other herbivores to be considered?

• Assess plant diseases that may be present at your site. Is there a need to alter your restoration activities because of disease?

• Consider the effects climate change may be having on your site. How might climate affect your site in the next 50 years? 100 years?

• Assess the importance of your site in a regional context. How does it connect to other nearby sites? Are there important services it provides to these other sites? How does your restoration affect this?

3.4.2 Garry Oak Ecosystems Stand Dynamics and Disturbances

Communities constantly change: organisms die and are replaced by others; energy, water, and nutrients pass through ecosystems; and natural succession is always at work. Many of these changes are gradual so it appears that there is little change in community form and function. Other changes establish new conditions, and plant communities may thereby change in significant ways (e.g., succession, invasive species, and disease outbreaks). For instance, shrubs and trees may enter into meadow ecosystems and eventually give rise to thickets or forests. These changes may be limited by environmental factors. For example, wind and salt spray limit the growth of shrubs and trees on many maritime meadows close to the ocean, while shallow soils are so prone to drought that woody species grow poorly. Ecosystem disturbances, such as fires and windstorms, may reverse or stall succession. Many areas of Garry Oak woodland and associated meadows were maintained over long periods by fires that were deliberately used by First Nations to maintain good conditions for growing camas (an important food source) and hunting game. As other peoples settled in the area, fires were suppressed and fire-sensitive trees, shrubs, and herbaceous plants gradually invaded many meadow and woodland areas. The introduction of many alien invasive species into the region means that fire alone is likely to favour dominance by alien invasive plant communities rather than cause a return to the ecosystems that were maintained in the past by First Nations. See Case Study 1 in Chapter 5 for an example of restoration considerations for a site with unusual ecosystem processes.

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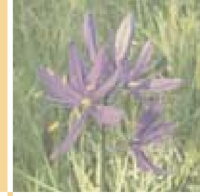


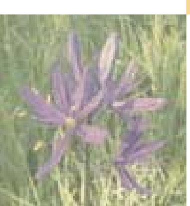
Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 4
Species and Ecosystems at Risk

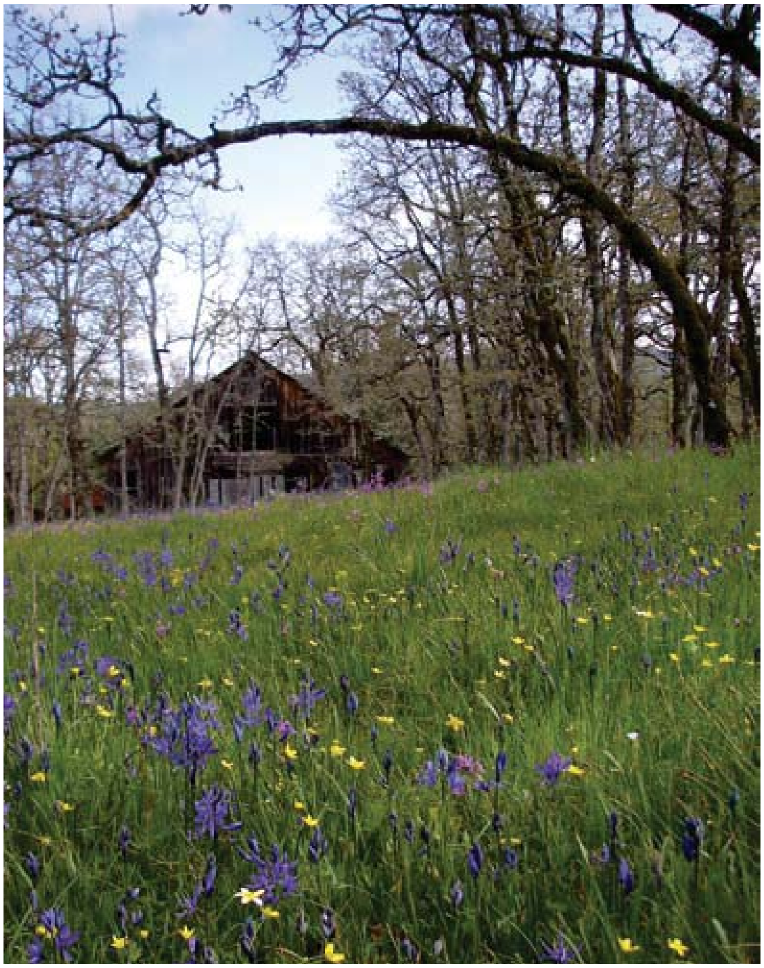
Contents



Chapter 4

Species and Ecosystems at Risk

by Kersti Vaino, in collaboration with Brenda Costanzo, Shyanne Smith, and Ted Lea



Garry Oak and associated ecosystems are highly biodiverse and have a disproportionately high number of species at risk. At least three species at risk are known and managed for at the Cowichan Garry Oak Preserve, one of the few remaining deep soil Garry Oak woodlands. Photo: Chris Junck

4.1 Introduction

Garry Oak and associated ecosystems have very high biodiversity and a disproportionately high number of species at risk compared to other ecosystems in British Columbia and Canada. Approximately 10% of the SARA-listed species at risk in Canada occur in Garry Oak ecosystems, and these ecosystems cover less than 2000 hectares (S. Smith, pers. comm. 2011). Garry Oak and associated ecosystems make up one of the most endangered ecosystems in Canada (T. Lea, pers. comm. 2009). It is important to conserve species and ecosystems at risk as they provide biodiversity, and many of these species occur nowhere else in Canada. Restoration practitioners need to be aware of all species and ecosystems at risk occurring on their site and carefully look for these prior to beginning any work. The purpose of this chapter is to provide guidance and direction on how to deal with these sensitive species and ecosystems during restoration.

The introductory section of this chapter defines species and ecosystems at risk. Section 4.2 lays out how these are protected under provincial and federal legislation, and discusses requirements for permits for restoration work, if necessary. Resources are provided in Section 4.3 regarding whom to contact for identifying and working with species at risk, as well as potential funding programs for the restoration of their habitats. The importance of identifying threats and defining recovery goals is also discussed. Section 4.4 discusses some common complications when it comes to restoring the habitats of species at risk, which should be taken into consideration. These include alien invasive species, hydrologic regimes, the timing of restoration, and translocations. Finally, monitoring requirements for the restoration of species and ecosystems at risk are discussed in Section 4.5.

4.1.1 Ranking Species and Ecosystems at Risk

Simply speaking, a species or ecosystem at risk is at risk of dying out or disappearing, either from a specific area (e.g., province or country) or from the world. In order to prioritize recovery actions, the level of risk needs to be determined for each species or ecosystem. In Canada, this ranking is done by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, www.cosewic.gc.ca) and provincially in British Columbia by the BC Conservation Data Centre (CDC, www.env.gov.bc.ca/cdc).

In Canada, risk status for species at risk is established by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent panel of experts. Provincially in B.C., the BC Conservation Data Centre ranks species at risk.

Species at risk are assessed and ranked by provincial, federal, and global authorities. Geyer's Onion (*Allium geyeri*) is a globally (G4G5) ranked and provincially Blue-listed species at risk that has not yet been assessed by COSEWIC. Photo: Chris Junck

COSEWIC is an independent panel of experts that advises the federal government on the status of species at risk (COSEWIC 2009a). The designations extinct, extirpated, endangered, threatened, special concern, not at risk, and data deficient (COSEWIC 2009b) are used to list species under the *Species at Risk Act* (SARA 2003). SARA establishes Schedule 1 as the official list of wildlife species at risk for those species designated extirpated, endangered, threatened, or special concern.

SARA does not include reference to ecosystems at risk but does permit a multi-species or ecosystem-wide approach to the recovery of listed species (GOERT 2007). As of 2010, there have been three multi-species recovery strategies prepared by GOERT, under SARA, for: Garry Oak woodlands (www.sararegistry.gc.ca/document/default_e.cfm?documentID=874); maritime meadows associated with Garry Oak ecosystems (www.sararegistry.gc.ca/document/default_e.cfm?documentID=873); and vernal pools and other ephemeral wet areas associated with Garry Oak ecosystems (www.sararegistry.gc.ca/document/dspDocument_e.cfm?documentID=875).

Taylor's Checkerpot (*Euphydryas editha taylori*) is an Endangered species (SARA Schedule 1) for which recovery planning is included in the multi-species recovery strategy for species at risk in maritime meadows associated with Garry Oak ecosystems. Photo: Andrew Fyson

SARA STATUS DEFINITIONS FOR SPECIES AT RISK IN CANADA

Extinct – a species that no longer exists anywhere in the world

Extirpated – a species that no longer occurs in the wild in Canada, but does occur elsewhere in the wild

Endangered – a species facing imminent extirpation or extinction

Threatened – likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction

Special concern – a species that may become threatened or endangered because of a combination of biological characteristics and identified threats

Not at risk – a species that has been assessed and found to be secure

Data deficient – not enough is known about the species to assess its status

The CDC assesses, ranks, and provides information on the status of species and ecological communities within the province of British Columbia. The CDC uses the NatureServe conservation status methodology to rank species and ecological communities (MOE 2007). Each entity is ranked both globally (G) and sub-nationally (S) on a scale of 1 (critically imperiled) to 5 (secure) (NatureServe 2009, www.natureserve.org). Based on these rankings, each entity is then assigned to either a *Red*, *Blue*, or *Yellow* List; the Red List is for those species at greatest risk, the Blue List for those at intermediate risk, and the Yellow List for those least at risk (MOE 2007).

As of 2011, there are 104 provincially-listed species at risk in Garry Oak and associated ecosystems and, of these, 55 are also listed federally (see Table 4.1) (GOERT 2011). The number of species listed federally will likely grow, as many species have not yet been assessed for listing under SARA. A current list (as of 2011) of all listed species at risk in Garry Oak and associated ecosystems is provided in Appendix 4.1 along with the Restoration Ecosystem Units (REUs) (see Chapter 2: Distribution and Description) for each species to assist restoration practitioners in knowing which species might occur on their site. Appendix 4.2 lists the species at risk potentially found in each REU.

There are currently 10 plant communities associated with Garry Oak ecosystems that are included on British Columbia's Red List; six more will likely be added to the Red List after assessment (C. Cadrin, pers. comm. 2009) (see Appendix 4.3). The CDC's ability to rank ecological communities is limited by the lack of available data (Fuchs 2001).

4.1.2 Why are These Species and Ecosystems at Risk?

Garry Oak and associated ecosystems are vanishing rapidly in British Columbia. Historically, their range in the province was limited within the already relatively small extent of the Coastal

THE BC CONSERVATION DATA CENTRE (CDC) PROVIDES AN IN-DEPTH DESCRIPTION OF BOTH THE RED AND BLUE LISTS.

The Red List "includes any ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in British Columbia. Extirpated elements no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered elements are facing imminent extirpation or extinction. Threatened elements are likely to become endangered if limiting factors are not reversed. Red-listed species and sub-species may be legally designated as, or may be considered candidates for legal designation as Extirpated, Endangered or Threatened under the *Wildlife Act* (see www.env.gov.bc.ca/wld/faq.htm#2). Not all Red-listed taxa will necessarily become formally designated. Placing taxa on these lists flags them as being at risk and requiring investigation (MOE 2010)."

The Blue List "Includes any ecological community, and indigenous species and subspecies considered to be of special concern (formerly vulnerable) in British Columbia. Elements are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed elements are at risk, but are not Extirpated, Endangered or Threatened (MOE, 2010)."

Table 4.1 Numbers of B.C.-listed and COSEWIC[a]-listed Species at Risk per taxonomic category within Garry Oak and associated ecosystems in 2011

	B.C. Listings		**COSEWIC Listings**			
Taxonomic Category	**Red**	**Blue**	**Extirpated**	**Endangered**	**Threatened**	**Special Concern**
Plants	51	19	1	30	4	4
Mammals		3				
Reptiles & Amphibians	2		1	1		
Birds	7	7		2	2	5
Invertebrates	7	8	1	3	1	
Totals	67	37	3	36	7	9
	104		**55**			

a- Committee on the Status of Endangered Wildlife in Canada

Douglas-fir biogeoclimatic zone (Chapter 2: Distribution and Description). It is estimated that less than 5% of the area covered by these ecosystems prior to European contact remains in a near-natural state today (Lea 2006). Habitat loss due to land conversion for agriculture and urban development is the primary cause of this alarming decline (GOERT 2002). Remaining Garry Oak and associated ecosystems are further threatened by habitat degradation and fragmentation, invasion by exotic species, and suppression of fire disturbance. Alien invasive species compete with native species and change the species composition of the ecosystem (Chapter 9: Alien Invasive Species), while suppression of fire alters ecosystem function (Chapter 3: Natural Processes and Disturbance). Climate change also impacts these ecosystems as changing weather patterns affect seasonal soil moisture patterns, the growth of alien species, and susceptibility to burning (GOERT 2002).

Land conversion is the primary threat to Garry Oak and associated ecosystems in B.C.; invasion by exotic species, habitat degradation and fragmentation, and fire suppression also play a role in their decline.

Many of the rare plant species and ecological communities occurring in Garry Oak and associated ecosystems are naturally rare (Fuchs 2001). The majority of them are endemic, meaning that they are found only in these ecosystems. These species are highly adapted to the unique conditions of these habitats, especially those found in such specialized habitats as seepages and vernal pools. It is this natural rarity combined with specialized habitat needs that makes many of these species particularly vulnerable to extinction. Political boundaries further add to the rarity of many of these entities in Canada, with their Canadian occurrences being at the very northern periphery of their ranges. Although they are uncommon south of the American border as well, many of these species are even less common in B.C. (Fuchs 2001).

Plants

In addition to these reasons for their natural rarity, many rare plant species are greatly threatened by habitat loss and fragmentation resulting from land conversion and management, including herbicide use (GOERT 2003a). Remaining populations are often damaged due to trampling and/or soil erosion. Many endemic species have adapted to the presence of soil moisture at key times in

Habitat loss is the primary threat to Bog Bird's-foot Trefoil (*Lotus pinnatus*), a Red-listed, Endangered species (SARA Schedule 1) that grows in seasonally wet meadows. The known occurrences of Bog Bird's-foot Trefoil in British Columbia are at the northernmost extent of the species' global range. Globally, this species is considered secure (G4G5). Photo: Chris Junck

their lifecycles; activities and invasive species that affect hydrological cycles can be devastating to these species. As the climate and resulting weather patterns change, further changes to hydrologic cycle become a key factor contributing to decline for some populations. Furthermore, many rare plants are grazed or browsed by both native and introduced fauna (GOERT 2003a).

Vertebrates

A number of vertebrates that were reliant on Garry Oak and associated ecosystems have become extirpated or endangered (Fuchs 2001). These include the Horned Lark *strigata* subspecies (*Eremophila alpestris strigata*), Vesper Sparrow *affinis* subspecies (*Pooecetes gramineus affinis*), Western Meadowlark (Georgia Depression population, *Sturnella neglecta*), Lewis's Woodpecker (Georgia Depression population, *Melanerpes lewisii*), and Western Bluebird (Georgia Depression population, *Sialia mexicana*) (Fuchs 2001). These species have been affected by rapid habitat loss, fragmentation, and degradation due to invasive plant and animal species, as well as insufficient food sources and loss of habitat elements such as tree cover, including large live trees and standing or downed dead wood (GOERT 2003a).

Invertebrates

Very little is known about most invertebrate species at risk associated with Garry Oak ecosystems, with the exception of several butterfly species (Fuchs 2001). Most of the invertebrate species at risk in these ecosystems are at risk due to loss of food sources and suitable habitat (GOERT 2003a). Moist meadow areas preferred by butterflies are being destroyed by urban development and heavy grazing or are being overgrown by invasive shrubs and grasses. Leaf litter, often providing shelter for overwintering pupae, is frequently cleared from the bases of oaks in residential areas. Butterfly populations are also affected by pesticide use, predation by pets, and the introduction of parasites from other introduced species such as the Cabbage White Butterfly (*Pieris rapae*) (GOERT 2003a).

4.2 Legislation

4.2.1 Legislated Protection of Species and Ecosystems at Risk

This section describes only federal and provincial legislation for the protection of species at risk. There are additional potential methods of legal protection for species at risk at the municipal level through the *BC Community Charter*, the *Local Government Act,* and the *Land Title Act*

(GOERT 2007). Under this legislation, local governments can create bylaws, manage land use zoning, designate environmentally sensitive areas, and manage development permits. In addition, restrictive covenants can be placed on a property's land title, which restrict the activities of both present and future holders of the title (GOERT 2007). Local regulations vary from region to region so are not discussed here in detail, but should be investigated by restoration practitioners. U.S. legislation, which falls under the federal *Endangered Species Act,* is also not discussed; more information can be found on the Endangered Species Program website of the U.S. Fish and Wildlife Service (www.fws.gov/endangered).

Federal

In Canada, federal protection for rare species falls under the *Species at Risk Act* (SARA 2003, www.sararegistry.gc.ca/approach/act/default_e.cfm). There is no legislative protection for ecosystems at risk; however, SARA does allow for an ecosystem-based approach to species at risk recovery. COSEWIC follows a multi-step process for assessing and ranking a species' level of risk (see the COSEWIC website, www.cosewic.gc.ca/eng/scto/assessment_process_e.cfm, for more details on this process) and provides a recommendation to the federal Minister of Environment. It is the Minister, in consultation with COSEWIC, who then determines the final ranking of the species. A species must be added to Schedule 1 to receive protection under SARA (Environment Canada 2009).

Species listed as Endangered or Threatened must have a recovery strategy and an action plan written, and a management plan must be developed for species of Special Concern.

Once listed on Schedule 1, an endangered or threatened species is automatically protected on federal lands; no person shall kill, harm, harass or possess an individual or cause damage to the residence of one or more individuals. The habitats of species at risk are also recognized as *critical habitat* under the SARA once species have been designated. Critical habitat is defined as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species".

SARA requires the development of planning documents to guide recovery for species at risk. For endangered and threatened species a recovery strategy and an action plan must be written, and for species of Special Concern a management plan must be developed. Once completed, these documents can be found on the SARA public registry (www.sararegistry.gc.ca/default_e.cfm). These documents guide species recovery and outline threats, limiting factors, knowledge gaps, targets, and actions for each species. Critical habitat is currently being identified and included in several recovery strategies and action plans for species in Garry Oak and associated ecosystems, as of April 2011. Signing up for the registry e-news is an easy way to keep up on newly posted recovery planning documents (www.sararegistry.gc.ca/involved/newsletter/default_e.cfm).

These recovery planning documents are often produced by a group of experts brought together as a recovery team. For the many species associated with Garry Oak ecosystems, the Garry Oak Ecosystems Recovery Team (GOERT) was formed to lead in recovery planning and to coordinate recovery activities (see www.goert.ca). In addition to the ecosystems-wide recovery strategy, three approved multi-species recovery strategies covering 20 species, two proposed single-species strategies, and three proposed single-species management plans are currently posted on the SARA registry (as of June 2011): Garry Oak woodlands; maritime meadows associated with Garry Oak ecosystems; vernal pools and other ephemeral wet areas associated with Garry oak ecosystems (www.goert.ca/publications); Rigid Apple Moss (www.sararegistry.gc.ca/virtual_sara/files/plans/rs_rigid_apple_moss_0411_e.pdf); Dense-flowered Lupine (www.sararegistry.gc.ca/virtual_sara/files/plans/rs_Dense_flowered_Lupine_0311_e.pdf); Coastal Wood Fern (www.sararegistry.gc.ca/virtual_sara/files/plans/mp_coastal_wood_fern_0411_e.pdf); Banded Cord-moss (www.sararegistry.gc.ca/virtual_sara/files/plans/mp_banded_cord_moss_0411_e.pdf); and Twisted Oak Moss (www.sararegistry.gc.ca/virtual_sara/files/plans/mp_twisted_oak_moss_0411_e.pdf).

Provincial

Protection of species at risk on non-federal land is under provincial jurisdiction and is subject to the legislation in each province. In British Columbia, there is currently no stand-alone legislation to protect species at risk or their habitats (i.e., protection for species at risk falls under several different Acts).

The *Wildlife Act* (1996, www.bclaws.ca/Recon/document/freeside/--%20W%20--/Wildlife%20Act%20%20RSBC%201996%20%20c.%20488/00_96488_01.xml) provides protection to all vertebrate species by prohibiting the possession, harassment, or injury of wildlife, or damage to designated wildlife habitat, other than as allowed by issued permits or licenses (e.g., for hunting) (MOE 1996). It also contains provisions to allow listing of vertebrate species as endangered or threatened. Only four species are currently listed under this act, none of which are associated with Garry Oak ecosystems (MOE 1996).

The *Wildlife Amendment Act 2004* (www.leg.bc.ca/37th5th/3rd_read/gov51-3.htm), which has not yet been brought into force by regulation as of 2010, enhances the protection of species at risk. It allows invertebrate and plant species (in addition to vertebrate species) to be listed, prohibits the

The Great Blue Heron *fannini* subspecies (*Ardea herodias fannini*) is a provincially Blue-listed species and a species of Special Concern nationally (SARA Schedule 1). On federal lands, it is fully protected under SARA and its nests and eggs are protected provincially under B.C.'s *Wildlife Act*. Additionally, the Great Blue Heron, its nests, and eggs are protected from harm under the Migratory Birds Convention of 1994 and from harm by forest and range practices by the *Forest and Range Practices Act*. Photo: Todd Carnahan damage or destruction of a listed species' residence, and increases the penalties if these species or their residences are harmed (including killed, taken, etc.) (MOE 2004b). A residence is defined as an area or natural feature of the habitat of a species at risk that is habitually occupied or used as a dwelling place by one or more individuals of the species at risk (e.g., nest or den) (MOE 2004b).

The *Forest and Range Practices Act* (2004, FRPA, www.for.gov.bc.ca/code) governs the activities of forest and range licensees on provincial Crown land (MOFR 2008). FRPA enables the designation of areas of special management for species listed in the Category of Species at Risk or the Category of Regionally Significant Wildlife (MOE 2006). Within these areas, called Wildlife Habitat Areas, listed species are protected from damage due to forest and range practices. As of 2010, the Short-eared Owl (*Asio flammeus*), Great Blue Heron *fannini* subspecies (*Ardea herodias fannini*), and Lewis's Woodpecker (*Melanerpes lewisii*) are the only species associated with Garry Oak ecosystems listed under the Category of Species at Risk under the FRPA (MOE 2006).

Federal-Provincial

The federal, provincial, and territorial governments have jointly signed the *Accord for the Protection of Species at Risk* (www.sararegistry.gc.ca/approach/strategy/default_e.cfm), in which the importance of intergovernmental cooperation for the protection of species at risk is acknowledged (Environment Canada 2009). The Canadian Endangered Species Conservation Council (CESCC), composed of ministers from each level of government, was established to oversee the activities of COSEWIC and the various levels of government. The British Columbian and federal ministries responsible for the management of species at risk have also signed the *Canada-British Columbia Agreement on Species at Risk* (www.llbc.leg.bc.ca/public/PubDocs/bcdocs/419585/aa_Canada-British_Columbia_agreement_on_species_at_risk_0805_e.pdf). This agreement provides a framework for a coordinated approach to species at risk conservation and protection in the province (Environment Canada 2009).

4.2.2 Permits

Federal

Where a species is protected under SARA, a permit or agreement is required for any "activity affecting a listed wildlife species, any part of its critical habitat or the residences of its individuals" (Environment Canada 2009). For restoration activities in which "the activity benefits the species or is required to enhance its chance of survival in the wild," permits or agreements may be issued (Environment Canada 2009). This also includes the introduction or re-introduction of species listed on Schedule 1.

The following conditions must also apply:

- All reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted;
- All feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals; and
- The activity will not jeopardize the survival or recovery of the species (Environment Canada 2009).

See the SARA public registry for further details on permits and agreements (www.sararegistry.gc.ca/sar/permit/permits_e.cfm, Environment Canada 2009).

Provincial

Under the *Wildlife Act*, the capture, possession, shipping, and import of a vertebrate species is forbidden without a permit (MOE 1996). Permits are therefore required for the translocation of any vertebrate wildlife species in British Columbia (see Section 4.4.5: Translocations).

Under the *Ecological Reserve Act* (1996) or the *Protected Areas of British Columbia Act* (2000), permits are required to conduct research activities in provincial parks and protected areas. Permitted activities relevant to restoration include "collection; monitoring; survey and inventory; and other research" (BC Parks 2007). See the BC Parks website for more information on permits (www.env.gov.bc.ca/bcparks/info/permit_overview.html) in provincial parks and protected areas.

Local

Permits are often required to work on municipal or regional district lands. This varies from one municipality or regional district to the next. Practitioners having restoration sites on such public lands should consult their local government regulations.

4.3 Planning for Restoration

Before beginning planning for ecological restoration involving species or ecosystems at risk, the practitioner must be able to guarantee a multi-year commitment to the restoration project. Most projects require on-going maintenance and monitoring (Chapter 7: Inventory and Monitoring); if this maintenance is not possible then restoration work should not begin. If restoration activities

Permits are needed for any activity that has the potential to affect a species at risk or its critical habitat on federal lands. A permit was required to conduct this survey of the Endangered (SARA Schedule 1) Yellow Montane Violet (*Viola praemorsa* spp. *praemorsa*) on Navigation Canada land at Mt. Tuam on Salt Spring Island. Photo: Carolyn Masson are abandoned, previous efforts are rendered futile and can result in harming the species or ecosystems. Chapter 5: Restoration Planning goes through the process of planning a restoration project in detail; the information in this section will help you to flesh out the steps identified there.

4.3.1 Who to Contact

> Before beginning planning for ecological restoration involving species or ecosystems at risk, the practitioner must be able to guarantee a multi-year commitment to the restoration project.

Species or Ecosystems at Risk Identification

Early in the planning phase of any restoration project in a sensitive Garry Oak or associated ecosystem, restoration planners should determine whether there are any species or plant communities at risk at the site.

- A detailed species inventory should be completed by a qualified biologist as there are a number of factors to consider in examining rare species. Among other considerations, these include familiarity with the species, time of year, and annual population fluctuations. The Garry Oak Ecosystems Recovery Team can provide referrals to qualified professionals (phone: 250-383-3427; email: info@goert.ca).
- Consult the B.C. Ministry of Environment's Conservation Data Centre to find out if they have any such records at the restoration site. This can be done by using their online mapping tool (http://webmaps.gov.bc.ca/imfx/imf.jsp?site=imapbc) or by contacting the CDC staff directly (phone: 250-356-0928; email: cdcdata@gov.bc.ca).
- Consult the B.C. Species and Ecosystems Explorer (www.env.gov.bc.ca/atrisk/toolintro.html) to see if any of the species found on the site are provincially listed as at risk.
- Check the SARA public registry (www.sararegistry.gc.ca/species/default_e.cfm) to see if any of the species found on the site are also federally listed.

Expert Advice

Obtain expert advice from a qualified specialist when planning any restoration project. Such a specialist can include university researchers, specialized consultants, local stewardship groups, or government biologists (GOERT 2003a). Again, GOERT can be contacted for referrals to such specialists.

In addition, for many SARA-listed species, recovery teams consisting of government and conservation experts have been formed. When working with any species for which such a recovery team exists, the team must be involved in the entire planning and restoration process. A list of the recovery team chairs and their contact information can be found on the SARA website (www.sararegistry.gc.ca). For species occurring in Garry Oak or associated ecosystems, contact GOERT.

Landowner Contact

Permission should be obtained from all relevant landowners to conduct restoration work on their land. If landowners are municipalities or other government agencies, this might require additional permits (see Section 4.2.2).

Conducting detailed inventories of a site is an important first step in the planning of any restoration project. Photo: Kersti Vaino

4.3.2 Identifying Threats

All threats to rare species or ecosystems, both imminent and long-term, should be identified. This will need to be done by a qualified professional or in consultation with a recovery team, if applicable, who will likely already have produced a list of threats. For those species having a recovery strategy (see Section 4.2.1), the strategy will include a section on identified threats, as will any COSEWIC status reports (www.sararegistry.gc.ca/search/advSearchResults_e.cfm?stype=doc&docID=18). Potential threats that might occur as a result of restoration activities (e.g., trampling and soil compaction or disturbance) should also be identified so that these can be minimized.

4.3.3 Identifying Habitat

Very little is known about many species at risk and their habitat requirements. It is therefore important that the restoration practitioner learn as much as they can about the species' biology in order to understand its habitat requirements to the fullest extent possible. The habitat important to the species' survival at the site should then be identified. GOERT maps and monitors habitat for many of the species at risk in Garry Oak and associated ecosystems and can provide this information on request to assist with restoration efforts. Habitat elements that are important to consider include seepages, plant associations, and shade that provide essential ecosystem functions (see Section 3.4.2) for the species. Suitable habitat (i.e., additional habitat that meets the species' requirements but does not contain the species) should also be identified. Restoration activities should maintain these habitat elements and ecosystem functions to ensure the survival of the species at this site. More information on a number of species at risk, including their habitat requirements, is available in the field manual, *Species at Risk in Garry Oak and Associated Ecosystems in British Columbia* (www.goert.ca/pubs_at_risk.php).

Case Study 1. Golden Paintbrush and Parasitic Associations

by Matt Fairbarns

Golden Paintbrush (*Castilleja levisecta*) is a perennial herbaceous plant that occurs in a small proportion of native grassland areas on islands near Victoria, B.C., and similar habitats in Puget Sound. It is globally rare and listed as Endangered in Canada, where only two populations remain (Ryan and Douglas 1995). The Garry Oak Ecosystems Recovery Team has supported recovery actions for Golden Paintbrush, including the removal of invasive species from its habitat, studies into its seasonal development and population processes, and experiments on propagation techniques. A key requirement for successful propagation involves the establishment of an essential parasitic relationship with a suitable host plant.

Parasitism is often viewed in a negative light but this view is incompatible with a mature appreciation of biodiversity, considering the rich assemblage of native plants and animals which are parasitic on others. Upon reflection, parasitism is evidently similar to predation in many respects (although many hosts may cope with parasitism, while predation tends to have more fatal consequences).

Golden Paintbrush (*Castilleja levisecta*) blooming among the Common Camas (*Camassia quamash*) of Trial Island. Photo: Chris Junck

Some parasitic plants extract both basic nutrients and complex energy sources from their hosts. They typically lack chlorophyll, since they rely upon the photosynthesis of their host plants. Lacking chlorophyll, their stems and leaves are often white rather than green. Such species are referred to as holoparasites. Golden Paintbrush, in contrast, is a hemiparasite. It invests little effort in building an extensive root system; instead it simply latches on to the roots of other plants using special suction-cup structures called haustoria. The haustoria extract water and mineral nutrients from the host plant and for this reason hemiparasites are also called root parasites. Unlike holoparasites, however, they do produce green leaves containing chlorophyll, which harvest energy from the sun to build carbon-based structures.

It is likely that Golden Paintbrush, like many of its close relatives, is capable of growing even in the absence of a host. Nevertheless, by latching on to the roots of a suitable host it can reduce the amount of energy expended in creating an extensive root system and use the "savings" to build larger shoots and more seeds.

The association between hemiparasite and host is a relatively random process and a broad range of species may be parasitized. A single Golden Paintbrush plant may form haustorial connections with more than one host and populations may collectively form a complex network of interconnected root systems with many host plants across a wide range of species. Different host plants may have different effects on their hemiparasite's growth and reproduction, and some hosts may actually reduce the parasite's success.

Golden Paintbrush is not easily re-introduced to areas where it formerly occurred, nor is it easy to add plants to existing populations to increase their population size. Attempts to do so by adding seed tend to meet with little success, even when large numbers of seed are used and a favourable seedbed is created at the translocation site. For example, Fairbarns (2009) sowed 9,000 seeds of Golden Paintbrush into a maritime meadow site on Trial Island, site of Canada's largest population of Golden Paintbrush. The experimental site lay within 20 metres of an existing subpopulation of Golden Paintbrush and shared the same habitat conditions. Despite the large number of seeds, no Golden Paintbrush plants were observed in the experimental area over the following four growing seasons. While some germination may have occurred (the seedlings are extremely small and very difficult to observe), the experiment was unsuccessful in augmenting the existing population. Similar results have been obtained in Washington State: Pearson and Dunwiddie (2006) found that even with large numbers of seed sown over a number of years, these efforts alone were insufficient to establish a new population. They had much greater success planting out Golden Paintbrush plants which had been raised in a greenhouse environment together with a suitable host plant.

Future trials to establish Golden Paintbrush plants would benefit by using greenhouse-reared plants growing with a host such as Woolly Sunflower (*Eriophyllum lanatum*), a host plant which occurs naturally in the maritime meadow environments favoured by Golden Paintbrush.[1]

Golden Paintbrush is not the only hemiparasitic species at risk in Garry Oak ecosystems. Victoria's Owl-clover (*Castilleja victoriae*), a globally endangered species entirely restricted to vernal seeps associated with Garry Oak ecosystems, is a closely related species. Rosy Owl-clover (*Orthocarpus bracteosus*) and Bearded Owl-clover (*Triphysaria versicolor*) are also hemiparasitic species at risk found in vernal seeps and pools associated with Garry Oak ecosystems. Attempts to restore the three owl-clover species are complicated by the fact that they are delicate, short-lived annuals which may be difficult to propagate and are likely to die when transplanted. These difficulties, along with their hemiparasitic life strategy, complicate translocation efforts.

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1 In 2009, Parks Canada translocated 250 greenhouse-reared Golden Paintbrush plants to a small islet in Gulf Islands National Park Reserve. The experimental translocation is designed to address key biological and ecological knowledge gaps and to test translocation methodologies. If successful, the experimental population will be augmented to establish a viable self-sustaining population. (N. Kroeker, pers. comm. 2011).

4.3.4 Defining Goals

A critical step for any successful restoration project is to set target restoration goals. For species at risk, it is further necessary to ensure that these fit into the long-term recovery goals for the species, which are determined in consultation with the recovery team and recovery strategy, when these exist, and/or a qualified expert. Recovery goals should be applied to the individual project, resulting in restoration goals and objectives that address the site-specific threats to the species.

Typical recovery goals for a species at risk are:

- To maintain the current population
- To expand the current population
- To re-introduce or introduce a new population or sub-population

To maintain the current population, restoration objectives should mitigate identified threats and maintain identified important habitat. In addition to this, objectives for expansions of current populations should maintain or create suitable habitat adjacent to the existing population. Objectives for the introduction or re-introduction of a species at risk (via translocation; see Section 4.4.4 for more information on translocations) should maintain existing, or create new, suitable habitat at the recipient site.

When a site has species at risk, target restoration goals must fit into the long-term recovery goals for the species.

The provincially recognized recovery goals for Endangered Sharp-tailed Snakes (*Contia tenuis)* are to ensure the species persistence across its native range in Canada over the long-term, and to maintain known occurrences of Sharp-tailed Snakes in the short-term. Creating artificial cover objects, like the ones pictured above, is one way to counteract the degradation of Sharp-tailed Snake habitat. Photo: Carolyn Masson

4.3.5 Funding Programs

There are several government sources of funding available for work on the protection and recovery of species at risk. Target groups involved in restoration projects can apply for funding from these sources.

Table 4.2 Government funding sources available for the restoration of species at risk

Name	Description	Target Groups	Agency
Habitat Stewardship Program (HSP) www.ec.gc.ca/hsp-pih/default.asp?lang=En&n=59BF488F-1	"The overall goal of the HSP is to "contribute to the recovery of endangered, threatened, and other species at risk, and to prevent other species from becoming a conservation concern, by engaging Canadians from all walks of life in conservation actions to benefit wildlife.""	Any group conducting activities on private lands, provincial Crown lands, Aboriginal lands, or in aquatic and marine areas	Environment Canada with Parks Canada and the Department of Fisheries and Oceans
Inderdepartmental Recovery Fund (IRF) www.fir-irf.gc.ca/dspConfirmation_E.cfm?action=not_logged_in	"The IRF provides access to funding for federal departments and departmental corporations for implementing recovery activities for and conducting surveys on species at risk that occur on federal lands or waters, or for species under federal jurisdiction."	Federal departments and departmental corporations	Environment Canada
Endangered Species Recovery Fund (ESRF)[a] wwf.panda.org/who_we_are/wwf_offices/canada/projects/index.cfm?uProjectID=CA0063	"The ESRF sponsors high-priority research and education projects to assist in the recovery of extirpated, endangered and threatened Canadian species, and to prevent other species from becoming so classified."	University researchers and conservation organizations	Environment Canada and World Wildlife Fund–Canada
Ecological Gifts Program www.cws-scf.ec.gc.ca/egp-pde	"In order to help Canada's landowners and conservation groups preserve Canada's natural heritage, the Government of Canada has eliminated the tax on capital gains for all certified ecological gift donations made on or after May 2, 2006 by reducing the inclusion rate to zero."	Private landowners and corporations	Environment Canada
EcoAction www.ec.gc.ca/ecoaction	"EcoAction encourages project submissions that will protect, rehabilitate or enhance the natural environment, and build the capacity of communities to sustain these activities into the future."	Non-profit groups	Environment Canada

a This funding source is under review as of 2010

4.4 Special Considerations for Restoration Methods

Restoration methods should be tailored for every site and species. Best management practices are not known for many species and are changing as new and more effective methods are discovered. Methods should therefore be determined in consultation with an expert and using an adaptive management approach, which may require some experimentation. Adaptive management allows restoration practitioners to learn about the species throughout the restoration project and to adapt their methods and objectives based on the responses of the target species.

These considerations for restoration methods are meant to complement Chapter 8: Restoration Strategies with specific reference to species at risk. Other sources and experts should be consulted. GOERT's *Species at Risk in Garry Oak and Associated Ecosystems in British Columbia* (www.goert.ca/pubs_at_risk.php) manual has some management information for a growing number of species at risk, and GOERT is producing an increasing number of documents to guide activities in Garry Oak and associated ecosystems. Restoration practitioners should regularly check GOERT's webpage (www.goert.ca/publications) for new materials.

General management recommendations that apply for all species and ecosystems at risk occurrences include the following (GOERT 2003):

- Access to the site as well as land use should be limited, particularly at times of the year when the occurrence is most sensitive
- Pesticides and herbicides should be used with extreme caution in the immediate and surrounding areas
- All affected landowners should be notified of the occurrence of an at-risk species or ecosystem and appropriate management practices encouraged

Case Study 2. Habitat Restoration for an Endangered Bird Species, the Coastal Vesper Sparrow, at the Nanaimo Airport: a Study in Adaptive Management

by Trudy Chatwin

The Coastal Vesper Sparrow, listed federally under the name Vesper Sparrow, *affinis* subspecies, (*Pooecetes gramineus affinis*) is a small bird that occupies sparsely vegetated grasslands with scattered shrubs or trees, and occurs west of the Cascade Mountains (COSEWIC 2006). It is rare in Canada and is federally listed as Endangered and is also on the provincial Red List. The Garry Oak Ecosystems Recovery Team's Vertebrates at Risk Recovery Implementation Group (Verts RIG) has been working over the past 7 years (2003–2010) to recover the remaining population of around 6 pairs of the sparrow. An inventory of Vancouver Island in 2002 revealed that the only remaining site occupied by Coastal Vesper Sparrows in Canada is at the Nanaimo Airport. Funding from the Habitat Stewardship Program, the GOERT Society, and Canadian Wildlife Service has supported inventory, stewardship, and restoration work at the Nanaimo Airport since that time.

The federally Endangered, provincially Red-listed Vesper Sparrow *affinis* subspecies (*Pooecetes gramineus affinis*) nests on the ground. Extreme caution must be taken when surveying the habitat of this species and when coordinating restoration efforts. Photo: Shyanne Smith

Issues and Considerations

The Coastal Vesper Sparrow utilizes habitat at the south end of the airport that is comprised of grasses, forbs, shrubs, and the occasional cottonwood tree. In some areas, vegetative cover is minimal due to the gravelly nature of the substrate and the majority of the cover is comprised of introduced species of grasses and forbs and Scotch Broom (*Cytisus scoparius*). The sparrows nest on the ground under partial cover of mown broom, Himalayan Blackberry (*Rubus armeniacus*), and other forbs. Males use the broom, as well as fences, for singing perches, while both sexes also use the broom as escape cover. Although the sparrows use the broom patches and sparsely vegetated grassland in between, the Verts RIG is concerned about allowing the aggressive invasion of broom to continue. It is thought that ultimately this invasion will result in filling in the open areas and also result in excessive nitrogen in the soil, thus promoting lush grass growth and reducing habitat quality. The Nanaimo Airport Commission is also concerned that the broom harbours introduced European Rabbits (*Oryctolagus cuniculus*) that cause significant safety concerns at the airport.

Restoration History

In 2002, the Verts RIG began discussions with the Nanaimo Airport Commission on how to maintain the habitat of the endangered bird and meet the commission's safety interests. A Stewardship Agreement was signed which recommended that no more than 20% of broom be removed in the area occupied by the sparrow and that any mowing and broom removal not be done during the breeding period. From 2003 to 2005, some areas were hand-thinned using loppers and weed trimmers and a larger adjacent area was cleared using a mechanical mower in 2003. In 2005, native shrubs (Common Snowberry (*Symphoricarpos albus*), Saskatoon (*Amelanchier alnifolia*), and Nootka Rose (*Rosa nutkana*)) were planted to replace the broom but within months these had been chewed by the introduced rabbits. The sparrows used all the areas following clearing; however, the mowed areas were quickly re-populated by broom growing to 90 cm high! In 2006 and 2007, hedgerows of the burgeoning broom were cleared. In March 2007, excavators were used to scarify the habitat in the south-east corner of the airport, leaving only about 5% herbaceous cover. Large piles of cut broom were left on site. Despite this major habitat alteration, the sparrows used the hedgerows and the broom piles as singing perches. However, during the nesting seasons, the majority of the population shifted further to the south end of the airport. The habitat that had been excavated filled in with sparse grasses and herbs by 2008 and looked as though it would serve as nesting habitat in the 2009 breeding season. However, the Coastal Vesper Sparrows shifted their nesting south again. Only one bird held a territory at the south end of the excavated area and no nests were found in the hand-cleared areas.

Adapting Restoration to Changing Habits of the Coastal Vesper Sparrow

Given the changing nesting pattern, it was uncertain what direction to take for restoration. In the fall of 2008, members of the Verts RIG did a joint field inspection with airport staff to discuss this. It was decided that a hydro-mower would be hired to cut all non-native vegetation in an area north[1] of the birds' territories. Prior to the hydro-mowing, all native Nootka Rose, Cottonwood (*Populus* sp.), and Trailing Blackberry (*Rubus ursinus*) were flagged and broom was hand cleared around them. In this way, the hydro-mower could clearly avoid the native shrubs. After mowing, the vegetative debris was raked from gravelly areas in order to avoid undesirable mulching of the potentially suitable habitat. Native shrubs were again planted with protective barriers in April just before the sparrows returned to nest. In the 2009 breeding season, the sparrows continued their southward movement and did not use the restored areas. It is believed that this movement was due mostly to bird site fidelity and conspecific attraction[2], rather than habitat preference.

Due to the ever-burgeoning broom problem, restoration activities in fall 2009 and 2010 involved hand-cutting broom in patches adjacent to the habitat used by the sparrows in those years. The patches were based on a 5 m radius around patches of likely habitat on gravelly substrate. The cleared patches have been mapped to better judge the effectiveness of the program.

Conclusion

While there were limitations to the effectiveness of the restoration program, each year joint field

1 There was concern that cutting broom in the existing territory of the sparrows might alter the habitat too much.

2 Conspecific attraction is the attraction of being near others of the same species.

meetings were held to determine the plan of action based on the response of the sparrows, the vegetation, and the interests of the Nanaimo Airport Commission. A variety of techniques were used, ranging from hand-cutting to excavating, to restore the degraded ecosystem. The most effective method for maintaining Coastal Vesper Sparrow habitat at the Nanaimo Airport appears to be a combination of mowing and hand-clearing.

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4.4.1 Alien Invasive Species

Second only to habitat loss, the presence of alien invasive species is the greatest threat to Garry Oak and associated ecosystems and their species at risk. However, there are instances when alien invasive species can serve a critical ecosystem function for a species at risk and might need to be preserved. For example, some rare plants may rely on protection from herbivory provided by invasive shrubs, and some rare butterflies feed extensively on invasive plant species. See Chapter 9 for more information on alien invasive species and control methods.

Before any alien invasive species are removed, the impact of their removal should be evaluated and a strategy developed to minimize potential negative impacts. The removal of invasive plants by pulling up the roots can disturb the soil, which further encourages the germination of alien plant seeds (e.g., see Ussery and Krannitz 1998). Plants should therefore be removed in a manner that minimizes soil disturbance. This can be achieved by cutting instead of hand pulling or, if pulling is required, by doing so in the wetter winter months when the soil is softer. The presence of some invasive species also affects the chemistry of the site. For example, Scotch Broom (*Cytisus scoparius*) fixes nitrogen from the air and increases soil nutrient levels (GOERT 2003b). Once cut, broom can leave behind nitrogen-rich soils favourable to invasive species, and cut broom plants should be removed from sensitive areas to reduce the effects of the phytotoxin they produce which inhibits growth of other plants.

Before any alien invasive species are removed, the impact of their removal should be evaluated and a strategy developed to minimize potential negative impacts.

The impacts of invasive and/or alien species should be evaluated prior to their removal. Many Garry Oak ecosystems have been used for sheep grazing, beginning in the mid- to late-1800s, and sheep remain feral on Salt Spring Island today. Exclosure experiments can be used to assess the potential positive and negative effects that this alien species has on Garry Oak and associated ecosystems. The exclosure fencing is protecting a population of Endangered, Red-listed Yellow Montane Violet (*Viola praemorsa* spp. *praemorsa*) from sheep grazing. Photo: Carolyn Masson

4.4.2 Hydrologic Regimes

Hydrologic regimes can be important to plant and animal species alike. Many rare plants in these ecosystems, particularly those adapted to seasonally flooded areas or seeps, rely on the presence of soil moisture at critical times of the year for survival. For some animals, the dependence on soil moisture is indirect, such as the Common Ringlet butterfly (*Coenonympha california insulana*) relying on green grasses throughout the dry summer months to provide habitat for larvae, and the Sharp-tailed Snake (*Contia tenuis*) relying on the presence of slugs for food, which require moist soils (GOERT 2003). It is important that restoration practices do not disrupt the hydrology of the site, or if it has already been disrupted, that the hydrology be restored. Soil compaction due to trampling or the use of heavy machinery should be avoided around sensitive areas; also, if hydrology-altering species are present e.g., Orchard-grass (*Dactylis glomerata*) or Sweet Vernalgrass (*Anthoxanthum odoratum*), restoration for the site should include removing and controlling them.

4.4.3 Timing of Restoration

Appropriate timing is critical to the effectiveness of restoration efforts and must be incorporated into the work plan. Restoration work conducted in the vicinity of a species at risk occurrence could be more damaging than beneficial if carried out at the wrong time of year. Areas in the vicinity of a species at risk should be avoided during the most sensitive times in the species' lifecycle, e.g., when plants are developing, flowering, and setting seed; when insect larvae are developing; and when birds are nesting. It is important instead to undertake restoration activities when they will have the least negative effect on the target species and its critical habitat. For plants this will usually be after they have set seed or when they are dormant, and for animals this time is typically after the young have matured. If restoration work must be conducted during the sensitive period, extreme care must be taken not to damage the target species.

Restoration work conducted in the vicinity of a species at risk occurrence could be more damaging than beneficial if carried out at the wrong time of year.

Restoration work, including planting native grass plugs (as shown here), is conducted each fall at Somenos Garry Oak Protected Area in Duncan, B.C. By mid-fall all the native forbs, including at least three species at risk, are dormant at the site and restoration work can be conducted with minimal damage to the native species. Photo: Dave Polster

Due to the seasonality of Garry Oak and associated ecosystems (i.e., extreme wetness in winter and spring followed by summer drought), the sensitive time of year for most species falls between early spring and early summer. However, this is not the case for all species, such as the White-top Aster (*Sericocarpus rigidus*) which flowers in late summer, and the Common Ringlet butterfly, which produces a second brood during the summer. It is therefore important that enough is known about the biology and lifecycle of a species to be able to avoid its sensitive times (see Section 4.3.3 Identifying Habitat). More information on a number of species at risk, including their life histories, is available in the *Species at Risk in Garry Oak and Associated Ecosystems in British Columbia* (www.goert.ca/pubs_at_risk.php) manual.

4.4.4 Translocations

By translocation, a species can be either re-introduced to where it was once known to occur or introduced to a new site where it has not historically occurred. Translocations are only to be used when the long-term survival of existing populations cannot be ensured and other management options have failed. It is important that translocations never come before the protection and management of plants *in situ* and are not viewed as a solution to their destruction at a site.

Translocations are the deliberate movement of individuals or propagules from one location to another. They can be used to re-establish the historical distribution of a species (see Case Study 3), to maintain or restore biodiversity, to promote conservation awareness, and to increase our understanding of the biology, ecology, and genetic adaptation of a species at risk (Austin 2004; Vallee et al. 2004; McKay et al. 2005). Translocation may include adding new individuals to an existing population (augmentation), establishing a new population within the historical range (introduction), or establishing a population in a location which had previously supported the species (re-introduction). Translocation beyond the historical range of the species should only be done in well-thought-out circumstances, for example, when no other sites that seem appropriate are available within the range, or in anticipation of long-term climate change.

Translocations must be planned very carefully, as poorly conducted ones may cause damage to both donor and recipient sites. Insufficient knowledge of the biology, ecology and genetic adaptation of the species at risk can lead to failures (see Fiedler 1991; Falk et al. 1996) through the introduction of pathogens, alteration of ecological processes, and/or displacement of other species (see Fahselt 1988; Vallee et al. 2004). Many translocation projects are expensive and have low success rates due to the fact that they need long-term maintenance and necessary goals and targets are not established. Few monitoring data are available to prove the long-term viability of translocated populations.

Case Study 3. The San Juan Islands Western Bluebird Re-introduction Project

by Lisa Dumoulin

A bright spring sky falls
Speck by speck into the valley
Bluebirds returning

–ELIZA HABEGGER

Background

After an absence of almost 50 years, Western Bluebirds (*Sialia mexicana*) are once again migrating to breed in the San Juan Islands, a small archipelago north of Puget Sound, Washington. The spring and summer of 2010 saw the return of 24 Western Bluebirds, the most to return to the islands since their extirpation in the 1960s (K. Foley, pers. comm. 2010). The birds' return is a mark of success for the San Juan Islands Western Bluebird Re-introduction Project: a five-year project (2007–2011) to re-establish a breeding population of the birds on the San Juan Islands.

A male and female Western Bluebird perch on the feeding station near their nestbox on San Juan Island. Their nesting is one of the many incremental successes that the San Juan Islands Western Bluebird Re-introduction Project has had since its initiation in 2007. Photo: Elyse Portal

The natural range of Western Bluebirds is from Mexico to Canada, west of the Rocky Mountains (Peterson 1990). Western Bluebirds began to decline in abundance in the northern extent of their range during the 1930s due to the loss of suitable habitat (e.g., Garry Oak woodlands and meadows). The extirpation of the Georgia Depression population of Western Bluebirds from the San Juan Islands was driven primarily by the declining availability of a specific habitat element—nest cavities—through the conversion of oak woodlands to agricultural lands and through management practices that removed large dead trees. Prior to their decline, Western Bluebirds were a significant part of the landscape (www.sjpt.org). The San Juan Islands Western Bluebird Re-introduction Project (a partnership of the San Juan Preservation Trust [SJPT], the American Bird Conservancy, the San Juan Islands Audubon Society, and the Ecostudies Institute) has embraced the bluebird as a "flagship species" for their ongoing efforts to restore and preserve the integrity of the San Juan Islands' Garry Oak ecosystems (Slater 2009).

Justification

Ecologically, the Western Bluebird is an ideal candidate species for a re-introduction program. Bluebirds breed in a wide variety of open habitats, as long as nest cavities, low perches and an open understorey are present (Guinan et al. 2008). Moreover, individuals often show site fidelity, returning to the same nesting territory year after year. Juveniles, too, have been observed to return to their site of fledging (Scriven 1999). Being cavity nesters, they also respond well to nestbox programs (Slater 2009). Western Bluebirds have re-colonized areas of their former range in Oregon and Washington where nestbox programs have been managed effectively. Furthermore, the recent successful re-establishment of Eastern Bluebirds (*Sialia sialis*) in South Florida through translocation offers transferable methodologies suitable for a re-introduction of Western Bluebirds (Slater 2001, Lloyd et al. 2009).

Equally, the San Juan Islands are well-suited for supporting bluebirds. The San Juan Islands and the Canadian southern Gulf Islands were among the last strongholds for the Georgia Depression population of Western Bluebirds in the northern extent of their range. Although much of the land on the San Juan Islands has been transformed for agricultural purposes, a pre-project assessment indicated that suitable habitat was sufficient (with nestbox management) in north Puget Sound, centred on San Juan Island, to support a population (G. Slater, pers. comm. 2010). By providing bluebird-specific nestboxes, a key component of their habitat needs—cavities for nesting—is restored.

Translocation

For the San Juan re-introduction, bluebirds are translocated as pairs from the source population at Fort Lewis, WA by road and ferry. The birds are then placed into large outdoor aviaries located in suitable habitat at sites on San Juan Island. Pairs are held until there is evidence of nest-building or other breeding behaviour. Pairs are released after three weeks if no breeding or nest building activity is observed during the holding period. Later in the breeding season, some pairs are translocated with nestlings. During transport, nestlings are separated from their parents so that they can be fed and to reduce stress to the adults. Juveniles and their parents are reunited in the aviary upon arrival to San Juan Island (K. Foley, pers. comm. 2010a). These family groups are released once the young have fledged and are capable of sustained flight (G. Slater, pers. comm. 2010). Single females are also translocated to balance the increasing male-bias of the re-establishing population.

Results

To date (fall 2010), 79 adults have been translocated, and in 2010, after the fourth year of the project, the established bluebird population size on San Juan Island has reached 33 adults (San Juan Islands Bluebird Project, unpublished data). The program has met preliminary criteria of success: individuals have been safely translocated to the release site and released individuals have established breeding territories; both translocated individuals and their offspring have reproduced successfully; and the re-introduced population has grown in size each year (G. Slater, pers. comm. 2010). In 2007, the first year of the project, only one pair was observed to have bred and only three young are known to have fledged. In 2010, 84 juveniles fledged. Program managers are optimistic that the population will continue to increase in 2011, the last year of re-introductions. However, as with any re-introduction or translocation project, the re-colonization process is slow, and the establishing San Juan Islands bluebird population is vulnerable, making long-term monitoring an important component of a re-introduction project.

The San Juan Islands Western Bluebird Re-introduction Project has followed IUCN's Guidelines for Re-introductions (International Union for Conservation of Nature, IUCN 1998). Results from the project will contribute to the growing documentation of re-introduction projects, particularly for land birds. Therefore, the results should help improve the success rate of species re-introductions, a primary goal in the field of re-introduction biology (Sutherland et al. 2010; Ewen and Armstrong 2007; Seddon et al. 2007).

Challenges and Successes

Among the most challenging aspects of the project were developing and implementing translocation protocols, adapting aviary logistics, and finding and monitoring released birds. Much of this project's success can be attributed to the Bluebird Project's adaptive management practices. Several aspects of the project have been refined as the project has progressed. For example, the project switched to using larger aviaries and longer holding times after territory establishment was relatively low with small aviaries and a short holding period (K. Foley, pers. comm. 2010b). Project managers also responded to the increasingly male-biased sex-ratio of the establishing population by developing translocation and release protocols for single females. The project has increased juvenile survival and adult reproductive success by increasing the amount of supplemental food (mealworms) provided to nesting pairs during periods of cold weather and periods when young are feeding in the nest, and the first several weeks following fledging. Predator and competitor deterrents have also been erected where necessary (K. Foley, pers. comm. 2010a).

Access to greater funds has also allowed the Bluebird Project to realize increased successes. In the first year of re-introductions there were no available funds to support a full-time technician, despite the need for consistent monitoring of the released birds' health and whereabouts. Since 2008, however, the Bluebird Project has been able to fund a full-time summer technician. The technician plays an essential role, monitoring the birds post-release and surveying for returning birds, monitoring nestboxes in established breeding territories, providing supplemental food, and identifying and mediating threats in each nesting territory.

Community involvement in the Bluebird Project has also contributed to its successes. The SJPT, who has responsibility for the majority of the local education and outreach efforts, initially approached the San Juan Island community through educational seminars prior to commencing the re-introduction. Interested nestbox hosts and monitors were sought and community concerns were addressed. Nestbox hosts often play an important role in the project (the nest that produced three clutches in 2010 is provided supplemental mealworms by its nestbox host twice a day), acting in addition to the summer technician. Being able to play a significant role in supporting a family of bluebirds encourages a sense of ownership of the project for nestbox hosts. The SJPT hopes that this involvement in turn may encourage greater community support for prairie oak ecosystem preservation (www.sjpt.org). The SJPT has also engaged its community creatively, providing nestbox kits for purchase, holding nestbox building workshops, staffing outreach booths at local farmers' markets, conducting educational programs for schoolchildren, conducting media releases, writing a website blog, distributing an e-newsletter, and even holding a bluebird haiku contest (K. Foley, pers. comm. 2010b)! Generating and sustaining sufficient community support for the re-introduction project has been crucial to its success thus far.

Next Steps

For the re-introduced San Juan Island Western Bluebird population to persist, additional populations or sub-populations will need to be established within the northern extent of the species' range (Slater 2009). New populations may emerge through dispersal, as the San Juan Island population grows, but additional translocations may be necessary. A re-introduction project is currently being planned by the Garry Oak Ecosystems Recovery Team (GOERT) for 2012–2016 in the Canadian southern Gulf Islands, part of the same archipelago as the San Juan Islands. The GOERT project will face additional challenges, including permitting for the international transport of living species. The project will benefit, however, by the lessons learned and experience gained through the San Juan project.

CASE STUDY

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Surveys to monitor the results of restoration should be conducted annually by a qualified biologist and at the appropriate time(s) of year.

4.4.5 Monitoring

Prior to commencing restoration work on any site, it is strongly recommended that a baseline survey be conducted. A baseline survey provides a starting point for all future surveys to be compared against. The focus of the baseline survey for species at risk will be to gather data on the size (distribution and number of individuals) and condition (population health and reproductive success) of species at risk on the site.

All known populations of species at risk, whether the target of restoration efforts or not, should be monitored on a long-term basis for population trends (GOERT 2003a). As relatively little is known about many rare species, monitoring helps us to learn more about their biology, evaluate their viability, and detect developing threats. Surveys to monitor the results of restoration should be conducted annually by a qualified biologist (see Section 4.3.1 Who to Contact) and at the appropriate time(s) of year. Any new data on a species at risk occurrence should be reported to the Conservation Data Centre (GOERT 2003a). See Chapter 7: Inventory and Monitoring for more information on monitoring.

Experimental plots, like the exclosure and control pictured here, help to refine local knowledge and restoration practices but require a multi-year commitment to maintenance and monitoring. The restoration taking place at the site above has been on-going for three years. Experimental plots are being maintained to assess whether the restoration is benefiting the species of Special Concern at the site. Photo: GOERT

All known populations of species at risk, whether the target of restoration efforts or not, should be monitored on a long-term basis for population trends. Deltoid Balsamroot (*Balsamorhiza deltoidea*) is a Red-listed, Endangered (SARA Schedule 1) species at risk in Garry Oak woodlands. Photo: Carolyn Masson

4.5 Conclusions

It is important to consider species and ecosystems at risk during any restoration project and the effects that the project might have on them. This chapter provides resources to help restoration practitioners determine whether there are species or ecosystems at risk on their site. If present, then restoration practitioners should work with the appropriate experts to learn all that they can about the occurrence and how to manage for its survival. It is important that restoration activities not be detrimental to these sensitive species and that every effort be made to preserve them. The restoration project should be planned with care, utilizing the principles and guidelines discussed in this chapter.

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Appendix 4.1

Listed Species at Risk in Garry Oak and Associated Ecosystems[a]

A. ALPHABETICALLY BY ENGLISH NAME

English Name	Scientific Name	Global Rank	Provincial Rank	COSEWIC Status[b]	BC Status	REUs[c]
VASCULAR PLANTS						
Bear's-foot Sanicle	*Sanicula arctopoides*	G5	S1	E	Red	1; 3
Bearded Owl-clover	*Triphysaria versicolor* ssp. *versicolor*	G5T5	S1	E	Red	5; 6
Bog Bird's-foot Trefoil	*Lotus pinnatus*	G4G5	S1	E	Red	6
Brook Spike-Primrose	*Epilobium torreyi*	G5	SX	E	Red	5; 6
California Buttercup	*Ranunculus californicus*	G5	S1	E	Red	5
California Hedge-parsley	*Yabea microcarpa*	G5?	S1S2		Red	3; 4
California-tea	*Rupertia physodes*	G4	S3		Blue	3
Carolina Meadow-foxtail	*Alopecurus carolinianus*	G5	S2		Red	5
Coast Microseris	*Microseris bigelovii*	G4	S1	E	Red	6; 7
Coastal Scouler's Catchfly	*Silene scouleri ssp. grandis*	G5TNR	S1	E	Red	5
Coastal Wood Fern	*Dryopteris arguta*	G5	S2S3	SC	Blue	7;8
Common Bluecup	*Githopsis specularioides*	G5	S2S3		Blue	4
Cup Clover	*Trifolium cyathiferum*	G4	S1		Red	6
Deltoid Balsamroot	*Balsamorhiza deltoidea*	G5	S1	E	Red	1; 3;5
Dense Spike-primrose	*Epilobium densiflorum*	G5	S1	E	Red	2;5;6
Dense-flowered Lupine	*Lupinus densiflorus* var. *densiflorus*	G5T4	S1	E	Red	5
Densetuft Hairsedge	*Bulbostylis capillaris*	G5	S1		Red	4
Dune Bentgrass	*Agrostis pallens*	G4G5	S3S4		Yellow	5

Dwarf Sandwort	*Minuartia pusilla*	G5	S1	E	Red	6
Elegant Rein Orchid	*Piperia elegans*	G4	S3S4		Yellow	5
Erect Pygmyweed	*Crassula connata* var. *connata*	G5TNR	S2		Red	5
Farewell-to-spring	*Clarkia amoena* var. *caurina*	G5T5?	S3		Blue	5
Farewell-to-spring	*Clarkia amoena* var. *lindleyi*	G5T5	S3		Blue	5
Fern-leaved Desert-parsley	*Lomatium dissectum* var. *dissectum*	G4T4	S1		Red	3; 5
Foothill Sedge	*Carex tumulicola*	G4	S2	E	Red	5
Fragrant Popcorn-flower	*Plagiobothrys figuratus*	G4T4	S1	E	Red	5; 6; 7
Geyer's Onion	*Allium geyeri* var. *tenerum*	G4G5T3T5	S2S3		Blue	5
Golden Paintbrush	*Castilleja levisecta*	G1	S1	E	Red	5
Gray's Desert-parsley	*Lomatium grayi*	G5	S1	T	Red	3
Green-sheathed Sedge	*Carex feta*	G5	S2		Red	5; 6
Heterocodon	*Heterocodon rariflorum*	G5	S3		Blue	4; 5
Howell's Triteleia	*Triteleia howellii*	G3G4	S1	E	Red	5
Howell's Violet	*Viola howellii*	G4	S2S3		Blue	5
Kellogg's Rush	*Juncus kelloggii*	G3?	S1	E	Red	5; 6
Lindley's False Silverpuffs	*Uropappus lindleyi*	G5	S1	E	Red	3; 5; 7
Lobb's Water-buttercup	*Ranunculus lobbii*	G4	SH		Red	6
Macoun's Meadow-foam	*Limnanthes macounii*	G2	S2	T	Red	6
Macrae's Clover	*Trifolium dichotomum*	G4?	S2S3		Blue	7
Manroot	*Marah oreganus*	G5	S1	E	Red	7; 8
Muhlenberg's Centaury	*Centaurium muehlenbergii*	G5?	S1	E	Red	5; 6

Needle-leaved Navarretia	*Navarretia intertexta*	GNR	S2		Red	5 & 6
Nuttall's Quillwort	*Isoetes nuttallii*	G4?	S3		Blue	6
Oregon Lupine	*Lupinus oreganus* var. *kincaidii*	G5T2	SX	XT	Red	5
Poison Oak	*Toxicodendron diversilobum*	G5	S2S3		Blue	3
Poverty Clover	*Trifolium depauperatum* var. *depauperatum*	G5T5?	S3		Blue	5
Prairie Lupine	*Lupinus lepidus*	G5	S1	E	Red	3
Purple Sanicle	*Sanicula bipinnatifida*	G5	S2	T	Red	5
Pygmyweed	*Crassula aquatica*	G5	S4		Yellow	6
Rosy Owl-clover	*Orthocarpus bracteosus*	G3?	S1	E	Red	6
Scalepod	*Idahoa scapigera*	G5	S2		Red	5
Seaside Bird's Foot Lotus	*Lotus formosissimus*	G4	S1	E	Red	5
Sharp-pod Peppergrass	*Lepidium oxycarpum*	G4	SX		Red	2(?); 5 (?); 6
Slender Popcorn-flower	*Plagiobothrys tenellus*	G4G5	S1	T	Red	5
Slender Woolly-heads	*Psilocarphus tenellus* var. *tenellus*	G4	S3	NAR	Blue	6
Slimleaf Onion	*Allium amplectens*	G4	S3		Blue	5
Small-flowered Godetia	*Clarkia purpurea* ssp. *quadrivulnera*	G5T5	S1		Red	5
Small-flowered Tonella	*Tonella tenella*	G5	S1	E	Red	3
Small-headed Tarweed	*Hemizonella minima (Media minima)*	G4	S1		Red	3
Smooth Goldfields	*Lasthenia glaberrima*	G5	S1	E	Red	6
Spanish-clover	*Lotus unifoliolatus* var. *unifoliolatus*	G5T5	S3		Blue	5
Tall Woolly-heads	*Psilocarphus elatior*	G4Q	S1	E	Red	3; 6
Texas Toadflax	*Nutallanthus texanus*	G4G5	S3		Blue	3; 5

Victoria's Owl-clover	*Castilleja victoriae*	G1	S1	E	Red	6
Water-plantain Buttercup	*Ranunculus alismifolius* var. *alismifolius*	G5T5	S1	E	Red	6
Western rush	*Juncus occidentalis*	G5	S3S4		Blue	5;6
White Meconella	*Meconella oregana*	G2G3	S1	E	Red	5
White-lip Rein Orchid	*Piperia candida*	G3	S2		Red	1;8
White-top Aster	*Sericocarpus rigidus*	G3	S2	SC	Red	2; 3
Winged water-Starwort	*Callitriche marginata*	G4	S1		Red	5; 6
Yellow Montane Violet	*Viola praemorsa* ssp. *praemorsa*	G5T3T5	S2	E	Red	5
REPTILES						
Gopher Snake, *catenifer* subspecies	*Pituophis catenifer catenifer*	G5T5	SX	XT	Red	Extir-pated
Sharp-tailed Snake	*Contia tenuis*	G5	S1	E	Red	1,2,3,5, 7,8
MOSSES						
Banded Cord-moss	*Entosthodon fascicularis*	G4G5	S2S3	SC	Blue	3
Rigid Apple Moss	*Bartramia stricta*	GU	S2	E	Red	3
Twisted Oak Moss	*Syntrichia laevipila*	GNR	S2S3	SC	Blue	1; 2
MAMMALS						
Ermine, *anguinae* subspecies	*Mustela erminea anguinae*	G5T3	S3		Blue	8?
Roosevelt Elk	*Cervus elaphus roosevelti*	G5T4	S3S4		Blue	1, 2, 8?
Townsend's Big-eared Bat	*Corynorhinus townsendii*	G4	S3		Blue	1, 3
INVERTEBRATES (excluding butterflies)						
Blue Dasher	*Pachydiplax longipennis*	G5	S3S4		Blue	Un-known
Blue-grey Taildropper	*Prophysaon coeruleum*	G3G4	S1	E	Red	3

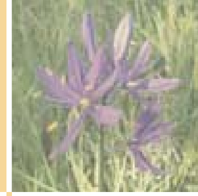
Western Pondhawk	*Erythemis collocata*	G5	S3		Blue	Un-known
Autumn Meadowhawk	*Sympetrum vicinum*	G5	S3S4		Blue	Un-known
BUTTERFLIES						
Boisduval's Blue, *blackmorei* subspecies	*Plebejus icariodes blackmorei*	G5T3	S3		Blue	4?
Common Ringlet, *insulana* subspecies	*Coenonympha california insulana*	G5T3T4	S1		Red	5; 7
Common Wood-nymph, *incana* subspecies	*Cercyonis pegala incana*	G5T4T5	S2		Red	5; 7
Dun Skipper	*Euphyes vestris*	G5	S3	T	Blue	4?; 6?
Great Arctic	*Oeneis nevadensis*	G5	S4		Yellow	3
Island Blue	*Plebejus saepiolus insulanus*	G5TH	SH	E	Red	4?;6?
Island Marble, *insulanus* subspecies	*Euchloe ausonides insulanus*	G5T1	SX	XT	Red	1;2
Moss' Elfin, *mossii* subspecies	*Incisalia mossii mossii*	G4T4	S2S3		Blue	3
Propertius Dusky-wing	*Erynnis propertius*	G5	S2S3		Blue	1;2;3;5; 7
Taylor's Checker-spot	*Euphydryas editha taylori*	G5T1	S1	E	Red	5
Western Branded Skipper, *oregonia* subspecies	*Hesperia colorado oregonia*	G5T3T4	S2S3		Blue	5; 7
Western Sulphur	*Colias occidentalis*	G4	S4		Yellow	3
Zerene Fritillary, *bremnerii* subspecies	*Speyeria zerene bremnerii*	G5T3T4	S2		Red	3
BIRDS						
Band-tailed Pigeon	*Patagioenas fasciata*	G4	S3S4B	SC	Blue	8
Barn Owl	*Tyto alba*	G5	S3	T	Blue	1,2
Horned Lark, *strigata* subspecies	*Eremophila alpestris strigata*	G5T2	SXB	E	Red	5

Lewis's Wood-pecker (Georgia Depression population)	*Melanerpes lewis* pop. 1	G5TXQ	SXB, SNA	T	Red	1,2,3,5, 7,8
Northern Pygmy-owl, *swarthi* subspecies	*Glaucidium gnoma swarthi*	G4G5T3Q	S3		Blue	1,2,3,5, 7,8
Great Blue Heron, *fannini* subspecies	*Ardea herodias fannini*	G5T4	S2S3B,S4N	SC	Blue	1, 5
Peregrine Falcon, *anatum* subspecies	*Falco peregrinus anatum*	G4T4	S2?B	SC	Red	7
Purple Martin	*Progne subis*	G5	S2S3B		Blue	Ukn.
Short-eared Owl	*Asio flammeus*	G5	S3B,S2N	SC	Blue	1
Vesper Sparrow, *affinis* subspecies	*Pooecetes gramineus affinis*	G5T3	S1B	E	Red	3
Western Bluebird, Georgia Depression population	*Sialia mexicana* pop. 1	G5TNRQ	SHB, SNA		Red	1, 2, 3, 5, 7
Western Meadow-lark, Georgia Depression population	*Sturnella neglecta* pop. 1	G5TNRQ	SXB		Red	1
Western Screech Owl, *kennicottii* subspecies	*Megascops kennicottii kennicottii*	G5T4	S3	SC	Blue	8
Yellow-billed Cuckoo	*Coccyzus americanus*	G5	SXB		Red	Extir-pated

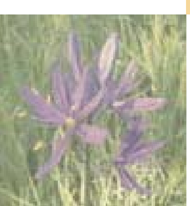
a Source: Garry Oak Ecosystems Recovery Team (GOERT). 2011. Species at Risk. GOERT. Victoria, B.C. www.goert.ca/pubs_at_risk.php (Accessed June 19, 2011).
b SC = Special Concern, T = Threatened, E = Endangered, XT = Extirpated.
c REU: Restoration Ecosystem Units as defined in Chapter 2: Distribution and Description

B. ALPHABETICALLY BY SCIENTIFIC NAME

Scientific Name	English Name	Global Rank	Provincial Rank	COSEWIC Status[b]	BC Status	REUs[c]
VASCULAR PLANTS						
Agrostis pallens	Dune Bentgrass	G4G5	S3S4		Yellow	5
Allium amplectens	Slimleaf Onion	G4	S3		Blue	5
Allium geyeri var. *tenerum*	Geyer's Onion	G4G5T3T5	S2S3		Blue	5
Alopecurus carolinianus	Carolina Meadow-foxtail	G5	S2		Red	5
Balsamorhiza deltoidea	Deltoid Balsamroot	G5	S1	E	Red	1; 3;5
Bulbostylis capillaris	Densetuft Hairsedge	G5	S1		Red	4
Callitriche marginata	Winged water-Starwort	G4	S1		Red	5; 6
Carex feta	Green-sheathed Sedge	G5	S2		Red	5; 6
Carex tumulicola	Foothill Sedge	G4	S2	E	Red	5
Castilleja levisecta	Golden Paintbrush	G1	S1	E	Red	5
Castilleja victoriae	Victoria's Owl-clover	G1	S1	E	Red	6
Centaurium muehlenbergii	Muhlenberg's Centaury	G5?	S1	E	Red	5; 6
Clarkia amoena var. *caurina*	Farewell-to-spring	G5T5?	S3		Blue	5
Clarkia amoena var. *lindleyi*	Farewell-to-spring	G5T5	S3		Blue	5
Clarkia purpurea ssp. *quadrivulnera*	Small-flowered Godetia	G5T5	S1		Red	5
Crassula aquatica	Pygmyweed	G5	S4		Yellow	6
Crassula connata var. *connata*	Erect Pygmyweed	G5TNR	S2		Red	5
Dryopteris arguta	Coastal Wood Fern	G5	S2S3	SC	Blue	7;8
Epilobium densiflorum	Dense Spike-primrose	G5	S1	E	Red	2;5;6
Epilobium torreyi	Brook Spike-Primrose	G5	SX	E	Red	5; 6



Githopsis specularioides	Common Bluecup	G5	S2S3		Blue	4
Hemizonella minima (Media minima)	Small-headed Tarweed	G4	S1		Red	3
Heterocodon rariflorum	Heterocodon	G5	S3		Blue	4; 5
Idahoa scapigera	Scalepod	G5	S2		Red	5
Isoetes nuttallii	Nuttall's Quillwort	G4?	S3		Blue	6
Juncus kelloggii	Kellogg's Rush	G3?	S1	E	Red	5; 6
Juncus occidentalis	Western rush	G5	S3S4		Blue	5; 6
Lasthenia glaberrima	Smooth Goldfields	G5	S1	E	Red	6
Lepidium oxycarpum	Sharp-pod Pepper-grass	G4	SX		Red	2(?); 5 (?); 6
Limnanthes macounii	Macoun's Meadow-foam	G2	S2	T	Red	6
Lomatium dissectum var. *dissectum*	Fern-leaved Desert-parsley	G4T4	S1		Red	3; 5
Lomatium grayi	Gray's Desert-parsley	G5	S1	T	Red	3
Lotus formosissimus	Seaside Bird's Foot Lotus	G4	S1	E	Red	5
Lotus pinnatus	Bog Bird's-foot Trefoil	G4G5	S1	E	Red	6
Lotus unifoliolatus var. *unifoliolatus*	Spanish-clover	G5T5	S3		Blue	5
Lupinus densiflorus var. *densiflorus*	Dense-flowered Lupine	G5T4	S1	E	Red	5
Lupinus lepidus	Prairie Lupine	G5	S1	E	Red	3
Lupinus oreganus var. *kincaidii*	Oregon Lupine	G5T2	SX	XT	Red	5
Marah oreganus	Manroot	G5	S1	E	Red	7; 8
Meconella oregana	White Meconella	G2G3	S1	E	Red	5
Microseris bigelovii	Coast Microseris	G4	S1	E	Red	6; 7
Minuartia pusilla	Dwarf Sandwort	G5	S1	E	Red	6



Navarretia intertexta	Needle-leaved Navarretia	GNR	S2		Red	5 & 6
Nutallanthus texanus	Texas Toadflax	G4G5	S3		Blue	3; 5
Orthocarpus bracteosus	Rosy Owl-clover	G3?	S1	E	Red	6
Piperia candida	White-lip Rein Orchid	G3	S2		Red	1;8
Piperia elegans	Elegant Rein Orchid	G4	S3S4		Yellow	5
Plagiobothrys figuratus	Fragrant Popcorn-flower	G4T4	S1	E	Red	5; 6; 7
Plagiobothrys tenellus	Slender Popcorn-flower	G4G5	S1	T	Red	5
Psilocarphus elatior	Tall Woolly-heads	G4Q	S1	E	Red	3; 6
Psilocarphus tenellus var. *tenellus*	Slender Woolly-heads	G4	S3	NAR	Blue	6
Ranunculus alismifolius var. *alismifolius*	Water-plantain Buttercup	G5T5	S1	E	Red	6
Ranunculus californicus	California Buttercup	G5	S1	E	Red	5
Ranunculus lobbii	Lobb's Water-buttercup	G4	SH		Red	6
Rupertia physodes	California-tea	G4	S3		Blue	3
Sanicula arctopoides	Bear's-foot Sanicle	G5	S1	E	Red	1; 3
Sanicula bipinnatifida	Purple Sanicle	G5	S2	T	Red	5
Sericocarpus rigidus	White-top Aster	G3	S2	SC	Red	2; 3
Silene scouleri ssp. *grandis*	Coastal Scouler's Catchfly	G5TNR	S1	E	Red	5
Tonella tenella	Small-flowered Tonella	G5	S1	E	Red	3
Toxicodendron diversilobum	Poison Oak	G5	S2S3		Blue	3
Trifolium cyathiferum	Cup Clover	G4	S1		Red	6
Trifolium depauperatum var. *depauperatum*	Poverty Clover	G5T5?	S3		Blue	5

Trifolium dichotomum	Macrae's Clover	G4?	S2S3		Blue	7
Triphysaria versicolor ssp. *versicolor*	Bearded Owl-clover	G5T5	S1	E	Red	5; 6
Triteleia howellii	Howell's Triteleia	G3G4	S1	E	Red	5
Uropappus lindleyi	Lindley's False Silverpuffs	G5	S1	E	Red	3; 5; 7
Viola howellii	Howell's Violet	G4	S2S3		Blue	5
Viola praemorsa ssp. *praemorsa*	Yellow Montane Violet	G5T3T5	S2	E	Red	5
Yabea microcarpa	California Hedge-parsley	G5?	S1S2		Red	3; 4
REPTILES						
Contia tenuis	Sharp-tailed Snake	G5	S1	E	Red	1,2,3,5,7,8
Pituophis catenifer catenifer	Gopher Snake, *catenifer* subspecies	G5T5	SX	XT	Red	Extir-pated
MOSSES						
Bartramia stricta	Rigid Apple Moss	GU	S2	E	Red	3
Entosthodon fascicularis	Banded Cord-moss	G4G5	S2S3	SC	Blue	3
Syntrichia laevipila	Twisted Oak Moss	GNR	S2S3	SC	Blue	1; 2
MAMMALS						
Cervus elaphus roosevelti	Roosevelt Elk	G5T4	S3S4		Blue	1, 2, 8?
Corynorhinus townsendii	Townsend's Big-eared Bat	G4	S3		Blue	1, 3
Mustela erminea anguinae	Ermine, *anguinae* subspecies	G5T3	S3		Blue	8?
INVERTEBRATES (excluding butterflies)						
Erythemis collocata	Western Pondhawk	G5	S3		Blue	Unkn.
Pachydiplax longipennis	Blue Dasher	G5	S3S4		Blue	Unkn.
Prophysaon coeruleum	Blue-grey Taildropper	G3G4	S1	E	Red	3

Prophysaon coeruleum	Blue-grey Taildropper	G3G4	S1	E	Red	3
Sympetrum vicinum	Autumn Meadowhawk	G5	S3S4		Blue	Unkn.
BUTTERFLIES						
Cercyonis pegala incana	Common Wood-nymph, *incana* subspecies	G5T4T5	S2		Red	5; 7
Coenonympha california insulana	Common Ringlet, *insulana* subspecies	G5T3T4	S1		Red	5; 7
Colias occidentalis	Western Sulphur	G4	S4		Yellow	3
Erynnis propertius	Propertius Duskywing	G5	S2S3		Blue	1;2;3;5;7
Euchloe ausonides insulanus	Island Marble, *insulanus* subspecies	G5T1	SX	XT	Red	1;2
Euphydryas editha taylori	Taylor's Checkerspot	G5T1	S1	E	Red	5
Euphyes vestris	Dun Skipper	G5	S3	T	Blue	4?; 6?
Hesperia colorado oregonia	Western Branded Skipper, *oregonia* subspecies	G5T3T4	S2S3		Blue	5; 7
Incisalia mossii mossii	Moss' Elfin, *mossii* subspecies	G4T4	S2S3		Blue	3
Oeneis nevadensis	Great Arctic	G5	S4		Yellow	3
Plebejus icariodes blackmorei	Boisduval's Blue, *blackmorei* subspecies	G5T3	S3		Blue	4?
Plebejus saepiolus insulanus	Island Blue	G5TH	SH	E	Red	4?;6?
Speyeria zerene bremnerii	Zerene Fritillary, *bremnerii* subspecies	G5T3T4	S2		Red	3
BIRDS						
Ardea herodias fannini	Great Blue Heron, *fannini* subspecies	G5T4	S2S3B,S4N	SC	Blue	1, 5
Asio flammeus	Short-eared Owl	G5	S3B,S2N	SC	Blue	1
Coccyzus americanus	Yellow-billed Cuckoo	G5	SXB		Red	Extirp.
Eremophila alpestris strigata	Horned Lark, *strigata* subspecies	G5T2	SXB	E	Red	5

Falco peregrinus anatum	Peregrine Falcon, *anatum* subspecies	G4T4	S2?B	SC	Red	7
Glaucidium gnoma swarthi	Northern Pygmy-owl, *swarthi* subspecies	G4G5T3Q	S3		Blue	1,2,3,5,7, 8
Megascops kennicottii kennicottii	Western Screech Owl, *kennicottii* subspecies	G5T4	S3	SC	Blue	8
Melanerpes lewis pop. 1	Lewis's Woodpecker (Georgia Depression population)	G5TXQ	SXB, SNA	T	Red	1,2,3,5,7, 8
Patagioenas fasciata	Band-tailed Pigeon	G4	S3S4B	SC	Blue	8
Pooecetes gramineus affinis	Vesper Sparrow, *affinis* subspecies	G5T3	S1B	E	Red	3
Progne subis	Purple Martin	G5	S2S3B		Blue	Unkn.
Sialia mexicana pop. 1	Western Bluebird, Georgia Depression population	G5TNRQ	SHB, SNA		Red	1, 2, 3, 5, 7
Sturnella neglecta pop. 1	Western Meadowlark, Georgia Depression population	G5TNRQ	SXB		Red	1
Tyto alba	Barn Owl	G5	S3	T	Blue	1,2

Appendix 4.2

Listed Species at Risk in Garry Oak and Associated Ecosystems[a], per Restoration Ecosystem Unit (REU)[c]

REU	English Name	Scientific Name	Global Rank	Provincial Rank	COSEWIC Status[b]	BC Status
1	Bear's-foot Sanicle	*Sanicula arctopoides*	G5	S1	E	Red
	Deltoid Balsamroot	*Balsamorhiza deltoidea*	G5	S1	E	Red
	Twisted Oak Moss	*Syntrichia laevipila*	GNR	S2S3	SC	Blue
	White-lip Rein Orchid	*Piperia candida*	G3	S2		Red
	Roosevelt Elk	*Cervus elaphus roosevelti*	G5T4	S3S4		Blue
	Townsend's Big-eared Bat	*Corynorhinus townsendii*	G4	S3		Blue
	Sharp-tailed Snake	*Contia tenuis*	G5	S1	E	Red
	Island Marble, *insulanus* subspecies	*Euchloe ausonides insulanus*	G5T1	SX	XT	Red
	Propertius Duskywing	*Erynnis propertius*	G5	S2S3		Blue
	Barn Owl	*Tyto alba*	G5	S3	T	Blue
	Great Blue Heron, *fannini* subspecies	*Ardea herodias fannini*	G5T4	S2S3B,S4N	SC	Blue
	Lewis's Woodpecker (Georgia Depression population)	*Melanerpes lewis* pop. 1	G5TXQ	SXB, SNA	T	Red
	Northern Pygmy-owl, *swarthi* subspecies	*Glaucidium gnoma swarthi*	G4G5T3Q	S3		Blue
	Short-eared Owl	*Asio flammeus*	G5	S3B,S2N	SC	Blue
	Western Bluebird, Georgia Depression population	*Sialia mexicana* pop. 1	G5TNRQ	SHB, SNA		Red
	Western Meadowlark, Georgia Depression population	*Sturnella neglecta* pop. 1	G5TNRQ	SXB		Red
2	Dense Spike-primrose	*Epilobium densiflorum*	G5	S1	E	Red
	Twisted Oak Moss	*Syntrichia laevipila*	GNR	S2S3	SC	Blue
	White-top Aster	*Sericocarpus rigidus*	G3	S2	SC	Red

	Roosevelt Elk	*Cervus elaphus roosevelti*	G5T4	S3S4		Blue
	Sharp-tailed Snake	*Contia tenuis*	G5	S1	E	Red
	Island Marble, *insulanus* subspecies	*Euchloe ausonides insulanus*	G5T1	SX	XT	Red
	Propertius Duskywing	*Erynnis propertius*	G5	S2S3		Blue
	Barn Owl	*Tyto alba*	G5	S3	T	Blue
	Lewis's Woodpecker (Georgia Depression population)	*Melanerpes lewis* pop. 1	G5TXQ	SXB, SNA	T	Red
	Northern Pygmy-owl, *swarthi* subspecies	*Glaucidium gnoma swarthi*	G4G5T3Q	S3		Blue
	Western Bluebird, Georgia Depression population	*Sialia mexicana* pop. 1	G5TNRQ	SHB, SNA		Red
2(?)	Sharp-pod Peppergrass	*Lepidium oxycarpum*	G4	SX		Red
3	Bear's-foot Sanicle	*Sanicula arctopoides*	G5	S1	E	Red
	California Hedge-parsley	*Yabea microcarpa*	G5?	S1S2		Red
	California-tea	*Rupertia physodes*	G4	S3		Blue
	Deltoid Balsamroot	*Balsamorhiza deltoidea*	G5	S1	E	Red
	Fern-leaved Desert-parsley	*Lomatium dissectum var. dissectum*	G4T4	S1		Red
	Gray's Desert-parsley	*Lomatium grayi*	G5	S1	T	Red
	Lindley's False Silverpuffs	*Uropappus lindleyi*	G5	S1	E	Red
	Poison Oak	*Toxicodendron diversilobum*	G5	S2S3		Blue
	Prairie Lupine	*Lupinus lepidus*	G5	S1	E	Red
	Small-flowered Tonella	*Tonella tenella*	G5	S1	E	Red
	Small-headed Tarweed	*Hemizonella minima (Media minima)*	G4	S1		Red
	Tall Woolly-heads	*Psilocarphus elatior*	G4Q	S1	E	Red
	Texas Toadflax	*Nutallanthus texanus*	G4G5	S3		Blue
	White-top Aster	*Sericocarpus rigidus*	G3	S2	SC	Red

	Banded Cord-moss	*Entosthodon fascicularis*	G4G5	S2S3	SC	Blue
	Rigid Apple Moss	*Bartramia stricta*	GU	S2	E	Red
	Ermine, *anguinae* subspecies	*Mustela erminea anguinae*	G5T3	S3		Blue
	Sharp-tailed Snake	*Contia tenuis*	G5	S1	E	Red
	Blue-grey Taildropper	*Prophysaon coeruleum*	G3G4	S1	E	Red
	Great Arctic	*Oeneis nevadensis*	G5	S4		Yellow
	Moss' Elfin, *mossii* subspecies	*Incisalia mossii mossii*	G4T4	S2S3		Blue
	Propertius Duskywing	*Erynnis propertius*	G5	S2S3		Blue
	Western Sulphur	*Colias occidentalis*	G4	S4		Yellow
	Zerene Fritillary, *bremnerii* subspecies	*Speyeria zerene bremnerii*	G5T3T4	S2		Red
	Lewis's Woodpecker (Georgia Depression population)	*Melanerpes lewis* pop. 1	G5TXQ	SXB, SNA	T	Red
	Northern Pygmy-owl, *swarthi* subspecies	*Glaucidium gnoma swarthi*	G4G5T3Q	S3		Blue
	Vesper Sparrow, *affinis* subspecies	*Pooecetes gramineus affinis*	G5T3	S1B	E	Red
	Western Bluebird, Georgia Depression population	*Sialia mexicana* pop. 1	G5TNRQ	SHB, SNA		Red
4	California Hedge-parsley	*Yabea microcarpa*	G5?	S1S2		Red
	Common Bluecup	*Githopsis specularioides*	G5	S2S3		Blue
	Densetuft Hairsedge	*Bulbostylis capillaris*	G5	S1		Red
	Heterocodon	*Heterocodon rariflorum*	G5	S3		Blue
4?	Boisduval's Blue, *blackmorei* subspecies	*Plebejus icariodes blackmorei*	G5T3	S3		Blue
	Dun Skipper	*Euphyes vestris*	G5	S3	T	Blue
	Island Blue	*Plebejus saepiolus insulanus*	G5TH	SH	E	Red
5	Bearded Owl-clover	*Triphysaria versicolor* ssp. *versicolor*	G5T5	S1	E	Red

Brook Spike-Primrose	*Epilobium torreyi*	G5	SX	E	Red
California Buttercup	*Ranunculus californicus*	G5	S1	E	Red
Carolina Meadow-foxtail	*Alopecurus carolinianus*	G5	S2		Red
Coastal Scouler's Catchfly	*Silene scouleri* ssp. *grandis*	G5TNR	S1	E	Red
Deltoid Balsamroot	*Balsamorhiza deltoidea*	G5	S1	E	Red
Dense Spike-primrose	*Epilobium densiflorum*	G5	S1	E	Red
Dense-flowered Lupine	*Lupinus densiflorus* var. *densiflorus*	G5T4	S1	E	Red
Dune Bentgrass	*Agrostis pallens*	G4G5	S3S4		Yellow
Elegant Rein Orchid	*Piperia elegans*	G4	S3S4		Yellow
Erect Pygmyweed	*Crassula connata* var. *connata*	G5TNR	S2		Red
Farewell-to-spring	*Clarkia amoena* var. *caurina*	G5T5?	S3		Blue
Farewell-to-spring	*Clarkia amoena* var. *lindleyi*	G5T5	S3		Blue
Fern-leaved Desert-parsley	*Lomatium dissectum* var. *dissectum*	G4T4	S1		Red
Foothill Sedge	*Carex tumulicola*	G4	S2	E	Red
Fragrant Popcornflower	*Plagiobothrys figuratus*	G4T4	S1	E	Red
Geyer's Onion	*Allium geyeri* var. *tenerum*	G4G5T3T5	S2S3		Blue
Golden Paintbrush	*Castilleja levisecta*	G1	S1	E	Red
Green-sheathed Sedge	*Carex feta*	G5	S2		Red
Heterocodon	*Heterocodon rariflorum*	G5	S3		Blue
Howell's Triteleia	*Triteleia howellii*	G3G4	S1	E	Red
Howell's Violet	*Viola howellii*	G4	S2S3		Blue
Kellogg's Rush	*Juncus kelloggii*	G3?	S1	E	Red
Lindley's False Silverpuffs	*Uropappus lindleyi*	G5	S1	E	Red
Muhlenberg's Centaury	*Centaurium muehlenbergii*	G5?	S1	E	Red

Needle-leaved Navarretia	*Navarretia intertexta*	GNR	S2		Red
Oregon Lupine	*Lupinus oreganus* var. *kincaidii*	G5T2	SX	XT	Red
Poverty Clover	*Trifolium depauperatum* var. *depauperatum*	G5T5?	S3		Blue
Purple Sanicle	*Sanicula bipinnatifida*	G5	S2	T	Red
Scalepod	*Idahoa scapigera*	G5	S2		Red
Seaside Bird's Foot Lotus	*Lotus formosissimus*	G4	S1	E	Red
Slender Popcornflower	*Plagiobothrys tenellus*	G4G5	S1	T	Red
Slimleaf Onion	*Allium amplectens*	G4	S3		Blue
Small-flowered Godetia	*Clarkia purpurea* ssp. *quadrivulnera*	G5T5	S1		Red
Spanish-clover	*Lotus unifoliolatus* var. *unifoliolatus*	G5T5	S3		Blue
Texas Toadflax	*Nutallanthus texanus*	G4G5	S3		Blue
Western rush	*Juncus occidentalis*	G5	S3S4		Blue
White Meconella	*Meconella oregana*	G2G3	S1	E	Red
Winged water-Starwort	*Callitriche marginata*	G4	S1		Red
Yellow Montane Violet	*Viola praemorsa* ssp. *praemorsa*	G5T3T5	S2	E	Red
Sharp-tailed Snake	*Contia tenuis*	G5	S1		Red
Common Ringlet, *insulana* subspecies	*Coenonympha california insulana*	G5T3T4	S1		Red
Common Wood-nymph, *incana* subspecies	*Cercyonis pegala incana*	G5T4T5	S2		Red
Propertius Duskywing	*Erynnis propertius*	G5	S2S3		Blue
Taylor's Checkerspot	*Euphydryas editha taylori*	G5T1	S1	E	Red
Western Branded Skipper, *oregonia* subspecies	*Hesperia colorado oregonia*	G5T3T4	S2S3		Blue
Great Blue Heron, *fannini* subspecies	*Ardea herodias fannini*	G5T4	S2S3B,S4N	SC	Blue

	Horned Lark, *strigata* subspecies	*Eremophila alpestris strigata*	G5T2	SXB	E	Red
	Lewis's Woodpecker (Georgia Depression population)	*Melanerpes lewis* pop. 1	G5TXQ	SXB, SNA	T	Red
	Northern Pygmy-owl, *swarthi* subspecies	*Glaucidium gnoma swarthi*	G4G5T3Q	S3		Blue
	Western Bluebird, Georgia Depression population	*Sialia mexicana* pop. 1	G5TNRQ	SHB, SNA		Red
5 (?)	Sharp-pod Peppergrass	*Lepidium oxycarpum*	G4	SX		Red
6	Bearded Owl-clover	*Triphysaria versicolor* ssp. *versicolor*	G5T5	S1	E	Red
	Bog Bird's-foot Trefoil	*Lotus pinnatus*	G4G5	S1	E	Red
	Brook Spike-Primrose	*Epilobium torreyi*	G5	SX	E	Red
	Coast Microseris	*Microseris bigelovii*	G4	S1	E	Red
	Cup Clover	*Trifolium cyathiferum*	G4	S1		Red
	Dense Spike-primrose	*Epilobium densiflorum*	G5	S1	E	Red
	Dwarf Sandwort	*Minuartia pusilla*	G5	S1	E	Red
	Fragrant Popcornflower	*Plagiobothrys figuratus*	G4T4	S1	E	Red
	Green-sheathed Sedge	*Carex feta*	G5	S2		Red
	Kellogg's Rush	*Juncus kelloggii*	G3?	S1	E	Red
	Lobb's Water-buttercup	*Ranunculus lobbii*	G4	SH		Red
	Macoun's Meadow-foam	*Limnanthes macounii*	G2	S2	T	Red
	Muhlenberg's Centaury	*Centaurium muehlenbergii*	G5?	S1	E	Red
	Needle-leaved Navarretia	*Navarretia intertexta*	GNR	S2		Red
	Nuttall's Quillwort	*Isoetes nuttallii*	G4?	S3		Blue
	Pygmyweed	*Crassula aquatica*	G5	S4		Yellow
	Rosy Owl-clover	*Orthocarpus bracteosus*	G3?	S1	E	Red
	Sharp-pod Peppergrass	*Lepidium oxycarpum*	G4	SX		Red

	Slender Woolly-heads	*Psilocarphus tenellus* var. *tenellus*	G4	S3	NAR	Blue
	Smooth Goldfields	*Lasthenia glaberrima*	G5	S1	E	Red
	Tall Woolly-heads	*Psilocarphus elatior*	G4Q	S1	E	Red
	Victoria's Owl-clover	*Castilleja victoriae*	G1	S1	E	Red
	Water-plantain Buttercup	*Ranunculus alismifolius* var. *alismifolius*	G5T5	S1	E	Red
	Western rush	*Juncus occidentalis*	G5	S3S4		Blue
	Winged water-Starwort	*Callitriche marginata*	G4	S1		Red
6?	Dun Skipper	*Euphyes vestris*	G5	S3	T	Blue
	Island Blue	*Plebejus saepiolus insulanus*	G5TH	SH	E	Red
7	Coast Microseris	*Microseris bigelovii*	G4	S1	E	Red
	Coastal Wood Fern	*Dryopteris arguta*	G5	S2S3	SC	Blue
	Fragrant Popcornflower	*Plagiobothrys figuratus*	G4T4	S1	E	Red
	Lindley's False Silverpuffs	*Uropappus lindleyi*	G5	S1	E	Red
	Macrae's Clover	*Trifolium dichotomum*	G4?	S2S3		Blue
	Manroot	*Marah oreganus*	G5	S1	E	Red
	Sharp-tailed Snake	*Contia tenuis*	G5	S1	E	Red
	Common Ringlet, *insulana* subspecies	*Coenonympha california insulana*	G5T3T4	S1		Red
	Common Wood-nymph, *incana* subspecies	*Cercyonis pegala incana*	G5T4T5	S2		Red
	Propertius Duskywing	*Erynnis propertius*	G5	S2S3		Blue
	Western Branded Skipper, *oregonia* subspecies	*Hesperia colorado oregonia*	G5T3T4	S2S3		Blue
	Lewis's Woodpecker (Georgia Depression population)	*Melanerpes lewis* pop. 1	G5TXQ	SXB, SNA	T	Red
	Northern Pygmy-owl, *swarthi* subspecies	*Glaucidium gnoma swarthi*	G4G5T3Q	S3		Blue
	Peregrine Falcon, *anatum* subspecies	*Falco peregrinus anatum*	G4T4	S2?B	SC	Red

	Western Bluebird, Georgia Depression population	*Sialia mexicana* pop. 1	G5TNRQ	SHB, SNA		Red
8	Coastal Wood Fern	*Dryopteris arguta*	G5	S2S3	SC	Blue
	Manroot	*Marah oreganus*	G5	S1	E	Red
	White-lip Rein Orchid	*Piperia candida*	G3	S2		Red
	Sharp-tailed Snake	*Contia tenuis*	G5	S1	E	Red
	Band-tailed Pigeon	*Patagioenas fasciata*	G4	S3S4B	SC	Blue
	Lewis's Woodpecker (Georgia Depression population)	*Melanerpes lewis* pop. 1	G5TXQ	SXB, SNA		Red
	Northern Pygmy-owl, *swarthi* subspecies	*Glaucidium gnoma swarthi*	G4G5T3Q	S3	T	Blue
	Western Screech Owl, *kennicottii* subspecies	*Megascops kennicottii kennicottii*	G5T4	S3	SC	Blue
8?	Ermine, *anguinae* subspecies	*Mustela erminea anguinae*	G5T3	S3		Blue
	Roosevelt Elk	*Cervus elaphus roosevelti*	G5T4	S3S4		Blue

a Source: Garry Oak Ecosystems Recovery Team (GOERT). 2011. Species at Risk. GOERT. Victoria, B.C. www.goert.ca/pubs_at_risk.php (Accessed June 19, 2011).
b SC = Special Concern, T = Threatened, E = Endangered, XT = Extirpated.
c REU: Restoration Ecosystem Units as defined in Chapter 2: Distribution and Description
"?" = uncertainty whether the species occurs in this REU

Appendix 4.3

Ecological Communities at Risk in Garry Oak and Associated Ecosystems[a]

Restoration Ecosystems Unit (REU) Number and Name	Scientific Name	English Name	G rank	CDC list	Biogeo-climatic Unit	Reference
Restoration Ecosystem Unit #1: Deep Soil, Average Moisture Garry Oak Communities	*Quercus garryana – Festuca roemeri*	Garry Oak – Roemer's Fescue		Red[b]		Erickson and Meidinger (07)
	Quercus garryana – Bromus carinatus	Garry Oak – California Brome	G1	Red	CDFmm/00	Conservation Data Centre
	Quercus garryana – Camassia quamash – Elymus glaucus	Garry Oak – Common Camas – Blue Wildrye plant association		Red[b]		Erickson and Meidinger (2007)
	Quercus garryana – Camassia leichtlinii – Elymus glaucus	Garry Oak – Great Camas – Blue Wildrye plant association		Red[b]		Erickson and Meidinger (2007)
Restoration Ecosystem Unit #2: Deep Soil, Wetter Garry Oak Communities	*Quercus garryana – Holodiscus discolor*	Garry Oak – Oceanspray	G1	Red	CDFmm/00	Conservation Data Centre
	Quercus garryana – Symphoricarpos albus – Holodiscus discolor	Garry Oak – Oceanspray – Common Snow-berry plant association		Red[b]		Erickson and Meidinger (2007)
Restoration Ecosystem Unit #3: Shallow Soil Garry Oak Communities	*Festuca roemeri – Koeleria macrantha*	Roemer's Fescue – Junegrass	G1	Red	CDFmm/00; CWHxm1/00	Conservation Data Centre
	Quercus garryana – Racomitrium elongatum – Selaginella wallacei	Garry Oak – Grey Rock-moss – Wallace's Selaginella plant association		Red[b]		Erickson and Meidinger (2007)

Restoration Ecosystem Unit #3 (cont.): Shallow Soil Garry Oak Communities	*Quercus garryana – Dicranum scoparium*	Garry Oak – Broom-moss plant association		Red[b]		Erickson and Meidinger (2007)
	Quercus garryana – Arbutus menziesii	Garry Oak – Arbutus	G1	Red	CDFmm/00	Conservation Data Centre
	Quercus garryana – Acer macrophyllum – Prunus spp.	Garry Oak – Bigleaf Maple – cherries	G1	Red	CWHds1/00	Conservation Data Centre
	Arbutus menziesii – Arctostaphylos columbiana	Arbutus – Hairy Manzanita	G2	Red	CDFmm/00; CWHxm1/00	Conservation Data Centre
Restoration Ecosystem Unit #4: Shallow Soil Seepage Communities	*No communities defined*					
Restoration Ecosystem Unit #5: Maritime Meadow Communities	*No communities defined*					
Restoration Ecosystem Unit #6: Vernal Pool Communities	*Myosurus minimus – Montia* spp. *–Limnanthes macounii*	Tiny Mousetail – Montia –Macoun's Meadow-foam	G2	Red	CDFmm/00	Conservation Data Centre
Restoration Ecosystem Unit # 7: Coastal Bluff Communities	*No communities defined*					

Restoration Ecosystem Unit #8: Douglas-fir Communities	*Pseudotsuga menziesii – Mahonia nervosa*	Douglas-fir–Dull Oregon-grape	G2	Red	CDFmm/01	Green and Klinka (1994); Conservation Data Centre
	Pseudotsuga menziesii – Arbutus menziesii	Douglas-fir–Arbutus	GNR	Red	CDFmm/02	Green and Klinka (1994); Conservation Data Centre
	Pseudotsuga menziesii –Melica subulata	Douglas-fir –Alaska Oniongrass	G1	Red	CDFmm/03	Green and Klinka (1994); Conservation Data Centre

a Source: T. Lea, pers. comm. 2009
b Indicates that these would be red-listed plant communities if assessed by the BC Conservation Data Centre (C. Cadrin, pers. comm. 2009)

References

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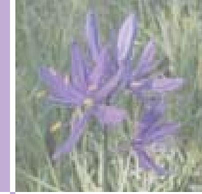

Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 5
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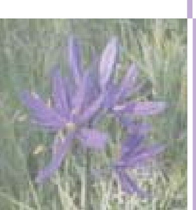

Chapter 5

Restoration Planning

by Conan Webb and Richard Hebda, in collaboration with Don Eastman, Shyanne Smith, Brenda Costanzo, Fred Hook, Dave Polster, and Thomas Munson

Restoration technicians at Fort Rodd Hill National Historic Site carrying out a hand-pulling treatment on Spurge-laurel (*Daphne laureola*). This was one of four manual treatments tried in this experimental removal of Spurge-laurel seedlings. While almost 100% effective, hand-pulling is labour intensive and there was a significant desire to find more efficient control methods. However, hand-pulling remains the standard removal method for Spurge-laurel seedlings at Fort Rodd Hill as other methods turned out to be unacceptable: weed-eating (exposure to Spurge-laurel toxin and excess litter disturbance), hoeing (soil disturbance, more labour intensive), mulching (disruption of native plant regeneration, and costly). Photo: Parks Canada/Conan Webb

5.1 Introduction

The complexity of restoration projects varies widely. You may want simply to remove invasive species in the backyard, or at the other end of the spectrum, you may wish to initiate and carry out a restoration of Garry Oak and associated ecosystems within a regional park that includes the re-establishment of rare species. In all cases, there needs to be some sort of route mapped out to the end point. The end point is the goal. Goals are a broad statement of what you want to achieve; a project may have a few goals or only one. This route towards achieving goals is mapped out by

Golden Paintbrush (*Castilleja levisecta*), an Endangered species in Canada. Restoration work can have unforeseen and detrimental consequences for rare species populations that are already stressed. A well-informed restoration plan, based on thorough research about the restoration site, is critical to prevent harm to rare species (see Case Study 1, Chapter 4). Photo: Nicole Kroeker

objectives. Objectives are very focused and specific: most projects will tend to have a few too many objectives for each goal. Each objective will likely require many tasks to be completed before it is achieved.

A restoration plan lays out the project goal(s), objectives, and tasks. Having a well thought-out plan is especially important where species at risk or multiple agencies are involved, when reporting to a grant provider is required, and for the sake of efficient use of human and financial resources (Nuzzo and Howell 1990).

> A restoration plan lays out project goals, objectives, and tasks; includes a good schedule; incorporates monitoring; and is based upon sound knowledge of the site and species involved.

While any restoration project has its complexities, working with rare species has its own special considerations, some of which are discussed in Chapter 4: Species and Ecosystems at Risk. A well-informed restoration plan is important because all restoration work, no matter how well-meaning, can have unforeseen and potentially deadly consequences for rare species populations that are already stressed. In some cases, rare plants and animals could be trampled and killed during restoration work—sometimes knowing where not to step is just as important as knowing what to do. In other cases, rare species may have become dependent on alien invasive species for food or shelter, and removing the alien species could lead to the loss of a rare population (e.g., the case of Taylor's Checkerspot (*Euphydryas editha taylori*) and its host plants Case Study 1). For these reasons it is important to learn as much as you can about your restoration site before the project begins, so that your restoration plan is well-informed. A tenet many restoration practitioners try to follow is "do no harm"; after all, you are trying to fix a problem, not create another.

A good schedule is a central element of successful restoration projects. Obviously, you will become frustrated if you have organized a broom removal event, and no one shows up because the date happens to coincide with another major environmental initiative or public event.

Additionally, you may discover in your planning process that the restoration project will take much longer than you had anticipated due to the need for consultation meetings or permits, for example. Further, various restoration tasks are season-sensitive, such as planting and invasive species removal. A schedule is particularly important when working around streams where legal regulations afford only a narrow annual work window.

An oft-repeated Garry Oak ecosystem example involves the desire to plant camas bulbs in a meadow restoration. A project team or group gets excited about the project, and finally gets the approval and budget to buy the bulbs; however, the bulbs need to be purchased before the end of the fiscal year, and it is now late fall. The team calls up the supplier, who says that camas bulbs, like many other bulbs, are really only available in the late summer and fall. For the rest of the year the group either has to obtain potted plants (expensive and not usually available), or dig living plants and hope for the best. See Chapter 10: Species Propagation and Supply, Section 10.7, for further discussion regarding planning timelines. With a little planning, including the development of a schedule, such problems can be avoided or mitigated.

We approach the development of a restoration plan by considering a general series of stages that are common to restoration projects. These stages allow you to break the project down into smaller chunks to consider in sequence rather than trying to grasp the entire project at once. These stages are also useful for organizing tasks into a chronological sequence, or schedule. Once specific tasks have been identified and organized, you can assign required resources to each task and develop a budget for money and other resources (e.g., staff or volunteer time). Even if you are not necessarily spending dollars, you are, at the very least, using up your own time and that of others—the value of this time cannot be understated.

This chapter has two parts: a summary description of a restoration project and some associated tasks and planning issues, and a description of a planning tool—the planning table—to help you develop your own plans. When carefully considered, the process outlined below will help you develop a solid plan, which will increase your chances of success and reduce the risk of doing harm.

In Oregon, the remaining populations of Endangered Taylor's Checkerspot *(Euphydryas editha taylori)* currently oviposit exclusively on a non-native larval host plant. This novel association requires restoration practitioners and land managers to re-think traditional approaches to managing alien species and is further complicated by the need to control other invasive plants in order to ensure adequate ground cover of the non-native host plant. Photo: Nicole Kroeker

Case Study 1. Reconsidering the Role of an Invasive Plant: Conserving Habitat Requirements for Taylor's Checkerspot (*Euphydryas editha taylori*), an Endangered Native Butterfly Species in Western Oregon

by Lisa Dumoulin

A restoration plan needs to carefully consider the suite of species and ecosystem processes that are interacting at a given site. Additionally, the goals of a restoration project must be clearly defined. Although common anthropogenic disturbances, particularly the presence of invasive species, are often targeted for mitigation in ecological restoration, the goals of the restoration should be the primary guides for decision making in the planning process. There is growing recognition that the mediation of disturbances such as invasive species must be reconsidered in light of each new restoration project (SERISPWG 2004).

Invasive species have become a prolific problem around the globe. Novel associations of invasive and native species are well documented (Graves and Shapiro 2003, King et al. 2006) and have been used to support the concept of ecological fitting (Agosta 2006). In brief, for plant-insect associations, the concept of ecological fitting proposes that the associations we observe presently (e.g., butterflies and their host plants) are not necessarily the result of tight co-evolution. Rather, an association may have formed through coincidences of time, space, and the innate suite of characteristics that the plant and insect carried at the time they came into contact. Novel associations, especially when involving species at risk, certainly complicate the process of restoration planning.

Such is the case in the Willamette Valley in western Oregon, where the two remaining populations of the Endangered Taylor's Checkerspot butterfly in the state currently oviposit exclusively on a non-native larval host plant, Ribwort Plantain (*Plantago lanceolata*). To the north, in Washington, some of the remaining small populations of Taylor's Checkerspot also feed on Ribwort Plantain but use a small variety of native host plants (paintbrushes, *Castilleja* spp.; Blue-eyed Mary, *Collinsia* spp.; and Sea Blush, *Plectritis congesta*) as well. Although many of the same native larval host plants consumed in Washington are also found throughout the Willamette Valley, only Sea Blush is found at a site where a remaining population of Taylor's Checkerspot persists, and despite its presence, the adult females in the Oregon population do not oviposit on it. Instead, the females favour Ribwort Plantain as the larval food source and oviposit only on this alien species (Severns and Warren 2008). Since no native species of *Plantago* are known to occur in Oregon, the dependency of Taylor's Checkerspot on Ribwort Plantain in that state is considered a novel association between an invasive and an Endangered species, presumably the result of a host shift, though the previous native host plants of Taylor's Checkerspot in Oregon remain unknown (Severns and Warren 2008).

Photo: Nicole Kroeker

Although it may seem reasonable to think that the Oregon populations of Taylor's Checkerspot might benefit from the re-introduction of other potential native host plants (those observed as larval host plants in

Washington) to replace the use of the potentially invasive Ribwort Plantain, further investigation reveals that this is not a reasonable restoration or conservation effort. For example, in Oregon, the timing of the above-ground growth of *Castilleja* spp. and the emergence of Taylor's Checkerspot larvae from their winter dormancy do not coincide (Severn and Warren 2008, Severns 2008). Moreover, if the timing of these events did coincide, another host shift could lead to a reduction in the effective population size, causing a population bottleneck in the already small butterfly populations (Severns and Warren 2008). The exclusive use of Ribwort Plantain as a larval host plant by Taylor's Checkerspot in Oregon requires restoration practitioners and land managers to rethink traditional approaches to managing alien species and to protect the exotic plant in habitats currently occupied by, and of potential importance to, the remaining Taylor's Checkerspot populations (Severns and Warren 2008).

Restoration management decisions at the sites of the Oregon Taylor's Checkerspot populations also need to consider the presence of two invasive grass species. The increased cover of the tall invasive grasses Slender False Brome (*Brachypodium sylvaticum)* and Tall Fescue (*Festuca arundinacea)* is correlated with a decrease in ground cover of Ribwort Plantain. These grasses also out-compete native forbs, including Wild Strawberry (*Fragaria virginiana*), the primary native food plant on which adult Taylor's Checkerspots feed during their flight period (mid-April to early May). Oviposition patterns show that Taylor's Checkerspot in Oregon require habitat with sufficient larval food plants and adult nectar sources for successful reproduction (Severns and Warren 2008). Although Ribwort Plantain is an abundant weed, occurring widely throughout the Willamette Valley, the extant populations of Taylor's Checkerspot only inhabit remnant prairie areas where the cover of tall invasive grasses is low enough that native forbs persist as well. Therefore, to maintain high quality feeding and reproductive habitat in Oregon, restoration activities to remove the invasive grasses, or to control their spread, are necessary to protect native forbs as well as the exotic Ribwort Plantain.

This case study highlights contemporary problems that restoration practitioners face due to alien invasive species. Often, invasive species threaten native ecosystems and warrant removal. In Oregon, however, the exotic Ribwort Plantain is sustaining two extant populations of an endangered butterfly, and despite its weedy tendency and potential to become highly invasive, it requires protection within the suitable remaining habitat for Taylor's Checkerspot (Severns 2008). Traditional ecological restoration in North America may seek to return an ecosystem to a pre-colonial state. However, there is growing recognition that invasive species need to be considered for all of their potential roles in an ecosystem before management actions are taken (Rodriguez 2006, GOERT 2010). As native species are continuously out-competed by exotic ones, new species associations (herbivory, predation, and parasitism) will inevitably form (Agosta 2006). Some of these new associations may turn out to be critical in maintaining a native species, leaving restoration practitioners and land managers with complex management dilemmas. Consideration of the facilitative effects of invasive species in comparison to their detrimental effects should increasingly weigh into the decision-making framework for ecological and ecosystems restoration (Rodriguez 2006).

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5.2 The Structure of a Restoration Project: How do I Organize and Carry Out Restoration?

How to approach carrying out a major initiative may at first seem like an overwhelming question. Even a small project may be more complex than you think, especially if it involves a variety of groups or property other than your own. However, if you approach the matter systematically, step-by-step, rather than trying to grasp it all at once, you can develop a solid plan.

In general, a restoration project can be broken down into several steps or stages. While the specific number of stages varies somewhat according to the person describing them and the emphasis of the project, these stages provide an outline for planning. This restoration outline can be followed from beginning to end; it will help simplify the planning process and help ensure all the pieces for a solid restoration plan are put together. The following description considers seven stages, each with many tasks. This breakdown is taught in the University of Victoria's introductory course to Restoration of Natural Systems (Hebda 2007) and has at its core the concept that a restoration project is a very broad initiative involving more than just the actual on-the-ground work. Identifying the restoration goals and objectives is a key component of the project, as is widespread involvement of the public, if appropriate. Thus, the project stages cover much more than what people might typically consider when they think of restoration. While we will touch on the topic of public involvement in this chapter, readers should refer to Chapter 6: Outreach and Public Involvement for further information.

The outline of the restoration project is presented in a more or less chronological order (see box, Restoration Project Stages). In **Stage 1** the goals and objectives of the project are established.

The initial broom removal on Mill Hill was a major initiative requiring extensive planning for volunteers and equipment. Here Scotch Broom (*Cytisus scoparius*) is being prepared to be airlifted by a helicopter. A systematic, step-by-step approach to restoration planning helps identify and coordinate all of the necessary tasks. Photo: Capital Regional District

Stage 2 involves the collection of data. **Stage 3** follows with the analysis of field samples and data collected in Stage 2, and potentially requires consultation with experts. **Stage 4** builds on data collection and analysis, and with as much information in hand as possible, the restoration plan is developed and verified with interested parties. In **Stage 5**, the restoration process may begin at the site through pre-restoration experiments and field tests. Finally, the restoration work itself, **Stage 6**, occurs. **Stage 7** is the final stage; in this monitoring stage you are checking to see if your objectives are being met and what adjustments need to be made, if necessary, to achieve the objectives and ultimately the goals of the project. Depending on the project, the monitoring stage may be relatively short (months) or very long (decades).

In the sections that follow, the stage descriptions are in list form with annotations. Selected parts have been chosen for extended discussion to provide you with specific practical advice and a rationale for steps. In the case of the monitoring stage, because of its great importance and frequent omission, we have devoted an entire chapter in this publication to monitoring (Chapter 7: Inventory and Monitoring). Elements of many other stages are covered to some extent in other chapters too.

RESTORATION PROJECT STAGES (summarized from Hebda, 2010)

Stage 1 – Establish the context, goals, and objectives for the site. Setting clear, realistic goals for the restoration project is essential for success.

Stage 2 – Inspect the project site and surrounding area: conduct an inventory of the site and an inventory of a comparative site (referred to as a reference ecosystem), and identify biotic or abiotic constraints to recovery.

Stage 3 – Conduct laboratory and other analyses, if needed.

Stage 4 – Develop and verify the restoration plan (establish and verify what you want to do) in consultation with interested parties. This plan will document the goals, objectives, and tasks required to complete the restoration project.

Stage 5 – Conduct controlled experiments and field trials (if needed). Operational trials can be used where uncertainty exists. Here, a series of treatments are applied that are expected to result in recovery of the site. Careful documentation of the treatments and results provides information to refine the treatments as needed.

Stage 6 – Conduct the restoration on-site.

Stage 7 – Monitor the restoration site after project completion and make necessary adjustments.

The strategies and practical details of terrestrial ecosystem restoration, such as those use for Garry Oak ecosystems, have their roots in forestry, agricultural, botanical, and horticultural experience. To begin with, reclamation/restoration projects were viewed simply as a soil issue, wherein the soil was raw or unproductive and had to be improved. Routine soil analyses were carried out to determine which nutrients were in short supply. The soil was treated accordingly, and a standard seed mixture was chosen and sown. In other cases, selected plants, such as shrubs or forestry stock trees (Garry Oak, *Quercus garryana*, trees, for example), were planted. This relatively straightforward and narrowly focused approach met with some success (Bradshaw and Chadwick 1980) and was relatively simple to plan. However, as the scope of restoration broadened in recognition of the complexity of ecosystems, practitioners realized that there was a need for detailed and comprehensive site investigations that covered all aspects of the ecosystem, including interests expressed by various stakeholder groups or individuals.

With the development of the holistic concept of natural system restoration (as reflected in the Society for Ecological Restoration's definition of restoration (see sidebar), the concept of a restoration project expanded in scope to include a broader range of activities than in the past, particularly those involving people and social issues. Clewell and Aronson (2007), for example, have proposed the four quadrant model of ecological restoration to address this diversity of interests by explicitly including personal, cultural, ecological, and socio-economic values. The geographic scope of many restoration initiatives has also expanded from a specific site to the landscape scale. Garry Oak ecosystem restoration is very much this sort of initiative, consisting of many small- to medium-scale projects that are integrated on a regional landscape scale.

"Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed."

This wider scope requires a broad approach to many projects. Consequently, the outline for developing a restoration plan is now more complex and includes an all-important initial step concerning site goals and objectives. As an example of this broader approach, you may want to undertake a simple, small restoration project in your neighbourhood. While you could proceed alone with your project, if you were aware of other nearby projects and the availability of resources, your project might be planned in the context of other projects, and in the long run would be likely to be more successful. You might have just the right spot for a rare plant species or to establish a key connection between two larger areas, but you become aware of this only when considering your project in the broader context (Raphael and Molina 2007). As a background to planning, you may want to look at Clewell et al. (2005) at the Society for Ecological Restoration website (www.ser.org/content/guidelines_ecological_restoration.asp); these authors consider the steps in a restoration project in detail.

5.2.1 Stage 1 – Establish the Context, Goals, and Objectives for the Site

Clear and shared goals are vital to a successful restoration project. These goals drive the objectives and tasks, which in turn shape the budget of the project. Unclear goals lead to confusion, and even to conflict among participants. In the case of a team, lack of a clear set of shared goals may result in inconsistent communication with supporting agencies and the public, including those who provided the budget. In other words, do not start doing anything until you know why you and others are doing it. The process of setting goals is a large subject: we will discuss some of the considerations below.

Setting goals consists of identifying the big-picture end points of your project. The goals for some major projects may be pre-specified by legislation and policy. For example, the restoration of roadsides falls into this category. At the other end of the scale, the goal of a small landholder may be to restore his/her backyard to a natural state. Though this goal may seem self-evident, we do need to consider how the landowner defines the "natural state" of the yard. Does the natural state include non-native and native species? Is it a natural state as exists today, or as existed 150 years ago? Are there municipal bylaws (such as tree removal or weed control requirements) that influence what that natural state may look like?

Clear and shared goals are vital to a successful restoration project.

Additional considerations, such as what the local community thinks or whether any adjacent lands or landowners/managers will be affected by the restoration, are also important. By speaking with these people prior to any on-the-ground work, they can help collaborate on the development of goals (if appropriate), and the discussion will help identify any potential issues up front. Many of these potential issues can be addressed in the restoration plan by adjusting goals relatively easily at the outset to avoid the major headaches of amending goals after work has already begun (see Chapter 6: Outreach and Public Involvement). This is particularly important where re-introduction of fire is being considered as a restoration tool. Below are a few steps to take during the development of project goals:

- Develop a list of parties who are interested in the project, such as:
  - landowners
  - adjacent landowners
  - environmental organizations
  - all levels of government, Provincial, Federal, and First Nations, and particularly local and regional
  - local residents
  - land users (recreational, etc.)
  - sources of support (e.g., volunteers, consultants, academic institutions)
- Meet with landowners, land users, and interested parties to develop restoration goals
- Facilitate a discussion of possible targets or end points for the restoration
- Involve those who have raised awareness of the issue through public means such as protests (this is particularly important)
- Establish ongoing communication links with interested parties to ensure feedback
- Establish which laws and policies apply (e.g., watershed restoration in a park will have very different legal requirements than wasteland reclamation). Also be aware of labour laws, union agreements, and other regulations that involve workers.
- Develop a list of resources for the project, as appropriate
- Gather basic background information and descriptions of restoration models and options
- Identify any biotic or abiotic constraints to recovery

These tasks are critical in planning the restoration project. In Section 5.3: Constructing a Plan, we will show how to construct a planning table, which is helpful in developing a schedule and budget for a restoration project.

Sun through the smoke and branches of a Garry Oak during a burn at the Cowichan Garry Oak Preserve in the Cowichan Valley. Fire re-introduction can be an important restoration tool, but often requires extensive consultation with adjacent landowners, permits, expertise, and planning that make it difficult to use in many restoration projects. Project goals may need to be adapted depending on the available tools. Photo: Thomas Munson

Assessing values and setting priorities is a useful and often critical exercise at this stage, since priorities provide a guide for making choices. For example, during the development of the master plan for Gowlland-Tod Provincial Park (just outside of Victoria, B.C.), preservation of the biodiversity of the park's coastal Douglas-fir ecosystem was identified as the first priority goal (BC Parks 1996). Available space for recreation was ranked as a lower priority goal. This important decision was made clear before any detailed planning began. As a result, intensive recreational activities such as mountain biking were restricted to areas of low biodiversity value. Where recreation activities occurred near biodiversity hot spots, such as rare species populations, actions were taken to eliminate the activity, minimize the risk, and encourage passive recovery (no active interference with the population, such as seeding, control of exotics, etc.). In this example, the work of restoration was the elimination of the activity, which allowed the site to restore itself.

It is important to make it clear that specific project details, such as what combination of plants to use, may need to change as new data are collected. However, the goal and priorities should be agreed upon at the outset because it will shape what field work and other activities take place in the next stage.

While the goals state broadly what is to be done, and they provide general direction, objectives state very specifically what needs to be achieved to reach each goal. Good objectives will be "SMART":

SMART: Specific, Measurable, Achievable, Realistic, and Timed (see examples in box below).

Specific – It is better to have many smaller objectives than one large one. It will be easier to communicate and monitor several small precise objectives.

Measurable – Where possible, objectives should be quantifiable. These objectives will determine what ecosystem attributes you select to monitor in later stages of planning. It is also easier to measure when a quantifiable objective has been achieved.

Achievable – There is no sense in having an objective that is not achievable under current circumstances.

Realistic – Do you have the resources to achieve the objective? Similar to the previous bullet, there is no sense in developing unrealistic objectives.

Timed – An objective should state a timeline. People need to know when an objective is expected to be achieved (weeks, months, years). It may be difficult to come up with a timed objective, but even if it is an educated guess, a timed objective will add context, help with consultation, and inform your monitoring plan and schedule. Without time-bounded objectives it will be difficult to know when to monitor.

Setting the objectives well in advance provides an opportunity to discuss the possibility of pre-disturbance tasks in the restoration. For example, if one objective is to have certain tree species colonize a disturbed site, it may be important to plan to leave selected old trees of the desirable species to act as post-disturbance seed sources.

EXAMPLES OF SMART OBJECTIVES

A SMART objective: Within three years (1) the native grass species Blue Wildrye (*Elymus glaucus*) and Alaska Brome (*Bromus sitchensis*) will have a combined cover of 75%, and (2) the invasive Orchard-grass (*Dactylis glomerata*) will have less than 5% cover within the restoration area

A not-so-SMART objective: We would like to remove invasive grasses and encourage extensive growth of native grasses.

The SMART objective provides lots of information and direction to the project. It leaves little question about what is to be done and by when. The not-so-SMART objective, on the other hand, provides little concrete direction and leaves many questions: Which grasses to remove? Which grasses to encourage? When is the project to be finished? How will we know when the project is finished or whether progress is being made? This last question is particularly relevant. When you are asking for money or resources, you need to be able to report on progress, and to do that you need to know exactly what you are trying to do. Monitoring the SMART objective is relatively straightforward because it has specific, measurable, and time-bounded targets. Monitoring success will be difficult to impossible for the not-so-SMART objective: what is "extensive growth of native grasses"—30%, 60%, 90%?

It is important to identify any constraints at this stage. The removal or mitigation of any constraints may form the basis for objective(s) that must be achieved for a project to be successful. Biotic or abiotic factors that constrain natural recovery of a site are often called filters. Identification of the filters that are preventing recovery is one of the most important steps in planning a restoration project. It may be that invasive species such as Eastern Cottontail (*Sylvilagus floricanis*) rabbits are preventing the recovery of a diversity of native plant species. Simply planting the appropriate species will not solve the problem—you need to prevent the rabbits from eating them. Similarly, a rare species may do well where foot traffic prevents excessive growth of non-native grasses. Removal of the foot traffic may, in fact, result in a decline in the rare species. In this case, the invasive grasses are the filter and the foot traffic is inadvertently mitigating the impacts of the grasses.

Erickson and Edain's (1995) description of how to plan a restoration project (www.ser.org/sernw/pdf/FROSTY_HOLLOW_restoration_guide.pdf) takes a different approach to the beginning of a restoration project. This approach first identifies the problem, the cause of the problem, and the setting of a goal that will solve the problem. By contrast, the approach proposed in this publication is broader and begins by asking whether we all think there is a problem, and whether we see the same problem.

5.2.2 Stage 2 – Inspection and Inventory

Site inspection and inventory are vital to successful restoration because they provide the raw data to guide decisions about tasks. Site data also provide the basis for further consultation about the restoration plan and recommendations. In short, good comprehensive data lead to a good restoration plan. Poor or general data with gaps result in a poor restoration plan. Good inventories not only identify specific issues that need to be addressed but also may turn up unexpected values, such as an unknown population of a rare species.

Site inspection and inventory are vital to successful restoration; good, comprehensive data lead to a good restoration plan.

The discussion that follows outlines some general points concerning inventories, and it briefly mentions typical activities or tasks that fall into the inventory stage (much of this information also applies to monitoring). Chapter 7: Inventory and Monitoring provides a comprehensive description of how to carry out an inventory.

General Principles of Inventory

Collect observations in a standard manner using tested methods: You cannot escape the need for collecting data in a standard, repeatable, and credible manner. This may seem like an overwhelming task because of the diversity of data and technical skills required to collect it. It is important to learn (1) what type of information is most useful, and (2) when you should consult experts. It is important to acknowledge your limitations and consult others with more experience. You might consider taking the standard forms in the *Field Manual for Describing Terrestrial Ecosystems* www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh25-2.htm (BC Ministry of Environment, Lands, and Parks and BC Ministry of Forests 2010) and adapting them to your particular part of the world. The Ground Inspection Form from the manual (see Figure 5.1 Ground Inspection Form) is a comprehensive guide to data collection that is especially related to site location and characteristics and the all-important vegetation component.

British Columbia	**GROUND INSPECTION FORM**		
G ☐ vs V ☐	Photo	X: Y:	Date
Project Id.		Surv.	
Map Sheet		Plot #	Poly. #
UTM Zone	Lat. / North	Long. / East	
Aspect °		Elevation m	
Slope %	SMR	SNR	
Meso Slope Postion	☐ Crest ☐ Upper slope	☐ Mid slope ☐ Lower slope ☐ Toe	☐ Depression ☐ Level
Drainage - Mineral Soils	☐ Very rapidly ☐ Rapidly	☐ Well ☐ Mod. well ☐ Imperfectly	☐ Poorly ☐ Very poorly
Moisture Subclasses - Organic Soils	☐ Aqueous ☐ Peraquic	☐ Aquic ☐ Subaquic	☐ Perhumid ☐ Humid
Mineral Soil Texture	☐ Sandy (LS,S) ☐ Loamy (SL,L,SCL,FSL)	☐ Silty (SiL,Si) ☐ Clayey (SiCL,CL,SC,SiC,C)	
Organic Soil Texture ☐Fibric ☐ Mesic ☐ Humic		Surf. Organic Horizon Thickness ☐ 0–40 cm ☐ > 40 cm	
Humus Form ☐Mor ☐ Moder ☐ Mull		Root Restricting Layer Depth ________ cm Type___________	
Coarse Fragment Content ☐ < 20% ☐ 20–35% ☐ 35–70% ☐ > 70%			

TERRAIN	Component: TC1 ☐ TC2 ☐ TC3 ☐		
Terrain Texture	Surficial Material	Surface Expression	Geomorph Process
1	1	1	1
2	2	2	2

ECOSYSTEM	Component: EC1 ☐ EC2 ☐ EC3 ☐
BGC Unit	Ecosection
Site Series	Site Modifiers
Structural Stage	Crown Closure %

ECOSYSTEM POLYGON SUMMARY					TERRAIN POLYGON SUMMARY		
	%	SS	SM	ST		%	Classification
EC1					TC1		
EC2					TC2		
EC3					TC3		

Figure 5.1 Ground Inspection Form (first page) from *Field Manual for Describing Terrestrial Ecosystems* (BC Ministry of Environment, Lands, and Parks and BC Ministry of Forests 2010)

Make multiple visits: Good field observation for restoration purposes requires more than a single visit. In Garry Oak and associated ecosystems, field visits in the early spring to early summer are especially important for observing various herbaceous species (see box page 5-18, Best Practices for Conducting Rare Species Inventory).

Observe how people use the site and consult them about their interests and concerns: Site visits provide an opportunity to survey the wishes and concerns of the local people. It is a good opportunity to learn traditional or folk knowledge about the site and engage the local community (see Chapter 6: Outreach and Public Involvement).

Make a reconnaissance visit and get a general sense of the restoration site: Often the goal of the first field visit is to look around and get a sense of the scope of the site, both biophysically and geographically. Even in this first visit you must be prepared to make notes and sketches and collect preliminary samples, such as specimens of dominant plant species. Some analyses take many weeks and even months, so the sooner you get started, the better.

Be prepared for your main field visit: Take forms, maps, field guides, and a good field notebook. If you have determined that you need to bring along an expert (in soils, for example), the expert should visit the site along with you, if at all possible. Then all observations will be collected at the same time at the same site.

Make arrangements with experts for identifications and analyses before you start: These experts may provide advice about the site visit, including what you should look for in the way of indicators. You need to advise such experts well in advance that you may need their help in identification. Today, taxonomic experts are especially rare, and weeks or months may pass before they have the time to help, even if you have budgeted payment for their services.

During the inventory stage, in addition to assessing what is on the site, you should be looking for physical attributes, biological features or processes, or human activities that constrain natural processes on the site. These constraints will need to be dealt with during restoration and will likely be the focus of one or more objectives in the restoration plan. These constraints can be thought of as filters. Compaction may be a filter that is preventing recovery where an old road runs through a site (abiotic filter). Invasive species such as Scotch Broom (*Cytisus scoparius*) may be a filter that is preventing recovery (biotic filter). The absence of fire is a filter that plagues many Garry Oak ecosystems (see Chapter 3: Natural Processes and Disturbance). Whatever the case, identification of the filters operating at a site will be critical in developing effective strategies for recovery.

Types of Data

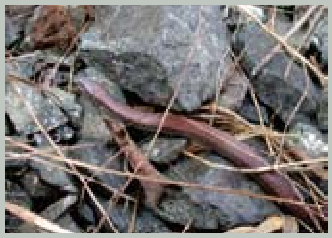
The following point-form summary lists the types of data you can collect, and it provides additional advice on selected points. The list is not comprehensive; however, you can use it to see the tasks that have to be carried out, get a sense of when they can be done, decide what equipment is necessary, and determine if you need to budget for these tasks.

Site description: Location, access, map references, air photo numbers, landforms, drainage characteristics, etc.

Photographs or a video of the site: Images help you recall details of the site after the visit, and they provide a visual baseline condition before the restoration takes place.

Soil description: General depth of soil, coarse fragment or rockiness, texture, drainage, root restricting layer, description of organic material and thickness, presence of earthworms and other biota, moisture regime, nutrient regime, surface Ah horizon depth.

Vegetation description: Vegetation composition often provides an easy way to describe the conditions at the restoration site because it reflects ecological conditions. The plant component of a site can be described simply by preparing a species list. Another approach is to describe plant vigour (how well are the plants growing?). More useful, however, is a description of the abundance and distribution of plant species. A most valuable skill to learn is how to estimate plant species cover by vegetation layer (see Chapter 7: Inventory and Monitoring). If possible, consider collecting data on vegetation composition in an undisturbed site and using it for comparison purposes. This other site may be the reference site, which you would like your site to resemble when restoration has been completed; these comparisons will help you to set your objectives. Also, note the occurrence of weedy invasive species, natural regeneration (a clue to species for restoration), and rare species and their location.



Left: Macoun's Meadowfoam (*Limnanthes macounii*). Photo: Conan Webb

Right: Sharp-tailed Snake (*Contia tenuis*). Photo: Nicole Kroeker

BEST PRACTICES FOR CONDUCTING RARE SPECIES INVENTORY

A qualified person who is familiar with any rare species that are likely to be present in the project area should be hired to conduct inventories. Inventories need to be conducted at the correct time of year. Many rare plants in Garry Oak ecosystems are detectable (or identifiable) only at certain times of the year.

A summer survey, for instance, will miss many of our rare spring flowering plants, such as Threatened Macoun's Meadowfoam (*Limnanthes macounii*), which germinates in the fall and is virtually undetectable by mid-May on most sites. On the other hand, the identification of Endangered Foothill Sedge (*Carex tumulicola*) can be confirmed only in the summer when it is fruiting; at any other time of the year it can be easily confused with more common related sedge species. Red-listed Carolina Meadow-foxtail (*Alopecurus carolinianus*) is a small annual grass that is restricted to vernal pools (small depressions that collect water in the fall, winter, and spring). This species grows very quickly during the summer after the standing water has dried up but before all the soil moisture has evaporated. However, in some years, if conditions are poor, the plants will not germinate.

So, conducting inventories is not as simple as heading out into the field whenever you have the opportunity, because proper surveys need to be planned and performed at the appropriate time of year. Ideally, surveys should be conducted more than once a year at a site to catch the early and the later species, and for more than one year because not all species are visible every year. For some particularly cryptic species it can take a very long time: there are several cases where it took over 50 surveys to detect the Endangered Sharp-tailed Snake (*Contia tenuis*); in one of these cases, it took five years and 62 surveys.

Left: Foothill Sedge (*Carex tumulicola*). Photo: Conan Webb

Right: Carolina Meadow-foxtail (*Alopecurus carolinianus*). Photo: Conan Webb

Measuring tree diameter at breast height (DBH) using a DBH tape. Data about your restoration site must be collected in a standard, repeatable, and credible manner. Photo: Thomas Munson

Weedy species may indicate some form of disturbance that had not been noticed. This disturbance may be as simple as a trail running through the site or the lack of fire. Pay particular attention to why the weeds have established because this will give you clues for designing the recovery systems you will need.

Tree mensuration data: A census of trees, including their size, health, and distribution, note old-growth trees, observe diameter at breast height (DBH), tree height, age at breast height (need an increment borer), signs of disease, scarring, and observed wildlife use.

Weedy species: They may indicate some form of disturbance that had not been noticed. This disturbance may be as simple as a trail running through the site or the lack of fire.

Coarse woody debris: Stumps or logs, which can be a positive indicator of site health.

Wildlife: Presence of animals or sign such as droppings or tracks.

Historical or archaeological features: Shell middens, trees where bark has been stripped, piled rocks that may be cairns, or old building foundations.

Local knowledge: In general, local naturalists and long-time residents may be a particularly rich source of knowledge about wildlife. For example, they may be aware of cougar and bear dens. The birders of a community often keep detailed lists of bird species in an area and may note where nests occur. Nests of raptors are often occupied for many years and become part of the local lore.

5.2.3 Stage 3 – Carry Out Analyses

Once data and any necessary samples are collected, you need to make sense of them to develop the restoration plan. Activities in this stage will vary widely depending on the project and what data have been collected. Some general activities included in this stage are listed below:

- Identify and verify plants and wildlife that were not readily identified in initial inventory visits
- Deposit voucher specimens collected in the field in an appropriate facility (e.g., plants would be deposited in a local herbarium)
- Conduct physical and chemical soil analysis
- Analyze water quality
- Consult experts to interpret results and provide recommendations based on your goals
- Do statistical analyses of survey data/questionnaires

Points 3 ("Site options analysis"), 4 ("Alternatives analysis") and 5 ("Decision") in Erickson and Edain (1995), present a detailed set of suggestions for carrying out an analysis.

5.2.4 Stage 4 – Develop the Restoration Plan

Using the objectives from Stage 1, combined with field data from Stage 2, and analysis from Stage 3, prepare a restoration plan that includes the following:

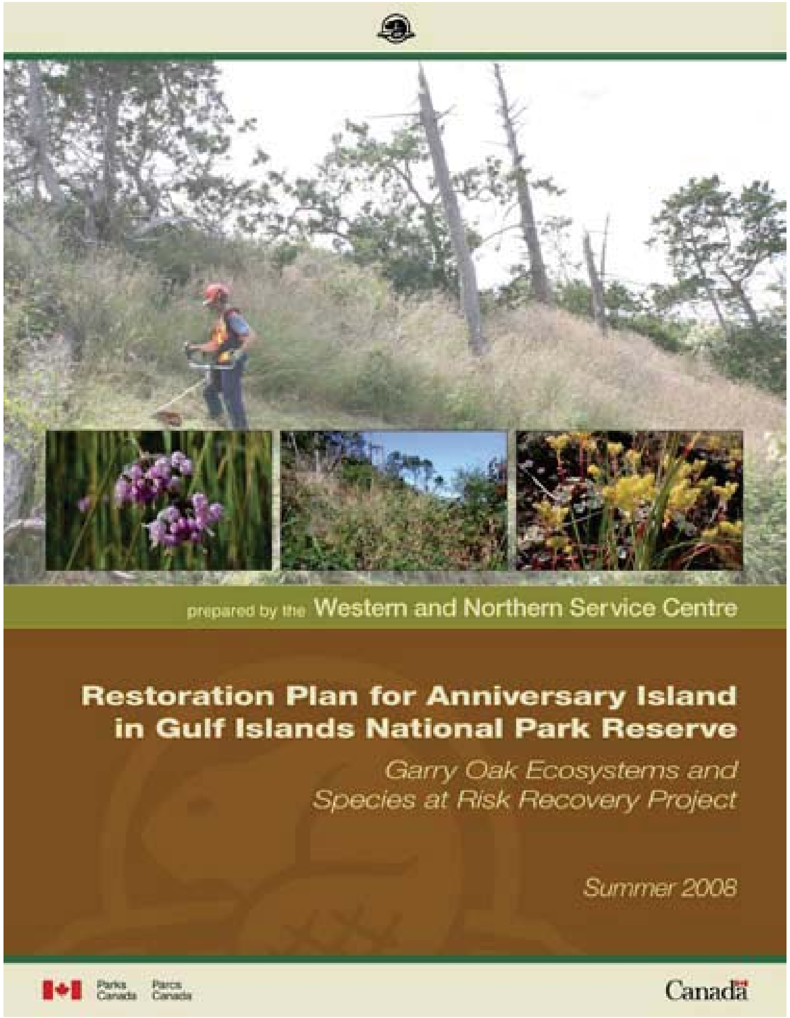
- Goals and objectives
- Identification of constraints
- Communication plan
- Experimentation and field trials
- Specific detailed restoration instructions and site plan
- Special requirements, such as sources of biological materials
- Consideration of structures to be built or modified
- Monitoring plan
- Schedule of tasks
- Budget, listing costs for each part of process
- A process to verify the budget and a mechanism for monitoring—this step is often forgotten

Erickson and Edain (1995) outline many of the considerations and actions needed when making a restoration plan and beginning to implement it. Think about these when you develop the plan. Also, refer to Appendix 5.1: Restoration Plan for Anniversary Island, which is a full restoration plan for a Garry Oak ecosystem restoration project on Anniversary Island in the Gulf Islands National Park Reserve.

Monitoring is discussed below in Stage 7 but deserves special consideration at Stage 4 as well. Monitoring helps you determine whether you are achieving your objectives. While the actual work of monitoring occurs during or after the work of Stages 5 and 6, it must be planned in advance. A monitoring plan must be fully developed in Stage 4 so that appropriate inventory or baseline data can be collected before any work alters the site. There will not be sufficient money or time to measure everything, so you must choose carefully what you will measure and how. What you measure should be determined by your objectives—you want to determine whether your restoration is achieving your objectives—and if your objectives are SMART, your task will be much easier.

After a draft of the restoration plan has been prepared, it should be shared with all participating parties. This is a chance for consultation and for verifying that everyone agrees on the goals and the tasks. This is also a good time to verify the budget with sponsoring client agencies and interested parties.

Monitoring helps you determine whether you are achieving your objectives. It is important to include monitoring in early phases of restoration planning to ensure not only that adequate resources are allocated but also that pre-work data are appropriate for measuring success.



Anniversary Island Restoration Plan found in Appendix 5.1 is an example of a restoration plan written for Garry Oak ecosystems.

5.2.5 Stage 5 – Carry Out Experiments and Field Trials

Garry Oak ecosystem restoration is still a highly experimental undertaking. We are only now beginning to see the results of some of our efforts after many years of restoration work. Before a large restoration project is implemented, it is wise to check if the proposed treatments will actually work at the site in the manner anticipated. If necessary, run trials for treatments you intend to use but whose effectiveness you are unsure of, consult with others, and thoroughly check the literature to verify the potential for success of your treatment before carrying it out. Many techniques and strategies can be tested on a small scale (e.g., proposed fertilization and planting combinations, fertility/capability of stored topsoil to support seed mixes, germination rates of native species, survival rates of rare species seedlings, resistance of outplantings to herbivores, response of desired species to control of invasive or aggressive native plants, resistance to human use).

Use of a small, well-observed experimental plot might save lots of money and effort in the future and avoid unforeseen results. However, such trials need to be planned in advance and worked into the schedule because their inclusion in the project could push the restoration timeline ahead by several months or even a year into the future.

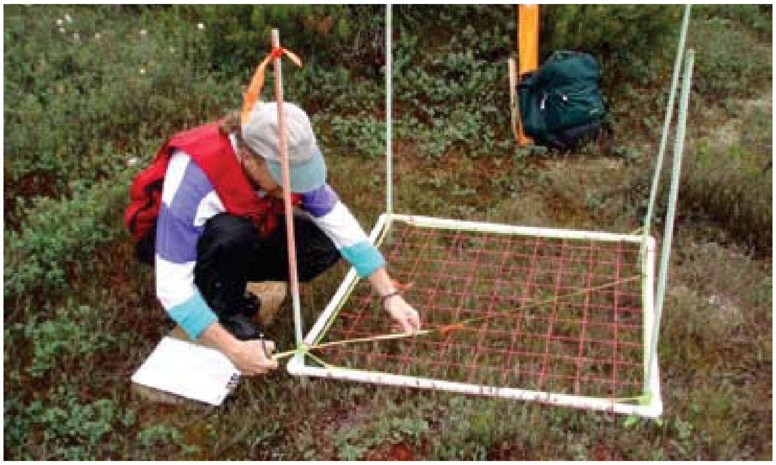
5.2.6 Stage 6 – Carry Out Restoration

The specific tasks involved in a Garry Oak restoration project are covered in several of the chapters in this publication—Chapter 6: Outreach and Public Involvement, Chapter 7: Inventory and Monitoring, Chapter 8: Restoration Strategies, Chapter 9: Alien Invasive Species, and Chapter 10: Species Propagation and Supply. Typical tasks include notifying the participants that work is commencing, preparing the site, and carrying out plantings or removal of invasive species. Be sure to include options in your plan for the schedule or tasks because field conditions change (e.g., atypical site conditions, bad weather, or excessive drought). Large projects should include a specific task to keep track of expenditures and to remain within budget. Having a well thought-out schedule is especially important to ensure that all the resources, such as tools and people, are clearly identified and on-site when required.

All restoration projects should include a plan to communicate progress from the start to the end of the project. Restoration practitioners learn from the mistakes and successes of others, and there is something to learn from any project, no matter how small or unsuccessful. Begin with some sort of pre-restoration notice, then report on progress at some predetermined stage/date during the work. In the end, provide a summary of how the restoration project proceeded and any lessons learned, and an outline for future work once the field work is completed. Even unsuccessful results are important to share with others so they know what has been tried and what techniques to avoid using in their own projects.

5.2.7 Stage 7 – Monitor and Verify Restoration

The importance of monitoring is discussed fully in Chapter 7: Inventory and Monitoring. However, it is worth repeating that in order to determine whether a restoration is successful, observations of the site must continue after the work has been completed. The post restoration data should be compared to the original data and the targets specified by the objectives. To be effective, monitoring must measure critical biological and physical features of the site that indicate whether or not the



A common method of monitoring vegetation involves using 1 m x 1 m quadrat frames. Site observations must continue after restoration activities in order to gauge the success of the restoration project. Photo: Thomas Munson

Monitoring is the process of making repeated measurements to detect change over time.

objectives of the restoration are being met (Harwell et al. (1999) discuss some of these characteristics). These attributes are often referred to as indicators.

The concept of monitoring is very important because restoration is a long-term activity. However, in practice, there is considerable confusion about what "monitoring" actually means, as well as what is involved in carrying it out.

Two other similar terms—evaluation and assessment—are often used in place of the word monitoring, but they have different meanings. Evaluation is the process of determining whether the work is being done correctly. For example, you can evaluate whether the right number of plants were planted in the prescribed pattern. Assessment is the process of comparing the results or condition of an indicator attribute to a desired condition. For example, a coarse woody debris (CWD) assessment involves carrying out an inventory of CWD and comparing it to the desirable standard or condition (how many pieces or what volume per hectare), which should be specified in the objectives.

To be effective, monitoring must measure critical biological and physical features of the site that are linked to the restoration objectives.

Monitoring strictly addresses the question "Is the baseline condition changing?" In other words, is the restoration progressing in the direction set out in the goals? Are the objectives being achieved? Monitoring may also be used to determine whether a desired condition is persisting or whether changes are occurring. It involves repeated visits to a site and collecting data in a similar or standard manner on each visit.

A monitoring plan should identify what is to be measured and observed, where and how frequently, and by what standards. Such a plan should be included in the restoration plan prepared in Stage 4. If needed, make sure that any structures and signs for monitoring are installed during this or the preceding stage. After you carry out the monitoring observations, make sure you deposit them in a secure and accessible place where others can use them. Key data have a tendency to disappear if no one is identified as their steward. Part of the process of monitoring involves communicating the results. In effect, the monitoring stage provides an opportunity to report on long-term progress of a project and demonstrate that the project is progressing. If progress is not being made as planned, then the monitoring stage provides an opportunity for taking corrective action. **A key task in developing a monitoring plan is to ensure that there is sufficient budget to monitor for the interval required.**

5.3 Constructing a Plan

Written plans are very important documents, especially for large and complex projects. They can be constructed in many ways, such as flow charts, point-form to-do lists, and text documents. Many restoration plans not only involve tasks but also integrate schedules and budgets. A planning table is a straightforward and effective tool for developing a restoration plan. In a table you can list the tasks, and for each task, list the required resources and budget. These tasks can then be organized in chronological order to form a schedule. The table serves as a living guide to the project, and helps you check at a glance whether your tasks are organized in a realistic manner, whether or not the tasks are getting done, and how the project schedule and budget are progressing. A planning table can always be adjusted as the project moves forward. It also provides a tool for reporting to project supporters and interested parties.

A planning table is a straightforward and effective tool for developing a restoration plan.

Because the restoration stages cover the full range of tasks involved in restoration and set out the flow of a project more or less in chronological order, they can be used to help order restoration tasks and ensure that none are missing. For complex projects, such as restoring a native Garry Oak ecosystem in a large park, planning under each of the stage headings is necessary. In smaller projects, such as restoring your backyard, some of the stages, such as carrying out lab analyses, may be omitted. Even if little or no budget is involved and the schedule is mostly up to you, a planning table helps you order your tasks. The columns of a planning table can be filled out as follows and as modelled in Table 5.1. Restoration stages are listed in the first column of the table. They help group project tasks, which are the drivers and measures of a project's progress. They are the things you have to do, and for which you need to find the resources, budget, and time.

Tasks are listed in the second column of the table, grouped by stage. For example, under the first stage, in which you establish the context and objectives for the project, there are typically several tasks that need to be done, such as developing a list of interested parties; gathering background information; facilitating a discussion with the interested people to outline possible targets or end points for the restoration; checking on applicable laws, policies, and strategies; and establishing a means of regular communication. It is not so important to place each task precisely under an appropriate restoration stage, but it is important to list all the tasks that need to be done.

After you list the tasks, you then need to sort out who will do them. The "who" column provides project managers an opportunity to list potential volunteers, funding agencies, and individuals with key expertise. The "who" column also enables you to make sure that for every task there is somebody assigned to complete it. For example, you do not want to get a project underway and discover that nobody checked on municipal bylaws concerning the removal of exotic plant debris or use of noisy machinery.

Once the people or agencies that will complete the tasks are identified, they need to be provided with the tools or resources for the work. For example, in the case of a broom pull by volunteers, somebody has to ensure that the pullers, cutting tools, and collecting tools (tarps), plus perhaps refreshments for the volunteers, are all brought to the site. Even in Stage 1, resources are needed. Gathering interested parties together requires arranging a meeting place and providing refreshments. The task of obtaining background information may require access to a vehicle or other travel means. Stage 2 may require all sorts of field sampling equipment, according to the nature of the inventory. These resources can be entered in the fourth column.

> The "who" column provides project managers an opportunity to list potential volunteers, funding agencies, and individuals with key expertise.

Based on the resources required for each task, you can fill out the fifth column with the estimated cost. For example, funds will be required to purchase or rent resources such as tools, and expert consultants generally charge a fee for their time. You can estimate the value of volunteer time and that of donated expert services, equipment, and facilities. Many granting agencies specifically require an estimate of in-kind materials and volunteer time. These in-kind contributions demonstrate commitment of the community or participants to the project. The budget column ensures that you have a full cost accounting, and it can help you justify or explain the cost of the project and develop a grant application. The budget entries also allow you to keep track of expenditures by category as money is being spent.

The budgeting exercise helps project leaders see whether they have distributed the costs realistically (e.g., Stage 7, monitoring and making adjustments, often receives insufficient or no funding). If you invest all or most of your funding in Stages 2 and 6 and very little in monitoring, you may never know whether or not you achieved the restoration objectives. As well, if things go wrong, there will be no money or few resources to make corrections. As a guideline, the monitoring stage should be at least 10% of the overall budget, and in some cases even 15–20%, particularly if detailed observations are required for several years and/or the treatment is highly experimental.

> As a guideline, the monitoring stage should be at least 10% of the overall budget, and in some cases even 15–20%.

Having a well thought-out schedule is critical for achieving success with the restoration project. Filling out the final column of the planning table allows you to schedule each task. The drafting of a schedule, even if only by season, reveals how long a project may realistically take to complete. If permits and various meetings are required, time needs to be allocated for these tasks before any ground work is initiated. Furthermore, certain types of tasks are constrained by the season. For example, a full inventory and mapping of rare plants in Garry Oak ecosystems should be conducted from mid-spring to early summer. Also, the removal of invasive plants at a time when rare plants are not visible could be disastrous if the locations of rare species have not been identified. Conversely, many rare plants are less sensitive to disturbance in the summer when they are dormant. Therefore, scheduling must be assessed on a site-by-site basis using the expertise of your project team. Planting of seedlings or sowing of seeds can be more successful when carried out in the fall and winter; therefore, the schedule needs to be built around these constraints. Often this means working back in time from a critical season so that Stage 1 begins early enough before the actual work in the field is required. This means that community consultation meetings may need to be held many months (or years in the case of large, complex projects) before any on-the-ground work begins.

The specific information you need to develop a planning table is provided in many chapters of this publication. Remember, tasks do not have to occur in a specific stage; they may occur in various stages of the project. It is up to the project planner or team to determine where they fit best in the table.

TABLE 5.1 Example Restoration Planning Table

Restoration Stage	Task	Who	Resources	Budget	Schedule
Stage 1	Talk to stakeholders (neighbours, site users, owners)	John	Pen and paper, background information	1 day	January–March
Stage 1	Determine goals	John/Lisa			January–March
Stage 2	Inventory site	John, Botanist, Restoration practitioner	Camera, notebook, plant press	2 days consultant fees in-kind	April
Stage 4	Write restoration plan	John/Lisa	Computer lab/office space	5 days	May
Stage 4	Consult with experts and stakeholders	John/Lisa		2 days	May–June
Stage 6	Recruit volunteers	John/Lisa	Print shop	$25 (poster printing)	August
Stage 6	Source tools to borrow	Lisa	Borrowed tools		June–August
Stage 7	Collect before photo-point photos	John/Lisa	Camera, notebook, scale pole, tripod, compass, chalkboard, chalk	1 day	August
Stage 6	Pick up lunch for volunteers	John	Car	$50	August
Stage 6	Meet volunteers and remove broom	John/Lisa	Borrowed tools, food	1 day	August 25
Stage 7	Collect after photo-points	John	Camera, notebook, scale pole, tripod, compass, chalkboard, chalk	0.5 days	August 26
Stage 7	Write summary report	John/Lisa	Computer lab/office space	1 day	September 1

5.4 Conclusions

Whether a Garry Oak ecosystem restoration project is small or large, planning will always be vital. It will help you grasp the full scope of the project and identify what needs to be done and by whom. Furthermore, the plan will help you develop a realistic schedule and budget. Without some sort of systematic planning, the project may end up being unrealistic, have gaps, run into problems in the community or on the ground, and lead to unnecessary effort, costs, and even failure. Considering the great task we have before us, it is an absolute must to work in a well-organized and effective manner.

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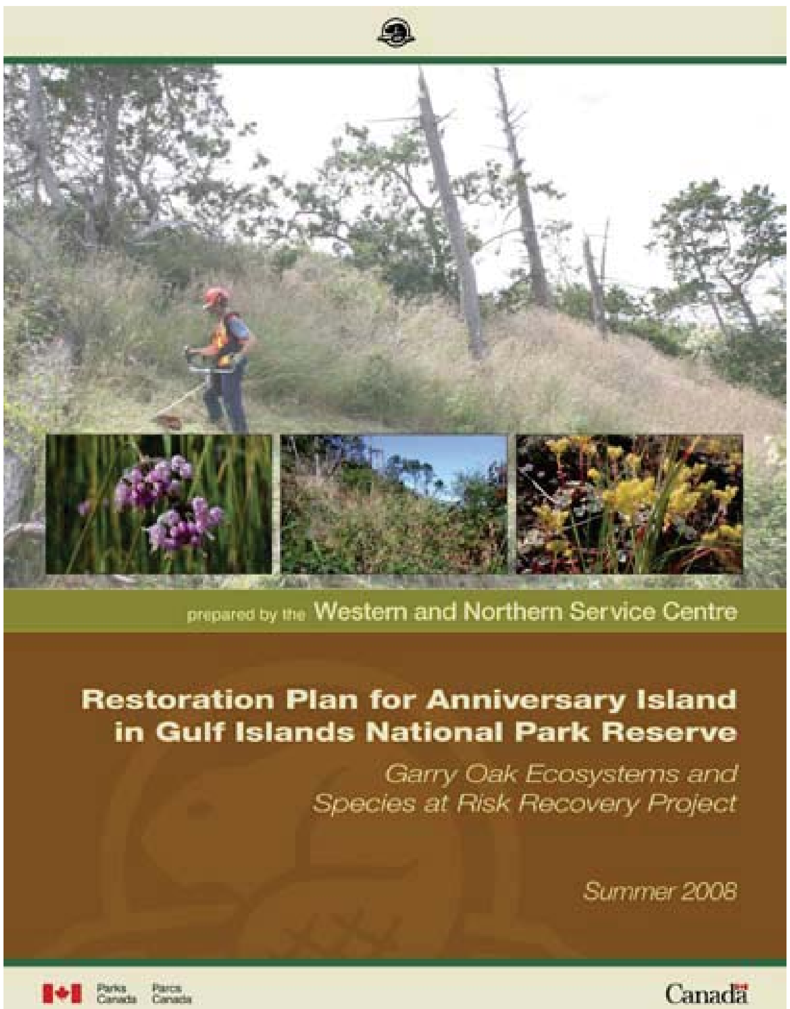
Appendix 5.1

Restoration Plan for Anniversary Island in Gulf Islands National Park Reserve

Report prepared by Marian McCoy and Nicole Kroeker, Western and Northern Service Centre, Parks Canada, with input from the Garry Oak Ecosystem and Species at Risk Recovery Project (GOESARR) Coordinating Committee, Conan Webb, and Phil Lee.



Plan begins on following page.

prepared by the Western and Northern Service Centre

Restoration Plan for Anniversary Island in Gulf Islands National Park Reserve

Garry Oak Ecosystems and Species at Risk Recovery Project

Summer 2008

Parks Canada Parcs Canada

Canada

Approval signatures

Signature: Aug. 21/08

Brian Reader	Species at Risk Ecologist	
Name	Title	Date

Signature: AUG 26, 2008

Ron Hamilton	GINPR Superintendent	
Name	Title	Date

Cover photo

Main: Species at Risk field crewmember cutting agronomic grasses in polygon B on the northeast side of Anniversary Island.

Left inset: Native nodding onion (*Allium cernuum*) is scattered throughout exposed grassy areas on Anniversary Island.

Centre inset: Photo of Himalayan blackberry infestation along the bottom bench in polygon B taken in 2005. The blackberry was subsequently removed.

Right inset: Native broad-leaved stonecrop (*Sedum spathulifolium*).

Report content

Report prepared by Marian McCoy and Nicole Kroeker, Western and Northern Service Centre (WNSC), with input from the GOESARR Coordinating Committee, Conan Webb (WNSC Ecosystem Scientist), and Phil Lee (WNSC Monitoring Ecologist).

A concept report by Dave Polster (Polster Environmental Services, 2007) provided the basis for the approach to controlling agronomic grasses adopted in this restoration plan.

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Figures

Tables

1.0 Restoration plan overview

This document describes the restoration plan for Anniversary Island for implementation under the Garry Oak Ecosystems and Species at Risk Recovery (GOESARR) project, as funded by Priority Investment Fund for Species at Risk Recovery. It is designed to extend to 31 March 2009; however, some elements will continue beyond that timeframe.

This restoration plan elaborates upon the activities described in the Environmental Assessment Screening Report form GI07-05 *Restoration Plans for Anniversary Island and Eagle Island*, which was submitted to the First Nations committees for comments and subsequently approved by the Gulf Islands National Park Reserve management team. This plan covers the same elements presented in the environmental assessment report, but provides more detail, a monitoring protocol, communications and outreach plan, and a workplan. This plan is also based in part on a report submitted by Polster Environmental (2007) that discusses restoration concepts for Anniversary Island and Eagle Island. Readers are invited to refer to these documents to see the contents in their original form.

This restoration plan follows an ecosystem-based adaptive management approach (*sensu* Johnson 1999). Adaptations to the plan will be made as we apply treatments, monitor using ecologically sound methods, and learn. Changes to this restoration plan, all data collected, results of monitoring, and modifications to methods will be recorded routinely and reported annually to Parks Canada staff. Significant revisions to the plan must be vetted by the GOESARR Coordinating Committee.

2.0 Goals

The overarching goal of this restoration plan is to improve the ecological integrity of Anniversary Island. With respect to Canada's national parks, ecological integrity means, "…a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes (Canada National Parks Act 2000)".

At Anniversary Island, where "natural region" includes coastal Douglas-fir, Garry oak and associated coastal bluff ecosystems of the Strait of Georgia Lowlands, ecological integrity is relatively intact. Native plant communities are 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 are threatening the native communities and are 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. As such, this restoration plan does not aim 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 objectives, targets, and monitoring protocols described in the next sections are directly linked to the restoration goal.

3.0 Site description

3.1 Overview

Anniversary Island is a 1.8 hectare islet located about one kilometre northwest of Saturna Island, within the Belle Chain Islets, in the Strait of Georgia at N48°49'00" W123°11'00" (NAD83) (Figure 1). At its widest point, Anniversary Island is ~ 47 m across. Its long NW-SE axis is ~ 449 m excluding the un-vegetated rocky shoreline. This narrow islet is a mosaic of rocky outcrops with thin soils and patches of deeper soils that are sufficient to support dense shrub thickets and some trees throughout the middle section. Both sides of the islet drop steeply to the bedrock shore.

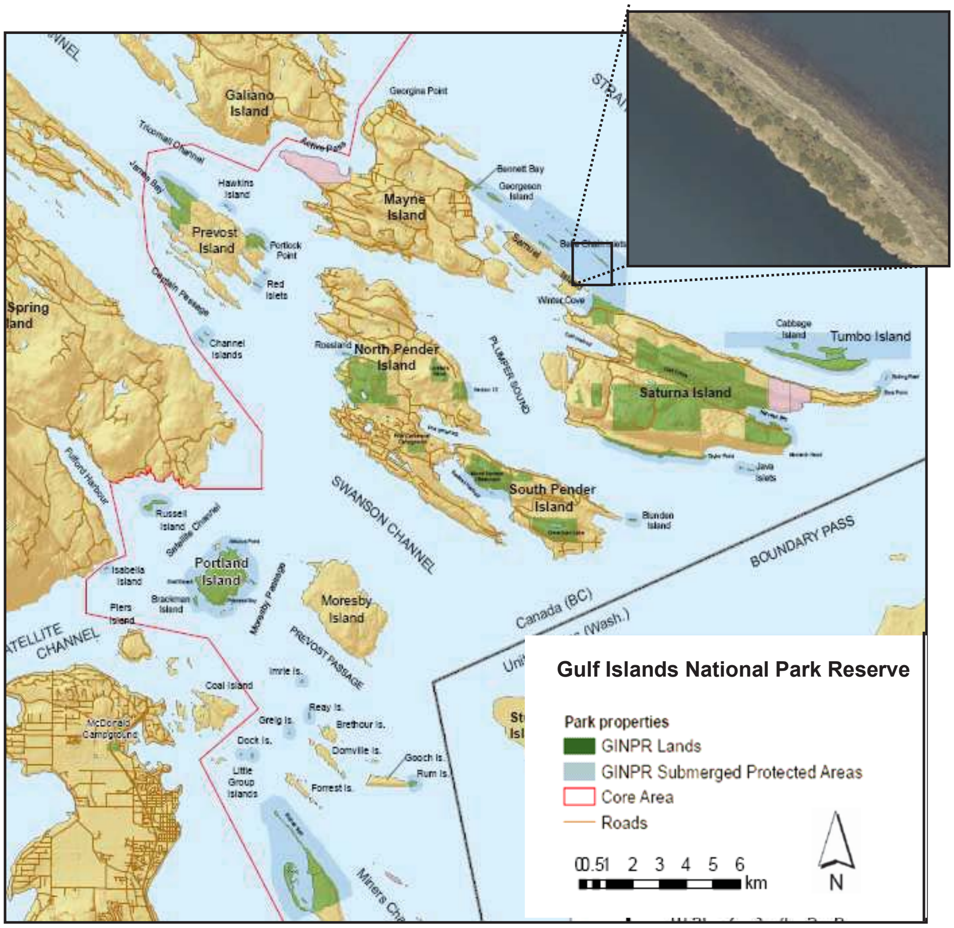

Figure 1. Map showing location of Anniversary Island in Gulf Islands National Park Reserve.

3.2 Ecological conditions

Anniversary Island lies within the moist maritime subzone of the coastal Douglas-fir (CDFmm) biogeoclimatic zone. It is primarily a coastal bluff ecosystem dominated by dense, shrubby Garry oak (*Quercus garryana*), snowberry (*Symphoricarpos albus*), Nootka rose (*Rosa nutkana*), and mature seaside juniper (*Juniperus maritima*)[1]. Several stunted Douglas-fir (*Pseudotsuga menziesii ssp. menziesii*) and once-mature snags are also present. Coastal bluff ecosystems are naturally rare throughout eastern Vancouver Island and the southern Gulf Islands. These ecosystems are of increasing concern due to development pressure, increased recreational use, and exotic species infestations. Anniversary Island is designated as Zone 1 (Special Preservation), meaning that only authorized access is permitted [2]. Among animal species that utilize Anniversary Island, of special interest in this restoration plan is the black oystercatcher (*Haematopus bachmani)*.

Seven plant community types have been identified on Anniversary Island. Rather than occurring as discrete units on the landscape, these plant communities tend to exhibit common elements and often grade into one another, although some may occur in clearly defined pockets depending on micro-site variations. Details regarding these plant community types and how they were classified are provided in Appendix 1. Figure 2 shows the plant community types identified for Anniversary Island by Blackwell *et al*., (2007) using a terrestrial ecosystem mapping methodology.

Despite infestations of agronomic grasses—primarily common velvet-grass (*Holcus lanatus*), sweet vernalgrass (*Anthoxantham odoratum*), Kentucky bluegrass (*Poa pratensis*), orchard grass (*Dactylis glomerata*), and Himalayan blackberry (*Rubus armeniacus*), Anniversary Island is generally ecologically intact. Sufficient native species diversity and cover (estimated ~75%, C. Webb, pers. comm. 2008) remain to warrant restoration of the degraded areas.

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[1] Described in Adams, R. P. 2007. *Juniperus maritima*, the seaside juniper, a new species from Puget Sound, North America. Phytologia 89: 263 - 283.

[2] Access is permitted for such activities as research or restoration work, or when authorized by the park superintendent in advance.

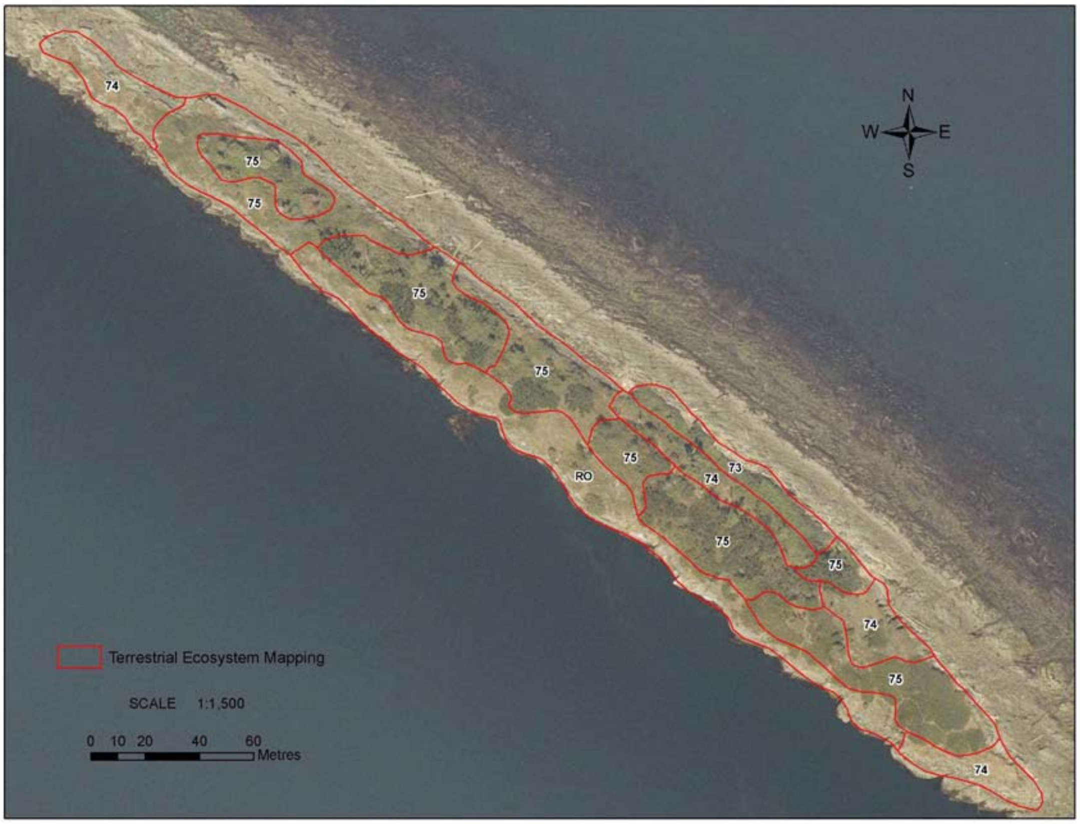

Figure 2. Plant community (site) types identified for Anniversary Island by Blackwell (2007) using terrestrial ecosystem mapping methodology. Site types are described in Appendix 1.

3.3 Ecological degradation

Infestations of invasive exotic plant species noted above are considered the primary cause of ecological degradation on Anniversary Island and are the focus of this restoration plan. Between 2003 and 2006, volunteers devoted several days of work to clear two areas of Himalayan blackberry by hand-cutting and some root ball removal (Figure 3). Due to these efforts, by 2008 native shrubs within and around the perimeter of this area have expanded by more than a metre in height and breadth.

Unfortunately, agronomic grasses that were present around and among the blackberry (Figure 4) have also expanded. Common velvet-grass now dominates in the bench and up the slope seen in Figure 3, and in other locations where Himalayan blackberry was removed. Native shrubs can be expected to continue advancing. In time, they may out-compete the agronomic grasses. This restoration plan aims to ensure and expedite that process through an integrated pest management approach of repeat cutting and re-vegetation with appropriate native species as recommended by Polster (2007).

Figure 3. June 2004 photo of Himalayan blackberry removal area on southeast side of Anniversary Island. This area is now the primary agronomic grass treatment area (polygon B) in this restoration plan. (Photo: Parks Canada).

Figure 4. June 2004 photo of Himalayan blackberry removal area on southeast side of Anniversary Island. Agronomic grasses are visible in background and lower right. This area is now part of the primary agronomic grass treatment area (polygon B) in this restoration plan. (Photo: Parks Canada).

3.4 Cultural features

In July 2007, an archaeological crew spent a half-day conducting a reconnaissance of Anniversary Island. This cursory survey indicated that the island was most certainly used by First Nations. While some features were detected on the southern half of the island, dense shrub oak, rose, and Himalayan blackberry thickets limited visibility and other features could have been missed. There are camas patches on the island, including two small meadows that appear to have been cleared of rock. These have been recorded as archaeological sites. Areas with clear evidence of intense burning are also present, and these may be the remains of camas roasting pits. Significant fire scars are also evident on some of the older juniper trees but these scars have not been dated or otherwise analyzed.

3.5 Disturbance

Ecosystem structure and function are influenced over time not only by natural disturbance processes, such as soil disturbance by mammals, but also by pre-historic and historic influences such as managed fires, digging for camas, and the introduction of exotic species.

Today, primary disturbance processes include wind-throw, exotic plant species, slides and runs created by northern river otters (*Lontra canadensis*), and by people using or creating pathways. While disturbance has an important influence on Anniversary Island plant communities, edaphic factors (primarily soil depth and moisture) appear to control the general plant community structure. Once target exotic plant species are controlled, edaphic factors are expected to maintain an ecologically acceptable vegetation structure. One exception (there may be others) is a cultural feature at the south end of the island. In the absence of site-specific management, it is possible this feature will succeed to native shrub thickets; however, monitoring and research are needed to determine which management actions are appropriate (see recommendations in section 7.2).

4.0 Objectives and targets

With the exception of exotic species infestations described previously, native plant communities on Anniversary Island are relatively intact. There are no plans to modify these communities within the timeframe of this project. The objectives of this restoration plan are therefore focused on removing Himalayan blackberry, replacing agronomic grasses with native shrub species in specific treatment areas, and removing isolated occurrences of other target exotic plants. This will facilitate a return to higher native species diversity and ecological integrity on Anniversary Island. The target treatment areas (polygons) are shown in Figure 5, below. All treatment and monitoring methods are described in Section 5.

This restoration plan has three objectives:

1. Replace infestations of agronomic grasses (polygons A and B) with native shrubs;
2. Permanently remove large Himalayan blackberry thickets (polygons A, B, C, D, E, F);
3. Permanently remove smaller Himalayan blackberry occurrences and other high priority invasive exotic plants that occur incidentally throughout the island.

Figure 5. Orthophoto of Anniversary Island annotated with polygons showing treatment areas.

4.1 Objective 1—Replace agronomic grasses in polygons A and B

As described above, polygons A and B are areas where Himalayan blackberry was removed and existing agronomic grasses subsequently expanded. The density of these two infestations has reduced the available habitat for native flora, and possibly fauna, on the island. In polygon A, the grass infestation has been limited by re-infestation of Himalayan blackberry and an expanding patch of stinging nettle (*Urtica dioica*). In polygon B, the grass infestation is most dense along the lower part of the slope and along the bottom bench where blackberry was previously removed.

The target for objective 1 is to establish > 80 percent native species cover in polygon A and along the bottom bench in polygon B. Nootka rose, wild clustered rose, snowberry, oceanspray, and krummholtz Garry oak are the predominant native shrub species on Anniversary Island. Because rose and snowberry tend to form dense layers beneath which agronomic grasses do not dominate, and because they are most easily propagated from cuttings, these species will be used for re-vegetation. There is no intent to use pesticides on the agronomic grasses on Anniversary Island. Longer term plans to restore native plant biodiversity in polygon B are discussed in section 7.1. Indicators and management prescriptions are summarized in Table 1. Management effectiveness will be monitored and evaluated by sampling plant species percent cover.

Table 1. Objective 1 indicators and management prescriptions

Indicator	Management
Total native species cover in polygons A and along the bottom bench in polygon B > 80% within 4 years after baseline.	On-going monitoring; adapt treatment if required after 4 years.
Total native species cover in polygons A and B < 80% at 4 years after baseline.	Adapt to problem areas using different methods of treatment, e.g., carpet knife to cut out strongly tufted species, change planting density/species mix. Apply more aggressive on-going maintenance as appropriate.

4.2 Objective 2—Remove Himalayan blackberry in all polygons

In summer 2007, a survey for exotic invasive plant species was carried out and polygons delineating infestations were mapped using a GPS. This and other surveys revealed Himalayan blackberry thickets of varying size throughout the island and particularly in the treatment polygons (A, B, C, D, E, F). Polygons A and B have been partially re-invaded with blackberry after previous removal efforts; Polygons C and F comprise blackberry thickets among a native shrub community; Polygon D is comprised of roughly 90 percent blackberry; and Polygon E is comprised of intermediate sized thickets scattered along an open meadow on the west side of the island.

Thickets and patches will be controlled through cutting and treating stems with a pesticide in accordance with a Parks Canada Integrated Pest Management Plan (IPM) approved in March 2008. Where necessary to ensure that one exotic species is not replaced with another, bare patches and/or agronomic grasses that might exist under the thickets will be re-vegetated with native plants using methods appropriate to the site, but generally following those used in polygon B.

The target for objective 2 is to replace large and medium Himalayan blackberry thickets with native species within two years of baseline (Aug 2008). Indicators and management prescriptions are summarized in Table 2. Management effectiveness will be monitored and evaluated by sampling plant species percent cover.

Table 2. Objective 2 indicators and management prescriptions

Indicator	Management
Total occurrence of Himalayan blackberry in all polygons decreases by 75% or more within 2 years from baseline.	On-going monitoring.
Total occurrence of Himalayan blackberry has decreased by less than 75% at 2 years from baseline.	If re-sprouting occurs within 6 months, follow up with repeat cutting or pesticide treatment. Dig out root ball as last resort and immediately replant. with fast-growing native species suited to site.

4.3 Objective 3—Remove incidentally occurring exotic plants

Outlying occurrences of single plants or patches of Himalayan blackberry and other invasive exotic plant species on Anniversary Island have the potential to spread and displace native species; however, not all exotic species demonstrate invasive tendencies. This makes it neither necessary nor effective to treat all exotics equally. Prioritizing when and which species to treat facilitates effective treatment and allocation of resources.

Table 9 in Appendix 2 lists the known exotic plant species on Anniversary Island as of 2007. Species identified as top priority for treatment (highlighted in grey) 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 Garry Oak and Associated Ecosystems* (GOERT 2007) as guides. This list should be revised as new data are collected and treatments applied.

Although common velvet-grass, sweet vernal-grass and orchard grass are identified as top priority species, their predominance and difficulty in controlling them precludes them from being treated outside the treatment polygons. See recommendations in section 7.1 regarding longer-term agronomic grass management.

The target for objective 3 is to reduce the total number of priority exotic plant occurrences (excluding agronomic grasses) on Anniversary Island by at least 75 percent relative to the baseline (July 2008). Table 3 summarizes the indicators and management prescriptions for objective 3. If new methods are found that have proven effective for treating agronomic grass species elsewhere, and these are appropriate to Anniversary Island, they will be considered for use.

Table 3. Objective 3 indicators and management prescriptions

Indicator	Management
Total occurrence of priority exotic species decreases by 75% or more within 3 years from baseline.	On-going monitoring and maintenance as needed.
Total occurrence of priority exotic species has decreased by less than 75% at 3 years from baseline.	Assess and adapt treatments to address either an increasing rate of infestation or methods that are ineffective for existing occurrences (e.g., same plants are re-sprouting).

5.0 Methods and materials

5.1 Protection of cultural features

This restoration plan takes into account the presence of cultural features on Anniversary Island. Details regarding the nature and location of known features are provided in Appendix 4, which must be referred to prior to commencement of any work. A thorough archaeological survey will take place in August 2008, after blackberry thickets have been removed thereby making it possible for archaeologists to see the ground. Cultural features will then be accurately mapped and future work planned accordingly.

Throughout the work described below, a key consideration is to avoid damaging or altering cultural features. As such, non-mechanical methods will be used whenever feasible (e.g., hand sheers, rakes, loppers). The use of gas-powered equipment will be kept to a minimum and will not be used to cut close to the ground.

5.2 Mitigating wildlife interactions

Islets within GINPR are home to a number of sensitive wildlife species. Of special interest is the black oystercatcher (*Haematopus bachmani).* Because they are confined to a narrow band of shoreline habitat, populations of this large shorebird are vulnerable to natural and human disturbances including predation of eggs and young by native and introduced predators, coastal infrastructure development, and human disturbances such as induced nest abandonment and trampling. This species is an important indicator of rocky inter-tidal community health and is part of the Parks Canada Ecological Integrity Monitoring Program (Parks Canada 2008). Black oystercatchers are present on Anniversary Island (Butler and Golumbia 2008 [in press]).

This restoration plan takes into consideration the presence and activities of the black oystercatcher. A survey will be undertaken in June 2008 to evaluate this species' presence and nesting activity. Findings will be reported to the park ecologist and activities planned to avoid nest areas. Gas-powered equipment such as a brush saw and a weed whip will not be used within 20 m of black oystercatcher nests. Workers will avoid traversing inter-tidal areas unless necessary for personal safety.

5.3 Exotic vegetation treatment

The following sections describe treatment methods for specific vegetation. Whenever possible, vegetation will be cut/removed using hand tools. A gas-powered brush saw and a weed whip will be used to cut grasses in parts of polygons A and B. A brush saw with a blade may be used to cut the upper portions of Himalayan blackberry thickets. Use of gas-powered equipment will follow safety requirements (i.e., appropriate face and leg protection, and steel-toed boots), and with respect to cultural features as discussed above.

5.3.1. Agronomic grasses (objective 1)

Control of agronomic grasses will focus primarily on parts of polygons A and B. The most abundant exotic grass species in those polygons is common velvet-grass, although orchard grass, sweet vernal-grass, and Kentucky bluegrass (*Poa pratensis*) are present in high numbers.

Common velvet-grass forms dense stands that exclude other plants and reduce species diversity, and there is evidence that it may have an allelopathic effect on other plant species (Bond et al., 2007). Common velvet-grass can be controlled by intensive mowing or grazing. Seed persistence varies depending on seed depth in soil, but can be as long as ten years (*Ibid*), while sweet vernal-grass seeds do not remain viable for more than a year. Because of these and other characteristics, agronomic grasses can be difficult to control without broadcast spraying with non-selective pesticides such as glyphosate. Due to the ecological sensitivity of Anniversary Island and the nature of non-selective pesticides, their use is not desirable. Instead, grasses will be repeatedly cut to deplete their energy reserves, and native shrubs planted to out-compete them, as recommended by Polster (2007).

Starting in June 2008, exotic grasses in polygons A and B will be cut, mulched, and left to decay *in situ* to suppress re-infestation until native shrub cuttings and live stakes are planted in the fall. For safety and to avoid damage to native species and features on the ground, hand shears will be used where possible. In some cases, hand-pulling is necessary to avoid damaging co-occurring native grasses. In flatter areas where native species can be avoided, a gas powered weed whip will be used.

The first cutting will be at the time of anthesis [3] (typically early June depending on seasonal weather), and repeated through the summer when grasses are at maximum re-growth. The same protocol will be required in 2009 prior to native shrub planting, and possibly again in 2010. Where native species already occur or have been planted, grass cutting will be done by hand to avoid damage.

5.3.2. Woody shrubs (objectives 2 and 3)

Himalayan blackberry is the main woody shrub of concern on Anniversary Island. In July 2008, blackberry thickets and patches will be cut and then spot-treated with a selective pesticide following the methods described in the approved IPM. The method for cutting

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[3] The period during which a flower is fully open and functional.

thickets will follow the protocol that was described in the approved Environmental Assessment Screening Report form, i.e.: as required, an experienced operator will use a brush saw to carefully remove the exterior canes from one side of the thicket, working from the top down. This will allow the operator to see to the ground for objects. The operator will continue to cut, but no lower than 50 cm above ground. Immediately before pesticide application, hand loppers will be used to open a fresh cut to receive the pesticide. Smaller blackberry plants (objective 3) will be cut following the same protocol except loppers and rakes will be used instead of a brush saw. The initial cutting does not need to take place on the same day, as long as stems are re-cut immediately before pesticide treatment.

Other invasive exotic woody shrubs such as Scotch broom (*Cytisus scoparius*) or gorse (*Ulex europaeus*) are not present on Anniversary Island. Two paradise apples (*Malus pumila*), an exotic species with invasive tendencies, have established at the north end of the island. In June 2008, both trees were heavily infested with a defoliating insect and were in poor condition. They will be monitored and repeatedly cut if necessary.

5.3.3. Forbs (objective 3)

Target forb species listed in Appendix 2 (Table 9) will be removed by hand, by either cutting or careful hand-pulling. Re-vegetation will be carried out in accordance with the guidelines described in section 5.4.6.

A small patch of burr chervil (*Anthriscus caucalis*) was identified at the north end of the island in 2007 and may be a recent arrival. An exotic winter annual that is a prolific seed producer, burr chervil spreads rapidly and can choke native spring forbs if not diligently managed. It must be hand-pulled in early spring before seeds mature (10-12 weeks after flowering). This will start in 2009 and should be maintained indefinitely to ensure this species does not establish on Anniversary Island.

Bull thistle (*Cirsium vulgare*) is another target species that is present on Anniversary Island. This species reproduces entirely by seed, so control prior to seed production is critical. Once plants bolt but before they flower, they will be pulled if possible to get the taproot, or cut ~ 3 cm below the soil surface. This will stop the plant from re-sprouting. Small rosettes will be carefully dug up and the tap-root removed if possible without significantly disturbing the soil.

5.3.4. Plant material management

Himalayan blackberry thickets—If there is little native vegetation growing among the thicket, stems will be cut and removed. If there is a substantial amount of native vegetation, such as *Lonicera* spp., growing up among the stems, the stems will be cut into smaller pieces and left in place to decay to reduce the potential for damage to the beneficial native plants.

Other plant material—Small amounts of material from plants other than Himalayan blackberry will be left to decay in place if there are no seeds or viable roots attached. Fruits and flower heads that could produce seed will not be left to decay *in situ*. Stems with viable roots will be hung in surrounding vegetation to desiccate. Note: The Capital

Regional District's Hartland Landfill does not accept noxious weeds because they cannot be composted.

Storage and removal—Cut plant material that is not left to decay *in situ* will be stored on rock above the inter-tidal, well away from sites that are frequently used by black oystercatchers. Under the guidance of park staff, the material will be burned when conditions are appropriate, most likely in the fall. The Saturna and Mayne Island Fire Departments, and the public will be notified in advance when burning is planned (see section 6.0—Communication and outreach).

5.4 Re-vegetation

Re-vegetation will focus on the six treatment polygons and, only if required, in incidental patches where exotic plants are removed. At this time, no replanting or other management activities are planned for the meadow at the south end of Anniversary Island, although see recommendations in section 7.2. All six polygons contain some combination of agronomic grasses and/or Himalayan blackberry. Polygons A, B and D will require re-vegetation after treatment whereas polygons C, E and F may not require re-vegetation due to the presence of native species. In fall 2008, after agronomic grasses are repeatedly cut and the blackberry is treated, snowberry and rose will be planted. This approach will successionally shift the sites back to the woody shrub stage (Polster 2007).

In June 2008, several hundred 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, thereby limiting the area that can be adequately re-vegetated in 2008 [4]. For this reason, and so that we do not rely on only one method, a combination of native shrub plugs, live stakes, and layering will be used to re-vegetate the treatment areas. Appendix 3 provides collection, propagation and planting details for each of these methods.

Plugs from cuttings are 10 cm long and 4 cm wide and although they have a root system they will take longer to establish in the ground than live stakes. For this reason, and to allow for some mortality, plugs will be planted to a density of five per m^2.

Live stakes are similar to cuttings but are longer (80–100 cm) and, after collection, are planted directly in the ground without rooting hormone. Snowberry and Nootka rose are both known to establish well from live stakes (Darris 2002a, 2002b, WSU 2007). Because of their length, diameter, and sturdiness, live stakes reach competitive size sooner than cuttings and hence require a lower planting density—two per m^2 is recommended. If necessary once stakes establish, they may be carefully thinned to a lower density to reduce competition with one another. Removed stakes can be moved to another planting site on the island.

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[4] Actual plug yields in June 2008 were 782 for rose and 896 for snowberry. At a planting density of five plugs per m^2, if there is no mortality in the greenhouse, these will cover ~335 m^2 of treatment area. Allowing for 25 percent mortality in the greenhouse, anticipated plug yields are 585 for rose and 672 for snowberry, covering only ~250 m^2 of treatment area.

Plugs and live stakes will be planted in species clusters to emulate natural dispersal patterns (Robinson and Handel 1993). If possible, species will be planted in proportions that emulate the 60/40 snowberry to rose abundance ratio that occurs on Anniversary Island.

5.4.1. Polygon A

Polygon A is classified as a Juniper-Oak association (site type 75, Blackwell 2007), a somewhat closed community with snowberry, Nootka rose, and Garry oak as dominant shrub species. Because the soil in polygon A is shallow, cuttings and layering rather than live stakes will be used. Planting will be in October 2008, after agronomic grasses have been repeatedly cut and Himalayan blackberry has been treated and the biomass removed. Polygon A is approximately 100 m^2; however, agronomic grasses have invaded no more than half of the polygon thus requiring ~250 plugs to achieve a density of five per m^2. Stinging nettle will continue to expand and the removal of Himalayan blackberry will alleviate suppression of the existing native shrub community. To reduce the number of plugs needed, layering of snowberry that exists on the perimeter of the polygon is recommended. Snowberry establishes well by layering (King County 2004) and is a viable option in shallow soils. The amount of layering and plugs needed will be determined after the exotic plants have been treated.

5.4.2. Polygon B

Polygon B is classified as two site types, a Camas-Herb association at the top of the slope and a snowberry association on the bottom bench of the polygon (site types 73 and 74 respectively per Blackwell 2007; see Appendix 1 for characteristics). Although agronomic grasses will be cut in all of polygon B, re-vegetation will focus on the bottom bench area where Himalayan blackberry was previously removed. This bench receives more moisture and has deeper soil than the steeper slope above. Better soil conditions should improve cutting survival. Even without re-vegetation, repeat cutting of agronomic grasses on the slope above will release existing native vegetation from some competition and facilitate natural regeneration. Vegetation data collected in June 2008 indicates higher native species diversity exists near the top of the slope compared with the bench area. Restricting re-vegetation to the bench at the bottom will maintain the existing Camas-Herb and snowberry associations.

The lower portion of polygon B is about 350 m^2 and requires ~1750 cuttings to meet the recommended density of five per m^2. To mitigate jeopardizing the vigour of existing native shrubs, and to reduce logistical challenges, the lower portion of polygon B will be re-vegetated in sections over two years: half in 2008 and half in 2009. Phasing this work also allows the treatment approach to be monitored and modified in the subsequent phase, if necessary. The re-vegetation area is approximately 5 m wide[5] and excludes a 1m buffer between the lower perimeter of the polygon and the expanding line of existing native shrubs. As cuttings and existing shrubs grow, this buffer will be over-topped. This

[5] The re-vegetation area along the bottom bench in polygon B will vary in width according to edaphic factors along the slope thus emulating natural succession.

buffer is also routinely used by otters, and this will help destroy the common velvet-grass, which is susceptible to trampling (Bond *et al*., 2007).

5.4.3. Polygon C

Like polygon F, polygon C comprises a large thicket of Himalayan blackberry among an existing native shrub community; however, the re-vegetation approach differs between these two sites due to edaphic and physical factors. Polygon C is at the bottom of a northeast facing slope and is classified as a snowberry association (site type 73, Blackwell 2007; see Appendix 1 for characteristics) which typically has more moist and deeper soils than elsewhere on the island. Because of these characteristics, and because the number of cuttings available for fall 2008 is limited, live stakes rather than cuttings will be planted in this site. Live stakes also have a better competitive advantage than cuttings against re-sprouting blackberry and agronomic grasses.

5.4.4. Polygon D

Facing southwest at the top of a hyper-steep slope, polygon D is classified as a Juniper-Oak association inland and bedrock along the edge of the island (site types 75 and RO per Blackwell 2007; see Appendix 1 for characteristics). Once the blackberry is cut, polygon D will be evaluated and the most effective re-vegetation approach applied. Fast-growing native forbs such as sea blush *(Plectritis congesta)* for open micro-sites and native grass species (e.g., *Elymus glaucus*) that occur in the adjacent meadows are recommended for the Juniper-Oak association. The goal is to minimize opportunities for agronomic grasses and other exotic species to dominate in the absence of Himalayan blackberry.

5.4.5. Polygon E

Facing southwest along a hyper-steep slope, and classified as bedrock (site type RO, Blackwell 2007), Polygon E supports stunted seaside juniper and arbutus among shallow soil and open meadow dominated by grasses and native forbs. Himalayan blackberry thickets in polygon E vary in size from small (< 1 $m^{2)}$ to medium (> 1 m^2 and < 5 $m^{2)}$ throughout the polygon. Once the blackberry is removed, polygon E will be evaluated and the most effective re-vegetation approach applied. Fast-growing native forbs such as sea blush *(Plectritis congesta)* for open micro-sites and native grass species (e.g., *Elymus glaucus*) occurring in the adjacent meadow are recommended. If necessary, plugs will be grown from seed collected nearby and planted in fall 2008 or spring 2009 depending on species. Bare patches greater than about 20 cm x 20 cm or that lack native plants nearby will be re-vegetated using suitable native species.

5.4.6. Polygon F

Like polygon C, polygon F comprises a large thicket of Himalayan blackberry among an existing native shrub community. Polygon F is classified as a Juniper-Oak association (site type 75, Blackwell 2007), a somewhat closed community with snowberry, Nootka rose, and Garry oak as dominant shrub species. Once the blackberry is cut, polygon D will be evaluated and the most effective re-vegetation approach applied.

5.4.7. Forbs and grasses—general guidelines for re-vegetation

Collection and propagation of forb and grass seed varies significantly depending on species. Seed availability, site needs and conditions (e.g., relative densities of existing native species, soil depth, moisture) will determine which and how much native grass and forb seed will be collected. If there is a lack of propagules or a risk of genetic depression due to collection from Anniversary Island, propagules will be collected from a nearby GINPR site following established seed collection protocols (primarily GOERT 2007). Seed will be grown in a nursery or directly broadcast where needed and as appropriate, based on the guidelines described above. Preference will be given to fast growing / early seral stage native forbs.

Outside of the treatment polygons, small bare patches of soil that remain after exotic vegetation removal will in most cases be left to re-vegetate naturally, provided suitable native vascular plants as noted above occur immediately adjacent. Bare patches greater than about 20 cm x 20 cm or that lack native plants nearby will be re-vegetated using suitable native species. Where native grasses are appropriate, grass plugs will be planted at 25 cm spacing. Forbs are typically planted at lower densities than grasses. Plug planting requires simply opening a slit in the soil no more than 10 cm deep and inserting the plug.

5.5 Monitoring

Formal monitoring of restoration efforts on Anniversary Island will focus on the treatment polygons, although island-wide systematic surveys for target exotic species will also be carried out. All observations, data, and results will be recorded when collected. All data will be reported annually, or upon request. Monitoring will initially be carried out by GOESARR staff, and later by park staff once the GOESARR project comes to an end.

5.5.1. Objective 1 - Replace agronomic grasses in polygons A and B

The target for objective 1 is to achieve greater than 80 percent cover of native vascular plant species in polygons A and B after four years from baseline in 2008. The target for objective 1 will be evaluated using a transect method.

Eight parallel transects 10 m apart and perpendicular to the slope will be established in polygon B. Each transect will be sampled every 50 cm starting from the bench to the top of the slope along two strata at 50 cm and 130 cm above ground. Any plant that intercepts either height is identified and recorded. The data are later analyzed to yield percent cover in the polygon for each species detected. Two transects 2 m apart and parallel to the long axis of the treatment area will be established in polygon A. The sampling method used in polygon B will be applied in polygon A. Sampling will be repeated each year in June, before the first grass cutting and exotic species removal of the season, for at least four years, until the desired successional stage is achieved.

Photos will be captured as a qualitative record of change in each polygon over time. Photos will be taken from the centre of each polygon in the four cardinal directions using a surveyor's barber pole for scale. Photos will be captured before the first grass cutting and subsequently twice per year in spring and fall.

5.5.2. Objective 2 - Remove Himalayan blackberry in all treatment polygons

The target for objective 2 is to achieve decreases of Himalayan blackberry in polygons A, B, C, D, E and F by 75 percent or more within 2 years from baseline. Sampling will be repeated each July, before treatment, for at least two years

For all polygons objective 2 will be evaluated by measuring the extent and intensity[6] of Himalayan blackberry infestations. The extent of each infestation will be determined by defining the boundary using a GPS unit whereas a crude estimate of percent cover will be recorded to determine intensity. The size of each blackberry infestation will be calculated and analysed to determine the total extent across the entire island.

Photos will be captured as a qualitative record of change in each polygon over time. Photos of the Himalayan blackberry infestations will be taken from an elevated point along the perimeter of the infestation pre- and post-treatment.

5.5.3. Objective 3 - Systematic monitoring for exotic species occurrences

Starting in early May 2008 and thereafter each May and October, a field crew will systematically survey Anniversary Island to search for and remove exotic plants. Because of the density of vegetation, this may take up to two person-days per survey. An air photo should be used to help ensure complete coverage without overlap. A tally sheet will be used to record total occurrences for each species.

Occurrences will be defined as follows: for forb species, any individual more than 2 m from its nearest neighbour will be considered a separate occurrence; for shrub species, any individual more than 5 m from its nearest neighbour will be considered a separate occurrence. Data will be used to modify the treatment approach if necessary.

5.5.4. Re-vegetation monitoring

Although establishment of native species in the re-vegetation areas will be sampled by the percent cover transects, it is also important to monitor general health and survival of cuttings, live stakes, and layered stems. Each re-vegetation area will be checked in spring 2009, and thereafter during each visit to the island. Plant condition and mortality will be evaluated and recorded. A survival rate of ≥75 percent will be considered a success. Data will be used to adapt methods for establishing future plantings.

6.0 Communication and outreach

Anniversary Island restoration activities will provide opportunities for public education and enhanced visitor experience. Various initiatives will help the public learn about Parks Canada's commitment to improving ecological integrity, and gain knowledge about ecological restoration methods that can be applied elsewhere. When the restoration plan is approved, it will be made available to interested community and restoration groups.

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[6] Intensity meaning a crude percent cover estimate of Himalayan blackberry in each treatment polygon.

Public education will be achieved through interpretation activities delivered by park staff, with contributions from GOESARR staff, through several means:

- from the vantage point at nearby Winter Cove, through non-personal media (e.g., signs) and as a stop on guided walks where the viewscape looks out to Anniversary Island;
- a website feature that utilizes the on-going monitoring photos of the restoration activities;
- articles in local newspapers/island newsletters;
- information provided during the park's participation in local markets and fairs.

When specific restoration activities, such as plant material disposal and burning, are planned, GOESARR staff will ensure park Communications staff are briefed so they can inform the public in a timely manner.

Although Anniversary Island is Zone 1, removing Himalayan blackberry thickets and agronomic grasses and restoring some of the former native species diversity may enhance visitor experience for boaters and kayakers who pass by.

7.0 Planning beyond the GOESARR project

The GOESARR project has a finite timeframe that extends to 2010, and possibly longer. During the project timeframe, GOESARR staff and contractors will carry out most of the work, with support from GINPR and the Western and Northern Service Centre staff, depending on the nature of the work and staff availability. Beyond the GOESARR timeline, some of the work requires continuity if the objectives are to be reached and desired ecological conditions maintained.

Below is a description of work that needs to be continued, and recommendations for the park to consider incorporating into its Management Plan to further improve ecological integrity and visitor experience.

7.1 Required work

7.1.1. Exotic plant species monitoring and control—7.5 person-days per year

Monitoring and control of exotic plant species should be continued indefinitely. Work completed under the GOESARR project will substantially reduce the percent cover and occurrence of target species, thus minimizing the amount of work required by park staff; however, gains will be temporary unless on-going maintenance is carried out as part of the park's Integrated Pest Management Plan. Two activities are required:

1. Systematic surveys for exotic plant species occurrences and manual removal should be continued twice annually, in spring and at the onset of fall rains. Two surveys are needed to capture different species phenologies. The timing facilitates removal when soils are moist, to minimize disturbance. Estimated resource requirements: 1 day x 4-person crew plus 1 day x 2-person crew plus 0.5 day x 1 person for data entry = 6.5 person-days per year. Refer to Table 9 for current exotic species list.
2. The list of target exotic plant species should be re-evaluated each year using the GOERT Decision Support Process (2007) or similar invasive species evaluation method to determine if new species should be added or others downgraded due to successful treatment. Estimated resource requirements: 1 day x 1 person = 1 person-day per year.

7.1.2. Vegetation monitoring—5 person-days every year

Sampling of vegetation transects should continue every two years. The monitoring protocol established in this plan should be continued. Estimated resource requirements: 2 days x 2-person crew per survey = 4 person-days every year.

Photos of all six polygons from an identified photo point should be captured every year at the same time of year to provide a visual record of changes. Estimated resource requirements: 0.5 day x 2-person crew every year = 1 person-day per year.

7.2 Recommendations

Shrub and tree encroachment—Succession to dense native shrub understorey and closed forest due to fire exclusion is rendering Garry oak meadows and woodlands increasingly rare (Gould and Harrington 2008). On Anniversary Island, encroachment by krummholz [7] Garry oak, Nootka rose, and snowberry may be occurring in the camas meadow site at the south end, and perhaps elsewhere; however, monitoring is needed to confirm this. If the park decides to proceed with camas meadow management, objectives should be clearly defined before any methods are employed.

Although prescribed fire may seem an obvious control method, both Garry oak and snowberry are fire resistant and sprout vigorously after a low-intensity fire (Gucker 2007). Nootka rose and other Rosa species found in BC usually initially decrease in cover after wildfire. Thereafter, cover gradually increases, and then declines as the canopy closes. In a study of Nootka rose in Washington and Oregon, burning had little effect on abundance, although multiple fires can significantly reduce cover of rose species (Haesseler et al., 1990).

The park might consider working with First Nations to maintain the meadow feature using traditional methods that do not include fire, such as camas harvesting, or employing harvesting along with repeated prescribed fires. Relying on one single fire event will almost certainly result in increased shrub and exotic plant species cover.

[7] Low-growing shrub form of tree caused by strong and persistent wind or other factors. that influence rate of growth and form.

Agronomic grasses—While eradication of agronomic grasses from Anniversary Island is unachievable, the park needs to decide to what degree these grasses are acceptable and whether focused control is desirable. Again, potential control methods should be carefully evaluated before applied. In a five-year field experiment in a degraded oak savanna, MacDougall and Turkington (2007) tested the impacts of fire, cutting and raking, and weeding on two factors critical for restoration: controlling dominant invasive grasses and increasing subordinate native flora. They manipulated the season of treatment application and used sites with different soil depths because both factors influence fire behavior. They found no significant difference among the treatments: all were similarly effective at suppressing exotics and increasing native plant growth. This occurred because light is the primary limiting resource for many native species and each treatment increased its availability. The effectiveness of disturbance for restoration depended more on the timing of application and site factors than on the type of treatment used. Summer disturbances occurred near the reproductive peak of the exotic grasses, so their mortality approached 100 percent. Positive responses by native species were significantly greater on shallow soils because these areas had higher native diversity prior to treatment.

Native species diversity—Planting rose and snowberry in the treatment areas is an interim measure designed to expedite treatment of agronomic grass infestation. If this measure is successful, the park might consider restoring native species diversity by planting other species from the corresponding site type (see Appendix 1). Native species already occur in these sites and could easily provide propagules.

Volunteer stewardship—The engagement of volunteers to act as stewards of Anniversary Island is encouraged. The BC Parks' Volunteer Warden Program that was established in 1980 for ecological reserves could provide a model. The role of volunteer stewards could be limited to observing, recording, reporting, and recommending on conditions and issues pertaining to ecological integrity of the site. The volunteer(s) could work with the Parks Canada ecologist and act as a liaison with the Park Interpreter program to help enhance visitor experience and the public's understanding and appreciation of the Species at Risk program and Parks Canada's role in improving ecological integrity. The Saturna and Mayne Island communities could be consulted to help find people who would be interested and willing to make a long-term commitment to this role.

8.0 Project work plan

A project work plan for 2008/09 and 2009/10 is presented in Table 4. The GOESARR project will directly contribute approximately $11,000 to the restoration of Anniversary Island in 2008/09. This effort will be enhanced with communications and outreach activities. The investments made by the GOESARR project will result in completion of the more expensive initial stages of improving ecological integrity on this island (e.g., monitoring set-up, invasive species removal, re-vegetation).

Table 4. Anniversary Island restoration project workplan to Dec 2010.

Anniversary Island Workplan		2008									2009												2010											
Actvity	Tasks	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Field work																																		
Monitoring & surveying																																		
Objectives 1 & 2— Percent cover of vascular species	Collect fixed transect data			●												●												●						
Objective 3—Systematic monitoring for exotic species occurrences	Collect exotic species occurrence data and remove plants				●			●							●					●							●							
Photos	Before first grass and H. blackberry cutting			●												●										○								
	After grass and H. blackberry cutting				●	●											●	●																
Re-vegetation	Check cutting, layering, and live stake condition; estimate mortality														●												●							
Archaeological survey	Complete survey after Himilayan blackberry removed and treated					●																												
Exotic Plant Treatment																																		
Agronomic grass cutting	Polygons A & B - Cut at first anthesis			●												●												●						
	Repeat as needed at maximum regrowth through summer				○	○	○										○	○	○										○	○	○			
Himalayan blackberry	All 5 treatment polygons - Cut thickets with brush saw and/or by hand				●	●																												
	Treat all with pesticide					●																												
	2009/2010: Treat new plants; re-treat old, re-sprouting plants that have long runners															○												○						
Other occurrences	Burr chervil (*Antrhiscus caucalis*) - remove by hand in early spring													●												●								
	Bull thistle (*Cirsium vulgare*) - remove when bolting but not flowering				●											●												●						
	Other exotics - remove by hand as needed		○	○	○	○	○								○	○	○	○	○								○	○	○	○	○			
Plant material management	Stockpile above intertidal				○	○	○										○	○	○										○					
	Burn in fall once authorized by park and Fire Depts.							●												●												●		
Propagation & planting																																		
Native shrub cuttings	Collect & ship whips for cutting propagation		●												●																			
	Collect and plant live stakes							●												●														
	Plant cuttings							●												●												●		
Data management																																		
	Input transect data						●												●												●			
	Create attribute tables						●																											
	Create output maps						●												●												●			
Outreach & Reporting																																		
Report	Prepare summer work report					●												●												●				
	Prepare & submit annual workplan to GOESARR committee for info	●				●							●					●							●					●				
Outreach	Present update to Saturna Island–PCA Liaison Committee	○				○								●				●								○				●				

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Appendix 1—Plant community descriptions

Two methods were used to describe vegetation communities on Anniversary Island:

1) Plant community classification using relevé data collected in April 2007 (Polster 2007). See Table 6.
2) Terrestrial ecosystem mapping, whereby polygons encompassing similar ecological properties are delineated on air photos, and data characterized based on photo interpretation and field sampling. Using these data a set of attributes is then assigned to each polygon. Site classification is based on the biogeoclimatic ecosystem classification (BEC) for British Columbia (Meidinger and Pojar 1991) and enhanced to reflect units encountered on Anniversary Island and elsewhere that are not recognized in the BEC system (Blackwell 2007). See Table 7.

Using the first method, Polster identified two plant species-relevé groups on Anniversary Island: a Quercus group, which includes oceanspray (*Holodiscus discolor*) and Pacific sanicle (*Sanicula crassicaulis*) as dominant species; and a Triteleia group is characterized by hyacinth broadiaea (*Triteleia hyacinthine)*, Idaho fescue (*Festuca idahoensis* ssp roemeri), and ribwort plantain (*Plantago lanceolata)*. Within these species-relevé groups Polster identifies four vegetation types (1, 2, 3, and 6) comprising 16 species and 77% of the cover on the islet.

Vegetation type 1 is defined by a strong occurrence of Garry oak (*Quercus garryana),* along with snowberry (*Symphoricarpos albus)* and greater camas (*Camassia leichtlinii)*. The relatively low number of species may allow this vegetation type to easily establish, and the density of cover when the vegetation is mature may assist in preventing invasion by exotics, making this type a potentially strong competitor against blackberry, orchard grass and common velvet-grass (Polster 2007).

Vegetation type 1 is similar to the Juniper-Oak association (site type 75) described by Blackwell (2007). Site type 75 occurs on the margins of rocky outcrops on Anniversary Island, with a short canopy of Garry oak, sparse stunted Douglas-fir, and seaside juniper. The shrub layer comprises 50-70% cover and includes snowberry, oceanspray, Nootka rose and tall Oregon-grape. The herb layer provides about 70-100% cover and includes camas, native bunchgrasses (e.g., Idaho fescue), cleavers *(Galium aparine*), miner's-lettuce (*Claytonia perfoliata*), and Pacific sanicle. Polygon C is classified as site type 75.

Vegetation type 2 is similar to type 1, but has fewer species (17 total) and slightly less cover, suggesting a more open structure.

Vegetation type 3 is defined by the presence of the Triteleia species-relevé group. This type has the highest number of species with camas, Western buttercup (*Ranunculus occidentalis*), Idaho fescue, blue wild-rye (*Elymus glaucus*), white fawn lily *(Erythronium oregonum*), and smooth cladonia *(Cladonia gracilis)* as predominant species. Type 3 also has a lower average percent cover relative to the other five vegetation types. While this open community is a valued ecosystem type, it is difficult to establish and makes a poor competitor against invasive exotic species (Polster 2007).

Vegetation type 6 is a more open community type and is the most commonly occurring community that Polster identifies on Anniversary Island. It includes seaside juniper, snowberry, tall Oregon-grape, Saskatoon berry *(Amelanchier alnifolia)*, California brome *(Bromus* *carinatus*), and Kentucky bluegrass (*Poa pratensis,* an exotic agronomic grass), with greater camas as a predominant species.

Vegetation types 3 and 6 are similar to the Camas-Herbs association (site type 74) described by Blackwell (2007). Site type 74 is predominantly an herb community comprising 70-100% cover. The few trees present are typically stunted Garry oak. A sparse shrub layer consists primarily of Nootka rose, dull Oregon-grape, Saskatoon berry, oceanspray, and snowberry. Camas-Herb communities are present throughout the island and also in pockets on the hyper-steep bedrock slope along the island's southwest edge (e.g., polygon D).

Blackwell (2007) also describes a snowberry community (site type 73) that is similar to site type 75 but which occurs in areas with higher soil moisture and deeper soils. This community has a higher shrub cover (80-100%) than site type 75, and a reduced herbaceous cover (30-50%). Blackwell identifies the east-facing slope of Anniversary Island (polygon B) that is currently infested with agronomic grasses as site type 73.

Table 5. Physiognomic vegetation classification table for Anniversary Island (Polster 2007). Vegetation types 1, 2 and 3 are non-forested, with increasing diversity and shrub cover. Type 6 plots are non-classified outliers with some shrub cover. Cover values are indicated in percent. R indicates much less than 1%; + indicates rare).

	Ann 018 Plot 16	Ann 007	Ann 013 Plot 11	Ann 008 Plot 6	Ann 019 Plot 17	Ann 014 Plot 12	Ann 010 Plot 8	Ann 009 Plot 7	Ann 016 Plot 14	Ann 017 Plot 15	Ann 012 Plot 10	Ann 020 Plot 18	Ann 011 Plot 9	Ann 015 Plot 13	Ann 002	Ann 003	Ann 006 Plot 5	Ann N End	Ann 005 Tower Base	Ann 004
Vegetation Type	1					2		3				6								
Trees																				
Arbutus menziesii							1													
Juniperus scopulorum							25	1					30			1				10
Pseudotsuga menziesii				R										5						
Quercus garryana	5	40	25	60	20		5				5									
SHRUBS - native																				
Amelanchier alnifolia		+						1			1		20	5		1				
Arctostaphylos uva-ursi		R																		
Holodiscus discolor						5	1	+									1	1	+	
Mahonia aquifolium	5		+		5	1			1		+	15	1							
Symphoricarpos albus	15	15	40	10	15	40		5	5			10	10	30	+	5				
SHRUBS - exotic																				
Malus pumila															5					
Rubus armeniacus																		1		5

Table 6 cont'd

Vegetation Type	1					2		3				6								
HERBS – native																				
Achillea millefolium	5									5					1		5		1	
Allium cernuum			1				5	1					1							
Bromus carinatus			10		1	10			5		1	10		10		1				40
Camassia leichtlinii	45	40	30	25	15	15	40		30	70	60	40	15	10	40	20	60	R		
Cardamine oligosperma													1	1						1
Castilleja hispida								1	+											
Cerastium glomeratum	5	1		5			5		1		1									
Cladonia gracilis								15												
Claytonia rubra ssp depressa																		1		
Collinsia parviflora								1	R		+							+	+	
Delphinium glaucum														R						
Distichlys spicata																		1		
Elymus glaucus	15							10	5	1			20							
Erythronium oregonum			5		5			15	+				10	1						+
Festuca idahoensis ssp. roemeri		R						10	5	5	5				1			1		
Fragaria virginiana									R											
Fritillaria affinis													R		+		1			
Galium aparine													1							
Grindelia integrifolia																		5	5	
Heuchara micrantha																	+			
Koeleria macrantha																+				
Leymus mollis				10													1		1	
Lomatium nudicaule									R	R								+	1	
Lonicera ciliosa			R										1	5						R
Lonicera hispidula				1	5		5				1									
Luzula multiflora								+												
Mimulus alsinoides										+										
Plectritis congesta	5							1	5	5	+	5		+	+	1				1
Poa pratensis												1			5	1	20	1	1	
Polypodium glycerhiza																1				
Ranunculus occidentals	5			1			1	5	25		5		1			1				
Rosa nutkana		1	15											5	+	60				+
Rubus ursinus					5				1					1	1					
Sanicula crassicaulis							5								+		20			
Sedum lanceolatum var. nesioticum										+	1									
Sedum spathulifolium								1												
Selaginella wallacei		1						+	1											
Stellaria media																+				
Trisetum spicatum								1												

Table 6 cont'd

Vegetation Type	1					2		3				6								
HERBS – native cont'd																				
Triteleia hyacinthine								1	1	10	1									
Urtica dioica																				10
Vicia americana		5						1												
Zygadenus venenosus									R											
HERBS – exotic																				
Cynosurus echinatus							10				5									
Dactylis glomerata		R	R			5								15						
Daucus carota															5					
Holcus lanatus				5								15								
Hypochaeris radicata								R												
Plantago lanceolata								R	R	R										
Rumex acetosella																		1		
Senecio vulgaris							+				R			+	+					
Vicia sativa							+		1						+		+			

Tables 6, 7 and 8 provide lists of constituent plant species, typical percent cover by strata and, in some cases, general edaphic qualities of the three terrestrial plant associations defined by Blackwell (2007) that occur on Anniversary Island.

- CDFmm/Snowberry (site type 73) (Table 6)
- CDFmm/Camas-Herbs association (site type 74) (Table 7)
- CDFmm/Juniper-Oak (site type 75) (Table 8)

Table 6. Site type 73: Snowberry association (Blackwell 2007).

	Typical Vegetation
Strata	Spp
A	*Quercus garryana*
B	*Symphoricarpos albus*
B	*Rosa nutkana*
B	*Amelanchier alnifolia*
B	*Holodiscus discolor*
B	*Mahonia aquifolium*
B	*Quercus garryana*
B	*Arbutus menziesii*
B	*Pseudotsuga menziesii*
B	*Rosa gymnocarpa*
B	*Salix scouleriana*
B	*Salix sp.*
C	*Camassia quamash*
C	*Erythronium oregonum*
C	*Grasses*
C	*Lathyrus japonicus*
C	*Allium cernuum*
C	*Cardamine oligosperma*
C	*Claytonia perfoliata*
C	*Collomia grandiflora*
C	*Fritillaria affinis*
C	*Lathyrus nevadensis*
C	*Leymus mollis*
C	*Lycopodium annotinum*
C	*Polypodium glycyrrhiza*

Plot	
Biogeoclimatic Zone	CDF
SubZone	mm
Elevation(m)	2-10
Slope Gradient(%)	0
Aspect (degrees)	999
Meso Slope Position	Level to Crest
Moisture Regime	2-3
Nutrient Regime	D
Root Restricting Depth(cm)	60
Soil Drainage	well
Humus Form (MOF 81)	Mull
Structural Stage	3
Strata Cover Tree(%)	0-10
Strata Cover Shrub(%)	80-100
Strata Cover Herb(%)	30-50
Strata Cover Moss(%)	0
Terrain	zsWGv/Rm
Root restricting type	Lithic Contact
Texture	Sandy Loam
OrgThick	1-2

Table 7. Site type 74: Camas-Herbs association (Blackwell 2007).

Strata	Typical Vegetation Spp
B	*Rosa nutkana*
B	*Mahonia aquifolium*
B	*Amelanchier alnifolia*
B	*Holodiscus discolor*
B	*Symphoricarpos albus*
B	*Quercus garryana*
C	*Grasses*
C	*Camassia quamash*
C	*Achillea millefolium*
C	*Grindelia integrifolia*
C	*Plectritis congesta*
C	*Sanicula crassicaulis*
C	*Collinsia parviflora*
C	*Fritillaria affinis*
C	*Plantago lanceolata*
C	*Rumex acetosa*
C	*Allium cernuum*
C	*Lomatium nudicaule*
C	*Triteleia hyacinthina*
C	*Vicia americana*
C	*Claytonia rubra*
C	*Geranium molle*
C	*Polypodium glycyrrhiza*
C	*Sedum spathulifolium*
C	*Trifolium microcephalum*
C	*Claytonia perfoliata*
C	*Erythronium oregonum*
C	*Ranunculus occidentalis*
C	*Ranunculus uncinatus*
C	*Sedum integrifolium*
C	*Selaginella wallacei*
C	*Trifolium willdenowii*
D	*Racomitrium canescens*
D	*Cladina rangiferina*
D	*Dicranum scoparium*
D	*Polytrichum juniperinum*
D	*Trachybryum megaptilum*

Site Characteristics	
Biogeoclimatic Zone	CDF
SubZone	mm
Elevation(m)	2-12
Slope Gradient(%)	0-20
Aspect (degrees)	S
Meso Slope Position	Level to Crest
Moisture Regime	0-1
Nutrient Regime	C-D
Root Restricting Depth(cm)	10-30
Soil Drainage	Very rapid to well drained
Humus Form (MOF 81)	Rhizomull
Structural Stage	2-3
Strata Cover Tree(%)	0
Strata Cover Shrub(%)	0-20
Strata Cover Herb(%)	70-100
Strata Cover Moss(%)	0-10
Terrain	silty/sandy weathered bedrock over rolling bedrock (sandstone)
Root restricting type	Lithic contact
Texture	sandy loam
OrgThick	1-10

Table 8. Site type 75: Juniper-Oak association (Blackwell 2007).

Strata	Typical Vegetation Spp
A	*Pseudotsuga menziesii*
A	*Quercus garryana*
B	*Symphoricarpos albus*
B	*Juniperus scopulorum*
B	*Rosa nutkana*
B	*Quercus garryana*
B	*Holodiscus discolor*
B	*Mahonia aquifolium*
B	*Amelanchier alnifolia*
B	*Arbutus menziesii*
B	*Lonicera ciliosa*
B	*Lonicera involucrata*
B	*Pseudotsuga menziesii*
C	*Camassia quamash*
C	*Grasses*
C	*Galium aparine*
C	*Sanicula crassicaulis*
C	*Claytonia perfoliata*
C	*Plectritis congesta*
C	*Vicia Americana*
C	*Sedum spathulifolium*
C	*Allium cernuum*
C	*Erythronium oregonum*
C	*Fritillaria affinis*
C	*Grindelia integrifolia*
C	*Polypodium glycyrrhiza*
C	*Sanicula bipinnatifida*
C	*Achillea millefolium*
C	*Cardamine angulata*
C	*Collinsia parviflora*
C	*Zigadenus venenosus*
C	*Allium acuminatum*
D	*Eurhynchium oreganum*
D	*Dicranum scoparium*
D	*Racomitrium canescens*

Site Characteristics	
Biogeoclimatic Zone	CDF
SubZone	mm
Site Series	
Elevation(m)	
Slope Gradient(%)	0-5
Aspect (degrees)	999
Meso Slope Position	Level to Crest
Moisture Regime	0-1
Nutrient Regime	D-E
Root Restricting Depth(cm)	15-50
Soil Drainage	rapid
Humus Form (MOF 81)	Mullmoder
Structural Stage	3
Strata Cover Tree(%)	0-10
Strata Cover Shrub(%)	50-70
Strata Cover Herb(%)	70-100
Strata Cover Moss(%)	0-10
Terrain	sDv/Rm
Root restricting type	Lithic Contact
Texture	Loamy sand
OrgThick (cm)	4-12

Appendix 2—Exotic plant species on Anniversary Island

Table 10 lists known exotic plant species on Anniversary Island as of 2007. Although agronomic grasses (e.g., common velvet-grass, orchard grass) are target species in the treatment polygons, there are no plans to control them throughout Anniversary Island during this project.

Table 9. Known exotic plant species on Anniversary Island as of 2007. Highlighted species have top priority for treatment. Plant occurrences from Roemer 2003, except as noted.

Common name	Scientific name	Common name	Scientific name
yellow hairgrass	*Aira caryophyllea*	paradise apple	*Malus pumila*
silver hairgrass	*Aira praecox*	English/ribwort plantain	*Plantago lanceolata*
sweet vernal-grass	*Anthoxanthum odoratum*	annual bluegrass	*Poa annua*
burr chervil [a]	*Anthriscus caucalis*	Himalayan blackberry	*Rubus armeniacus*
soft brome	*Bromus hordeaceus*	sheep sorrel	*Rumex acetosella*
ripgut brome	*Bromus rigidus*	curly dock	*Rumex obtusifolius*
poverty brome	*Bromus sterilis*	common groundsel	*Senecio vulgaris*
white goosefoot	*Chenopodium album*	spiny sowthistle	*Sonchus asper*
bull thistle	*Cirsium vulgare*	common sowthistle	*Sonchus oleraceus*
hedgehog dogtail	*Cynosurus echinatus*	common dandelion	*Taraxacum officinale*
orchard grass	*Dactylis glomerata*	small hop-clover	*Trifolium dubium*
Queen Anne's lace [b c]	*Daucus carota*	corn speedwell	*Veronica arvensis*
redstem stork's bill	*Erodium cicutarium*	tiny vetch	*Vicia hirsuta*
dove's-foot geranium	*Geranium molle*	common vetch	*Vicia sativa*
common velvet-grass	*Holcus lanatus*	brome fescue	*Vulpia bromoides*
hairy cat's-ear	*Hypochaeris radicata*	rat-tail fescue	*Vulpia myuros*
purple dead-nettle	*Lamium purpureum*		

[a] Hockin *et al* 2007; [b] Polster 2007

[c] A *Daucus carota* observed in April 2007 at the north end of the island will be removed in June 2008.

Appendix 3—Shrub propagation and planting methods

The following methods will be used for propagating and planting native shrubs on Anniversary Island. Regardless of method used, all collection will be done using sharp, clean tools. Unless stated otherwise, all cuts should be at a 45^{o} angle.

Cuttings

Cuttings are roughly 10 cm long sections cut from whips that are collected from the site and propagated into plugs. Whips should be collected in mid to late May, when shrubs are still leafing out. Whips should be at least 30 cm long, and cut from current year growth that is firm but not rigid. Once collected, whips should be bundled with damp peat moss and stored in a cooler on top of a layer of newspaper with ice beneath and shipped immediately to the nursery. Nursery staff are responsible for making cuttings and planting the plugs. Roughly three cuttings can be made from one whip. Each cutting becomes a plug. To estimate the number of cuttings required, allow for 35% "let down" in the greenhouse and up to 25% mortality once planted.

Live stakes

The following steps are adapted from http://dnr.metrokc.gov/wlr/pi/cutting.htm [accessed 2 April 2008]). Planting on Anniversary Island is planned for late October to early November 2008. This timeframe allows for poor weather conditions and difficulty accessing the island. The best time to plant live stakes is during our region's dormant season, from October to March http://www.soundnativeplants.com/livestake.htm [accessed 28 May 2008]. Even if planted during the growing season, live stakes planted into sites that remain moist will establish, but survival will be lower. Regardless of when planted, stakes will survive initially by rooting, but eventually leaves will sprout from the exposed ends.

1. Find mature, healthy shrubs that have long, upright branches. These will be cut to make the live stakes. **No more than 5% of branches should be cut from each plant**. Select stems that can yield 50 to 60 cm long stakes. This length is necessary to ensure sufficient energy is available in the stake, and because stakes will not tolerate much shade while leafing out. Rose stakes should be at least 2 cm in diameter; snowberry may be thinner (~ 1cm).
2. Locate a spot along the lower end of the stem and make an **angled** cut for the bottom end of the stake. The angled cut makes it easier to drive the correct end into the ground; stakes planted upside down will die. You should now have a length of older, woody stem that includes flexible new growth at the top. Select a place at the upper end of the older wood to create a cut for the top of the stake. There should be at least two buds on the upper 15% of the stake. Make a **straight** cut above these buds for the top end. The flexible tip of newer growth can also be retained for planting. Figure 6 shows a schematic diagram of established live stakes and illustrates the difference in angles for the top and bottom cuts.
3. To keep stakes from drying out, remove most leaves and small branches as soon as possible after cutting. Keep stakes moist in a bucket of fresh water or wet burlap sacks until ready to plant. Plant stakes within 24 hrs of collecting. If it is hot, keep them in shade until planted.

4. Use a rubber mallet to drive the angled end of the stake into the soil, perpendicular to the slope, at least 30 cm deep (the deeper the better, without burying the two top buds). Leave 15 to 20 cm above ground so stakes can sprout leaves from the buds. Because planting will take place once fall rains have started, the soil should be moist and pliable; if it is hard, use a length of rebar or planting stick to start the hole.

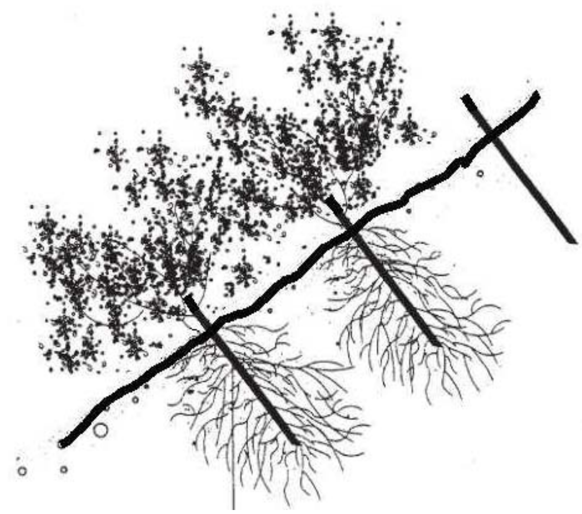

Figure 6. Diagram of live stakes (adapted from Gray and Sotir 1996, and Minnesota Dept of Natural Resources).

Layering

To propagate by layering from an existing plant, a low growing, flexible and living stem is bent to the ground. Part of the stem is then covered with soil, leaving the remaining 15 to 30 cm above the soil. The tip is then bent into a vertical position and staked in place (Figure 7). The sharp bend will often induce rooting, but wounding the lower side of the bent branch may help also.

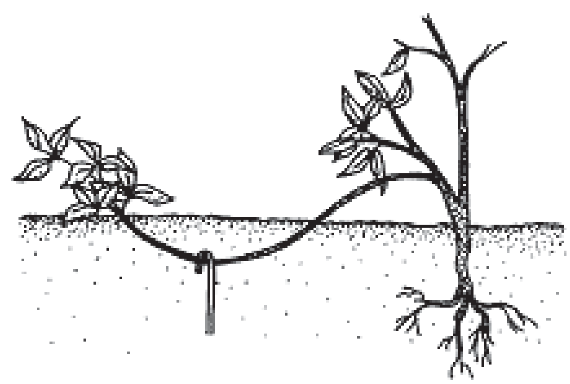

Figure 7. Method for layering snowberry (Evans and Blazich accessed 2008).

Appendix 4—Cultural features on Anniversary Island

INTERNAL USE ONLY

Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 6
Outreach and Public Involvement

Contents

Chapter 6

Outreach and Public Involvement

by Carolyn MacDonald, with contributions by Chris Junck and Jenny Eastman

Elise Croteau knee-high in camas (*Camassia* spp.) at Playfair Park in Saanich. Photo: Carolyn MacDonald

6.1 Introduction

> ... social engagement is a vital part of restoration and not merely an afterthought. (Higgs 2003)

Ultimately, successful protection and restoration of Garry Oak ecosystems will depend on the support and values of the public and communities in which these ecosystems exist. In Canada, the last remnants of Garry Oak ecosystems are found primarily in and around areas occupied by people. A well-planned public involvement and outreach approach can provide project support through community stewardship, funding opportunities, volunteer activities, and even restoration efforts that are expanded to adjacent properties. Communicating and working with the public and other stakeholders from the beginning planning stages can directly influence project success and sustainability.

Chapter 6 Outreach and Public Involvement

The Garry Oak Ecosystems Recovery Team (GOERT) is guided by the *Recovery Strategy for Garry Oak and Associated Ecosystems and their Associated Species at Risk in Canada* (www.goert.ca/documents/RSDr_Feb02.pdf). This Recovery Strategy acknowledges that communication and developing public involvement, awareness, and participation are essential aspects of the ecosystem recovery program (GOERT 2002). The Recovery Strategy identifies "motivating public and private protection and stewardship activities" as a key objective. Garry Oak ecosystem restoration projects play an important role in meeting Recovery Strategy objectives, which include public outreach and facilitating stewardship.

One of the preliminary restoration tasks outlined in the Society for Ecological Restoration's *Guidelines for Developing and Managing Ecological Restoration Projects* (Clewell et al. 2005) is to establish liaison with the public and publicize the project:

> Local residents automatically become stakeholders in the restoration. They need to know how the restored ecosystem can benefit them personally. For example, the restoration may attract ecotourism that will benefit local businesses, or it may serve as an environmental education venue for local schools. If residents favor the restoration, they will protect it and vest it with their political support. If they dislike the restoration, they may vandalize or otherwise disrespect it. (Clewell et al. 2005)

As you plan restoration, it is important to consider what level of commitment you are prepared to devote to the project. This chapter provides tools and resources for designing public involvement and public outreach for Garry Oak ecosystem restoration projects. No matter what scale or type of restoration project you are taking on—a grassroots, community-led project or a multi-stakeholder, government managed initiative—community consultation, education, public outreach, and volunteer management may be essential to your success.

EXAMPLES OF OUTREACH AND PUBLIC INVOLVEMENT

- Public consultation meetings
- Public presentations
- Educational field trips to Garry Oak ecosystems
- Information and resources provided to the public
- Parks interpretive programs
- Public signage
- Volunteer programs
- Landowner/neighbour contact programs
- Education programs within the schools

6.1.1 Overview of this Chapter

This chapter provides descriptions, best management practices, tools, and resources for developing outreach programs for Garry Oak ecosystem restoration projects and addressing public participation throughout project planning and implementation.

- Section 6.2 provides an overview of how to communicate with the public, gives guidelines and tools for building a communications/outreach strategy, and provides information on public involvement and consultation. This section ends with descriptions of, and tools for, effective communication methods.
- Section 6.3 looks at the social and cultural aspects of restoration, including historical cultural relationships, social implications of restoration, and implications of bringing people back into the ecosystems.
- Section 6.4 describes the building of a stewardship ethic, provides considerations regarding stewardship challenges, gives an overview of community-based restoration, and describes stewardship programs for youth. This section concludes with a description of, and best management practices for, landowner contact programs.
- Section 6.5 covers tools and best management practices for managing volunteer programs.
- Section 6.6 ends with "celebration" as a reminder of the importance of celebrating the ecosystems and our work.

6.2 Communicating with the Public

6.2.1 Overview

> The world we have created today as a result of our thinking thus far has created problems that cannot be solved by thinking the way we thought when we created them. (Albert Einstein)

Successful ecological restoration of Garry Oak ecosystems needs to be based on both participatory action and scientific knowledge. Outreach and public involvement strategies are best considered at the beginning stages of a project and should be re-evaluated throughout its implementation. A project that includes the community in its vision, goals, and objectives from the start is much more likely to have success and long-term sustainability. Successful projects not only reach out to the broader community and stakeholders but also see the community as active participants and knowledge holders who can assist with many facets of the overall restoration program.

Communicating with the public can be viewed as a spectrum of activities ranging from informing and educating to involving and collaborating with the public and other stakeholders in the project. Careful planning and implementation of this process ensures key concerns, information, and other goals are considered and incorporated into the project planning process. Ongoing outreach maintains the project's profile and community interest, support, and stewardship.

In planning for public communication, consider the following:

- Who is your audience?
- What do they want to know? What do they have to contribute to the project?

- When (and at what points) do you need to implement different types of communication?
- Why are you communicating? Are you informing, asking for participation, or looking for full collaboration?
- How do you want to communicate? What are your resources and goals?
- How can the community communicate their concerns and provide input?

It is important to develop a communications or outreach strategy for your restoration project. This strategy may be the key to building community support or collaboration and long-term sustainability.

> A communications strategy may be the key to building community support and long-term sustainability for your restoration project.

6.2.2 Building a Communications/Outreach Strategy

In order to build a communications/outreach strategy, consider the following:

Objectives: Define your communication and outreach objectives (e.g., "Objective 1: To build awareness and educate the community about Garry Oak ecosystems and ecological restoration").

Audience: To be successful in communication, it is vital to know your audience. Consider who your audience is, including their knowledge, perspectives, interests, and the best ways to reach them, and start from where they are.

Key Message: Be very clear about what message you are communicating to the public.

Achieving Objectives: Identify which communication, outreach, and public involvement strategies you will use to achieve your objectives.

Resources: Identify available resources to help you with your strategies.

Evaluating Success: How will you know if you are successful? For each strategy, identify evaluation techniques (e.g., for site tours: number of people who attend, response of participants, successful engagement of the media).

Adjust Strategy: Be prepared to adjust your strategy as you evaluate its success.

Objectives

Identifying specific goals and objectives will help you to be more focused and effective. This will also help you to effectively evaluate the success of your public outreach. When you are developing objectives, carefully consider the available resources, timeframe of your project, stakeholders, and other considerations specific to your project that may impact a communications strategy.

Using the **SMART** technique is one way to develop effective objectives (see also Chapter 5):

Specific – Is the scope narrow enough that it can be attained?

Measurable – How do you know when you have achieved your outcome/objective?

Achievable – Can this objective be achieved with the time and funding available?

Realistic – Is this objective or activity realistic, and relevant to the over-riding goal?

Timed – What is the timeframe? Can the task be completed in this timeframe?

Audience

One of the most important considerations for effective outreach planning is to identify your target audience. You may have a number of different audiences and different methods of communicating with each. Consider their individual needs and knowledge, and how they best receive information.

Consider who needs to be informed and/or involved. How does your audience relate to your project goals? Do you:

- require volunteers?
- need to change behaviours around site use and stewardship (such as trampling and dumping of garden waste)?
- have goals that include public participation or consultation in the project?
- want to expand restoration efforts to neighbouring properties?
- need funding and other support from your audience?

Key Message

Consider what specific messages you want to convey to your audience in order to achieve your objectives. When communicating with the public, the simplest messages can be the most effective. Be careful not to overwhelm people with information. Adapt your key message(s) to your specific audiences and be prepared to change those messages in response to community feedback.

Achieving Objectives

Once you have considered your objective(s), audience, and key message(s), you then need to select the best communication strategies. You may want to focus on one specific method that seems to be best for your audience, or develop a few strategies to reach your audience(s) in different ways. Most restoration projects use a variety of outreach strategies targeted at different goals or objectives. Signage and presentations may work best to change the behaviours of certain audiences, whereas media, newsletters, and direct contact may work best in engaging and involving other audiences.

Resources

There are many great examples of effective outreach tools for restoration projects. To conserve time and resources, look at outreach tools that have been developed by related organizations, existing manuals for ideas and guidance and even other Garry Oak ecosystem restoration projects with outreach programs. The list at the end of this chapter includes helpful resources for developing outreach tools. Also see Section 6.2.3 for descriptions of effective communication methods.

Evaluation Methods

There are many different ways you can evaluate the success of your public outreach program. You may use evaluation methods that have specific, measurable goals such as behavioural changes or participation levels. If you are evaluating a specific part of your outreach program, the method you use should be specific to that component. For example, if you are evaluating your volunteer program, you may use:

- focus groups
- participant surveys
- ongoing participation statistics

One evaluation technique, SWOT analysis, requires you to carefully examine your objectives, and then evaluate your success. This analysis may be done in a group setting. In your group, evaluate each of the four elements listed below (evaluation elements "SWOT"). For each element, make sure everyone in the group clearly understands the element, then brainstorm and discuss. For example: does everyone understand "strengths"—what are the strengths of this activity (specific activity) in achieving the objective(s)? When everyone is clear, brainstorm or discuss the strengths, creating a list. After the group has completed an analysis of each SWOT (strengths, weaknesses, opportunities, and threats), compare and group the lists gathered for each and analyze the results.

Evaluation Elements

Strengths: attributes that help in achieving the objective

Weaknesses: attributes that are harmful in achieving the objective

Opportunities: external conditions that are helpful to achieving the objective

Threats: external conditions that could damage the objective

Adjusting your Strategy

Use the results of your evaluation to adjust your ongoing and future public outreach and involvement strategies so they become increasingly effective.

6.2.3 Restoration Planning: Public Participation

> Restoration represents an indefinitely long-term commitment of land and resources, and a proposal to restore an ecosystem requires thoughtful deliberation. Collective decisions are more likely to be honored and implemented than are those that are made unilaterally. (Society for Ecological Restoration, SERISPWG 2004)

Public participation should be considered carefully because it implicitly includes the promise that the contributions of the public will influence the project. A good public participation process requires planning, effective facilitation, and follow-up (Figure 6.1). The benefits of the process may include increased project support.

Public involvement can be vital to a restoration project's credibility, support, and long-term sustainability. The benefits can include:

- the opportunity to address concerns of stakeholders and neighbours early in the project, and identify options that will be supported by the community
- the chance to use the public's knowledge about the site, which will inform the restoration planning process
- the ability to build awareness and understanding of the project
- the opportunity to build long-term support for the project, which may include labour, resources, funding, and/or general stewardship

Case Study 1. San Juan Preservation Trust: Community Support = Bluebird Re-Introduction Success

At one time, Western Bluebirds *(Sialia mexicana)* were a significant part of the landscape of the San Juan Islands in Washington State. As their habitat and landscape changed, including the loss of large dead trees for cavity nesting, Western Bluebird populations began to decline in the 1930s. By the 1960s they were extirpated from the northern extent of their range in the U.S.A. Small populations persisted on southern Vancouver Island and the Gulf Islands until the mid-1990s. In 2007, the San Juan Islands Western Bluebird Re-introduction Project began with a five year strategy to re-establish breeding populations of birds on the islands.

From the planning stages of this project, community outreach and involvement was considered essential. Public seminars were held before the project was implemented, to educate and gain support from the target communities and to engage volunteers. As the re-introduction began, the project depended on community volunteers as nestbox hosts and monitors. Monitoring is now conducted by a paid technician, but volunteer hosts play an invaluable role not only by providing space for the nestboxes, but in some cases also feeding mealworms to clutches (with some pairs having as many as three clutches in the season).

The San Juan Preservation Trust has overseen the majority of public education and outreach, providing not only the educational seminars and volunteer coordination, but wider public outreach. The Trust has reached out through nestbox building workshops, nestbox kit sales, outreach booths at local farmers' markets, educational programs for school children, media releases, a website blog, newsletter and even a bluebird haiku poetry contest (Kathleen Foley, personal communication 2010).

Elyse Portal inspects a Western Bluebird nestbox on San Juan Island. Photo: Carolyn Masson

Making partnerships in the community, conducting a sustainable volunteer program, and reaching out to build community support have been crucial to the success of this project. Re-introduction of the birds began in 2007, and the results of the 2010 spring and summer monitoring season were very encouraging. Twenty-four Western Bluebirds returned, seventeen more were translocated that season, and a total of eighty-four juvenile birds were banded. As the project continues and support grows, GOERT is planning a re-introduction project across the border on Vancouver Island and the Gulf Islands, with translocations to begin in spring 2012. The Canadian bluebird project will have the added benefit of lessons learned and experience gained through the successful San Juan Islands work. For more about this project, see Case Study 3 in Chapter 4 or go to www.sjpt.org/page.php?content_id=92.

A DEFINITION OF STAKEHOLDERS AND PUBLIC PARTICIPATION

(The International Association for Public Participation, www.iap2.org)

We define stakeholders as any individual, group of individuals, organizations, or political entity with a stake in the outcome of a decision. We define the public as those stakeholders who are not part of the decision-making entity or entities.

We define public participation as any process that involves the public in problem-solving or decision-making and that uses public input to make better decisions.

6.2.4 Decision-making for Public Process

Deciding what level of public process to undertake during the planning stages of a restoration project involves consideration of many factors, such as the mandate of the project, if being steered by an agency; goals for public participation; complexity of issues; community-related impacts; and First Nations participation. Appendix 6.1 provides an adapted version of the District of Saanich's checklist *Deciding Whether Public Involvement is Needed*. The checklist has been adapted to apply specifically to a restoration project. As described in the IAP2 public participation spectrum (Figure 6.1), each approach to public participation comes with expectations from the public that should be considered carefully. Good public process and/or involvement can make or break the success of a project.

6.2.5 Effective Communication Methods

After considering what level of public outreach and/or involvement best suits your project and after identifying your objectives, audience, and key messages, you will need to decide which communication methods are most effective for your situation.

This is where you can be both creative and resourceful by looking at what methods have been the most effective for other projects with similar objectives and audiences. These methods may include:

- printed materials (such as brochures, newsletters, articles, flyers, and letters)
- visual outreach tools (such as signage and posters)
- on-line media (websites and on-line social media such as Facebook and Twitter)
- events (including presentations, meetings, workshops, media events, and unique gatherings)
- direct contact (landowner contact and volunteer programs)
- tours (e.g., as in peak seasons)

Case Study 2. Scotch Broom Project Halted

by Christian Engelstoft

Even though Garry Oak ecosystems do not occur on Haida Gwaii, lessons learned about the importance of public outreach in restoration are worth sharing. Scotch Broom (*Cytisus scoparius*) was introduced to the islands in the early 1920s and to the Tlell area prior to 1936. In the fall of 1999, a program to control Scotch Broom was started in the Tlell area. Within a very short time, the work had to be stopped because the local community was in an uproar. Local citizens really liked the yellow flowering plant as it was one of the only plants that provided the landscape with colour and beauty; they saw no reason to pull it out. The outcome of that project could likely have been much different had the local community been educated about the effects of Scotch Broom on native ecosystems and consulted prior to the removal. To this day, Scotch Broom is a prominent part of the landscape, but control projects are now on-going.

Scotch Broom (*Cytisus scoparius*). Photo: Chris Junck

Christian Engelstoft *is a consulting biologist specializing in wildlife inventories and environmental studies, and is co-owner of Biolinx Environmental Research Ltd.*

INCREASING LEVEL OF PUBLIC IMPACT

INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
Public Participation Goal:	**Public Participation Goal:**	**Public Participation Goal:**	**Public Participation Goal:**	**Public Participation Goal:**
To provide the public with balanced and objective information to assist them in understanding the problems, alternatives and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision, including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
Promise to the Public:	**Promise to the Public:**	**Promise to the Public:**	**Promise to the Public:**	**Promise to the Public:**
We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.
Example Tools:	**Example Tools:**	**Example Tools:**	**Example Tools:**	**Example Tools:**
• fact sheets • web sites • open houses.	• public comment • focus groups • surveys • public meetings.	• workshops • deliberate polling.	• citizen advisory committees • consensus-building • participatory decision-making.	• citizen juries • ballots • delegated decisions.

Figure 6.1 Public Participation Spectrum (from the International Association for Public Participation 2007; used with permission).

A survey of outreach and communication methods used in twelve Garry Oak ecosystem restoration projects conducted on Vancouver Island and the Gulf Islands[1] indicated that the most popular methods were signage, newsletters, media, and presentations. The most effective methods, although not necessarily the most popular ones, were either direct personal contact and/or involving people in the project (however, signage was also one of the most effective methods).

Public outreach and involvement has many positive effects. The survey of Garry Oak ecosystem projects cited the most positive effects of their outreach to be increased volunteer participation, greater connection of children with the ecosystems, greater empowerment of people, increased community support and stewardship for the project/site, and greater public awareness of the values of Garry Oak ecosystems and threats to them.

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1 A survey was conducted by C. MacDonald (2009/2010) through a questionnaire sent via email to key contacts of Garry Oak ecosystem restoration projects in British Columbia that had outreach and public involvement programs. In total, 12 completed questionnaires were received.

Presentation at Playfair Park restoration site. Photo: Carolyn MacDonald

> Increased volunteer participation, increased community support, and greater connections between children and the natural world are some of the most positive effects of public outreach around restoration projects.

Interpretation

Many effective communication methods can be described as "interpretive". Interpretation can be defined as:

> Any communication process designed to reveal meanings and relationships of cultural and natural heritage to the public, through first-hand involvement with an object, artifact, landscape or site. (Interpretation Canada 1976)

Interpretation comes in many forms, from a sign or publication to a guided walk or theatrical program. In practice, it is a way of communicating enthusiasm, meaning, value, and wonder. Interpretation fosters connections between people and places, which is especially important for Garry Oak ecosystems.

> Far beyond the dissemination of factual information, interpretation aims to create in visitors meaning, so that they can put a place into personal perspective and identify with it in a way that is more profound and enduring than random fact-learning can alone produce. Interpretation is meaning making. (Ham 2002)

A good place to search for interpretation resources is the Interpretation Canada website (www.interpcan.ca/new).

The following descriptions profile some of the commonly used communication methods. The resources referred to here will help you to make the best use of each of these specific techniques.

Signage

Most signage used for Garry Oak ecosystem restoration sites identifies a site or project, and may provide a map, site interpretation, and other key information for site visitors. The twelve restoration projects surveyed identified signage as one of the most commonly used communication techniques.

The following are common types of signage used for ecological restoration sites:

- basic site/project identification signs
- interpretive signage
- kiosk-style map and interpretive signs
- seasonal signs
- sandwich boards (temporary)

Government-led projects will likely have their own signage production in-house and/or established procedures for signage development. Other projects and organizations may look to community professionals to provide information and assistance for signage development, production, and installation.

The following are some things to consider when planning for site signage:

- Is landowner consent (or partnership) required?
- Who is the main audience? (What are their needs and level of engagement?)
- What are the key messages (concise) and purpose of the signage?
- Is funding available?
- Is a project contact required? If so, consider the best long-term contact information. What materials are required to reduce the impacts of vandalism?
- What is the ideal location for, and height of, installation?

There are many resources available to help you plan for creating effective signage, e.g., *A Sense of Place: An Interpretive Planning Handbook* (Carter 2001).

Sandwich boards can be used to inform site users about temporary project activities, for example, on work party days to explain what volunteers are doing. Photo: Carolyn MacDonald

GOERT offers this series of "Stay on Track" signs to conservation partners to promote responsible use of sensitive ecosystems. For more, see www.goert.ca/stayontrack. Photo: Chris Junck

Kiosks can provide detailed site information such as maps and habitat descriptions. This photo shows the kiosk at Woodlands at Government House in Victoria. Photo: Carolyn MacDonald

Simple signs can be an unobtrusive way to inform users about a restoration site, such as this sign at Fort Rodd Hill National Historic Site. Photo: Carolyn MacDonald

With signs such as this Habitat Steward sign, GOERT recognizes landowners who allow access to their property for restoration and species at risk surveys. Photo: Chris Junck

Newsletters

Keeping regular contact with project partners, neighbours, volunteers, and other key stakeholders can be essential to the sustainability of your project. Newsletters are one way to keep people informed, interested, and even participating. A good newsletter can be provided with minimal costs, depending on your goals. Newsletters can be distributed via email, mail, and/or the internet.

There are many helpful tips on the internet for producing effective newsletters. Create a plan, an appealing design, and follow these guidelines:

- Banner: The banner should be simple and bold, clearly identifying the project or agency and including the publication date and number.
- Layout: Use consistent formatting such as fonts with a clean design. Printed newsletters often use 2–3 columns.
- Headlines: Make headlines eye-catching to draw in your readers.
- Graphics: Use good quality graphics to add interest and professional quality to your publication as well as making the newsletter easier to read.
- Writing style: Use a writing style that is brief, to the point, and uses a less formal style. Sub-headings help break up longer articles.
- Audience: Know your audience and what they want or need. Knowing your audience will also help decide what are the most important things to communicate about your project.
- Contact information: Make sure your contact information can be found easily in a consistent, strategic location.
- Distribution: Consider how best to distribute the publication for your intended audience, or provide a few options (such as print and email).

Websites

Increasingly, the public is accessing and wanting information through the internet. Websites can provide a way of promoting Garry Oak restoration sites and stewardship, and can be a way to connect participants with information, event announcements, newsletters, and resources. Currently, Garry Oak restoration projects are using a wide range of website approaches, from one very simple webpage with links to project webpages within a larger organization's website, to elaborate and professionally designed websites.

Most of us recognize the basic dos and don'ts of website design based on our own experience with accessing websites. The best designs are attractive, consistently formatted, and user friendly. Ecological restoration projects need to provide readily obtainable information about how to get involved, along with current contact information. Following are examples that have been created for Garry Oak restoration projects:

MT. TOLMIE CONSERVANCY

http://members.shaw.ca/mttolmieconservancy
This simple website has one main page which includes a clear statement of the project's purpose, contact information, and a list of upcoming events. The webpage provides links to a map, historical information, and photos. It is a very basic website with easy upkeep, and it focuses on providing specific information rather than using an engaging design.

COWICHAN GARRY OAK PRESERVE

www.natureconservancy.ca/site/PageServer?pagename=bc_ncc_CGOP
The Cowichan Garry Oak Preserve is an example of a project that has webpages within a larger organization's website (The Nature Conservancy of Canada, www.natureconservancy.ca). The main page directs readers to summaries and contacts for key aspects of their program, and information on upcoming events, research, and volunteer events. It also offers a concise description of the ecological and cultural history of the site, profiling why it is special.

CROW'S NEST ECOLOGICAL RESEARCH AREA

www.twu.ca/crowsnest
Trinity Western University provides webpages for its Crow's Nest research area within their larger website. The Crow's Nest pages are nicely organized and include a directory, giving it the appearance of an independent website. The site includes unique features, such as a digital herbarium, an inventory database of vertebrates and invertebrates, and an on-line tour of the research area using a map and photo links. The main purpose of the project is clearly stated, and the research description and links are easily accessible.

GARRY OAK RESTORATION PROJECT

www.gorp.saanich.ca
This website features a number of restoration sites, and the footer on each webpage includes contact information for the project coordinator. The website provides basic information about the project, as well as more in-depth information, newsletters, and announcements for volunteers and other interested parties. Maps provide information about each site, including how to access it by bus or walking trails. Note that information such as event listings are kept updated, which is an important website feature.

GARRY OAK ECOSYSTEMS RECOVERY TEAM

www.goert.ca

GOERT's website provides a good example of the key elements of successful website design. The website is attractive, carefully designed, and very user-friendly. Content is constantly updated, providing a go-to hub of Garry Oak ecosystem information. The website meets the needs of a wide variety of audiences, from engaging individuals who are new to Garry Oak ecosystems to providing in-depth information, resources, and tools for professionals. Extra links at the top of the banner provide easy access to contact information and information on donating to the organization or subscribing to its newsletter.

SALT SPRING ISLAND CONSERVANCY

www.saltspringconservancy.ca

This website is a great one to visit if you are looking to design a dynamic website for a non-government organization. Information is detailed and laid out in a very user-friendly manner. The footer at the bottom of each page tells you when the site was last updated. Specific project pages are especially in-depth. For example, the Sharp-tailed Snake (*Contia tenuis*) page includes good quality photos, information about the species and "how to help", and links to related resources, and the owl pages provide photos and species profiles, plus links to information on owl calls and nest box designs.

Carolyn MacDonald and Judith Carder pose at Chatterton Hill Park for a news story about supporting community projects. Photo: Diana Nethercott

On-line Social Media

Although many of us may still experience a "cringe factor" related to on-line social media or networking, it is a buzz we may need to listen to. There are many examples of projects and campaigns that have taken off due to their use of simple, on-line networking platforms. The most popular types of platforms include:

- microblogging (e.g., Twitter; short content on-line conversations)
- blogging (including free platforms such as Google Blogger)
- video (the most popular being YouTube)
- social networking (e.g., Facebook and MySpace)

On-line social networking is a means of connecting with people, and it can provide a way to reach a broader audience or even effectively communicate with a specific audience, such as youth. Many social networking sites provide a place to creatively draw interest and support for your project or campaign. If you aren't sure about venturing into this new world, find a young person to get you started!

Presentations

Presentations can be an excellent way to engage people and provide key messages or information about a project. They can also be a great way to put people to sleep or to put them off a topic. With careful planning and practice, presentations can be effective in reaching out to specific audiences. Plan your presentations so that you present key messages in a concise, engaging manner, and consider the following:

- Know your audience. Why is this relevant to them?
- Plan, prepare, and practice your presentation.
- Capture your audience's attention right from the start.
- Briefly tell your audience what you plan to present.
- Ensure your audience that you will not waste their time.
- Engage your audience. Pose a question or ask for some kind of response.
- Speak clearly, and use emphasis and pauses.
- Check your body language. Be confident.
- Look at your audience throughout the presentation.
- Use humour and enthusiasm.
- Tell short stories or provide examples to illustrate key points.
- Use visual aids, such as props, overheads, slides, or PowerPoint presentations.
- Keep to your allotted time.
- Have a clear conclusion and briefly summarize your key points.
- Ask your audience if they have any questions.

Use of PowerPoint and Other Slide Presentation Formats

Effective use of slide presentations uses this medium to enhance and highlight a presentation, rather than provide the substance of the presentation. Use good quality pictures, a standard

The author presenting a workshop on restoration. Photo: District of Saanich

design throughout, a minimum of text in abbreviated (even bulleted) form, and limit the use of tables, details, and anything with small text. Over-use of animation and different types of transition can be annoying and distracting. The focus of the presentation should be on the presenter, with PowerPoint slides serving as emphasis.

Workshops

Workshops are an effective way of engaging people in a topic. If your restoration site would benefit from good neighbours who are practicing stewardship on adjacent properties or if you need to train volunteers for a specific conservation project (such as rare species identification and protection or invasive species management), hosting a workshop might be the right approach.

Whether you host a workshop and bring in a skilled workshop facilitator/presenter or facilitate your own workshop, some general best practices apply:

- Have clear objectives
- Provide an icebreaker or an engaging welcome
- Start and end on time
- Provide a workshop agenda
- Know your audience (and start from where they are at)
- Address basic needs (comfort, washrooms, breaks/food)
- Use different types of activity types, such as small groups, brainstorming, and hands-on activities
- Provide participants with evaluation forms so they can provide feedback on the workshop

Workshop facilitators try to balance the input of participants; maintain focus; address disruptive behaviour; encourage brainstorming, questions, and discussion; and clarify workshop outcomes. Building trust and sharing enthusiasm are also important roles for facilitators.

Landowner Contact Programs

Landowner contact programs have been shown to be one of the most effective tools for encouraging land stewardship (Archibald et al. 2005). A description of best practices is provided in Section 6.4.5.

CASE STUDY

Case Study 3. Habitat Acquisition Trust (HAT) Good Neighbours Program

Habitat Acquisition Trust, based in Victoria, B.C., has developed an award-winning landowner contact program for protection and stewardship of Garry Oak ecosystems in the Capital Regional District (CRD). Through their *Good Neighbours* program, HAT has reached out to neighbours of protected areas to increase stewardship within protected areas, increase landscape connectivity and buffers on surrounding private lands, and raise awareness and appreciation within the community. One of the Good Neighbours projects reached the neighbours of Knockan Hill Park in 2008, aiming to bolster the on-going efforts of the Friends of Knockan Hill Park Society. Working with the Society, Royal Roads University, and other conservation partners, HAT reached out to landowners through information postcards, direct contact by phone, and landowner visits. The Knockan Hill Good Neighbours project delivered information to 97 interested residents following the postcard mail-out, provided 37 private land care consultations, and eventually signed 25 land care agreements. One of the successful social marketing tools used by HAT is stewardship signs, which land care stewards placed on their properties.

In addition to the direct landowner contact, HAT engaged the community through a speaker series in the park (historical and natural history topics) and a nature photography workshop. HAT promoted their vision for whole ecosystem conservation by engaging with local Cub Scouts to paint storm drains, reminding residents of salmon downstream. The success of this Good Neighbours project was marked by the great responses, action, and increased stewardship by Knockan Hill residents. In 2009, the CRD recognized HAT's creative and effective community-based stewardship approach with the Eco-Star Award for Land Stewardship.

Saanich Parks staff member/arborist Ron Carter discusses the value of wildlife trees and tree diagnostics with local residents at Knockan Hill Park. Photo: Todd Carnahan

Volunteer Programs

One of the most important methods of increasing stewardship and support for Garry Oak ecosystem restoration projects has been the development of volunteer programs. Successful volunteer programs share certain key elements whether they are developed within a grassroots community organization or as a formal program managed by a government body or agency. Volunteer programs and related resources and tools are described in Section 6.5.

Community-based Social Marketing

Community-based social marketing is an effective approach to promoting behavioural change that is becoming increasingly recognized and adopted. The following description is based on the book *Fostering Sustainable Behaviour*:

> Community-based social marketing is an attractive alternative to information-based campaigns. Community-based social marketing is based upon research in the social sciences that demonstrates that behaviour change is most effectively achieved through initiatives delivered at the community level, which focus on removing barriers to an activity while simultaneously enhancing the activity's benefits. (McKenzie-Mohr and Smith 1999).

Community-based social marketing involves four steps:

1. identifying the barriers and benefits*
2. developing a strategy that uses tools that have been shown to be effective in changing behaviour
3. piloting the strategy
4. evaluating the strategy once it has been implemented across a community

**Note: barriers and benefits refer to the barriers to a particular behaviour change and the benefits of that behaviour change.*

The types of tools that can be used in a strategy include:

- commitment techniques
- prompts
- social norms
- effective messages
- incentives to act

For detailed descriptions of these techniques and how to use them, see McKenzie-Moore and Smith (1999). The book also describes techniques for removing external barriers to behavioural change, and designing and evaluating effective programs. Much of the book's content is available on-line at www.cbsm.com.

Local programs have successfully used social marketing techniques to increase stewardship of Garry Oak ecosystems.

"The Coast Salish peoples of southern Vancouver Island cleared rocks and brush from their camas (*Camassia* spp.) meadows, leaving stretches of open parkland interspersed with stately Garry Oak trees (*Quercus garryana*). This practice utilized disturbance to maintain an early successional habitat in close association with mature forest habitat. The tending of the successional habitat mosaic provided the best possible conditions, not only for camas, but also for other root vegetable species, for wild strawberries (*Fragaria* spp.) and other berries, and for deer and other game at the edges of the woodlands, thus increasing the diversity of resources available in a limited geographic space." (Turner et al. 2003)

6.3 Social and Cultural Aspects of Restoration

> ...what is being restored encompasses cultural beliefs and practices along with ecological processes, structures and patterns. (Higgs 2003)

6.3.1 Historical Cultural Relationships

Historically, First Nations had a relationship with the land that included stewardship of natural systems that provided them with things like food and trade items. The First Nations peoples' historic use of fire maintained important wildlife habitat, plant resources, and the open canopy and understorey structure of Garry Oak ecosystems (see Chapter 2: Distribution and Description, and Chapter 3: Natural Processes and Disturbance). In this chapter, we describe some of the cultural and social aspects of restoration as they apply to planning public outreach, public involvement in the restoration project, and efforts to restore human relationships with the land.

It is important to include historical cultural practices in restoration projects. This photo shows prescribed burning at Playfair Park in Saanich. Photo: Carolyn MacDonald

MAKING CULTURAL CONNECTIONS

The following are some ways restoration projects can make and enhance cultural connections with the site, with Garry Oak ecosystems, and with historical relationships and practices:

- restoration planning
- traditional cultural practices at the site
- education and interpretation
- volunteer programs
- printed outreach materials
- site signage
- special events, celebrations
- website

Gordon deFrane of the Chemainus/Penelakut First Nations wrote the following description and introduction for *Garry Oak Ecosystems of British Columbia: An Educator's Guide* (MacDonald and Staniforth 2005):

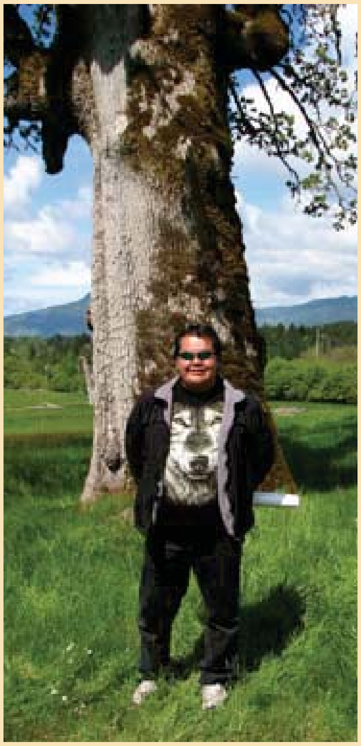
> O SI'EM NA SI'AYA
>
> The first inhabitants of what is now called Victoria referred to themselves as the people of the windy place, the Lekwungen. Their ancestors today are more frequently thought of as the Songhees. The Songhees are one of four social, linguistic and culturally distinct and unique indigenous nations that have continuously inhabited Vancouver Island since long before Vancouver, Cook or Juan de Fuca ever explored the waters off the coast of British Columbia.
>
> In the southern region of the island, the Straits Salish nation called Victoria, the Saanich Peninsula and the San Juan Islands home. From the north side of the Malahat to near Cape Mudge Island, the Coast Salish family of nations have lived and existed since the first humans fell from the skies long ago. From Cape Mudge to the north end of the Island is home to the kwakwak'awakw family of nations. The Nuu-chah-nulth family of nations calls the west coast of the island home.
>
> Each nation, clan or tribal group derived their livelihoods from the forests, rivers, oceans, mountains, marshes, lakes and...Garry Oak ecosystems. The Garry Oak ecosystems are ancient landscapes bounded up in the lives, lore and legends of the First Peoples of the Island. Healthy Garry Oak ecosystems meant healthy communities. Therefore, it is important to recall and to remember the ancestors of the First Peoples of Vancouver Island; each footstep stirs the dust of the ancestors that have gone before, which leaves a memory of the ancestors to follow. (Gordon deFrane)

CASE STUDY

Case Study 4. Field Trip with Cowichan Tribes

In May 2009, GOERT and several conservation partners in the Cowichan Valley provided students with a day-long tour of two Garry Oak ecosystem restoration sites. Thirty middle school students and about sixty youth and adult students from Cowichan Tribes schools attended. The day began at the Cowichan Garry Oak Preserve. Along with Nature Conservancy of Canada staff members who manage the site, facilitators included three Cowichan Tribes leaders and a rare plant specialist. The participants toured a Garry Oak meadow in bloom and a native plant nursery where rare plants are being grown, and ate their lunch while sitting under the largest Garry Oak tree in Canada. Students learned about uses of native plants, traditional camas digging practices, and words for some plants in the Hul'qumi'num language. The day wrapped up at nearby Somenos Garry Oak Protected Area with a walk around the site and a discussion of native plants and invasive species. For more, see www.goert.ca/news/2009/08/cowichan-tribes.

Cowichan Tribes leader Ken Elliott speaks to students about native plants in the nursery at Cowichan Garry Oak Preserve. Photo: Carolyn Masson



Cowichan Tribes leader Doug August greeted students at the big oak. Photo: Carolyn Masson

Cultural practices such as stewardship of meadows, use of fire, and harvesting of bulbs led to values that sustained ecosystems and spiritual connections with the land. It is recognized that "intensive cultural activity has shaped this ecosystem for millennia and appears necessary to maintain it into the future" (MacDougall et al. 2004). Restoring culturally sustained Garry Oak ecosystems that are currently threatened due to contemporary values and practices requires restoration of the relationships between people and the ecosystems.

> The cultural landscapes of southern Vancouver Island have changed dramatically in the last 160 years. Environmental change was not only influenced by shifting climatic and ecological processes, but by the behavior, practices, and economic choices of humans who dwelled within the environment. (Beckwith 2004)

Brown and Mitchell (2000) described the "...growing understanding of the link between nature and culture: that healthy landscapes are shaped by human culture as well as the forces of nature, that rich biological diversity often coincides with cultural diversity, and that conservation cannot be undertaken without the involvement of those people closest to the resources."

In terms of historical cultural aspects of restoration planning and outreach, it is important to include First Nations and historical cultural practices in planning and implementing Garry Oak ecosystem restoration projects. Any opportunity to engage First Nations should be taken to encourage the mutual sharing of information and to include First Nations as partners or key stakeholders in restoration planning. Engaging and educating youth are likewise important, especially for hands-on learning and cultural education with First Nations partners.

6.3.2 Social Implications of Restoration

> ...restoration must be conceived in a way that makes the connections between culture and ecology, people and place, prominent. (Higgs 2003)

Although some restoration sites may seem to exist in relatively isolated places, any restoration site has a community context that needs to be acknowledged. Historical First Nations practices on the site or practices used only since European settlement may be known. Recent historical use is also important in terms of the social implications of conducting restoration. For example, the site may have been used by the community as a place for local children to play, a favourite dog walking spot, a privacy barrier (e.g., a shrub hedge) from a road, a site for annual Easter egg hunts, a picnic destination, or a place where neighbours dumped yard waste. Both the historical (see Chapter 3: Natural Processes and Disturbance) and contemporary uses of the site need to be considered within restoration planning as well as outreach and public involvement.

Chapter 8: Restoration Strategies describes historical and cultural practices in relation to restoration strategies, and the impact of contemporary values and management of the use of the site by humans and dogs. The management of human use and impact of dogs are both big issues for restoration projects in urban areas. Restoration planning needs to address how to engage the community in the restoration project and how to design the project within the unique context of that community.

> Restoration practices that hold firm to ecological fidelity and embrace social and cultural goals are much more likely to prosper and endure (Higgs 1997).

CASE STUDY

Case Study 5. Tsawout First Nation: Restoring Land, Language, and Culture

Members of Tsawout First Nation are working to restore their ancestral lands, and at the same time, to restore their language and culture. Saanichton Bay has traditionally been a place of abundant harvest for the Tsawout Nation, but today shellfish beds are contaminated by excessive nutrients and sediments from upstream. With the help of Habitat Acquisition Trust's (HAT) TIXEN/Cordova Shore Good Neighbours Project and other partnerships, community members have been working to restore sand dunes, rare bluffs, a salt marsh, eelgrass meadows, and clam beds by repairing damage from development, excessive stream nutrients, foot traffic, vehicles, dogs at large, and invasive species. Festivals and guided activities have helped to engage the community in the project.

> "The Tsawout Lands Advisory Committee really identified with the concept that their threatened culture is an aspect of biodiversity worth protecting, that their language defines a unique world view, and that they as a People are therefore endangered. This story is one of community-based ecological restoration in the most comprehensive sense—that restoring community is just as important as restoring the land."
> –Todd Carnahan, HAT

> "The success of our common goal to conserve sensitive ecosystems really depends on the willingness of everyone to work together, and this is what we felt was so critical to the partnership with HAT, because they provided education to the public and our own members and created a better understanding of what we were trying to achieve. So I think this type of partnership is worthwhile for any community that has the goals to conserve the plants and medicines and water that we all thrive on."
> –Gwen Underwood, Tsawout Lands Advisory Committee

The project was highlighted for the conservation community when a panel from Tsawout First Nation presented at HAT's annual Conservation Connection Forum.

Photos: Todd Carnahan

PEOPLE AND ECOLOGICAL RESTORATION. WHO SHOULD BE INVOLVED?

- Restoration practitioners
- Specialists (e.g., botanists)
- Neighbours
- First Nations
- Community volunteers
- Funders
- Community organizations
- Schools; children and youth
- Post-secondary students
- Local businesses

GORP volunteers touring Woodlands at Government House restoration site. Photo: Carolyn MacDonald

Engaging the community in a restoration project may impact land management practices surrounding the site and within the community. The public, especially project volunteers and participants of landowner contact programs, may be engaged enough to change practices and increase stewardship surrounding the restoration project such as in private backyards, school grounds, church properties, and on municipal lands. There are excellent resources and programs available to support less formal efforts to conserve native species and habitats, especially on private lands, including the Naturescape BC program and GOERT's *Garry Oak Gardener's Handbook* (GOERT 2009). Landowner contact programs (see Section 6.4.5) can be a very successful way to engage and connect with the community.

6.3.3 Bringing People Back into the Ecosystem

> Restoration is a social and cultural act, an interaction between humans and nature (Edgar 2007).

There are both positive and negative implications of bringing people back into the ecosystem. On the positive side, the people involved will develop greater awareness and appreciation of Garry Oak ecosystems and will increase their understanding and knowledge of the ecosystems over time, which ideally will lead to increasingly positive actions in protecting and restoring Garry Oak ecosystems.

As we seek to bring people back into the ecosystem and develop healthier relationships between humans and the land, we face of the challenge of trying to balance the impacts of increased human traffic and use with environmental preservation. Conserving culturally modified ecosystems infers that people should be part of the system. However, determining what the appropriate human-nature relationship should now be can be challenging.

Lindon Carter with a Garry Oak Restoration Project sign in Playfair Park, Saanich. Photo: Ron Carter

> No matter how straightforward it appears to be, a restoration project is constructed by social norms. Sense of place, land tenure, sources of livelihood and traditions of community organizing all mediate the relationship between people and place (Edgar 2007).

The Society for Ecological Restoration's *Guidelines for Developing and Managing Ecological Restoration Projects* (Clewell et al. 2005) state that restoration planning should include cultural objectives that "pertain to the realization of cultural project goals. These objectives may involve publicity campaigns, public celebrations of restoration in progress, participation of stakeholders and school children in restoration implementation and monitoring, and other actions that ensure cultural intimacy with ecosystem recovery."

Restoration has a greater chance of success when a project is designed within a community context and in partnership with stakeholders, when it works to build stewardship of the site and within the community, when it seeks to rebuild cultural connections and practices, and when it takes on the delicate balance between maintaining ecological integrity and bringing people back into the ecosystem.

6.4 Stewardship

> The real substance of conservation lies not in the physical projects of government, but in the mental processes of its citizens. (Aldo Leopold)

There is a lack of consensus regarding definitions of environmental/ecological stewardship (Worrell and Appleby 2000; Fuchs 2004). Many definitions include elements of careful or responsible management, consideration of future generations, caring for natural systems, or consideration of cultural values and ethics. Stewardship is described as both an action and an ethic or value. Stewardship should be defined within restoration project planning so that its meaning and related objectives are clear. Establishing stewardship as an ethic within our society and local communities is an important overall goal in successfully protecting and restoring Garry Oak ecosystems.

Case Study 6. Mt. Tzuhalem Volunteer Stewardship

Syd Watts first visited the Mount Tzuhalem Garry Oak area as a Scout in 1938, at age 11. As a teen in the 1940s, Syd spent many happy hours exploring on the slopes of Mount Tzuhalem. It is not surprising that the area was made an ecological reserve in 1984 after Syd spent years leading tours and talking to people about the unique site. By that time, he had also spent five years with his wife and naturalist friends (many from the Cowichan Valley Naturalists' Society) clearing broom from the flower meadows he loved. Syd became the first (and so far only) warden for the ecological reserve. His work to spearhead broom removal since the late 1970s was taken over in 2003 by crews funded through the Habitat Stewardship Program. The beautiful flower meadows of Mount Tzuhalem Ecological Reserve are a testament to the dedication of Syd Watts and his willing crew of stewards.

Since the 1970s, Syd Watts and the Cowichan Valley Naturalists' Society have preserved this meadow, with its large population of Endangered Deltoid Balsamroot (*Balsamorhiza deltoidea*), from the ravages of Scotch Broom (*Cytisus scoparius*) invasion.

Deltoid Balsamroot (*Balsamorhiza deltoidea*). Photos: Dave Polster

The following are definitions of interest regarding stewardship:

> In its broadest sense, stewardship is the recognition of our collective responsibility to retain the quality and abundance of our land, air, water and biodiversity, and to manage this natural capital in a way that conserves all of its values, be they environmental, economic, social or cultural. (The Land Stewardship Centre of Canada, www. landstewardship.org)

> Efforts to creature, nurture, and enable responsibility in landowners and resource users to manage and protect land and its natural and cultural heritage. (Brown and Mitchell 2000)

A few of the challenges in defining stewardship include the tendency for the term to imply dominion over the natural world, that actions regarded as stewardship are essentially good (when this may be open to interpretation) and may imply delivery of some type of public benefit (Worrell and Appleby 2000). These issues reinforce the need to define stewardship in relation to the specific goals and objectives of a restoration project and in relation to the goals and objectives of the Garry Oak and associated ecosystems Recovery Strategy (GOERT 2001).

6.4.1 Building a Stewardship Ethic

The Garry Oak Ecosystems Recovery Team was formed to coordinate efforts to protect and restore endangered Garry Oak and associated ecosystems and the species at risk that inhabit them. Stewardship is an important element of successfully protecting and restoring Garry Oak ecosystems. In this context, stewardship would describe the human care, management, and value of Garry Oak ecosystems. Because these ecosystems are at risk primarily due to human activities, the mitigation of risk and the protection and restoration of these ecosystems will depend on the activities and values of people and society.

> We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect. (Leopold 1949)

The Cowichan Community Land Trust Society has worked to build stewardship ethics in the community, in part by connecting with people on the land. A report (Archibald et al 2005) of their landowner contact programs showed this direct contact with landowners changed land ethics significantly. Surveys of participants in landowner contact programs reported most significantly changes in attitudes about land stewardship, increased knowledge and understanding of land stewardship issues, and changes in environmental management practices (especially relating to wildlife habitat). Landowners were also more likely to join environmental and conservation organizations and contribute towards land acquisition campaigns (Archibald et al. 2005). See more on landowner contact programs in section 6.4.5.

A Few Strategies to Build Stewardship

with inspiration from Oregon State Parks, Centennial Horizon Principle 4 (2008)

- *Inspire* people to make connections with Garry Oak ecosystems by involving them in restoration projects or inviting them to explore the beauty of your restoration site with you.

- *Embrace* new ways to reach out to people, exchange ideas, and engage them in stewardship.
- *Listen* to people and what they are interested in; hear their stories.
- *Offer* interpretive programs and make the Garry Oak restoration site come alive.
- *Promote* regional and community approaches to stewardship, fostering a sense of place.
- *Encourage* teachers and post-secondary students (and professors) to use the restoration site as a laboratory, and contribute to site monitoring and research (see Section 6.4.4).
- *Develop* good volunteer programs that provide long-term stewardship and training opportunities (see Section 6.5).
- *Reach out* to neighbours through Landowner Contact Programs (see Section 6.4.5).
- *Create* partnerships for the restoration site to build community.

6.4.2 Stewardship Challenges

Many Garry Oak restoration projects have been initiated and their on-going success is due to the invaluable contributions of volunteers. "Volunteer stewardship programmes…have a critical role, not merely for the important habitats that are restored and monitored, but also for their influence in building a potentially powerful constituency of knowledgeable advocates for the environment" (Langenfeld 2009). Successful restoration projects aim to achieve a proper balance between stewardship and science.

In her paper, *Does Stewardship Work? Lessons from the Garry Oak Ecosystems Recovery Team*, Fuchs (2004) identified concerns and limitations about the reliance on volunteer stewardship for Garry Oak ecosystem recovery and restoration efforts. While Fuchs acknowledged that volunteer stewardship is vital to Garry Oak ecosystem recovery, she cited a "lack of clarity about the relative importance of social vs. ecological goals and objectives". Challenges occur when restoration projects rely primarily on non-expert volunteers for site assessment, identification of rare species, development of scientifically-based management strategies, long-term commitment, and "scientifically meaningful monitoring." Fuchs advocates for identifying appropriate roles in recovery efforts and finding methods and tools to "bridge the gap between science and stewardship".

Fuchs (2004) described two-thirds or more species at risk in Garry Oak ecosystems as being "cryptic and/or extremely difficult to identify in the field", and requiring identification by taxonomic experts. Because many of these species are extremely rare, the "consequences of inappropriate actions are potentially extremely serious". Fuchs advocates for the use of "experts to conduct inventories, design site and species specific management strategies", and she stresses that "research and rigorous monitoring are key components of the recovery program."

> Science should inform stewardship practice by helping define ecological goals and objectives, and by helping identify appropriate and effective actions to meet those goals (Fuchs 2004).

Fuchs (2004) identified concerns about public involvement in Garry Oak ecosystem restoration: volunteer participation "[drops] off after the large exotic shrubs have been removed", and there is a lack of interest in cryptic, non-showy species, a reluctance to undertake key elements of restoration planning, and a lack of "resources, expertise, or interest to institute scientifically meaningful monitoring programs."

Case Study 7. City of Victoria: Volunteer Groups Banding Together

In the City of Victoria, eleven community volunteer groups have taken an interest in their local parks and green spaces. Some of the key parks include the Garry Oak ecosystem sites of Beacon Hill and Summit Park. Others, such as the Ryan Greenway, may provide important stepping stones between the larger remnant sites. The City does not have a formal volunteer program as there is no agreement with the union for this, so City support is generally limited to an advisory role, supply of materials including soil and mulch, and removal of debris. These eleven groups are invited to meet monthly at the City's training room to share experiences and for training. The meeting is facilitated by the City of Victoria and training is provided by request. These groups have now formed a loose, larger organization called the Native Ecosystems in Victoria Public Areas Network (www.nevpan.org). Working together, their intention is to create a more cohesive voice in addressing city council and staff over parks and natural areas issues. They are exploring the possibility of becoming a non-profit society with the intention of applying for environmental grants that are open to such groups.

Volunteers at Beacon Hill Park.
Photo: City of Victoria

In her Master's thesis *The Value of Ecological Restoration Volunteer Programs: a Case Study in Western Washington State*, Langenfeld (2009) found limitations in the use of volunteers in restoration programs. In her case study of Garry Oak prairie restoration in Washington State, she found that the rate of volunteer "turnover and burnout" and conflicts between volunteers and managers regarding "visions of restoration goals" had negative effects on restoration programs. Langenfeld (2009) stated that these limitations can be addressed through proactive volunteer management and specific methods, and that investing in highly effective volunteer programs was essential to accomplishing restoration goals.

Ryan et al. (2001) showed that an important element in building a strong program that involves volunteers was to retain long-term volunteers by responding to their motivations as volunteers. One of their key findings was that volunteer involvement resulted in "transform[ing] the way that people view the natural environment and environmental issues" (Ryan et al 2001), which illustrates the importance of volunteer programs to stewardship and environmental education goals.

Langenfeld (2009) found that the longer volunteers are involved in a program, the more specialized their roles become and the more vital they are to the success of the restoration program. Volunteers with the South Sound Prairie Restoration Group moved from initial roles in invasive plant removal, seed collection, native planting, placement of habitat structures, and educational outreach to leadership roles and roles requiring ecological knowledge and specialized training, including mechanical and chemical alien invasive plant control, propagation of native plants, and ecological monitoring. Langenfeld states that maintaining staff and expert roles, as described by Fuchs (2004), is essential to consistently "bridge the gap between science and stewardship", but that volunteers provide invaluable contributions to the *science* of this restoration program.

> These individuals [volunteers] hold an invaluable amount of localized knowledge sometimes not held by anyone else. Skillful contributions...are by far some of the greatest advantages to long-term investment in volunteers. (Langenfeld 2009).

Woodlands at Government House volunteer leader Patricia Boyle giving a tour for GORP volunteers. Photo: Carolyn MacDonald

6.4.3 Community-based Restoration

Many restoration projects begin with or depend on grassroots community efforts. Stewardship as a community effort can be very powerful and effective. It is doubtful that Garry Oak ecosystems will recover without community-based efforts and initiatives. Fortunately, many of the challenges associated with this approach can be overcome with the support, resources, and tools now available to community-led projects. The following is a summary of some of the unique initiatives and tools available for community stewardship and restoration projects.

Tips for Starting a Project

The following is adapted in part from the *Citizen's Handbook* (www.vcn.bc.ca/citizens-handbook) and *Community Stewardship: a Guide to Establishing Your Own Group* (Fraser Basin Management Board 1996). The Community Stewardship guide and many other excellent resources for community-based projects are available through the Stewardship Centre of BC (www.stewardshipcentre.bc.ca).

Before starting a project, consider the following:

- Research your proposed site and project before jumping in.
- Is there an existing project or organization to address this?
- Is there community support for this project?
- Who can help?

When starting a community-based project, ask yourself the following questions:

- What are we trying to do?
- What are your goal(s) and objectives? (Strategize)
- Who is able to provide support?
- Are there groups to partner with?
- What skills/people do we need?

During restoration project planning, consider the following:

- Be clear regarding land ownership and establish official permission for the project.
- If the site is a park, work with land managers throughout the project stages.
- A good site assessment is an important place to start.
- If species at risk occur on the site, engage experts and GOERT in the project.
- Create an adaptive restoration plan with help from this publication.
- Strategize how to build support and resources for this long-term endeavour.
- Engage the community and celebrate!

Community-based Projects

There are many great tools available to support community-based restoration projects. The following are a few examples. Successful projects can take advantage of these existing tools and programs to reach their goals.

Case Study 8. Strawberry Vale Elementary: Engaging Elementary Students in Restoration and Stewardship

Strawberry Vale Elementary School in Victoria has a strong history of environmental stewardship thanks to dedicated teachers. The school community has engaged in a few restoration-type projects including stewardship of a heavily invaded Garry Oak ecosystem remnant on municipal land next to the school. In 2003-2004, students in grades 6 and 7 not only led a school-wide effort to remove English Ivy (*Hedera helix*) from this Garry Oak area, but also designed a costumed skit they performed for each class in the school. The skit was an engaging way to introduce Garry Oaks, the concept of an invasive species, and conservation messages. Strawberry Vale leaders went beyond student involvement, reaching out to families, the community, and partners in order to achieve their goals. With assistance from the District of Saanich, the Habitat Acquisition Trust (HAT), and others, the school undertook this restoration project not only for the restoration value, but also for the educational and stewardship values for the whole community.

Strawberry Vale students with the sign for their restoration project, which began as a legacy project for students in grades 6 and 7. The older students provided leadership and gave presentations to the younger students, including skits. Photo: Ron Carter

Case Study 9. Swan Lake Christmas Hill Nature Sanctuary: Engaging Secondary School Students

Nature sanctuary staff designed a project that would be interesting and manageable to engage local Reynolds Secondary students. A program was designed to teach the students about the role of fire in Garry Oak ecosystems, to introduce them to plot monitoring, and to engage them in active participation. In return, the nature sanctuary received valuable monitoring information about a burn site on Christmas Hill. The initial participants from Reynolds school were six grade 10 students, expanding to on-going plot monitoring for future students. The program teaches the students about mapping, using binoculars, taking samples, and learning to identify invasive and native plants. It was made to be highly engaging and fun. The wrap-up for a field session is usually wild tea made on the spot with natural ingredients like licorice root and arbutus bark.

Community Mapping has been a very successful endeavour for empowering community groups in British Columbia. Identifying unique features of the community and building a sense of place can be a powerful way of building awareness and beginning community dialogues. See Section 6.8 (Additional Resources) for *Giving the Land a Voice: Mapping Our Home Places* (Abbedey et al. 1995).

Conservation Networks can provide vital support for individual organizations or projects. For example, in the Capital Regional District (CRD), Habitat Acquisition Trust maintains a web-based network (www.conservationconnection.bc.ca), holds an annual Conservation Connection event (see their website at www.hat.bc.ca), and oversees a conservation listserv. There is also an ecoregional group, the Cascadia Prairie-Oak Partnership, which hosts a listserv focused on exchange of information related to conservation of prairie-oak ecosystems throughout their range west of the Cascade Mountains. The listserv is used to exchange technical information and to announce events related to prairies and oak woodlands in Cascadia. To subscribe, send a request to info@goert.ca.

Networks can be a great way to find partner organizations, avoid project overlaps, build support and constituency for your project, communicate your needs and events, learn from others and, well ... network!

For more information and resources, see the following websites:

- Stewardship Centre of BC (www.stewardshipcentre.bc.ca)
- Citizen Handbook (www.vcn.bc.ca/citizens-handbook)
- Community-based ecosystem monitoring (www.forrex.org/publications/forrex%20series/fs13.pdf)

6.4.4 Youth and Stewardship

Restoring Garry Oak ecosystems creates a legacy in both the physical and cultural landscape. Therefore, it makes sense to involve youth in restoration as much possible. Restoration projects provide unique opportunities for connecting youth with stewardship of Garry Oak ecosystems, thereby providing them with hands-on experiences, ecological literary, stewardship ethics, and skills training for future careers.

- The Salt Spring Island (SSI) Conservancy has a school program called *Stewards in Training* for students in Grades 1 to 8. The *Garry Oak Ecosystem Stewardship* sessions take place at the Andreas Vogt Nature Reserve and at Channel Ridge. These are hands-on environmental education programs with an action component that contributes to ecological restoration activities at the site.
- The *SSI Conservancy Stewards in Training Program Manual* describes the benefits of the program for the student participants. It also provides a fitting summary of the overall benefits of involving children and youth in stewardship and restoration. For example, students develop:

  -a connection to the natural world

  -an ecological understanding

  -a set of environmental ethics

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Case Study 10. Girl Guides of Canada: Uplands Park Stewardship Project

Since 1993, the Oak Bay Girl Guide groups have been stewards of Uplands Park, along with other partners including Scouts, other Girl Guides and school groups. The Girl Guides and their partners have targeted their contribution towards the restoration of Uplands Park on long-term removal of Scotch Broom (*Cystisis scoparius*). They not only have been successful in removing massive amounts of Scotch Broom in this time, but also have created a great deal of attention for the site through involving the media with the draw of what the young people are accomplishing. Leaders report the project has had a great impact on the children and youth involved, including building a connection with Garry Oak ecosystems and giving them a sense of empowerment. After 17 years of leading the Oak Bay Girl Guides as Uplands Park stewards, Margaret Lidkea has begun working with the local Glenlyon-Norfolk Middle School removing English Ivy (*Hedera helix*) and Spurge-laurel (*Daphne laureola*), tying stewardship action projects in with the B.C. curriculum. The Guides and other young people have much to gain from active participation in this project. Aside from becoming stewards of Garry Oak ecosystems, they are participating in healthy activity, gaining confidence, increasing social skills, and developing their sense of place.

Girl Guides of Canada have removed massive amounts of Scotch Broom (*Cytisus scoparius*) from Uplands Park since 1993. Photos: Margaret Lidkea

CASE STUDY

Case Study 11. University Undergraduate Involvement in Restoration: Trinity Western University Crow's Nest Ecological Research Area

by David R. Clements

Every spring, several students are hired by Trinity Western University to serve as restoration practitioners and researchers on Trinity Western University Crow's Nest Ecological Research Area (CNERA) on Salt Spring Island. Projects range from inventory and monitoring, to invasive species control, to involvement in Trinity Western faculty research projects. Many students end up completing an undergraduate thesis project related to Garry Oak ecosystem restoration. Recent research areas have included evaluating growth rings on Douglas-fir (*Psuedotsuga menziesii*) and Garry Oak (*Quercus garryana*) trees, biology of the Propertius Duskywing (*Erynnis propertius*) butterfly, lichens as indicators of Garry Oak ecosystem health, impacts of Scotch Broom, impacts of herbivory, impact of herbivores on Garry Oak tree growth, spatial studies of Garry Oak meadow boundaries, and the chemical ecology of invasive Sweet Vernalgrass (*Anthoxanthum odoratum*). The students also do work on nearby sites on Salt Spring Island.

The camp at CNERA has three cabins to house students and researchers, as well as a cook shelter, a composting toilet, and a storage shed. Every other year, Trinity Western University faculty also lead a set of travel study courses in plant ecology and marine biology on Salt Spring Island. The plant ecology course makes extensive use of CNERA, and students learn restoration techniques in the process, including practical experience in invasive species removal. Students working at CNERA also work with other groups involved in Garry Oak restoration such as the Salt Spring Island Conservancy. The exposure students get to Garry Oak restoration through these experiences is valuable for developing their awareness of the many restoration ecology issues surrounding Garry Oak ecosystems, which they can go on to apply either within this system or other ecosystems. One alumnus of the plant ecology and marine biology courses has arranged field trips to the site with his elementary school class, thus passing on his experiences to the next generation. For more information on CNERA, see the website: www.twu.ca/sites/crowsnest.

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Trinity Western University students hard at work removing invasive plants. Photos: Trinity Western University

-a sense of place
-a set of hands-on and observational skills
-an understanding of stewardship of the natural world
-a sense of self
(Bateman and McEwan 2009)

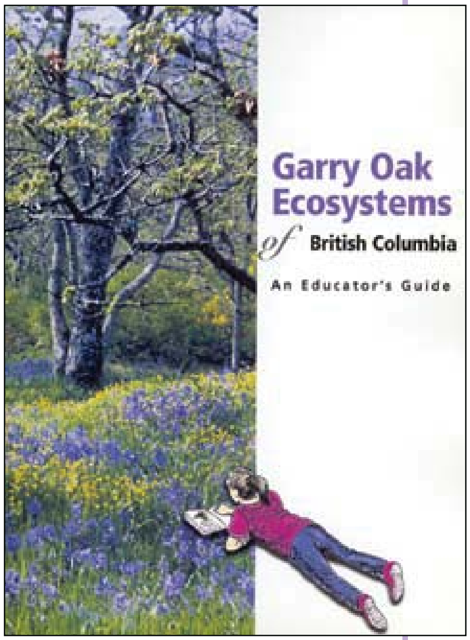
- Environmental education goals are summarized well in *Leap into Action* (Staniforth 2004):

  > Environmental education includes three critical components: developing awareness of, and appreciation for, the environment; developing knowledge and understanding of environmental, social, and economic systems; and creating potential and capacity for appropriate actions.

- *Garry Oak Ecosystems of British Columbia: An Educator's Guide.* In 2005, a team of Garry Oak ecosystem conservation partners completed a manual to support formal and non-formal educators in connecting youth with Garry Oak ecosystems (MacDonald and Staniforth 2005). The manual used B.C.'s curriculum guidelines in order to be a recommended resource for teachers. It provides background information on Garry Oak ecosystems and includes environmental education activities around Garry Oak ecosystems and supporting appendices. The manual and hands-on workshops are available through Wild BC (www.wildbc.org) of the Habitat Conservation Trust Foundation.

Youth Programs: Schools

Many schools and teachers have been interested in Garry Oak ecosystem restoration and stewardship on their school grounds. Projects have included invasive species management, planting of native plants, mulching over non-native grasses, and educational signage. Some schools have used the *Educator's Guide* (above) to continue connecting students with their school ground stewardship area while achieving curriculum learning outcomes.



One of the challenges of school ground restoration projects is long-term sustainability. Teachers may be too busy or schools may be challenged to keep the project going from year to year. There are organizations, such as Habitat Acquisition Trust in Victoria (www.hat.bc.ca) and Evergreen (www.evergreen.ca), that provide support and help schools keep projects moving forward.

While some ambitious schools and teachers have taken on restoration projects on their own properties (or adjacent ones), others have joined in as partners on a nearby restoration site. Participating in existing projects can be an excellent way for students to participate in restoration, learn valuable skills, and become stewards of a project that may be led by local experts and agencies or conservation groups. Many teachers have also used specialized educational opportunities within restoration sites to contribute to curriculum outcomes.

Restoration projects that provide programs for schools may want to consider using the following elements to engage this specialized audience:

- pre-trip information and warm up activities
- classroom visits* before the field component is undertaken
- specialized curriculum for specific grades
- age-appropriate approaches
- interactive, hands-on involvement as much as possible
- post-trip follow-up
- information to pass on to families through the students

**Note: classroom visits prior to the field component can be valuable to prepare students with some basic awareness and knowledge, expectations for the field session, and build enthusiasm for their participation in the project.*

Youth Programs: Community Groups

Many restoration projects have benefitted from volunteer efforts and stewardship activities of community youth organizations, such as Scouts, Guides, church youth groups, and young naturalist clubs. Some groups have environmental stewardship in their mandate, many can provide on-going stewardship and participation from year to year, and some may even be able to contribute other resources. Some of the considerations described above for working with school groups will also apply to youth community groups. Leaders of youth groups may even have the skills and willingness to take on a specific on-going role in the restoration project.

Youth Programs: Families

Involving families, especially neighbours of the site, can provide a wonderful stewardship opportunity. If a restoration project is going to include volunteers of different ages, some thought must be given to the types of safety issues, supervision, and activities that are appropriate for engagement. For more information on some of these volunteer considerations, see Section 6.5.

Beyond Youth: Post-Secondary Programs

Garry Oak restoration projects often benefit from the involvement of post-secondary students (of all ages) who may have special skills to contribute, are looking for training and experience in their chosen field, and enjoy the networking and social aspects of volunteering. These volunteers are potential future leaders in the field of ecological restoration (or related fields). Engaging post-secondary volunteers can also help train potential future staff for the project.

6.4.5 Landowner Contact Programs

> Landholder contact (LHC) has become a popular environmental tool in British Columbia and elsewhere. In LHC programs, representatives of an environmental organization or agency visit… landholders for the purpose of encouraging improved land stewardship. This may take the form of environmental education, assistance with restoration, facilitation of contact with stewardship resources, non-binding stewardship pledges, voluntary land management plans, legally binding management agreements, or conservation covenants (easements) (Lawrance et al. 2000).

ESSENTIAL ELEMENTS OF LANDOWNER CONTACT

- Planning
- Program coordination to reduce multiple contacts by other organizations
- Professional, knowledgeable staff or volunteers
- Outreach products
- Promotion
- Public involvement/community support
- Tracking of landowner contact data, site information
- Information/data sharing (if landholders permit)
- Follow up
- Thanks and recognition
- Evaluation

Landowner contact (LOC) or landholder contact programs involve direct communication with property owners or managers by representatives of conservation organizations, recovery teams, or government agencies for the purpose of increased wildlife and habitat protection. This may be achieved through land stewardship, informal land management plans and stewardship pledges, legally binding management agreements, conservation covenants (easements), tax incentives, the federal Ecological Gifts program, or similar means. Comprehensive LOC/LHC programs may include letters, phone calls, leaflet drops, public presentations or workshops, and/or door knocking campaigns to initiate contacts; distribution of written materials, environmental education, and facilitation of stewardship funding and other resources; property visits, biological inventories; assistance with stewardship or restoration plans and activities; follow-up monitoring; and further assistance as required.

Good landowner contact programs produce some or all of the following benefits:

- greater understanding and appreciation by landholders of the significance of habitat and species on their property
- improved cooperation among landholders, recovery teams, non-government organizations, and government agencies, and increased participation of stakeholders in the recovery planning process
- better land use decisions and improved land stewardship/restoration practices
- reduced harm, more protection, and recovery of endangered species and ecosystems

Case Study 12. Sharp-tailed Snake Recovery Project: Pender Island's Local Champion

The Sharp-tailed Snake (*Contia tenuis*) is a small, Endangered, Red-listed, elusive snake that occurs in Garry Oak and associated ecosystems and has been the target of outreach efforts throughout the CRD. On Pender Islands, Habitat Acquisition Trust (based on Vancouver Island) and the Pender Islands Conservation Association (PICA) collaborated on this outreach program.

In the spring of 2005, biologist Christian Engelstoft gave a public talk on Pender Island about the Sharp-tailed Snake's biology and identification. After his presentation he was approached by local naturalist David Manning, who handed him a bag with a dead snake he had found that week. He thought that it might be a Sharp-tailed Snake but wanted it confirmed. To Christian's surprise, it was the elusive Sharp-tailed Snake. Together, they visited the site where he had found the snake and it became clear that David would be a good person to involve in the Pender Island outreach program. From years of hiking the islands, and his involvement with eagle nest monitoring, David knew the landscape, and he was well-known and well-thought-of in the community. Thanks to his gentle and immediately likeable personality, he opened many doors in the community and the outreach program took off.

One of the outreach goals of this project was to encourage landowners to sign a land-care agreement. In other areas in the CRD, the Sharp-tailed Snake outreach project was successful in signing agreements with about 50% of visited landowners. On Pender Island, with this local champion, David bumped it to 99%. This is a great example of the benefits of engaging well-connected local stewards.

Sharp-tailed Snake (*Contia tenuis*). Photo: Christian Engelstoft

LANDOWNER CONTACT CONSIDERATIONS

- Have landowners previously received land care information?
- Are they interested in the topic?
- What is their level of education and/or experience?
- Are they physically and financially able to do stewardship? Do they need assistance?
- How long have they owned their land?
- Evaluation

Best Practices for Landowner Contact Programs

Based on Habitat Stewardship Program (HSP) Landowner Contact evaluation report (Kilburn & Passmore 2009)

WHO SHOULD YOU CONTACT?

With the vast array of communications tools available it is possible to reach all landowners within a designated area, but time and resource restrictions usually limit the number of landowners that an organization can *effectively* engage. It is usually best to focus on a subset of landowners.

What is the best way to select contact groups? Some organizations use a geographic or bio-centric approach. Their programs concentrate on property owners adjacent to parks or other important habitat areas. GOERT's program focuses mainly on landholders of properties that have or are likely to have species at risk occurrences, and/or other prominent ecological values.

Another approach that has proven to be highly successful is to identify local champions to promote your program—the "early adopters" and highly motivated individuals in a community. These leaders are often willing to take independent action after initial guidance and then promote their stewardship initiatives to friends and neighbours. They are often able to use their reputation and networking skills to achieve greater rates of landowner engagement. However, research also shows the merit of investing time and resources in developing high-quality workshops and other programs for the remaining landowners.

EFFECTIVE METHODS FOR CONTACTING AND ENGAGING LANDOWNERS

The most successful landholder contact programs employ a combination of communication and engagement methods in a multi-step process. Wide-reaching communication tools, such as media campaigns, posters, pamphlets, and letters can introduce a contact program and raise awareness. Workshops and community events provide opportunities for small groups of property owners and their neighbours to receive in-depth information about habitat stewardship best practices. These approaches can lead to personal, direct contact with landowners at a later date.

One of the most important aspects of landholder contact work is developing and maintaining strong interpersonal relationships with landowners. It is critical to employ contact personnel who have exceptional interpersonal skills as well as biological knowledge. To maintain landowner contact consistency, it is ideal to retain one core staff person who will work with landowners over multiple years.

Successful landowner contact programs provide regular, consistent contact that is tailored to individual needs and communication preferences. Even a six-month break in contact can be enough for landowners to lose interest. If regular, direct contact cannot be achieved, you can try to maintain contact by inviting landowners to events or send them educational materials and newsletters. Repeated contact promotes strong interpersonal relationships—which is the key to securing landowner participation in habitat stewardship initiatives. See HAT's Good Neighbours Program (Case Study 3).

BEST PRACTICES FOR BUILDING STRONG RELATIONSHIPS WITH LANDOWNERS

- Let the landowner take the lead
- Work on their time frame
- Start small and build gradually
- Respect confidentiality and privacy
- Be warm, friendly, sincere, professional, and respectful
- Use tact, diplomacy, sensitivity, and patience
- Find shared interests to build rapport
- Be an active listener
- Address questions and concerns promptly
- Be knowledgeable
- Present information in a non-judgmental way
- Use appropriate humour
- Quickly follow up contact with promised support

MOTIVATING LANDOWNERS TO PRACTICE STEWARDSHIP

The most effective way to motivate landowners to practice land stewardship is to visit them on their property and point out the significant natural features on their land. This is especially true if the site visits are conducted by species at risk experts and knowledgeable staff or volunteers who can address the landowners' questions and concerns, identify species, point out threats, and discuss mitigation or restoration strategies.

The best way to engage landowners is to talk about their interests, then promote habitat enhancement work that ties in with their interests. For example, many people are avid gardeners or enjoy watching birds and butterflies, so promoting Naturescaping with native plants can be a good first step towards land stewardship. Encouraging landowners to help professional biologists survey and monitor species at risk populations is another effective engagement tool.

The federal Habitat Stewardship Program (HSP) *Landowner Contact Evaluation Report* (2009) identifies other motivators for landowners:

> Some landowners are motivated by their belief in the intrinsic value of conserving biodiversity. Other landowners are more motivated to conserve certain habitats and species, usually with a focus on high profile "charismatic mega-fauna". LOC programs that highlight

Case Study 13. Garry Oak Ecosystems Recovery Team (GOERT): Working With Landholders to Protect Species at Risk

by Chris Junck

The Garry Oak Ecosystems Recovery Team's outreach program is guided by a comprehensive recovery strategy that aims to protect and restore Garry Oak ecosystems and their associated species at risk (SAR). The landholder contact program component is directed towards a diverse range of target audiences, some of which are often overlooked in other landowner contact programs. A variety of outreach approaches is used for three main audience groups:

First Nations and Local Government Land Managers and Planners

- meetings, seminars, and field workshops
- distribution of species at risk (SAR) occurrence data and maps, reports, and other relevant outreach materials and information
- provide input into development plans, land-use bylaws, official community plans

Development Industry

- provide information about Garry Oak ecosystems and SAR
- provide information about habitat and SAR protection measures
- provide technical advice and input into development plans
- participate in the development planning process

Private, Corporate, Industrial, and Institutional Landowners and Managers; Conservation Organizations

- letters, pamphlet drops, phone calls
- site visits and SAR inventories
- follow-up consultations to provide SAR inventory reports and maps and develop restoration plans and stewardship activities
- restoration signs
- stewardship agreements
- formal protection measures

Although these outreach initiatives are generally well-received, there are often challenges that need to be addressed:

- too few SAR experts available for plant inventories, workshops, and advice
- difficulty of building trust with landholders, especially when they are concerned about the possible implications of having SAR on their property
- balancing overall program objectives with the objectives and timelines of funding agencies. For example, the Recovery Team often contacts landowners on behalf of the federal government to secure permission to access properties for SAR assessments and critical habitat delineation, or

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GOERT staff Shyanne Smith and Chris Junck with landowner Rod Mitchell. Mitchell participates in restoration for species at risk on his land. Photo: GOERT

to provide assistance for the *Species At Risk Act* consultation process. This often happens with tight deadlines and there isn't always enough time to build rapport before delivering all of the required consultation messages, requesting permission for property access and data sharing.

Evaluation

GOERT uses several methods to evaluate the success of landowner contact:

- tracking all landowner contact sessions and outcomes.
- local government seminars and workshops—questionnaires, follow-up telephone interview with some of the managers approximately 6 months after the program to see how many SAR harm reduction strategies were or are planned to be implemented.
- GOERT has participated in a comprehensive evaluation of landholder contact programs conducted by Environment Canada, which included qualitative and quantitative evaluations (including a questionnaire and telephone interviews of landowners involved in contact programs), and a follow-up workshop with organizations engaged in LOC programs.

Chris Junck *is the Species at Risk Outreach Specialist with GOERT.*

the protection of at least one charismatic 'flagship' species are more likely to achieve broad public support. The Land Conservancy of B.C. works in bighorn sheep habitat, and although this species is not federally listed, it is an excellent flagship species for the program as it is a highly valued component of the ecosystem. Protecting this species in turn contributes to the protection of other SARA-listed species that occupy similar habitat. Once landowners are engaged, introducing less charismatic species to the program forefront is easier.

HSP recipients also recommended that landowners be publicly recognized and appreciated for their efforts and commitments to stewardship. Public recognition schemes where landowners are honoured for their stewardship activities are known to help build crucial community support and to maintain and build landowner motivation. Community-based social marketing advocates also note the importance of employing an appreciation and recognition scheme as a component of maintaining dedication to new behaviours and actions.

SECURING HABITAT THROUGH NON-BINDING STEWARDSHIP AGREEMENTS

Written and verbal stewardship agreements have been very effective tools for habitat protection and restoration projects. While these voluntary stewardship agreements do not guarantee permanent preservation, they are a good starting point for raising awareness and promoting sustainable land management practices. These protection measures are not legally binding, so there is no sacrifice in property value, legal fees, land survey costs, or other expenses associated with conservation covenants or other legal agreements. Landowners can focus on stewardship instead of financial trade-offs and the potential for lost market value. Legally binding habitat protection is generally easier to achieve once landowners have a greater understanding of the importance of habitat protection, and of the financial benefits associated with legally binding agreements.

INVESTING IN THE FUTURE

Planning and carrying out a comprehensive landowner contact program requires a multi-year commitment of time and resources. Carefully managed landowner contact programs provide many benefits for conservation organizations and restoration programs. Building and maintaining long-term working relationships with property owners and land managers can yield better restoration results, greater protection of habitats and species at risk and more support for an organization's programs.

6.5 Volunteer Programs

Volunteers are often essential to creating successful ecological restoration programs. Volunteer programs may achieve some of the project's education and outreach goals and build stewardship for the site. Volunteer programs range from informal to formal, engage volunteers occasionally to regularly, and provide simple to varied types of volunteer opportunities. Positive volunteer experiences keep volunteers coming back, and successful programs provide valuable support, resources, and labour for restoration projects.

This section provides information, resources, and considerations for volunteer programs in Garry Oak ecosystem restoration.

Case Study 14. Fort Rodd Hill National Historic Site: Volunteers Help Control Invasive Species

Invasive species removal can be a large and daunting task requiring the commitment of many years of management. At Fort Rodd Hill and Fisgard Lighthouse National Historic Sites of Canada in Colwood, B.C., volunteer efforts to control species such as Scotch Broom and Spurge-laurel have been ongoing since 2003, when Parks Canada adopted a volunteer program to assist in invasive species removal. Recently, co-op students working for Fort Rodd Hill have managed the program; their work includes organizing the program, advertising, and supervision of volunteers. The goals of the volunteer program are (1) to raise public awareness of invasive species, (2) to educate the public on ecosystem restoration, invasive species removal techniques, and on the value of rare Garry Oak and associated ecosystems at the site, and (3) to provide invaluable volunteer labour for invasive species removal. Each of the three objectives is considered of equal importance.

The volunteer program at Fort Rodd Hill encourages volunteer groups from a broad range of ages and abilities, with the understanding that removal of large quantities of invasive species is not the singular goal of the program. Volunteer education and experience builds long-term stewardship ethics and behaviour. Volunteers become increasingly skilled each time they attend an invasive species removal day, removing greater quantities of invasive plants with increased care. By providing positive volunteer experiences, the Fort Rodd Hill program encourages volunteers to return again and again.

Parks Canada Species at Risk Recovery Planner Conan Webb leads a tour at Fort Rodd Hill National Historic Site. Photo: Carolyn MacDonald

Case Study 15. Swan Lake Christmas Hill Nature Sanctuary's Formal Volunteer Program

In Victoria, this non-governmental organization (NGO) operating a nature sanctuary on public lands has a long-established formal volunteer program with a staff Coordinator of Volunteers. While there are different types of volunteer positions, many volunteers are involved in the Garry Oak native plant garden and restoration in natural areas of the sanctuary. With a shortage of staff, volunteers play a vital role in achieving restoration and native garden goals. All volunteers are formally registered, work in supervised teams, and receive good training. The volunteer program also includes youth and adults from correctional programs. One important restoration project that volunteers are assisting with is a burn site in the Garry Oak rock outcrops on Christmas Hill. Site Manager June Pretzer notes that the burn site is at an exciting stage with all the invasive Orchard-grass (*Dactylis glomerata*) now eliminated and the Hairy Cat's-Ear (*Hypochaeris radicata*) under control. In 2009, volunteers at the sanctuary contributed about 10,000 hours of work.

Volunteers removing invasive plants at Swan Lake Christmas Hill Nature Sanctuary. Photo: June Pretzer

Volunteer work party at Little Mount Douglas in Saanich. Recent studies show that Canadian volunteers are increasingly seeking opportunities for flexible work that incorporates socialization and fitness. Photo: District of Saanich

6.5.1 Volunteers in Restoration Projects

Many Garry Oak restoration projects in Canada depend on volunteers, and many projects are coordinated by volunteer stewardship groups. Successful restoration projects often depend on restoration practitioners who can carefully plan and encourage long-term committed volunteer involvement. While the benefits of working with volunteers in restoration projects are many, there are also complications that must be considered.

Recent Canadian trends show that volunteers increasingly seek out the types of experience that Garry Oak restoration projects can offer: meaningful, flexible work that incorporates socialization and fitness (Volunteer Canada 2007). Restoration projects offer very visible, tangible results for volunteers to experience in their neighbourhoods. Keeping the project messages positive and offering hands-on involvement are strong features that attract volunteers.

There are many benefits to including volunteers in restoration projects. Some of the key benefits are:

- providing "people power" and enthusiasm
- bringing community connections to the project
- providing broader perspectives and ideas
- accessing diverse abilities and skills
- increasing funding opportunities
- enabling messages to reach wider audiences

Along with the benefits of volunteers, there are also important implications and requirements involved in running volunteer programs. The following should be considered in the planning stages:

- increased cost, depending on the size and format of the program
- increased time to organize and supervise volunteers

- development of risk management procedures
- development of volunteer management procedures (such as intake)
- provision of training and services needed by volunteers
- processes for addressing volunteer issues and problem solving

The experiences that Canadian volunteers seek are changing. Recent trends tracked by Volunteer Canada (2007) show that volunteers wish to be involved in short-term projects that allow them to interact with family and friends. They want to make a real difference on projects that matter to them. They want to register and serve as volunteers in a quick and flexible manner. Volunteers also want to learn and use new skills. Increasingly, Canadians are seeking out volunteer opportunities with environmental projects. Remaining aware of changing trends in volunteerism will help restoration practitioners tailor their volunteer programs so that the success of their projects is enhanced.

6.5.2 Developing a Volunteer Program

Whether a volunteer program is formal or informal, or led by the community, an agency, or organization, it is wise to give consideration to minimum organizational standards:

- volunteer position (or role) descriptions
- policy development to address issues such as risk management
- volunteer intake procedures that are clear and efficient
- training for volunteers (and staff who work with them)
- volunteer recognition

Informal Programs

Some volunteer programs spontaneously spring up in communities as like-minded people organize themselves to achieve a common goal. For example, neighbours may start removing invasive plants and start a larger effort to restore a local park. Informal volunteer programs can move rapidly and be very successful. They may also eventually have some challenges to work through in regards to organization, resources, and long-term commitment.

In Section 6.4.3, community-based restoration projects are described along with tips specific to community based restoration projects, resources, and case studies.

Informal volunteer programs should still have:

- a key contact or coordinator
- a system to organize volunteer information
- waivers as required
- basic equipment (safety vests, gloves, first aid kit)
- a safety policy or agreement
- an agreement about project guidelines (e.g., how the work will be done, restrictions, public communication)

Formal Programs

Formal volunteer programs are often coordinated by a government agency or an established organization. They have a coordinator, policies and procedures for volunteer involvement, volunteer positions, and a management system for volunteer information, and may provide insurance and other benefits for volunteers. Often, formal programs have set intake procedures and may do some level of screening for appropriate volunteers. Whether the resources are available to create a formal program or not, aspects of these programs can be successfully implemented by almost all restoration projects that include volunteers.

6.5.3 Essential Elements of Volunteer Programs

Policies and Procedures

Depending on the project, policies and procedures may outline how and when work is conducted, what safety procedures are required, what training is required, and what types of communication policies are needed. Policies regarding volunteers may include requirements for the following:

- attending an orientation session before participation (or within a time period)
- training for different types of volunteer jobs
- obtaining criminal record checks
- addressing appropriate on-site conduct
- developing effective communication methods (e.g., who to contact for difference situations)
- developing public communication policies (e.g., media interview procedures, basic public outreach messages)

Spending time in developing these policies will help your organization communicate clearly with volunteers, avoid conflicts or misunderstandings, and smoothly integrate volunteers into the project.

> Volunteer Canada is the national professional organization that sets standards, suggests policies, and provides leadership on volunteer issues.

Risk Management

Identification and assessment of risks for your volunteer program is essential. Risks include health, safety, and legal risks. Agencies or organizations may have a risk manager who develops risk management forms, documents, and policies. If your agency or organization does not have a risk manager, you can look at what types of risk management systems other organizations have developed. You may also want to consult with a lawyer to ensure that all the legal implications of your volunteer program have been addressed.

Risk management includes creating safe work environments and developing policies to avoid risks to health and safety. Policies may be developed for various aspects of the project, such as how work will be conducted near a road, how site visitors will be alerted to risks while work is being conducted, how tools will be used safely and by whom, what safety equipment will be used, and how garbage pick-up will be handled safely. Other ways to address potential risks include developing volunteer medical alert information, planning first aid procedures, and creating reporting procedures for incidents. Insurance policies can also be obtained to provide registered volunteers some assistance in the case of accident or injury.

CASE STUDY

Case Study 16. Saanich Garry Oak Restoration Project (GORP): Risk Management

The District of Saanich employs a Risk Manager who works with staff and the GORP Coordinator of Volunteers regarding risk management policies and forms. A formal safety policy has been developed that includes volunteer supervision requirements, safety equipment requirements, waivers, site safety policies such as signage on trails and garbage pick-up, safe work practices (such as not working under the influence of drugs or alcohol and policies for work party supervisors). Saanich's waiver forms were developed by the Risk Manager and the Municipal Solicitor, with special forms for group waivers, individual registered volunteers, and a consent form for volunteers under the age of 19. The Risk Manager also coordinates an insurance policy for volunteers, providing limited insurance for injuries and loss of work for registered volunteers who have accidents while volunteering for the program. All this planning has provided for smooth procedures and safe work environments for 11 years of this program.

GORP volunteers removing Himalayan Blackberry (*Rubus discolor*) root crowns from the Camas Park site on McKenzie Avenue. Photo: Breanna Newhouse

Planting native grass plugs for trial restoration plots at Playfair Park GORP site in Saanich. Photo: Carolyn MacDonald

Legal risks also need to be addressed. Legal waiver forms are commonly used by organizations, agencies, and landowners/managers to address legal risks associated with land ownership, supervising volunteers, and with volunteers working on that land. Consider how you will address legal implications of working with minors (i.e., persons under 19 years of age), who cannot legally sign a waiver. There are also legal implications regarding the collection and care of personal information. See Appendix 6.2 for examples of waivers.

Risk management is becoming increasingly important to ensure the safety of volunteers and to address legal liabilities. It is critical to consider what risks volunteers and your organization will be exposed to and plan to minimize and address these risks. Staff and volunteers should all be aware of risk management policies and procedures.

6.5.4 Managing a Volunteer Program

Managing a volunteer program requires organization and enthusiasm to be effective. A coordinator of volunteers who values the efforts of volunteers and who has essential skills can lead and develop a successful program. It takes time and careful planning to organize volunteers. The effort put into this task will pay off in meaningful volunteer participation and long-term commitment.

Volunteer management is a distinct, established discipline. Many resources and types of support are available for developing successful programs.

Recruitment

Before recruiting volunteers, consider what kinds of volunteers are needed and what tasks they should be assigned. A critical first step is to develop position descriptions that specify what types of skills and qualities a volunteer should have (e.g., physical fitness, special training, or people skills), and what kinds of expectations volunteers should be prepared to meet. Consider what the organization can offer to volunteers, for example, career training or social opportunities.

When recruiting, target the places where you may find the volunteers that meet your needs. The following are possible sources of volunteers:

Volunteers and staff work side by side at Playfair Park in Saanich. When developing a volunteer program, it is important not only to develop clear roles for volunteers but also to ensure that they are able to achieve their goals and gain valuable experiences and training. Photo: Carolyn MacDonald

- post-secondary institutions (and specific programs, such as Environmental Studies)
- high schools (sources of keen, youthful volunteers) and other local schools
- local clubs and organizations with similar values (e.g., natural history groups)
- local youth groups
- organizations such as service groups with volunteer requirements (e.g., cadets, scouts)
- volunteer organizations (see Section 6.5.5)
- conservation or "green" minded businesses
- neighbourhood organizations
- site neighbours

Volunteer Intake

Focused and efficient volunteer intake is an important part of a program. Initial screening is critical to developing a reputable and sustainable volunteer program. Spending time on the first contact with a potential volunteer can be important. An application form provides basic information needed, and can be provided on-line or in paper form. Sample forms are provided in Appendix 6.2.

Interviewing a volunteer can help you determine what they hope to gain from volunteering, what types of skills and training they have, and how they will fit within the project. During the interview, the volunteer should be given a brief orientation to the organization, the project, and Garry Oak ecosystem restoration. The volunteer can be asked to provide personal references to complete the intake process, and criminal records checks can be requested if required by your program. Other screening methods are described on Volunteer Canada's website (www.volunteer.ca) under "Topics and Resources".

Placement

A successful volunteer program generally has clear roles for volunteers. A detailed position description provides volunteers and staff with a clear outline of what is expected and what success looks like. The overall goal is for the volunteers to help in achieving the project/organization goals. It is often best to place a new volunteer with a more experienced volunteer who can serve as a mentor. Checking in with new volunteers (especially in the first six weeks) can be very important and will help everyone make adjustments, as needed. This will help build long-term relationships. It is important to thank and recognize volunteers, and check in periodically on their training needs. One of the keys to placement is to make sure the volunteer is able to achieve his or her goals and gain valuable experiences and training.

Orientation and Training

Once volunteers have been brought into an organization or project, they need some kind of orientation. Many organizations have orientation sessions for groups of new volunteers, or may have an orientation procedure for one-on-one situations. Orientation sessions cover the basics of the organization and project, related policies and procedures, and any other requirements or expectations of the volunteers. Orientation sessions should be enjoyable, build enthusiasm, and provide refreshments (particularly in group sessions) as a way of thanking and welcoming volunteers.

HEALTH CHECK FOR A VOLUNTEER PROGRAM

The following questions should be considered when you are developing or evaluating your volunteer program. Strive to answer "yes" to each of these questions:

- Do your staff and volunteers work together and feel like a team?
- Do you track volunteer hours?
- Are your volunteers covered by insurance?
- Do your volunteers get thanks on a regular basis?
- Do you recruit from the whole diverse community?
- Do your volunteers have position descriptions?
- Does your volunteer program have a budget?
- Are volunteers thoroughly screened and trained at intake?
- Do you offer ongoing training?
- Do you deliver what you promise to your volunteers?

On-going training can be offered as needed, but should be provided at least several times a year to help volunteers develop and enhance their skills and knowledge. Training may be an important goal for some volunteers. Consider bringing in special speakers or guest trainers and include topics that keep alive the sense of wonder about Garry Oak natural areas. Providing training is also a good way to thank and recognize volunteers.

Evaluation

A healthy volunteer program places importance on evaluation. In addition to being evaluated in their position, volunteers should be given the opportunity to evaluate their experiences with the organization and the progress of the project. Evaluation and feedback to volunteers can be very informal, through frequent verbal comments and coaching by the volunteer coordinator. It can also be a formal process involving an annual interview between the coordinator and the volunteers. The coordinator should keep records of the feedback provided and received.

It is important for volunteers to be able to provide feedback in ways that feel comfortable for them. Having times when feedback is requested—either anonymously or otherwise—can be valuable in building strong organizations and relationships.

Retention and Recognition

Recognition of volunteers is important. Volunteers who feel appreciated and happy in their role are more likely to be retained long term and to bring in more volunteers and raise the public profile of the organization. Providing refreshments at work parties, social opportunities, and reference letters for employment are some great ways of showing appreciation for your volunteer efforts. Some programs host annual recognition events and provide certificates or awards, small gifts, and verbal recognition. Other forms of on-going recognition include informal notes and frequent words of appreciation for volunteer accomplishments. Volunteers also appreciate being kept informed about the organization or project, and should be allowed to provide feedback on how they like to be recognized. Consider what fits best for your team of volunteers and be creative.

Record Management

Volunteer programs need to manage the personal information of volunteers and their application forms, updated contact information, interview notes, reference checks, volunteer hours, and other key information. All personal information about volunteers must be kept in a secure location, and access to that information must be carefully controlled. Anyone in charge of keeping such information, especially within government organizations, should be aware of the requirements outlined in the *Freedom of Information Act* and the implications of keeping personal information.

Communication

Volunteers should be kept informed about the project, and clear lines of communication must be established between the volunteers and the volunteer coordinator and staff. Changes in the program or organization should be communicated directly to the volunteers rather than through the media. Volunteers like to be kept informed, and they do their jobs best when they are included in the program's communications network.

6.5.5 Volunteer Program Resources

There are many valuable resources available to enhance or build your volunteer program. The following list will help you get started. Sample forms and other key resources from formal volunteer programs for Garry Oak ecosystem restoration are included in the appendices.

A variety of resources are available through Volunteer Canada (www.volunteer.ca):

- Sample forms for volunteer programs
- Issues and policies related to developing volunteer programs
- Advice about requesting criminal record checks
- Canadian Code for Volunteer Involvement
- Other valuable information for developing volunteer programs

Local Volunteer Centres (examples)

Volunteer Victoria (www.volunteervictoria.bc.ca)
Volunteer Cowichan (www.volunteercowichan.bc.ca)
Volunteer Nanaimo (www.volunteernanaimo.ca)
Volunteer Salt Spring (www.volunteersaltspring.com)

These centres provide a central clearinghouse for interested community volunteers. By joining your local centre you will be able to participate in workshops about volunteering and will likely be part of a database that will profile your program for potential new volunteers.

CELEBRATING GARRY OAK ECOSYSTEMS AND RESTORATION

- Artistic celebrations
- Tree Appreciation Day
- Wildflower celebrations
- Volunteer recognition
- Earth Day and Biodiversity Day
- Fundraising celebrations
- Community picnics
- Poetry contests
- and more: honouring, engaging, and giving thanks

Thanking your volunteers can involve training days, awards, and time spent enjoying Garry Oak ecosystems. In this photo, GORP volunteers share a lunch at Gonzales Hill during a field-trip day where they visited a variety of restoration sites. Photo: Carolyn MacDonald

6.6 Celebration

> Communities are strengthened through the gathering of energy and commitment. (Higgs 2003)

The Canadian Oxford Dictionary definition of "celebrate" includes "make publicly known; extol, praise widely". The word originates from the Latin word *celebrare*, meaning honoured. Honouring and celebrating Garry Oak ecosystems raises public awareness, inspires, and helps build a sense of place and connection. Honouring and celebrating people and culture in relation to Garry Oak ecosystems builds connections, relationships, support, commitment, and a sense of belonging and community. Celebrating the restoration of Garry Oak ecosystems may play an important role in recognizing volunteers and other valuable contributions, may help with fundraising efforts, and may be a way to share joy in the success of good work.

"Restoration is a social and cultural act, an interaction between humans and nature" (Edgar 2007). As such, restoration may help restore relationships between people and the land, and thus become a meaningful and even sacred activity that brings people closer to nature (VanWieren 2008). We honour and celebrate that which we value—and value is a fundamental necessity for successful recovery and restoration of these rare ecosystems.

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Appendix 6.1

Deciding Whether Public Involvement is Needed

Adapted with permission from: District of Saanich Toolkit for Public Process (2002).

Public involvement includes the promise that the public's contribution will play a role in the decision process (though not necessarily determining what the decision will be). Informing and educating the public about a project should be incorporated even when a decision is made not to engage in a public involvement/planning process.

Always do public involvement when:

- **Recommended** – for example, by the funders or managers backing or requesting the project
- **Critical information is lacking** – available information isn't adequate to make a sound decision and it is anticipated that the quality of the decision would be enhanced by community involvement
- **Issues of conflict, heightened public concern, or public risk** – dispute or conflict that needs to be resolved; high degree of concern over the decision to be made (or project) or when there is the perception that the decision (or project) holds significant implications for public health or safety
- **Highly complex issues** – when the issue(s) or project is highly complex and/or there is not a clear understanding of the implications and outcomes of the decision or project
- **Consent and compliance needed** – there is a perception that involvement is essential to ensure a sense of shared responsibility and commitment to the project and/or when it is likely that compliance or cooperation is not assured unless all those affected are involved in the decision
- **Facing a strategic choice or unclear priorities** – when the decision involves a strategic choice between apparently equal alternatives or when public priorities are unclear

APPLICABLE EXAMPLES

- Projects that involve a statutory requirement for public involvement (e.g., within rezoning applications and development proposals)
- Major changes in land use
- Changing the use of public space (e.g., park plans)
- The project or decision will impact people's daily lives by altering:

  -the character of the neighbourhood

  -parks, recreation facilities

  -road infrastructure

  -the streetscape (e.g., landscaping, trees)

  -traffic and parking

  -pedestrian movement

  -levels of safety

  -levels of service (e.g., garbage removal)

Usually do public involvement when

- The public expresses interest in having input or the decision is likely to be seen as significant
- The decision has significant policy implications (e.g., enforcement issues)
- There is actual or potential conflict or dissenting views in the public around the issue/decision at hand
- There is a need to build awareness of the issues through public involvement
- There are financial implications such as those that involve spending money on new amenities or a taxation levy
- The negative impacts of a project can be mitigated based on advice from the public
- You need help choosing between options
- The decision is highly value-laden versus being driven by technical considerations

Rarely do public involvement (more informing) when

- Choices are limited or highly constrained; there are few options
- You know that public opinion is behind the project for the most part
- Choices are highly focused and technical and there is little room for influence based on values
- A clear consensus has already been reached through other processes (e.g., public petition)
- Less complex, minor decisions are being made

Never do public involvement when

- Your goal is to announce a decision
- The decision (or project) cannot be affected because

  the decision is already made

  the decision will be made outside of the public involvement process

  staff/landowners must make a decision and take action in an emergency situation
- The time frame and/or resources are too short for meaningful, informed input and cannot be changed
- You don't know what you're asking from the public
- You do not have support from the landowners or managers to engage in public involvement

Inform the public when

- Public involvement is not warranted, but the public needs to be alerted to a change or to understand what is going on
- You want to encourage public support of a project that is underway

Appendix 6.2 Example Volunteer Intake Forms and Waivers

(forms follow)

Making a difference...together

Regional Parks
490 Atkins Avenue
Victoria BC Canada V9B 2Z8

T: 250.478.3344
F: 250.478.5416
www.crd.bc.ca/parks

Mill Hill Restoration Project ~ Volunteer Application Form

Contact Information

Last Name:	Given Name(s):	
Address:	City:	Postal Code
Home Phone Number ( )	Work Phone Number ( )	Cell Phone Number ( )
Date of Birth (for insurance purposes):	Email Address:	

In case of Emergency notify:

Last Name:	First Name:	Relationship:
Address:	City:	Postal Code
Home Phone Number ( )	Work Phone Number ( )	Cell Phone Number ( )

Allergies:	
Medications/Medi-alert needs:	

How did you find out about the Mill Hill Restoration Project?	

I understand that my services will involve working outdoors in steep and uneven terrain under the direction of the Environmental Conservation Specialist and a Parks Worker 5 staff member or the Coordinator of Volunteers. I will be removing young broom seedlings and daphne at Mill Hill Regional Park. I understand that I will be following the directions and safety procedures that will be instructed on the day prior to volunteering.

I understand that in the event of a personal injury I am not covered by WCB but instead would be eligible for benefits under the CRD Volunteer AD&D policy (subject to terms and conditions).

I understand that I am responsible for the safety and security of all my property and possessions.

I understand that the CRD will indemnify me against any claims for damages arising out of the performance of my duties and, in addition, pay amounts required for the protection, defense, or indemnification arising there from provided that I am not guilty of dishonesty, gross negligence, or wilful misconduct, or the cause of the action libel or slander.

Signature of Volunteer ____________________ Date ____________________

FREEDOM OF INFORMATION WAIVER

Personal information contained on this form is collected under the authority of the Local Government Act and is subject to the Freedom of Information and Protection of Privacy Act. The personal information will be used for purposes associated with the Volunteer program. Enquiries about the collection or use of information in this form can be directed to the Freedom of Information and Protection of Privacy contact: Capital Regional District, Senior Coordinator, FOI (250) 360-3000.

Photo waiver

Regional Parks and the Capital Regional District has my permission to use any photographs, film, or other images taken of me participating in Parks-related activities.

I understand my photograph/image may be used in brochures, newsletters, fact sheets, news articles, posters, audio/visual materials, on the CRD website, or in other printed materials.

Signature　　　　　　　　　　　　　　　　　　　　　　　　Date

☐ I decline to have my image used.

Making a difference...together

Regional Parks
490 Atkins Avenue
Victoria BC Canada V9B 2Z8

T: 250.478.3344
F: 250.478.5416
www.crd.bc.ca/parks

Parental Consent Form

(Required for youth volunteers under 19 years of age)

Name of Youth Volunteer	Date of Birth (for insurance purposes):

Parent or Guardian Information

Last Name:	Given Name(s):	
Address:	City:	Postal Code
Home Phone Number ( )	Work Phone Number ( )	Cell Phone Number ( )

In case of Emergency notify:

Last Name:	First Name:	Relationship:
Address:	City:	Postal Code
Home Phone Number ( )	Work Phone Number ( )	Cell Phone Number ( )

Allergies:	
Medications/Medi-alert needs:	

I ______________________ hereby give consent for my son/daughter/legal ward, named above, to volunteer with the Capital Regional District Parks Volunteer-In-Parks program at ______________________

I affirm that I am the parent/guardian of the above named volunteer. I understand that there could be some risks associated with this activity. I have read the attached position description of the work the volunteer will perform and will discuss it with my son/daughter/legal ward.

In the event that my child/legal ward requires medical attention, I consent to my child being transported to the nearest emergency centre, including by ambulance if necessary, and accept that I am responsible for cost of such ambulance service.

______________________________ ______________________________

Parent/Guardian signature of Youth Volunteer Date

FREEDOM OF INFORMATION WAIVER

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I understand my photograph/image may be used in brochures, newsletters, fact sheets, news articles, posters, audio/visual materials, on the CRD website, or in other printed materials.

Signature　　　　　　　　　　　　　　　　　　　　　　　　Date

☐ I decline to have my image used.

The Corporation of the District of Saanich

RELEASE OF LIABILITY, WAIVER OF CLAIMS, ASSUMPTION OF RISKS AND INDEMNITY AGREEMENT

GROUP FORM

BY SIGNING THIS DOCUMENT YOU ARE WAIVING CERTAIN LEGAL RIGHTS, INCLUDING THE RIGHT TO SUE - PLEASE READ CAREFULLY

To: the District of Saanich, its officers, employees, elected officials, agents and volunteers,
And to: the owners and occupiers of private premises on which I conduct volunteer work for the District of Saanich,
(hereinafter called the “Releasees”)

ASSUMPTION OF RISK

I am aware that my volunteer work for the District of Saanich may involve risks caused or contributed by natural and man-made terrain, wildlife, plants, climatic conditions, my own physical condition, actions of the Releasees and other third parties, vehicular traffic, tools and equipment. I am also aware that such risks may foreseeably result in personal injury, illness, loss of life or property damage, but I freely assume the legal and physical consequences of these risks.

RELEASE and WAIVER

In consideration of being accepted as a volunteer for the District of Saanich, I covenant not to sue and hereby waive, release and discharge the Releasees from any and all claims of liability for personal injury, illness, loss of life or property damage of any kind or nature whatsoever and howsoever arising either directly or indirectly as a result of my volunteer work. This Release and Waiver applies to all claims, foreseen and unforeseen, including negligence and breach of statutory or other duty of care and is binding on my heirs, executors, administrators, or any others who may claim on my behalf.

INDEMNITY AGREEMENT

In consideration of being accepted as a volunteer for the District of Saanich, I agree to indemnify and save harmless the Releasees from any claim, lawsuit, liability, debt, demand, loss or judgment (including costs, defence expense and interest) whatsoever and howsoever arising either directly or indirectly as a result of any act or omission by me that is grossly negligent, wilful or outside my scope of authority or duties as a volunteer for the District of Saanich.

I acknowledge that I have read and understand the above, and I recognize that by signing this document I am waiving certain legal rights, including the right to sue.

Please sign accompanying sign-in sheet.

The Corporation of the District of Saanich

RELEASE OF LIABILITY, WAIVER OF CLAIMS, ASSUMPTION OF RISKS AND INDEMNITY AGREEMENT

By signing this document I acknowledge that I have read the accompanying form titled "Release of Liability, Waiver of Claims, Assumption of Risks and Indemnity Agreement" and that I am waiving certain rights, including the right to sue.

NAME (PRINT)	ADDRESS	SIGNATURE	DATE

The Corporation of the District of Saanich

RELEASE OF LIABILITY, WAIVER OF CLAIMS, ASSUMPTION OF RISKS AND INDEMNITY AGREEMENT

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I acknowledge that I have read and understand the above, and I recognize that by signing this document I am waiving certain legal rights, including the right to sue.

______________________________ Volunteer Signature	______________________________ Witness Signature
______________________________ Volunteer Name (please print)	______________________________ Witness Name (please print)
______________________________ Volunteer Address	
______________________________ Date	

06/2010

The Corporation of the District of Saanich

INFORMED CONSENT / PERMISSION FORM

THIS FORM MUST BE READ AND SIGNED BY EVERY MINOR WISHING TO PARTICIPATE IN VOLUNTEER WORK FOR THE DISTRICT AND A PARENT OR LEGAL GUARDIAN OF THAT MINOR. A MINOR IS A PERSON UNDER 19 YEARS OF AGE.

ELEMENTS OF RISK

I am aware that volunteer work for the District of Saanich may involve certain elements of risk. Injuries may occur while working, including; allergic reactions, cuts, abrasions, sprains, fractures, spinal injury and even death.

The risk of sustaining injury results from the nature of the activity itself, natural and manmade terrain, wildlife, plants, climatic conditions, the actions of third parties and the worker's own physical condition and actions. Injury can occur without any fault on the part of either the worker, the District of Saanich, its employees, consultants or other volunteers. By choosing to take part in this activity, you are accepting the risk that you/your child may be injured.

The chance of injury can be reduced by carefully following instructions and safe work practices at all times while engaged in the activity.

PARTICIPANT'S ACKNOWLEDGEMENT

I HAVE READ THE ABOVE AND THE VOLUNTEER SAFETY POLICY. I AGREE TO FOLLOW INSTRUCTIONS CAREFULLY AND EXERCISE SAFE WORK PRACTICES AT ALL TIMES.

Name of participant (please print): ______________________________

Signature of participant: ____________________ Date: ____________

PARENT/GUARDIAN'S ACKNOWLEDGEMENT AND PERMISSION

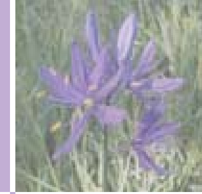
I HAVE READ THE ABOVE AND HAVE BEEN PROVIDED OR OBTAINED SUFFICIENT INFORMATION TO MAKE AN INFORMED DECISION ABOUT MY CHILD'S VOLUNTEER WORK. I ACKNOWLEDGE THAT THE DISTRICT OF SAANICH PROVIDES LIMITED ACCIDENTAL DEATH, DISABILITY, DISMEMBERMENT OR MEDICAL EXPENSE INSURANCE FOR REGISTERED VOLUNTEERS AND THAT BY ALLOWING MY CHILD TO WORK AS A VOLUNTEER, I AM ASSUMING THE ASSOCIATED RISKS AND UNINSURED EXPENSES. I GIVE MY CHILD PERMISSION TO WORK AS A VOLUNTEER.

Name of Parent/Guardian (please print): ______________________________

Signature of Parent/Guardian: ____________________ Date: ____________

Emergency contact: ____________________ Phone: ____________

Important health information: ______________________________



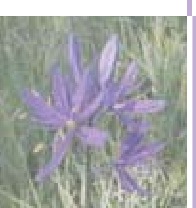
Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 7
Ecological Inventory and Monitoring

Contents



Chapter 7

Ecological Inventory and Monitoring

by Don Eastman and Christian Engelstoft, in collaboration with Brenda Costanzo, Fred Hook, James Miskelly, Todd Golumbia, Richard Hebda, Carrina Maslovat, Robert Maxwell, Dave Polster, and Conan Webb

Biologists Matt Fairbarns and Hans Roemer survey rare plants. Photo: Dave Polster

7.1 Introduction

Inventory and monitoring are key steps in restoring Garry Oak ecosystems (see Chapter 5: Restoration Planning). Without these activities, the success (or failure) of restoration projects cannot be evaluated, nor can the need for intervention be detected in a timely way. This chapter provides guiding principles and approaches for inventory and monitoring stages of Garry Oak restoration and describes commonly used methods. It shows practitioners how to design ecological inventory and monitoring programs that yield information on project outcomes that can be compared readily to data from other studies. Inventory and monitoring activities unique to the social component of restoration are addressed in Chapter 6: Outreach and Public Involvement.

> Inventory is the process of collecting information to describe the state of an ecosystem or ecosystem characteristics at a particular point in time.

Inventory is the process of collecting information to describe the state of an ecosystem or ecosystem characteristics at a particular point in time. Inventory is an integral element of a restoration project and corresponds to Stages 2 and 3 of the Restoration Project as presented in Chapter 5: Restoration Planning. An inventory provides information to assess the current status of a site (how badly degraded is the area and does it merit restoration?) and identifies what species are present and their abundance (what kind of restoration is needed?). Inventory helps identify key ecological processes and problems that need attention (e.g., invasive species), and provides the basis for deciding what type of restoration is needed. It also identifies "assets" of the site, such as the number and abundance of native species. Inventory is also the essential first step in the monitoring chain, as inventory data provide the baseline against which future observations will be compared. Without a baseline, change cannot be detected or measured. Finally, inventory is essential for characterizing reference ecosystems; these are critical for defining restoration targets and assessing progress.

Monitoring is the act of making repeated measurements of a meaningful indicator. It is an integral part of a restoration project, and corresponds to Stage 7 of the restoration project stages (Table 5.1 in Chapter 5). Monitoring is the "Achilles' heel" of restoration; too often, considerable effort applied at the outset of a restoration project wanes after the initial work is done. This scenario plays out time and again in Garry Oak restoration projects and in many other types of restoration. Failure to monitor is short-sighted because without monitoring there is no objective way to establish success. Why invest time and money in a project without knowing if the goal is achieved? Without monitoring, how can emerging problems be detected? Without monitoring, how can adaptive management be implemented?

> Monitoring is the process of making repeated measurements to detect change over time.

7.1.1 Guiding Principles for Inventory and Monitoring

In this publication, four key principles guide ecological inventory and monitoring:

1. Set clear objectives
2. Ensure reliability
3. Match effort with outcomes
4. Adopt an ecosystem-based approach

These principles apply specifically to the ecological aspect of restoration; they also apply to the important "social" dimension of ecological restoration covered in Chapter 6.

1. Setting Clear Objectives

Clear objectives are essential to project success. Unclear objectives often cause disagreements among participants, lead to lost opportunities, require additional expenditure of time or money or both, and can result in overlooking the collection of important data or collecting the wrong kind of data. Developing specific and measurable objectives takes time and careful consideration. For example, it is difficult to evaluate the success of a project for an objective such as "to restore

FOUR KEY PRINCIPLES GUIDE ECOLOGICAL INVENTORY AND MONITORING

1. Set clear objectives
2. Ensure reliability
3. Match effort with outcomes
4. Adopt an ecosystem-based approach

These principles apply specifically to the ecological aspect of restoration; they also apply to the important "social" dimension of ecological restoration covered in Chapter 6.

the native plant community". It is far easier to evaluate success when objectives are clearly defined, such as, "to reduce the distribution and abundance of Common Snowberry (*Symphoricarpos albus*) by 20% in two years" or "to increase the cover of Western Buttercup (*Ranunculus occidentalis*) by 50% in five years." In these two examples, it is clear that the inventories should record the distribution and abundance of the two species before restoration starts, and that monitoring should include techniques to measure the plant cover of each species. From the perspective of inventory and monitoring, defining clear objectives before a project begins is important for determining sampling design and methods.

As discussed in Chapters 5 and 6, one way of assessing whether or not objectives are useful is to see if they are "**SMART**", that is, are they:

Specific

Measurable

Achievable

Realistic

Timed

If project objectives pass the SMART test, they will likely be successful.

Defining clear objectives before a project begins is important for determining sampling design and methods.

2. Ensuring Reliability

Since many decisions are based on inventory and monitoring data, it is important to take steps to help ensure that data are objective and reflect the actual situation "on the ground". One step that helps ensure reliability is to collect data following standard methods that are applicable to Garry Oak ecosystems. A second step is to have appropriate sampling and experimental designs. However, the requirement to meet statistical goals is sometimes very onerous and may not even be possible because of small site sizes. In these cases, reporting results from all sites to a central clearing site may help at least strengthen "anecdotal" information. Notwithstanding these cases, restoration practitioners should aim for reliability of their data to promote the understanding and sharing the results of restoration projects and to further promote the recognition of restoration as a professional field.

3. Matching Effort with Objectives and Outcomes

Projects vary in the level of detail they require for inventory and monitoring. For example, restoring an urban backyard by removing invasive species requires different levels of monitoring than a project involving re-introduction of a rare species. The scope of inventory and monitoring activities should be driven by the scope and complexity of the project. Applying too much effort is unnecessary and impractical, and it wastes resources. In the first example above, photo-point monitoring might do the trick and show more flowering camas from year to year. In the second case, specific cover measurements in fixed-frame plots with measurements of cover, flowering success, and plant survivorship might be needed. Applying too little effort is short-sighted and can compromise the collection of relevant and reliable data. One method for implementing this principle is to have intensive and extensive sites within an overall restoration project site. At intensive sites, considerable effort is expended on detailed inventory and monitoring. At extensive sites, the level of effort is reduced with the aim of ensuring that the results from the intensive site are evident at other sites (that is, the results are generally applicable over the area of interest).

4. Adopting an Ecological or Ecosystem-Based Approach

In this approach, all ecosystem components on the site, including species and key processes, are evaluated for their significance to the project's objectives. In most restoration projects, only a subset of components (such as the abundance of one or two species) is measured. Nevertheless, it is important to evaluate all major components at the outset in order to select the elements that warrant measurement and ensure that the selected subset of components is representative. In an ecosystem-based approach, sites adjacent to the project are also examined. This approach encourages restoration practitioners to look at several spatial scales, including the landscape in which a restoration project is situated.

Biologist Carrina Maslovat conducts a vegetation survey using standardized methodology.
Photo: Dave Polster

7.2 Inventory: Determining What is Present

7.2.1 Design Considerations for Inventory and Monitoring

Five key design principles guide ecological inventory and monitoring:

1. Locate and describe reference sites and conditions
2. Establish control or untreated site(s)
3. Replicate sampling
4. Distribution of sample plots
5. Clearly organize information collection into three categories (stages)

1. Locate and Describe Reference Sites

It is critical to define and describe reference conditions for the restoration site—that is, the target ecosystem characteristics (see Chapter 8, Section 8.4). Therefore, the first design consideration is to locate and describe reference sites. The usual objective of restoration projects is to restore an ecosystem so that it resembles what was found historically on the site, or at least to restore it to an undamaged condition (except in the case of novel ecosystems (Hobbs et al. 2006, 2009)). Since degraded sites no longer resemble what was historically present, there is a need to determine what the undisturbed system looked like, i.e., the target ecosystem. Many approaches are used to determine what target ecosystems should look like, however, the standard way is to locate one or more reference sites that are ecologically comparable but not highly degraded. This strategy is not easy to apply, because all Garry Oak ecosystems are degraded. Other sources of information need to be examined to provide reference or target information, such as historical written accounts, old maps, photographs, paintings, and oral histories. For Garry Oak ecosystems, the undamaged state is usually taken to be what existed before settlement by Europeans.

FIVE KEY DESIGN PRINCIPLES FOR ECOLOGICAL INVENTORY AND MONITORING:

1. Locate and describe reference sites and conditions
2. Establish control or untreated site(s)
3. Replicate sampling
4. Distribution of sample plots
5. Clearly organize information collection into three categories (stages)

2. Establish Control or Untreated Site(s)

Control sites provide a reference to compare sites at which intervention occurs. Usually such sites are located in the restoration area and match the treated area in all respects, except for not being treated. A possible exception to this guideline is with projects involving the removal of invasive species. In these cases, control sites may have to be established away from the restoration site to avoid plants from the control site re-invading the restored area (D. Polster, pers. comm. 2010). Controls enable the effects of other factors, such as a very dry spring or an unexpectedly late frost, to be disentangled from the effects of the restoration treatment itself. Year-to-year variation needs to be distinguished from long-term trends if the real progress due to restoration is to be detected.

Controls enable the effects of other factors, such as a very dry spring or an unexpectedly late frost, to be disentangled from the effects of the restoration treatment itself.

3. Replicate Sampling

Replication strengthens confidence in the results. When only one plot or site is inventoried, it is unclear just how well that plot represents the entire site, even if the sample is chosen to be typical of the conditions. Sampling several areas at different locations within the restoration site helps characterize and appreciate variation. Both the size and the variability of a site influence the number of samples that should be taken, and both sample size (the number of plots) and plot size and shape are important considerations.

Sample size: The number of samples that should be taken depends on the variability of a site rather than its size. Large and very homogenous areas can be sampled with a low number of plots because variability is low; but large and very heterogeneous areas require large numbers of samples because of variability and not size. A rule of thumb used by Garry Oak restoration practitioners is to sample 15–30 plots but statistical formulae can be used to determine appropriate sample size.

Plot size and shape: This topic is addressed under each ecological component as it varies with the component being measured.

Garry Oak ecosystems are heterogeneous, creating difficulties in setting up a sampling design that is equally suitable for all component ecosystems (and the components of each ecosystem!). The desirable number of replicates (i.e., replicate samples, or plots) can be calculated by using statistical formulae (Zar 2009). However, one of the difficulties with relying on traditional statistical formulae is the high variability of many sites. Traditionally, accounting for this variability would involve increasing the number of sample plots at a site (i.e., increasing sample size). However, in ecosystems where variation is a natural characteristic of the ecosystem, for example small seepage areas on rock outcrops, using a greater number of small plots will not resolve the issue of high variance. In these cases, it may be more suitable to incorporate the ecosystem's natural variability into the sampling design by using larger plots, instead of more of them. Sample size and plot design are described in more detail in section 7.2.4, however, a full discussion of replication and statistical study design is beyond the scope of this document; restoration practitioners should consult appropriate textbooks (e.g. Zar 2009).

4. Distribution of Sample Plots

Plots are distributed in one of three ways: random, systematic, or representative (Zar 2009). All three designs have been used in Garry Oak restoration projects.

Random distribution of plots is necessary to make inferences with specified levels of precision and confidence. An element of randomness can be incorporated into a sampling design in a variety of ways. A common way of distributing sample plots is to use a table of random numbers, such as those that are found in most statistical textbooks, e.g., Zar (2009), to select the "x" and "y" coordinates shown on a grid superimposed on a map of the site (Note that random sampling method can be stratified to improve efficiency and obtain better results).

In systematic sampling, plots are distributed over a site according to a spacing rule, e.g., every tenth metre on a set of transects evenly spaced 25 metres apart.

Representative sampling requires that observers select site(s) that they think best represent the typical variation in an area. This subjective assessment is commonly used in British Columbia for characterizing ecosystems (BC Ministry of Environment, Lands and Parks; BC Ministry of Forests 1998). It is the basis of the sampling that was conducted to develop the ecological classification of the Province (Biogeoclimatic Ecosystem Classification), and thus has gained wide acceptance within the professional community as an effective sampling design for the diverse ecosystems of B.C. However, data collected from representative sample plots cannot be analyzed statistically.

Selective sampling of uncommon ecosystems or elements can provide an increased level of confidence that these parts of the ecosystem are being effectively monitored.

Whichever of these three methods is selected, it may mis- or under-sample conditions that are rare but important. For example, small ephemeral pools may represent less than 1% of the landscape in a Garry Oak area, and any of the three sampling methods could miss these pools.

Selective sampling of uncommon ecosystems or elements can provide an increased level of confidence that these parts of the ecosystem are being adequately described and effectively monitored.

Whatever sampling system is used, no matter how many replications are sampled, and whatever reference sites are chosen, the same methods must be used during the life of a project, or else comparisons among plots and sites over the life of a project will be invalid.

5. Clearly Organize Information Collection into Three Categories (Stages)

It is vital that information be collected in a systematic way, using standard formats. Among other

Whatever sampling system is used, no matter how many replications are sampled, and whatever reference sites are chosen, the same methods must be used during the life of a project, or else comparisons among plots and sites over the life of a project will be invalid.

Biologist James Miskelly surveys plants at a translocation site for Golden Paintbrush *(Castilleja levisecta)*. See Case Study 1, Chapter 4. Photo: Nicole Kroeker

benefits such as reproducibility, this approach avoids duplicating effort (A. Harcombe, pers. comm. 2009). The three parts are:

- Collecting information on the project area or property (Characterizing the site, 7.2.2)
- Defining the ecological units (Ecological classification, 7.2.3)
- Sampling within the ecological units (Ecological description, 7.2.4)

The next three sections describe details of these stages.

7.2.2 Characterizing the Site

Once a decision is made to restore a site, the first step is to inspect it, assuming that legal access to the land has been secured, and that the landowner has agreed to the restoration. The Land Trust Alliance of BC's *Guide to Baseline Inventories* (LTABC 2006) provides detailed procedures for producing a baseline inventoryreport for conservation properties and may serve as a useful guide for restoration practitioners. On the first field visit, the biophysical and geographical scope of the project area needs to be recorded, using notes and sketches. Often, this initial information helps confirm or revise project objectives and sampling plans. Preliminary samples can be collected, such as specimens of dominant plant species and water for chemical analyses. Since some analyses take many weeks and even months to complete, an early start on sample collection may save time later on.

Efficient and effective data collection requires adequate preparation prior to visiting the site. This implies having a sturdy, waterproof field notebook, preparing and printing data forms, securing maps, and gathering together appropriate equipment and field guides.

Characterizing a site involves recording basic information for the area. The *Field Manual for Describing Terrestrial Ecosystems*, 2nd edition, provides a section on site description that contains a list of relevant information, a description of each feature, and a form called the

Ground Inspection Form, number FS882C1) (www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh25-2.htm). This version builds upon an earlier edition (Province of British Columbia 1998: note that this inventory manual is a revision of a yet earlier version by Luttmerding at al. (1990) which has a greater level of detail (D. Polster, pers. comm. 2009)). Additional information that is often required for restoration projects can be found in Vesely and Tucker (2004) (see below).

Standard attributes on the Ground Inspection Form:

- exact location and boundaries, recorded as latitude and longitude or as UTM coordinates
- elevation or elevational range in metres
- general slope in percent or degrees and meso-slope position (crest, upper, middle, lower, toe)
- predominant aspect and range of aspects in cardinal directions or degrees
- topography at meso- and macro- levels (relative position of the site within the local area), including surface shape—convex, concave, even
- Ecoregion and Biogeoclimatic subzone or variant
- moisture regime
- nutrient regime (general conditions only, no need for detailed soil tests at this point)
- access points
- general climate
- drainage features, especially areas of waterlogging, wetlands, and drainage patterns

Additional information for Garry Oak and associated ecosystem restoration projects (adapted from Vesely and Tucker (2004) and Green and Klinka (1994)):

- land status: public or privately owned, presence of covenants or other legal features, legal boundaries
- land-use history, e.g., roads, trails, logging, mining, farming
- natural features on or in the vicinity of the site, such as cliffs and caves
- contact information for local environmental organizations. These groups often are valuable sources of information and can provide long-term stewardship for restored areas.

The use of photo-point monitoring is strongly recommended for conducting both inventory and monitoring.

As well as recording the above features, the project area should be photographed from different perspectives. One method is to take photographs in the four cardinal directions from the centre of an ecosystem polygon, as in the study of Anniversary Island in the Gulf Islands National Park Reserve (Parks Canada Western and Northern Service Centre 2008a). As well, a diversity of photographs should be taken each time the site is visited as these will be useful for presentations on the restoration project. The use of photo-point monitoring is strongly recommended for conducting both inventory and monitoring. Photographs from fixed points provide a visual record of baseline conditions and can be used as a monitoring tool to document changes over time. Hall (2002) provides detailed field procedures, concepts, and analysis methods. Also, Chapter 6 of the Grassland Conservation Council of British Columbia's grassland monitoring manual describes a photo-point monitoring procedure that could be adapted to Garry Oak ecosystems (Delesalle et al. 2009). (Download *Grassland monitoring manual for BC* at www.bcgrasslands.org/publications.htm.)

Case Study 1. Photo-point Monitoring

by Conan Webb

Photographs are perhaps the easiest method of creating a record of site conditions. When taken over a time interval, photographs can record vegetation changes over time—it is for this reason that photo-point monitoring is widely used in documenting changes.

Photos can be used for qualitative reference or for quantitative analysis; quantitative analysis, however, requires attention to repeatable protocols. Even if you don't plan on performing quantitative analysis, following a few simple protocols will make qualitative comparisons easier. In addition, following some simple protocols will make quantitative analysis possible if someone chooses to take this on at a later date.

Photo-point monitoring requires that each photo in the series be taken from exactly the same point (establish a permanent marker!) and precisely framed to encompass the same area of the site (try to include an immovable object such as a rock outcrop to assist with framing). Including a vertical, brightly-painted pole of a known length within the frame allows viewers to estimate heights of ground vegetation layers (this pole should be a known distance from the camera). Make sure that you take each photo at the same time every year so that the series shows long-term vegetation trends, not seasonal changes in foliage. Keep good notes about your photo sessions; it is all too easy to end up with just a pile of photos, and photos alone are useless if you don't know some basic details about where and when they were taken. Notes about the landscape might be important as well: while the identity of that yellow flower may have been obvious when you took the photo, it may not be identifiable a couple of years later from the photograph alone.

"Before" photo: The initial baseline photo taken in July 2002 prior to broom removal and deer fence installation. Note that this photo was taken at a different time of year and is not directly comparable to the May 2007 photo. The protocol for this site calls for both late- and early-season photos to be taken each year. The late-season photos such as this one capture late season flora such as grasses and, in general, can be directly compared only to other photos from the same season. However, invasive Scotch Broom (*Cytisus scoparius*), which is a perennial shrub and the primary species of interest, is obviously lacking from the May 2007 photo following.

"After" photo: A monitoring photo taken in May 2007 after six years of broom removal and two years after a deer fence was installed. This photo shows the early-season bloom of camas which is not evident in late-season photos. This is also a good time of year to capture Scotch Broom when it is in bloom and shows up well in photos. Note that the protocol has been updated to include a photo identification number and date on a chalkboard in the image. This keeps such information with the photo.

The preceding paragraph touches on only some of the considerations for photo-point monitoring. *The Photo Point Monitoring Handbook: Field Procedures* (Hall 2002) covers photo monitoring in much more detail. These protocols have been adapted for use in photo-point monitoring of Garry Oak ecosystems at Fort Rodd Hill National Historic Site and are included in Appendix 7.1.

The advantage of photos is that they are relatively quick to take; however analyzing the photographs still takes time and it is easy to end up with a backlog of photographs waiting for analysis. If analysis is planned time must be set aside for it. The *Photo Point Monitoring Handbook: Part B: Concepts and Analysis* (Hall 2002) goes over photo analysis in detail. While Hall's method is based on prints, this method has been adapted to a completely digital workflow for use at Fort Rodd Hill National Historic Site. This digital workflow uses free software and is outlined in Appendix 7.1.

While photographs are a widely used method, they do have limitations and the usefulness of photo-point monitoring must be assessed in light of project objectives. Photos are best for measuring changes in shrubs and trees, while some easily recognizable forbs can be monitored using photo-point monitoring, not all species can be easily identified in a photo.

References

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7.2.3 Ecological Classification

Classifying a site into its component ecosystems is important because different ecosystems:

- may have different restoration challenges
- often require different treatments
- may respond to treatments in different ways
- vary in their suitability for various native species, and
- provide a reference framework for comparison and may indicate reference conditions.

The appropriate level of ecological classification depends on the restoration objectives and the complexity of the area to be restored. Typically, small areas are generally uniform, so their ecological classification is straightforward. However, most Garry Oak ecosystems are ecologically complex, consisting of at least several different ecological units.

Classification involves subdividing the restoration area into component ecosystems that are generally uniform (i.e., have similar ecological attributes) within themselves but differ from others. Identifying ecosystems present on a site is often straightforward because the differences among them are obvious, even to the "untrained" eye. For example, a shallow soil ecosystem can be separated easily from a deep soil ecosystem by the plant community.

> Classification involves subdividing the restoration area into component ecosystems that are generally uniform within themselves but differ from others.

The different ecosystems are mapped as individual "polygons" on a study area map. Aerial photographs are a valuable source of information for delineating ecosystems. Generally, the most recent colour photographs at a scale of 1:5,000 or 1:10,000 are suitable for most restoration projects in Garry Oak ecosystems. Coverage of this sort is available for most of the range of Garry Oak ecosystems on Vancouver Island. Also, aerial photographs can obtained from the provincial government at http://archive.ilmb.gov.bc.ca/crgb/airphoto/index.htm. Aerial photographs can be viewed at the Map Library at the MacPherson Library at University of Victoria. Individuals with a University Library card can also check out photographs and borrow stereoscopes (calling ahead to 250-721-8230 will help ensure that library staff are available to help). Viewing aerial photographs stereoscopically is even more helpful in delineating ecosystems because slopes, aspects, and vegetation heights are discernable.

The CRD Regional Community Atlas is a very useful tool for sites in the Capital Regional District (www.crdatlas.ca). It has relatively recent colour orthographic aerial photographs, on which you can make measurements, and with the capability of displaying contour intervals. In most cases, individual trees are easily recognizable and identifiable.

Ecological classification can also be completed using satellite imagery combined with Geographic Information Systems to create three-dimensional images. Other imaging technologies, such as LIDAR (Light Detection and Ranging), can also be used to facilitate ecological classification.

Several terrestrial ecological classification systems are used in British Columbia, and at least three have been used for Garry Oak ecosystems (Blackwell 2007, Erickson and Meidinger 2007, Green and Klinka 1994). For the purposes of this publication, the Restoration Ecosystem Units

Figure 7.1 A preliminary attempt, for illustration purposes, at applying the Restoration Ecosystem Units (REU) classification system to the vegetation of Fort Rodd Hill National Historic Site of Canada.

(REU) system proposed in Chapter 2 is recommended. The REU classification is ecologically sound because it is based upon previous studies of Garry Oak ecosystems by qualified ecologists (Erickson and Meidinger 2007). As well, the REU classification system is compatible with the two other ecological classification systems that are widely used in British Columbia—the biogeoclimatic system (Meidinger and Pojar 1991) and the ecoregional system (Demarchi 1995). REUs are of special importance to restoration practitioners because they also function as treatment units, i.e., all polygons of a particular type of REU should respond similarly to a restoration treatment.

The CRD Regional Community Atlas is a very useful tool for sites in the Capital Regional District (www.crdatlas.ca). It has relatively recent colour orthographic aerial photographs, on which you can make measurements, and with the capability of displaying contour intervals. In most cases, individual trees are easily recognized and identified.

The Restoration Ecosystem Units (REU) system proposed in Chapter 2 of this publication was developed to create functional treatment units for restoration practitioners. It is based on previous studies of Garry Oak ecosystems and is compatible with other ecological classification systems used in B.C.

Typically, delineated REU polygons will contain small areas of other ecosystems. Following protocols used in Terrestrial Ecosystem Mapping (BC Ministry of Forests and Range 2007), these inclusions are usually not mapped if they comprise <10% of a polygon's area. However, it is important to note their occurrence and to estimate the proportion of the polygon they comprise because it may be the complex of ecosystems that is important. For example, a species of bird may nest in a small ecosystem that is situated within the polygon of a large ecosystem, and forage in the larger ecosystem. In this case, both ecosystems are important for supporting the species. Also, these inclusions may provide important habitat for species at risk, in which case a finer ecological resolution may be needed, such as identifying small vernal pools containing the Endangered Fragrant Popcorn-flower (*Plagiobothrys figuratus* ssp. *figuratus*). Study objectives should indicate the need for this level of classification.

The Restoration Ecosystem Units (REU) system proposed in Chapter 2 of this publication was developed to create functional treatment units for restoration practitioners. It is based on previous studies of Garry Oak ecosystems and is compatible with other ecological classification systems used in B.C.

Whatever classification system is used, the key point is to define and map the area's ecosystems accurately. If the classification is poor or the ecological polygons are poorly defined, or the maps produced have low resolution or poor spatial representation, the restoration plan will be built on a poor framework that could jeopardize the success of restoration efforts (A. Harcombe, pers. comm. 2009).

7.2.4 Ecological Description

Each restoration ecosystem unit or REU needs to be described ecologically. For the purposes of this publication, ecosystems or REUs consist of the following five components:

- Plants (vascular plants, non-vascular plants and lichens)
- Animals (vertebrate and invertebrate)
- Soils, landform, and surficial geology
- Water (hydrology)
- Climate

Restoration practitioners need to decide which components require an inventory and what level of detail is required for each component. These choices are determined primarily by project scope, project objectives, and available resources. For example, mycorrhizal fungi may be important in the successful establishment of some woody plants, and therefore it may be important to inventory these fungi. Notwithstanding the need to consider all ecosystem components, for practical reasons and because of the availability of expertise, most Garry Oak restoration projects focus on vascular plants, soils, vertebrates and "showy" invertebrates like butterflies.

Typically, choosing appropriate methods for conducting inventories is a daunting task because each ecosystem component can be described by many different methods. Two considerations help narrow the choices: First, the methods must produce data that relate clearly to the objectives. For example, if an objective is to decrease the cover of exotic grasses, then a technique that measures the cover of these grasses is vital. Second, methods should be selected from recognized methodologies because they yield reliable data which enable comparisons to be made with information from other projects. In cases where there are no established methods, subject-area experts can help to develop suitable approaches. The following table may help select appropriate methods (Table 7.1).

In British Columbia, established methods for inventory of ecosystem components are well documented in the series published by the British Columbia Resources Inventory Standards Committee (www.ilmb.gov.bc.ca/risc/pubs/index.html), and the reader is referred to this source for additional information on inventory methods.

Two key considerations will help to choose appropriate inventory methods. The methods must produce data that relate clearly to the objectives, and follow recognized methodologies.

Table 7.1 Levels of inventory for restoration of Garry Oak ecosystems

Level of detail	Cost and degree of effort	Sampling system (how information is collected)	Rigor, reliability and utility	Ecosystem components examined (scope and depth of detail)
I	Low	Whole area surveys; no replication	Subjective; low rigor; applies only to site; often used for reconnaissance	Most conventional components covered but not in depth; overall picture recorded; qualitative, lists of species for example
II	Medium	Representative sampling; some plot-based sampling; little or no replication	Subjective or without estimate of error; improved reliability	Vascular plants; conspicuous animals, mostly vertebrates; general soil features such as texture and depth; some invertebrates; hydrology; quantitative
III	High	Systematic or random; plot-based with replication	Improved reliability and utility; results may be publishable in technical journals	Vascular and non-vascular plants; vertebrates and many invertebrates; increased attention to soils and hydrology; quantitative; basic statistical analyses

Emily Gonzales conducts a vegetation survey in a Garry Oak meadow. Photo: Rebecca Best

7.2.4.1 Vegetation

Vegetation inventory documents the distribution and abundance of plants in an area slated for restoration or in a reference site. Many methods are available for collecting this information (see Table 7.3), and the final choice is based on restoration objectives, the scope and complexity of the restoration area and time available. Whatever methods are selected, the aim is always to collect data that can document the success or failure of the restoration.

Whatever methods are used, reliable vegetation inventories have several features in common. They:

- Collect voucher specimens. Ideally, this should be done for all species, but certainly for unidentifiable plants, according to methods described by Brayshaw (1996). Rare species should not be collected but photographed instead.
- Make multiple visits to a site (Hebda 2007). Limiting factors or essential ecosystem characteristics are often not evident if only a single visit is made during a pleasant time of the year. Also, some plant species, including some rare ones, are visible only early in the growing season. Hence, they would not be detected during a summer or autumn survey. Thus, a plant survey at the wrong time of the year may not provide the information needed to carry out a successful restoration, or worse, the restoration activities might destroy an endangered or threatened species. It is also important to visit a site after extreme events or conditions, e.g., heavy rainfall, snow, drought.
- Note plant vigour. Lack of vigour may indicate nutrient shortages or toxicities. Special attention needs to be given to plants that have narrow ecological tolerances.

SMALL AND UNIFORM SITES

For small and uniform project sites with simple restoration objectives, vegetation inventory may consist of a walk over the area to record the distribution and relative abundance (e.g., common, less common, rare) of vascular plants present (tree seedlings, shrubs, ferns, herbaceous plants, and grasses) in the understorey. Mosses and lichens should also be recorded. Of course, special attention should be paid to recording rare, desirable, keystone and invasive species. If the area occupied by these types of species is important, a GPS unit can be used to define the area's perimeter. Observations on the distribution and abundance of dead trees and fallen limbs and logs, commonly referred to as coarse woody debris (CWD), should also be made as these elements are crucial habitat materials for many wildlife species.

Also, in the small and uniform areas typical of some Garry Oak meadow plant communities (vernal pools for example), it is often possible to count, map, and measure all trees in the overstorey. All trees, including damaged and dead ones (snags), should be measured for their height, diameter at breast height (DBH), and crown diameter. Tree height is most easily measured by using a "tree measuring stick" or Biltmore stick or by using a clinometer, tape measure, and simple geometry. Tree diameter is measured at a standard height of 1.3 m (4.5 ft) from the ground (Diameter at Breast Height or DBH). This measurement can be made using a Biltmore stick or a diameter tape that measures diameters directly. Snags are measured using the same techniques. Crown diameter, or the width of the tree crown, is estimated by measuring the longest axis of the crown and then the longest axis at a right angle to the first axis, and taking the average of these two measurements. Note any signs of disease, such as scarring (and possible causes, e.g., fire, lightning, machinery), dead tops, broken off branches, bracket fungi, and discoloured foliage. Plant species, including mosses and lichens, growing on trees should not be overlooked: unknown species can be photographed and submitted afterwards to experts. Also, note any evidence of use by wildlife, such as browsing, cavities, and bark damage. Ages of trees can be obtained by using an increment borer to extract a core from the trunk at 1.3 m above ground level which can then be aged by counting annual rings. Taking an increment core from a Garry Oak (*Quercus garryana*) tree can be difficult as oak wood is very hard. Note that the age based on cores taken at 1.3 m is the age of a tree *above that height*, referred to as breast height age. To determine the actual age of the tree, the breast height age has to be corrected for the estimated number of years it takes trees to reach 1.3 m: unfortunately, this correction factor has not been developed for Garry Oak. Alternatively, age can sometimes be determined by counting annual rings in a section of a recently downed log.

REGENERATION SURVEYS

If the regeneration of Garry Oak is an important component of a restoration project, a regeneration survey can estimate the number of young oaks on a site. This information can then be used to determine if plantings are needed to meet a desired stocking level, i.e. a specified number of young oaks per hectare. A survey methodology for British Columbia's Garry Oak ecosystems has not yet been developed, but a modification of the method described by Vesely and Tucker (2004) for Oregon could probably be used until an acceptable method is developed. These authors suggest distributing circular plots systematically over the area of interest, and counting seedlings (DBH <5 cm) and saplings (5–10 cm) in each plot. A plot radius of 5.63 m yields a plot area of 0.01 ha, so that multiplying plot counts (either for individual plots or for the mean of all plots) by 100 converts readily to a "per hectare" basis. Regarding the number of plots to be used, Vesey and Tucker (2004) noted that survey accuracy generally increases with increases in survey intensity, that is, the percentage of the survey area that is included within measurement plots. The calculation is: survey area multiplied by survey intensity divided by plot area: the result of this calculation is the number of plots required for a survey. Typically, suitable survey intensities range from 5%–10%.

COMPREHENSIVE VEGETATION INVENTORY

Larger and ecologically more complex areas need a more comprehensive vegetation inventory than the simple surveys described above. For these inventories, some form of sampling is required because it is not possible or feasible to count everything. There are three important considerations in designing more detailed surveys:

- plot size and shape (square, rectangle, circle, plotless)
- plot distribution (representative, systematic, or random)
- sample size (number of plots)

Selecting the most suitable combination of these three variables can be determined by considering project objectives, available resources, and desired reliability of the resulting data Consult a biostatistician for advice. Fortunately, previous workers in Garry Oak ecosystems have developed several approaches that restoration practitioners can use.

Provincially, the most commonly used method of vegetation inventory in forested ecosystems is described by BC Ministry of Environment, Lands and Parks and BC Ministry of Forests (1998). In this approach, 20 x 20 m plots (400 m^2) are located at sites judged by the investigator to be representative of the ecosystem unit under study. Thus, in the forest ecosystems of southern Vancouver Island, 400 m^2 plots are considered adequate. *Note: for relatively uniform Garry Oak ecosystems, 100 m^2 may be an appropriate plot size (D. Polster, pers. comm. 2009).*

LARGER SAMPLE PLOTS

Where the ecosystems being sampled are very heterogeneous, e.g., rocky slopes with pockets of deeper soil and ephemeral pools and seepage zones, a larger sample plot may be more suitable to represent the variability of the site. In these situations, instead of using the sample plot sizes described above, size can be determined using the minimal area concept described by Oosting (1956). Basically, this method entails establishing plots of increasing size, doubling the size of the plot each time, until no (or very few) new species are found. The plot size at this point is considered the minimal area (some ecologist then double this area for their surveys). For example, an initial plot of 0.5 m^2 might be used. The number of species recorded in that plot is totalled. The plot size is then doubled to 1 m^2 and the number of species is counted. The plot size is again doubled to 2 m^2 and the number of species is again recorded. If no more species were recorded in the 2 m^2 plot, then this would be the minimal plot size.

Regardless of plot area and shape, vegetation is divided conventionally into four layers (Table 7.2), and the cover of each species is estimated for each layer as a percentage of the surface area of the plot, to the nearest whole number. Defining layers and estimating percent cover takes a lot of practice, and training with an experienced surveyor is desirable. For specific information on defining layers and estimating cover, refer to Section 3 in the *Field Manual for Describing Terrestrial Ecosystems* (www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh25-2.htm). Note that some low-growing shrub species (e.g., Kinnikinnick (*Arctostaphylos uva-ursi*)) have been assigned to the herb layer. Consult Table 3.1 in the above Field Manual for a list of these species. Also, record species seen in the area but not recorded in the plot, as well noting species not seen but expected in the area.

All trees in the overstorey, or A layer, are identified and measured for DBH, height, and crown area, using methods noted previously.

Table 7.2 Vegetation layers commonly used in inventory of Garry Oak ecosystems (after BC Ministry of Environment, Lands and Parks and BC Ministry of Forests (1998))

Layer	Vegetation	Description
A	Tree layer	Includes all woody plants greater than 10 metres tall
B1	Tall shrubs	Includes all shrubs and regenerating trees between 2 and 10 m
B2	Low shrubs	Includes all shrubs and regenerating trees less than 2 m tall
C	Herbs	Includes all non-woody plants such as ferns, grasses, grass-like plants, forbs, saprophytes, some low-growing, woody species, and species of "doubtful" life form
D	Ground layer	Includes tree seedlings less than 2 years old and mosses, lichens, and liverworts

MEASURING COARSE WOODY DEBRIS

Coarse woody debris can be measured by using two 24 metre transects that are centered on the plot centre. The bearing of the first transect is randomly selected and the second transect is placed at right angles to the first. The following characteristics are measured for each piece of CWD intercepted by these transects:

- diameter
- decay class, based on the entire piece, by using the table of decay class indicators (in www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25.htm)
- tilt angle of each piece
- length of each piece, measured or estimated

Consult the following website for additional details: www.ilmb.gov.bc.ca/risc/pubs/teecolo/fmdte/cwd.htm.

SMALL PLOT SURVEYS

Instead of using one large plot, another approach involves using a set of small plots. In this method, plant cover is estimated for each understorey vegetation layer. Typically, the herb and ground layers (C and D in Table 7.2) are assessed using either 1 m^2 plots that are square, circular, or rectangular, or a 20- x 50 cm quadrat (Gayton 2003), called the Daubenmire frame after an American plant ecologist who pioneered this approach. The shrub layer (B) is assessed using a larger plot, usually 2 m^2 or 3 m^2 in size. Plots are either clustered together around a plot centre in a grid pattern, or spaced along one or more transects. For systematic layouts, sample plots are usually placed along transects that are oriented across the slope of the site to maximize the amount of variability within a transect. Note that an element of randomness is preferred if statistical inferences are planned, and a biostatistician can advise how best to do this.

In these small plot surveys, plant cover is usually estimated visually for each plot, either to the nearest percent or by cover classes (see BC Ministry of Forests and Range and BC Ministry of

Environment (2010) for a guide to cover classes). Estimating cover to the nearest percent may seem to be the best choice, but percent cover is difficult to estimate consistently among observers. Using cover classes helps overcome this problem. For example, individuals are more likely to agree on a cover class rating that spans 5–20% than they are to agree on a cover estimate of 15%. Two commonly used plant cover scales are the Daubenmire method, with six cover classes, and the Braun-Blanquet system which features ten cover classes (Mueller-Dombois and Ellenberg 1974).

POINT AND LINE INTERCEPT METHODS

Although visual estimation of plant cover in small plots is the most commonly used technique in Garry Oak ecosystems, some workers have used point and line intercept methods, e.g., on Anniversary and Eagle Islands in the Gulf Islands National Park Reserve (Gulf Islands National Park Reserve 2008a, 2008b). An example of the point intercept method was on Anniversary Island, where plant species occurring at 50 and 130 cm above the ground at 50 cm intervals along a transect (a tape measure stretched between two end points) were recorded. In a variation on this method, forb and grass intercepts were recorded on a 10 cm spaced grid in a 1 x 1 m quadrat. With line intercept, the length of the transect intercepted by each plant species is recorded.

There is a group of methods that do not require laying out plots. Known as "plotless" methods, they rely on measuring distances between plot centres and individual plants and/or distances between individual plants. These methods do not appear to have been used in Garry Oak inventories, and so are not covered in this chapter. If readers wish more information on these methods, they should contact a plant ecologist or consult a plant ecology text.

7.2.4.2 Soils, Landforms, and Surficial Geology

Soil inventories can reveal potential management problems such as predisposition to erosion or compaction, and can help guide the selection of plant species for re-vegetation. Similar to vegetation inventory, soils can be inventoried at various levels of detail. Whatever level of detail is selected, it is useful to bear in mind that soils have three major components—physical, chemical, and biological—and that all soil information can be organized under these three headings.

The first step for soils inventory is to collect information from existing soil survey reports for the site and the surrounding area. Consult Day et al. (1959), Jungen (1985), and Muller (1980) for soils information for southeastern Vancouver Island. This step provides a preliminary information base, but a field-based inventory is also needed to: a) relate soils of the study area to those described in the soils reports, and b) collect information specific to the area.

The second step is to subdivide or stratify the project area into meaningful soil units. Usually, the restoration ecosystem units (REUs) defined in Chapter 2 serve this purpose, just as they do for vegetation. However, it is helpful to confirm this stratification with a soil scientist to ensure its accuracy.

The third step is to characterize the soil in each REU polygon. This calls for digging several test holes (soil pits) in each major REU and at reference sites. Test holes should extend through the root zone, usually 50-60 cm deep, but may be shallower if the basic parent material is reached. Soil inventories should be conducted in June, when soils can be dug easily. This approach was used in surveying Garry Oak Restoration Project (GORP) sites in Saanich municipality (Giasson and Maxwell 2002).

TABLE 7.3 Methods used to sample vegetation in selected projects in Garry Oak ecosystems

Source/ study area	Sampling system and aim	Sampling design	Plot size and shape for layers sampled	Layers sampled	Sampling frequency	Sampling intensity
Anniversary Island – monitoring for Polygon B	Line intercept for percent cover	8 parallel transects, 10 m apart, oriented perpendicular to the slope	Species intercepted every 50 cm at 50 cm and 130 cm above ground	Understorey and low shrub layers		
Anniversary Island – monitoring for Polygon A		2 transects 2m apart, oriented parallel to the long axis of the treatment area	As for Polygon B			
Eagle Island effective-ness monitoring	Point intercept	Randomly distributed quadrats	1 x 1 m, permanently marked with steel	**Forbs and grasses:** 120 x 120 cm frame with a nylon grid spaced every 10 cm – all species recorded as well as ground cover **Shrub layer:** 2 x 2 m frames centred over the 1 x 1 m forb /grass plots–percent cover estimated for two vertical strata: low shrubs <2 m, and tall shrubs from 2–10 m	April and late June –early July	50 plots for 1.4 ha open coniferous forest, rock outcrops, shrubland, open canopy Garry Oak
Mill Hill (Maslovat 2008)			3 x 3m, corners marked with rebar and spray painted orange with metal tag on SW corner indicating plot number (GPS coordinates recorded)	Percent cover of tree canopy and shrub canopy, calculated as foliar cover; mosses on rock and wood not included		
Somenos Garry Oak Protected Area	Transects with Daubenmire plots	Uniformly spaced along transect	1 m² with ¼ m² smaller plots nested in corner	All layers	Conducted annually	8 transects with 10 plots each

The following properties can be gathered from soil test holes (Green and Klinka 1994):

- general depth of soil, i.e., depth to the parent material
- presence and average thickness of accumulated humus (Ah horizon) and other visible layers
- proportion of coarse fragments (rocks > 2 mm) of soil volume
- texture in the rooting zone. Texture is estimated in the field by a simple technique that indicates the relative proportions of sand, silt, and clay in the soil (see Appendix 4 in Green and Klinka (1994) or Steinfeld et al. (2007:52)
- presence of mottling or gleying that indicates temporary or fluctuating water tables
- humus form (see pages 15-16 in Soils section of BC Ministry of Forests and Range and BC Ministry of Environment (2010))
- root restricting layer, if present, and type of restriction, e.g., bedrock, cemented layer
- surficial materials, e.g., lacustrine, glacial till, alluvium, colluvium.
- description of organic material and thickness
- presence of earthworms and other biota
- relative moisture regime (see Appendix 5 in Green and Klinka (1994))
- relative nutrient regime (see Appendix 6 in Green and Klinka (1994))

In addition to these features, chemical attributes such as pH can be assessed using field kits, e.g., Hach kits or the LaMotte waterproof pH meter.

All of these soil features can impact restoration treatments. For example, depth to an impervious layer, texture, extreme rockiness, proneness to compaction, erosion susceptibility, burning history, and drainage can all affect the selection of plants to be used for restoration. Soil samples should be collected and pictures taken of the soil profile if unusual situations are encountered, e.g., suspected contamination.

In some situations, a more detailed level of soil inventory is required. This entails digging soil pits and describing a wide variety of soil attributes (e.g., colour, texture) for each soil layer or horizon. If even more complex analyses are warranted, e.g., if trace element deficiencies are suspected, soil samples can be sent to an analytical laboratory. Most soils laboratories specify the method for collecting soil samples for analyses. Usually, soil samples are collected from at least six sites to a depth of 15 cm, and then mixed thoroughly. Of course, if the project area has obviously different soils (e.g., a wet low-lying area versus an exposed shallow soil area) each type needs to be sampled separately.

Detailed inventory of soil biota is best left to experts. Inventories and identification of soil organisms usually requires specialized knowledge and equipment. The need for this level of detail in a restoration project can be judged by referring to project objectives and by consulting a soil scientist.

7.2.4.3 Inventory and Monitoring of Animals

GENERAL CONSIDERATIONS

Inventory and monitoring of animals faces many challenges. Animals are:

- mobile (so it is often difficult to see them clearly and to know how much time they actually spend in an area)
- cryptic (so they are difficult to see)
- night-active (which makes detection difficult)
- often silent for most of the year (so using auditory clues is not always possible)
- widely variable in their behaviour and ecology, necessitating inventory methods that are "customized" to take advantage of their particular attributes. For example, some bat calls are beyond human hearing ability and so specialized equipment is needed for their detection.

Thus, collecting animal data on an ecological unit basis can be tricky. Detected individuals may be from a broader area, and the animal may freely roam around many units. Observers may displace animals from their typical habitat, complicating an understanding of species-habitat relationships.

Three types of vertebrate inventory are possible: present/not detected, relative abundance, and absolute abundance (Caughley 1977). The choice of type of inventory depends on project objectives, but estimates of absolute abundance are not often undertaken because they are expensive, time-consuming, and usually unnecessary. The basic level of inventory involves recording *animal presence*. Not seeing an animal *is not* conclusive proof that it is absent, even after many surveys. The most that can be said is that the species was not detected. *Relative abundance* involves using methods that detect changes in numbers, but do not yield the actual numbers of animals present nor the actual change in numbers. *Absolute abundance* uses methods that estimate the actual numbers of individuals present. This is almost always estimated by sampling as it is virtually impossible to make accurate direct total counts of animals.

For all three types of inventory, many methods are available. The reader is advised to consult standard textbooks, such as Krebs (1999), for further information, or consult species experts. Another invaluable source of information for British Columbia is the provincial government's Resource Inventory Standards Committee (RISC) website which contains standard methods for most vertebrate and some invertebrate species (http://archive.ilmb.gov.bc.ca/risc/pubs/tebiodiv/index.htm).

Any inventory that involves handling or marking vertebrates requires permits as specified by legislation (e.g., Wildlife Act, *Species At Risk Act*), and by permitting policies of municipal, regional, provincial, and federal governments. All necessary permits must be obtained before field work begins.

Special mention must be made for studies of amphibians, especially for surveys where several ponds are visited. It is essential to follow the Standard Operating Procedure: Hygiene Protocols for Amphibian Fieldwork. Also, consult the Amphibian Disease page on the BC Frogwatch Program's website (www.naturewatch.ca/english/frogwatch/bc) to avoid spreading diseases such as the amphibian chytrid fungus (*Bratrachochytrium dendrobatidis*) and ranavirus. In short, thoroughly disinfect boats, boots, and equipment between survey sites.

A useful first step in animal inventory is to create a list of species expected at the site. Such a list can be based on check lists, relevant references, and the expertise and experience of competent local biologists and naturalists.

In the field, all species seen or heard should be recorded, noting the date, time of day, weather conditions, and the habitat(s) or REUs in which animals are sighted. For unknown animals, photographs and detailed notes (e.g., colour, size, prominent features) will aid in identification. Because many animals are difficult to find, signs such as tracks, scats, burrows, or dens are often the only evidence of a species' presence.

AMPHIBIANS

Identification of amphibians found in Garry Oak ecosystems can be facilitated by field guides and the pamphlet published by BC Ministry of Environment (see BC Frogwatch Program). These sources help determine the species to be expected at study sites and also aid in the identification of adults, larvae, and egg masses of amphibians. Data collected on frogs can be entered in the BC Frogwatch Program website (www.naturewatch.ca/english/frogwatch/bc). Note that all frog species found in B.C.'s Garry Oak ecosystems are pond breeders. Of the six salamanders that occur here, three species do not require standing water. General information on inventory methods is presented below, and the reader is directed to the following website (http://archive.ilmb.gov.bc.ca/risc/pubs/tebiodiv/index.htm) for detailed descriptions of standard survey methods for pond-breeding amphibians and terrestrial salamanders.

Present/not detected surveys

Amphibian surveys are either aquatic or terrestrial, and involve searching for egg masses, larvae, and adults.

One aquatic approach is to listen for vocal species that can be detected and recorded by call at the appropriate times of year during optimum weather conditions, such as warm calm evenings. Silent species and surveys at the wrong season or in sub-optimal weather conditions will yield incomplete information. For example, Pacific Chorus Frogs (*Pseudacris regilla*) call from late March to May; Northern Red-legged Frogs (*Rana aurora*) call under water in February and can only be heard using a hydrophone; Bullfrogs (*Lithobastes castesbeianus*) bellow their characteristic call in July.

A second aquatic method is to search ponds for adult frogs, salamanders, and toads by sitting or walking quietly along pond edges, especially at the north-eastern corner of ponds where amphibians often aggregate. Binoculars and dip nets are two important pieces of equipment for these surveys.

A third aquatic method focuses on larvae and egg masses. Tadpoles and salamander larvae can be captured using a dip net while wading along shallow parts of a wetland or from a boat, canoe, or kayak. Minnow traps work well, but traps must be partly in air as trapped animals must have access to air. Identification of tadpoles and larvae can be tricky, and is best done by an experienced herpetologist.

Surveys for egg masses require exploration of pond edges by walking or by canoe, rowboat, or kayak. Egg masses are gelatinous blobs with dark centres, often attached to underwater vegetation or submerged branches. Detecting and identifying egg masses requires practice, so field guides and local herpetologists are important resources. Because not all species lay their eggs at the same time, surveys must be conducted at the optimum time for the target species.

Terrestrial surveys are also used to detect amphibians. Most amphibians found in Garry Oak ecosystems can be found in the terrestrial environment at some time during a year. Some of these species will travel a considerable distance from water, such as Rough-skinned Newt (*Taricha granulosa*) and Western Toad (*Anaxyrus boreas*). Some of the salamanders found in Garry Oak ecosystems, such as Ensatina (*Ensatina eschscholtzii*), Western Redback Salamander (*Plethodon vehiculum*), and Wandering Salamander (*Aneides vagrans*), do not require standing water to breed and are found in the terrestrial environment all year round.

The best way to locate these species in daylight is to look under woody debris, vegetation, and other cover objects where the animals hide (taking care not to destroy their habitat in the search!). During the spring, amphibians like colder and wetter weather, and might come out of hiding so they are more easily detected. During wet nights, amphibians can be detected on the forest floor or on the roads in the survey area. For night surveys, strong flashlights or flood lights are required and for safety reasons, work in teams of at least two people. The terrestrial salamanders are often easiest to find using cover boards (see the appropriate RISC manual for details).

Relative abundance

Relative abundance can be obtained by standardizing the above mentioned searches for amphibians. For example, the relative abundance for vocalizing frogs can be determined by listening for a set number of minutes at predetermined spots in wetlands. At each spot, estimate how many frogs can be heard and what species are calling. Sometimes it is not feasible to count individual frogs when many are calling, such as the Pacific Chorus Frog. In these situations, number categories (0, 1-5, 6-20, >20) or categories of relative calling intensity can be created, such as those recommended by Frogwatch (www.naturewatch.ca/english/frogwatch/bc/steps.html).

For example:

T (trace) – no frogs or toads heard
L (low) – individuals can be counted; calls not overlapping
M (medium) – some individuals can be counted; other calls overlapping
H (high) – full chorus; calls continuous and overlapping; individuals not distinguishable

Aquatic spotting surveys can be standardized by establishing survey points, duration, time of day, and weather conditions, and repeating surveys under these conditions, as much as possible. Even with rigorous standardization, it is important to keep in mind that observer bias influences detection of adults and eggs masses. Since observers are likely to vary from survey to survey and year to year, it may be preferable to rely on trapping because it has the least observer bias.

To obtain relative abundance of terrestrial salamanders, the best method is to conduct cover board surveys under standardized conditions. However, for some species, mark-recapture techniques can be used to establish relative abundance. The latest marking method uses coloured elastomers or passive interrogation tags (PIT): both methods require injecting the marker under the animal's skin. To prevent injuring the animals, both of these methods require involvement by professionals with relevant experience in injecting markers. In lieu of professionals, proper training is essential and is likely to be a mandatory condition of a permit.

Absolute abundance

Short of draining a pond and counting what is present (not logistically feasible nor acceptable), the method of choice is mark-recapture. This technique is labour intensive and is usually not necessary unless changes in numbers of amphibians is a project objective. Moreover, there is currently no RISC manual available to determine absolute abundance of terrestrial salamanders.

REPTILES

Snakes and Lizards

Four snake species and two lizard species occur in B.C.'s Garry Oak ecosystems. The most abundant snake is the Northwestern Garter Snake (*Thamnophis ordinoides*), and the two less common species are the Common Garter Snake (*T. sirtalis*) and the Western Terrestrial Garter Snake (*T. elegans*). The Endangered Sharp-tailed Snake (*Contia tenuis*) is the rarest species. The two lizard species are the native Northern Alligator Lizard (*Elgaria coerulea principis*), which is relatively common and widespread, and the introduced European Wall Lizard (*Podacris muralis*) which is mainly found in parts of the Capital Region District (Durrance Road, south of Brentwood Bay in Saanichton) and in Duncan (Bertram 2004).

Identification of reptiles found in areas with Garry Oak ecosystems can be facilitated by field guides or the pamphlet published by the Ministry of Environment (see BC Frogwatch Program website). The BC Frogwatch Program website also allows data to be entered and helps determine what species occur in the area.

Present/not detected surveys

Surveys for the presence of reptiles can entail sight surveys, trapping, or use of artificial cover objects (ACOs). The procedure for sight surveys calls for walking quietly around the study

Herpetologist Christian Engelstoft creates a monitoring station by placing an asphalt cover object in potential Sharp-tailed Snake (*Contia tenuis*) habitat. This method avoids disturbance of natural habitat features like rotten logs, rock piles, and forest litter. Landowners contribute to the research by checking for snakes under the artificial cover objects. Photo: Todd Carnahan area on warm sunny days in the spring, or along roads during summer nights, and searching for animals.

A more intensive survey method involves trapping. Most snakes and lizards can be trapped in funnel traps outfitted with drift fences that lead the animals into the traps. The Sharp-tailed Snake is a special case and the best way to detect this species is by distributing up to 20 ACOs (small pieces of asphalt roofing materials approximately 30 x 60 cm) every 5–10 metres along meandering transects in suitable micro-habitat, i.e., south-facing rocky slopes with CWD or litter or duff. The ACOs are then checked approximately weekly to see if snakes are underneath. Because the Sharp-tailed Snake can be found in areas with rare plants it is important not to cover any of these plants with ACOs. As with amphibian inventory, it is critical to ensure that all applicable permits have been obtained before handling reptiles.

Relative abundance

As with amphibians, relative abundance can be assessed by standardizing presence surveys. Another approach is to use time-constrained, quadrat or transect searches (See RISC Manual 38: www.ilmb.gov.bc.ca/risc/pubs/tebiodiv/snakes/assets/snake.pdf) under standardized conditions. For example, search a defined area for 15 minutes in the summer under sunny and warm conditions. When the same area is to be searched several or more times, it is important to minimize damage to the habitat, for example by dividing an area into subunits and searching different subunits on different surveys. Weekly surveys of ACOs in spring and fall and bi-weekly in summer can be used, but these surveys are very labour-intensive and their effectiveness is untested.

Absolute abundance

Direct counts for determining total numbers is not possible for reptiles, so some type of mark-recapture study is necessary to estimate absolute abundance. Unless a restoration project is directed at the recovery of an endangered reptile, this level of intensity is not necessary.

Turtles

The two most common turtles found in B.C.'s Garry Oak ecosystems are the Endangered Western Painted Turtle (*Chrysemys picta belii*) and the introduced Red-eared Slider (*Trachemys scripta*). Several other introduced species can be found throughout the region.

Present/not detected surveys

Determining the presence of these species requires a land-based vantage point or a floating platform, such as rowboat, canoe, or kayak, from which the shoreline can be scanned. Surveys need to take place on sunny days in the spring (March, April, and May) when basking is at its peak. Up to 3–5 surveys may be necessary to confirm presence or likely absence of turtles.

Relative abundance

Relative abundance can be estimated by conducting visual surveys that are standardized either by time or survey locations or both. Relative abundance can also be obtained by mark and recapture methods, but before engaging in capturing and handling turtles, practitioners need to take training and obtain the appropriate permits, as both species are protected by the BC Wildlife Act.

To capture turtles, basking traps and baited hoop traps are tried-and-true methods, and both might be needed as there appears to be seasonal variation in the success of these traps. From mark and recapture methods, population estimates can be derived if individual turtles can be identified. A marking method is described in RISC manual 37, and the shell notching approach is recommended as it is the least invasive method. There are no RISC methods to determine absolute population estimates of turtles.

BIRDS

Present/not detected surveys

The simplest method is to record all birds seen and heard in the area, preferably over the course of a year to pick up resident, breeding, and migrating species (Many field guides are available, e.g., Dunn and Alderfer (2006), and the novice can consider improving their bird identification skills by participating in birding field trips offered by local naturalist clubs.) Many birds are most likely to be detected at dawn during breeding season, but Gross (1995) conducted winter surveys. The presence of owls can be detected, especially during the breeding season, by listening, calling, or playing calls plugged into a loud speaker. As well, all signs of bird activity, such as tree cavities or old nests, should be recorded. If it is only possible to sample one time, then spring is best as it will most likely pick up birds breeding in the area, although migrants will be missed. Field data can often be augmented by reference to local bird checklists and by contacting local naturalists.

Relative abundance

Relative abundance can be estimated in a variety of ways, but whatever methods are used, surveys should be conducted within two hours either side of sunrise when birds are most active. One common and straightforward way to get a sense of estimating relative numbers is to use the subjective scale of abundance, often found in bird checklists. Most owls are an obvious exception
to this method: owls are usually surveyed at night and the rate of calling under standard conditions can indicate approximate changes in abundance.

More detailed information can be gathered by recording birds seen along transects. In this method, the observer walks along transects at a steady pace and records all birds seen or heard within a pre-determined strip centered on the transect, over a specified time period. One variation on this method is to record the distance and angle of birds seen from the transect. When transects are surveyed repeatedly, temporal patterns can be detected.

The most detailed method for estimating relative abundance is spot counts. In this method, a series of stations are set out along transects that are distributed across the study area. The observer records all birds seen or heard at each station during a fixed time period, usually 5–20 minutes. Transects and stations need to be placed far enough apart to minimize duplicate counting.

Absolute abundance

As with other vertebrates, absolute abundance can be estimated with mark-recapture studies, but these require significant effort.

MAMMALS

Present/not detected surveys

As with birds, record all mammals seen, plus all signs of activity, such as tracks, scats, and dens.

Relative abundance

Inventory methods for mammals vary according to the type of mammal being counted. Live-trapping is usually used to inventory small mammals like rodents because they are unlikely to be seen. Traps are baited and placed along transects that cover the entire study area. Pitfall traps have been used for shrews but they are problematic because the trapped animals often die.

Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*) are the most common large mammal found in Garry Oak ecosystems, and they are often a consideration in restoration because they can damage plantings. For most Garry Oak restoration projects, estimating the relative abundance of deer is the most practical type of inventory. Relative abundance is commonly based on pellet group counts, and for details on conducting pellet group surveys consult http://archive.ilmb.gov.bc.ca/risc/pubs/tebiodiv/index.htm (Manual 33).

A local example of a pellet group survey is that designed by Mercer (2006) for use in the Gulf Island National Park Reserve. Pellet counts involve regular counting and clearing of pellet groups in 10 m^2 circular plots that are spaced at 40 m intervals along sampling transects. The plot area is defined by placing the end loop of a 1.78 m plot cord over the centre point (e.g., nail) of the plot and extending the cord to its full length, to establish the plot radius. Moving the plot cord in a clockwise or counter-clockwise direction 360^{o} around the plot defines the full plot. Any pellet group that is 50% or more within the plot area and (a) consists of 10 or more pellets, 10 cm or more away from the next closest pellet group, or (b) is distinguishable ("newer" or "older") from the next closest pellet group, is counted. After all groups are counted, the plot cord is rotated in the opposite direction and groups are counted a second time to verify the initial count. The plot is cleared of pellet groups when the count is completed to the satisfaction of the sampling team, so that subsequent sampling will detect pellet groups deposited since the previous sampling date. To detect seasonal changes, plots can be cleared and counted in the fall and thereafter in early spring and late fall. Additional surveys can be conducted in mid-summer (late June to early July).

Results of pellet group surveys must be interpreted with caution. Increased pellet group densities could indicate an increase in numbers, but they could also indicate increased use of the survey area, or a combination of both.

Absolute abundance

Determining absolute abundance for vertebrates is a costly and time-consuming enterprise, and should not be undertaken without the advice and guidance of a vertebrate ecologist. Normally, this level of measurement is not required in Garry Oak restoration, except for threatened and endangered species, in which case estimates of absolute numbers may be necessary.

INVERTEBRATES

Present/not detected surveys

Certain large invertebrates, like butterflies, can be detected by searching for them systematically during appropriate times of day and weather conditions. All potential habitats should be searched. Time of year is important. In the case of butterflies, a site should be re-surveyed every two to three weeks from early spring through the summer to account for different flight seasons among the different species.

Species that are under-represented in visual searches may be detected more easily with a variety of passive trapping approaches. For example, spiders are usually sampled using pitfall traps. Other groups may be better sampled using pan or malaise traps. These are generally lethal methods, but may be the best way to confirm the presence of certain taxa. Some groups may be sampled non-lethally using artificial cover objects.

Relative abundance

Relative abundance can be determined by using the same methods as for presence/absence status but standardizing and repeating the sample. For example, the usual way to determine relative abundance in butterflies is to walk a fixed-width transect at a fixed rate of travel during standardized weather conditions and times of day (Pollard 1977). Only those butterflies that are seen within a certain distance from the observer are counted.

In other parts of North America, native bees are being surveyed through timed observation of a single variety of sunflower (LeBuhn 2010). A similar approach could be developed using native flowers, or a site-specific plan could use a fixed transect where all flowers are checked at a fixed rate.

In the case of species that are best detected using traps or artificial cover objects, relative abundance could be determined through repeat sampling of objects or traps that are set in fixed locations, representative of the whole site, and checked after set periods of time.

Absolute abundance

Absolute abundance can really only be determined through mark/recapture studies. It is important to note that these studies can have significant negative impacts on invertebrates (Murphy 1988). Determining absolute abundance is of questionable value for invertebrates, especially for rare species. Many invertebrates have short life cycles (often one year) and population numbers are highly responsive to variables, such as weather conditions and relationships with predators and parasites. Absolute abundance is likely to vary greatly from one year to the next. With rare species or small populations, mark/recapture studies will result in estimates with very low certainty (Murphy 1988). Moreover, the population is the more meaningful conservation unit in these cases anyway, and relative abundance is likely to be a better tool for measuring changes.

For butterflies, transects can be set up and then monitored regularly. It is important to be consistent and to account for factors such as weather (e.g., monitor only under optimal conditions for butterfly flight, which are generally warm, sunny weather during the warmer period of the day).

For other insects, regular observations can be made of pollinators. Transects can be set up to make regular observations of the presence and abundance of insects in foliage.

Gastropods

An emerging topic is the distribution and species composition of gastropods in Garry Oak ecosystems, partly because of the increasing number of listed species and the occurrence of invasive species. Examples are the Endangered Blue-grey Taildropper slug (*Prophysaon coeruleum*), the Red-listed Threaded Vertigo snail (*Nearctula* spp), the Blue-listed Pacific Sideband snail (*Monadenia fidelis*) and the Blue-listed Scarletback Taildropper slug (*Prophysaon vanattae*). Forsyth's (2004) *Land Snails of British Columbia* is a helpful reference.

For larger species in the study area, present/not detected surveys can be done by searching leaf litter, downed woody debris, tree trunks, vegetation, and similar objects. Placing and monitoring artificial cover objects made of corrugated cardboard (30 x 30 cm, 3 layers deep) is another approach often used to determine the presence of gastropods, e.g. Ovaska and Sopuck (2010). For smaller species (less than 5 mm), samples of the litter layer are dried and then sifted with three sifts, each with progressively smaller holes.

Relative abundance can be determined by conducting searches that are limited in the size of the search area or in their duration (often referred to as time and/or area constrained searches) or by quadrat searches. Standardized searches of artificial cover objects can also be used to estimate relative abundance. Absolute abundance is not possible to determine with current methods. See Duncan et al. (2003) for a full discussion of survey methods for gastropods.

7.2.4.4 Water (Hydrology)

Inventory of water primarily involves observations of drainage patterns. Maps and field surveys in the wet season are needed to locate low lying areas, seeps, and vernal pools. Indicator plants (see Klinka et al. 1989) are often helpful in determining damp places.

It is also important to assess adjacent areas for the risk of topographic alternations that could affect the restoration area's hydrology. If there is funding, and the restoration area is large, then hiring a hydrologist for a day or two is helpful. However, this is probably not necessary for small projects unless there will be major construction or development adjacent to the site, with an increased potential for changes in water flow on the restoration site.

Attention should be directed to investigating historical changes to hydrology. For example, a restoration site's hydrology could have been altered already by underground drainage pipes and ditching or the redirection of drainage courses, as was carried out historically above the Garry Oak woodland at Government House in Victoria. Such historical impacts could change habitats for some rare plants (B. Costanzo, pers. comm. 2010).

The location and extent of all streams, lakes, and wetlands need to be carefully delineated, as all activities in the adjacent riparian zones are regulated by the provincial government's Riparian Areas Regulation (www.env.gov.bc.ca/habitat/fish_protection_act/riparian/riparian_areas.html). Note that ephemeral or winter streams are included in this regulation, so it is important to survey project areas in winter to identify these streams: they may not be apparent in the summer when they have dried up.

A useful strategy is to visit a restoration site in the late winter after a heavy rainfall and note where there are pools of standing water and drainage trackways and what their limits are. Noting the elevation limits of high water in ponds and lakes at this time of the year helps define the hydrologic conditions in some Garry Oak stands. Common Rush (*Juncus effusus*) is a useful indicator of sites that are wet during the winter months. Mottled soils are also good indicators of poor drainage.

7.2.4.5 Climate

For most Garry Oak restoration projects, climate information is usually referenced as part of a general description of the study area. The usual parameters of interest are:

- rainfall: average monthly and average annual amounts
- temperature: monthly and annual means; average monthly and annual maxima and minima
- frost-free period

Typically, this information is taken from long-term Environment Canada climate stations, usually located at airports. Since most Garry Oak sites are not at airports, these data may not accurately reflect the local climate of a site. More local records may be available from the University of Victoria's school-based weather system (www.victoriaweather.ca). More than 20 stations have been established in the Greater Victoria school districts, many of which are close to restoration sites. Stations have also been installed as far north as Campbell River, and these may provide local records for Garry Oak sites elsewhere on Vancouver Island. It is also possible to collect weather data inexpensively by using iButtons to measure temperature and relative humidity (www.maxim-ic.com/products/ibutton).

Variation in site-specific climate (also referred to as micro-climate) is of most interest to restoration practitioners. These fine-scale variations are important for selecting plant species and for determining where and when particular species are planted. Noting where late season frost pockets occur is a useful observation when selecting plant species or scheduling planting.

7.3 Monitoring: Assessing Success

Monitoring is the act of making repeated measurements of a meaningful indicator. It involves answering the question: Is the baseline condition changing? Monitoring is an integral part of a restoration project, and corresponds to the seventh stage in the process of conducting a restoration project (see Chapter 5: Restoration Planning). Monitoring is a tool that measures progress in achieving restoration objectives, and identifies problems that might affect their achievement. If recovery of a damaged ecosystem is important enough to invest time and money, then it is equally important to assess whether or not restoration actions are effective. A monitoring program can identify deviations from the projected trajectory of ecosystem recovery, so that adjustments can be made. For example, if a project objective was to eradicate an exotic plant, and monitoring showed that the species was still present after a specified period of time, then an opportunity and need exist to use alternative removal methods before the species recovers to dominate the site again.

This section addresses the following aspects of a successful monitoring program:

- What is monitoring and why is it important?
- What sites should be monitored?
- What should be measured?
- What methods should be used?
- When, how often, and for how long should monitoring be done?

The material in this section is adapted with permission from Hebda (2010) and the Coastal Services Center, National Atmospheric and Oceanic Administration's website (www.csc.noaa.gov/coastal/management/management.htm).

7.3.1 What is Monitoring and Why is it Important?

There are three different types or purposes of monitoring: implementation monitoring (*evaluation*), effectiveness monitoring (*assessment*), and *validation* monitoring. The first type, *evaluation*, involves determining how well a restoration prescription or program was implemented compared to the plans. For example, were techniques applied properly and at the appropriate time, were the designated plant species used and planted according to directions?

Assessment or effectiveness monitoring, involves determining whether or not the prescription had the intended result of restoring the ecosystems. Gaboury and Wong (1999) noted that effectiveness monitoring has at least five important benefits:

- it results in more efficient allocation of effort
- it provides measures of states of recovery
- it identifies areas where research may be required
- it offers technical feedback for refining restoration techniques and approaches, and
- it provides opportunities for training in field methods and for fostering stewardship when local communities are involved

Validation provides measures of the validity of the theories upon which restoration treatments are based. It is used by researchers to test hypotheses and techniques, and it often draws upon data from long-term restoration projects. As this type of monitoring is primarily a research endeavour, it will not be covered in this publication.

Monitoring faces major challenges. Gayton (2003) pointed out the following monitoring challenges for British Columbian grasslands, but they apply equally well to Garry Oak ecosystems:

- Ecosystems vary dramatically over time and space. The magnitude of seasonal and year-to-year variation is often greater than the progressive changes resulting from a treatment.
- Locating areas that are comparable and large enough for reference sites is difficult. This is especially so in Garry Oak ecosystems because of the small natural size of patches and their historical fragmentation.
- All sites have experienced some degree of human disturbance
- Differences among observers and different applications of the same methods by different observers reduce the reliability of data

- Some species are difficult to identify
- Exclosures (fenced off areas) are key tools in measuring change, but are almost non-existent
- Long-term monitoring has problems of staffing, funding, lost plots, missing data, and damage to sampling sites from repeated activity

7.3.2 What Sites Should be Monitored?

Although it may seem necessary to monitor all sites in a restoration area with equal effort, limited resources usually preclude this intensity of monitoring. In fact, such an even-handed approach wastes or misallocates resources because this level of monitoring is usually unnecessary. The challenge is to balance the availability of resources with a level of monitoring that reliably detects changes.

Gaboury and Wong (1999) suggest three levels of monitoring that can be used to help allocate monitoring effort:

- *Routine*: relatively low intensity that uses inexpensive and rapid, routine data collection, and relies more upon indices than direct measurements. Most sites would be monitored in this way.
- *Intensive*: requires special study design with more expensive and time-consuming collection and analysis of data. Only a few sites would be monitored in this way.
- *Operational techniques refinement*: focuses on machinery, techniques, or cost efficiency. As with the intensive level, only a few sites would be monitored in this way, and the focus would be on techniques rather than on the success of the restoration.

This approach of dividing sites into different levels of monitoring effort can be used also if more

Biologist Tracy Fleming conducts a vegetation survey at Somenos Garry Oak Protected Area. Use of standardized protocols reduces data variability from different observers. Photo: Dave Polster than one restoration area is being monitored, e.g., all the Garry Oak restoration projects in a municipality. In this situation, perhaps all but one or two sites would receive routine monitoring, while the remaining representative sites would receive intensive scrutiny.

7.3.3 What Should be Measured?

A key step in monitoring is selecting what to measure. Most importantly, what is measured should relate to restoration objectives. For example, if an objective is to increase the cover of Deltoid Balsamroot (*Balsamorhiza deltoidea*) by 50%, then the monitoring protocol must include a technique for measuring its cover. On the other hand, if the goal is to increase the natural character and species diversity of site by removing invasive species, then a simple list of native plant species year to year might do the job.

Selecting what to measure also involves the following considerations:

- Attributes should be readily sensitive indicators of biological and physical changes that indicate whether or not restoration objectives are being met. Responsive measurables enable early detection of progress or failure and so enable prompt responses to problems. The indicator should not have a wide range of (year-to-year) variation, which would make detecting change difficult.
- Attributes should be scientifically based so that they withstand scrutiny of peers, funding agencies, and management agencies.
- Attributes should be easily measurable and unambiguously observable so that monitoring is reliable, yet kept within the bounds of time and money.
- At least several parameters should be chosen because relying on only one parameter may result in insufficient information being collected, or it may be difficult to understand.
- Attributes should include all major ecosystem components, i.e., soil, vegetation, animals, and water, as measuring only one component may overlook important changes in other components.

7.3.4 What Methods Should be Used?

Another key step in monitoring is selecting the methods that are appropriate to documenting the parameters used. Methods should be robust enough so that variation due to different observers (something that is almost inevitable!) is minimized or is measurable, so that correction factors can be used. The actual methods used will be determined largely by the level of inventory used. Thus, it is critical that the same methods used in inventory be used in monitoring so that data are comparable.

Three basic questions should be asked when selecting methods for monitoring:

1. Do the methods effectively provide accurate data on the parameters of interest?
2. Are the methods repeatable?
3. Are the methods feasible within time and cost constraints?

As noted above, all sampling methods used should follow accepted and documented protocols.

Table 7.4 Examples of qualitative and quantitative evaluation techniques used for Garry Oak ecosystems

Qualitative measures	Quantitative measures
Plan (vertical overhead) view map showing observation points and estimated vegetation coverage	Scaled vegetation map quantifying coverage areas
Vegetation (species list and qualitative abundance estimates)	Vegetation density, cover, number of individuals of a species and biomass
Fixed-point panoramic photographs	Elevation
Rainfall and water level data	Water quality and soil properties data
Wildlife use observations	Wildlife counts
Invertebrate species list and qualitative abundance estimates	Invertebrate density and distribution

Many agencies have well-developed monitoring standards (e.g., RISC). Examples and sources of monitoring standards are provided throughout this section as well as in the References Cited at the end of this chapter.

For reasons of economy and efficiency, sampling methods should be selected that allow data to be collected on more than one parameter. For example, a soil core sample can provide information on rhizome development, physical and chemical attributes, and invertebrate communities. As well, check for information collected by others, such as local universities and colleges, government agencies (local through to federal), consultants, environmental groups, and landowners. Many agencies and volunteer groups cooperate readily because they have common goals, but ensure permission is obtained before using information, and always acknowledge sources.

Selecting "the best" methods for monitoring is often overwhelming, even for seasoned restoration practitioners. Consider the following three points when selecting monitoring methods:

1. Let your objectives "drive" your selection of methods (and parameters).
2. Use several methods. Since all methods have shortcomings, using several will likely strengthen confidence in conclusions.
3. Decide if your methods should be qualitative or quantitative. Erwin (1990) suggested that quantitative methods should be used when there is uncertainty associated with the restoration technique or when success criteria are related to obtaining specific thresholds. Use qualitative evaluations in situations where success is more likely, and where performance is not tied to specific quantitative criteria. A combination of quantitative and qualitative methods can also be used effectively in the same monitoring program (Table 7.4).

Photographs taken frequently (at least annually) are one of the easiest ways to monitor changes over time, especially vegetation. Each photo in the series should be taken from exactly the same point (establish a permanent marker or a reference point such as a rock knoll) and should be precisely framed to encompass the same area taken on previous occasions. Including a vertical, brightly-painted pole of a known length within the frame allows viewers to estimate heights of ground vegetation layers. It is important to take each photo at the same time each year so that the series shows long-term vegetation trends, not seasonal changes in foliage. Taking good notes about the photo sessions is essential. Photo-point monitoring is widely used to document changes (See Hall (2002), Case Study 1, and Appendix 7.1 for further information).

7.3.5 When, How Often, and for How Long Should Monitoring be Done?

Successful monitoring programs are designed before conducting baseline studies, so that methods remain constant over the various phases of the project and costs are minimized. Timing, frequency, and duration of monitoring are influenced by the ecosystem type and its complexity, the uncertainty of restoration methods used, and study objectives. Sometimes controversial projects require a higher degree of scrutiny which increases the level of monitoring effort needed. Seasonality must also be taken into consideration. For example, if a particular plant species is conspicuous only during spring flowering, sampling must be conducted at that time.

Successful monitoring programs also have a systematic timetable that includes a start date, the time of the year when field work will take place, the frequency of field work, and the end date for the program.

Monitoring of restoration and associated reference sites can be performed in two ways: 1) by concentrating all tasks during a single site visit, or 2) by carrying out one task or a similar set of tasks at several sites in a single day. The second strategy is preferable, because it minimizes seasonal effects and variability in conditions from day-to-day. Repeating the same task on the same day may save time. However, it is not always practical if sampling sites are far apart or difficult to access. Sampling of specific parameters in reference areas should be done at the same time of year as sampling in restored areas.

Frequency of sampling can vary within years as well as among years. In general, new ecosystems

Table 7.5 Monitoring plans for selected Garry Oak restoration projects

Study area	Monitoring frequency	Monitoring indicators	Sources and notes
Anniversary Island (polygon B)	Annually for four years	Changes in cover of native vascular plants	Parks Canada Western and Northern Service Centre (2008a)
Eagle Island	Twice annually (April, September) for four years		Parks Canada Western and Northern Service Centre (2008b)
Somenos Garry Oak Protected Area	Annually for both general vegetation and rare species	Rare species number of individuals and changes in vegetation	Roemer (2004)
Mill Hill Regional Park	Annually	Changes in the number of plant species and their abundance	Maslovat (2009)

change rapidly and should be monitored more often than older ones. This is especially true for ecosystems for which success is highly uncertain. By sampling more often, deviations from the expected stages of development may be corrected more easily than those allowed to progress further. As the system becomes established, it is generally less vulnerable to disturbances, and monitoring can be done less frequently.

Determining the duration of the monitoring program is a challenging issue. In general, monitoring should extend beyond the period of most rapid change and into the period of stabilization. Monitoring over this time period will enable the success (or failure) of the restoration plan to be assessed. New, constructed ecosystems that start with no vegetation take a longer time to develop than systems in which only minor adjustments of existing habitats are necessary.

Beyond the initial period of rapid development, sampling frequency can change from once or more per year to once every few years. The timing of this adjustment depends on the response of the ecosystem to restoration and the degree of impact restoration activities have on the site. Less frequent sampling (once every several years) is appropriate if the ecosystem response is considered appropriate and stabilizing, but more frequent sampling (every year or several times each year) is appropriate when ecosystems depart from expected pathways or significant changes continue to occur annually. Table 7.5 provides examples of monitoring plans.

Garry Oak ecosystems are the result of disturbance regimes, therefore monitoring must address changes resulting from either re-establishment of the disturbance regime or some surrogate, or provide corrections to account for the lack of historical disturbance regimes. Low-intensity fire is considered the dominant disturbance regime of Garry Oak ecosystems so where fire is not re-introduced, some means of accounting for the lack of fire needs to be incorporated with the monitoring program.

SOME FINAL POINTS TO REMEMBER:

- Make sure you have enough money or committed human resources
- Make sure the monitoring stage is explicit in the plan
- Include a compulsory monitoring report that includes evaluation and assessment and makes recommendations

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Appendix 7.1

Photo-point Monitoring Protocols and Analysis Methods Used in Restoration Monitoring at Fort Rodd Hill National Historic Site

The following protocols have been adapted from the 2010 annual report for restoration at Fort Rodd Hill National Historic Site (Carere et al. 2010).

Camera Calibration and Photo Monitoring Instructions

CAMERA INFORMATION

CAMERA: CANON 30D

LENS = 24 MM FIXED LENS

ISO = HOW SENSITIVE THE SENSOR IS TO LIGHT (RANGE OF 100–1600)
Generally we want a low ISO (range of 200–800)

APERTURE = THE SIZE OF THE HOLE LETTING LIGHT THROUGH
A higher aperture # = *smaller* aperture (hole size)
The higher aperture # the more the image is in focus
Generally, below 3 is not good (hole too wide)

SHUTTER SPEED: 60 (1/60TH OF A SECOND) IS STANDARD
A faster shutter speed will be needed to take a sharp photo on windy days.
A lower shutter speed should be avoided, but may be neccesary when under dense canopy

AUTO EXPOSURE BRACKET (AEB):
Used to capture the image with 3 exposure levels to minimize the loss of data or need to retake photos due to overexposed or under exposed shots

CAMERA SETTINGS

- Focus set to 10 metres (done by rotating the lens)
- Mode is on “P” for program
- Set bracketing to automatically take 3 different exposures
- Menu button: select AEB (auto exposure bracket), adjust until 3 exposures (–1, 0, +1) are underlined, push enter and exit Menu (this needs to be redone every time the camera is turned off).
- Take images as RAW + Large JPG files (RAW files are used for high quality editing/analysis though large JPG files have been typically used for photo analysis)

SETTING UP THE TRIPOD AND LINING UP THE PHOTOGRAPH

- Centre the tripod according to the description and/or marker in photo-point binder

- Measure the appropriate lens height and level the tripod. New photo points should be set up with the lens at a standard 1 m height, but older photo points had a variable height which must be used for consistency.
- Check that all views can be lined up from the tripod position before pictures are taken. If photos are not lining up check that tripod is located accurately.
- Measure 10 m from tripod centre to scale pole, place the pole according to previous photos and ensuring that the pole is not leaning: this is important for analysis of the photos
- Make sure the scale pole's tripod does not obscure the camera's view of the coloured 25 cm increments (i.e., make sure you can see the edges of all the red paint marks)
- Align the left side and top of view through camera with previous photos (the focus length is slightly different with the new camera so the entire photo won't line up properly)
- Record the date, site, and view on chalkboard and place in lower left hand corner of photo. Date format: year-month-day (e.g., 2007-04-30)
- Take three photos (one at each exposure) for each view

UPLOADING AND ARCHIVING PHOTOS

Uploading and archiving of the photos should be done soon after photo-monitoring is complete in case any sites are missed or need to be redone.

PHOTO-POINT ANALYSIS DIRECTIONS USING THE PHOTO EDITOR GIMP 2.6.1

The basic idea is that a photo-point picture is opened with GNU Image Manipulation Program (GIMP) and a grid overlaid on the photo. Next grid intercepts which overlap a species of interest are marked with coloured dots and dots are automatically counted using the GIMP's built in tools. This method provides a relatively quick and easy relative abundance measure, and avoids laborious manual counting. What follows is a detailed account of how to implement this method using the free GIMP software. The analysis is based on Scotch Broom and *Camassia* spp. but can be adapted to any species which is readily identifiable at a distance in a photograph.

First you need the GIMP. It is available for a variety of operating systems including Microsoft Windows, Linux, and Mac OS X. Source code and binaries for the latest version can be found at www.gimp.org; however, most people will probably want the ready to install windows version which can be found here www.gimp.org/windows. Once you have the GIMP installed you can follow the directions below to analyze monitoring photos. Note that these instructions are based on a particular version of the software and while the process should be similar for newer versions, specific steps may be different. It should also be noted that these directions are base on a windows operating system. There is lots of help for the GIMP on-line, so if you need additional help, check your favorite search engine.

Below are step-by-step guidelines for effectively preparing and analyzing the photo-point pictures: for analysis you will be using only spring photos because these show the flowering *Camassia* spp. and Scotch Broom. You can use late-summer photos to help you determine what is or isn't broom, but note that late-summer photos have been taken after most of the plants have been removed, so they do not always show where the plants were. Next, decide which of the three exposures best shows the blooming broom and camas. Some photos may be too bright, blurry or washed out, so find the photo that will be easiest to analyze. Make note of the photo number, e.g., IMG_ 1334. In the following step you will need to know the image resolution. In Windows XP (and possibly later versions) you should be able to obtain this information by viewing the image properties from Windows Explorer or My Computer (right click on the image file, select Properties, and click the Summary tab). Make note of the photo width and height in pixels (e.g., a pixel dimension of 2048 x 1536). Alternatively this information can be obtained from most image editing software: the GIMP displays the pixel dimensions (along with other information) in the title bar of each image's window.

- **Starting GIMP:** When the GIMP is running, three windows will pop up: a GNU Image Manipulation screen and a Toolbox and Layers screen. In The GIMP dialogue box "*GNU Image Manipulation Program*", click *File–New*. A box will pop up in which you must check the pixel width and height of the photo you chose. If GIMP shows different values, change them to
  what the initial photo values are. Press *Enter*. A blank working space, "*Untitled–1.0 (RGB, 1 layer) 3504 x 2336 – GIMP*" will pop up in the main dialogue area.

- **Opening a File as a Layer:** When you open a file as a layer a new box will pop up in which you will search the drive for the file you chose in step 1. Once you find that file, double click on it or click *Open* and it will show in the *Untitled–1.0 box*. Note that at the bottom of the screen you can set the photo to various pixel magnifications. Manipulating screen size will make it easier for you to find the broom and camas

- **Saving:** In the *Untitled project dialogue* box, click *File–Save As*. Re-name the file in this format: *2011 10–1-1* (this is the year followed by the image identification number). Use the drop down menus to select for file type .xcf and save the file. Saving the file to .xcf format means that all the working layers are saved. Essentially all your work will be saved in this format.

- **Editing Brightness:** Once the photo is open you can now play with the light levels to get the photo at the right lighting. GIMP has many tools that allow you to do this. The *Levels* tool is commonly used and is located in the *Colours* menu at the top of the screen. You'll see a bell curve that has three little black triangles at the base that you manipulate. Move the far left triangle so that it is directly under the base where the bell curve hits the horizontal. The other triangles can also be manipulated. The only other tool normally used is the *Sharpen* tool, which is located under *Filters* / *Enhance* / *Sharpen*. Remember, if you want to edit the photo in any way you must first highlight that layer in the layers dialogue box. This is described below.

- **The Layers, Channels, Paths Window:** When creating a new .xcf file or opening an existing file a window should be displayed that is titled "Layers, Channels, Paths, Undo". From this window one can select between multiple layers and create new layers. In an existing .xcf file the layers that will appear will most likely be a photo layer (of the photo to be analyzed), a white background layer, an outline layer (on which the dots are placed), and several text layers that provide pertinent information.

  Layers can be renamed by double-clicking on the name (the name is to the right of the 'eye' icon). Typically photos are named to correspond to their year and season e.g., "2010 Spring." If you cannot find the layers dialogue box, use the shortcut *Crtl–L* and it will appear. The layers can be arranged so that you can see the photograph with the grid with colour dots overlaid.

The layers will be saved in the end so that you can always go back and re-work a photo without losing information.

- **Adding New Layers:** At the bottom of the *Layers* dialogue box you will see a series of icons. Click on the first one (looks like a tiny piece of paper) at the bottom left-hand corner—it will allow you to add a new layer to your project. In order to create a new "*Outline*" layer name the new layer "*Outline*" and set it to "*Transparency*". Click OK. Make sure the *Outline* layer is always above the photo layer in the dialogue box. You can drag layers to whatever location within this box. Similarly, to create a background layer create a new layer title 'Background' and set it to *white*. You can toggle between layers; whichever layer is highlighted is the one that your edits will be on. You can turn layers on or off by clicking the eye icon to the left of each layer. Make sure that all edits are made on the *Outline* layer. If, by accident, you paint on the photo layer itself and then find that you made a mistake and must erase your work, you may run into problems. Either you will end up erasing a part of the photo or you will be clicking the back button to undo your work.

- **Setting the Grid:** With the photo layer turned on, go to the bottom of the screen and increase the magnification of the photo to 200%. Navigate to the height pole in the photo and go to where you can clearly see a red increment—you are going to measure this increment in pixels (NB in this project the scale pole is 200 cm long and painted in alternating 25 cm increments). Go to the *Toolbox* and click the *Measure* tool. Move the tool over the base of where a red increment begins. Click, hold and drag the measure tool up to where the cross hairs meet the top of the red increment. You can sway the measure line with your mouse while looking at the base of the photo and watching when the degrees reach 90^o. Depress the mouse when at 90^o. The number to the left of the degrees is the number of pixels in one scale pole increment, e.g., 97.0 pixels. When setting the grid aim to have **two grid squares** per red increment. Divide the pixel number by 2. In this case the value becomes 48.5 or 48 pixels. Now click on *Image/Configure Grid.* Under *Spacing Width*, type in 48. Click in the *Height* area and it will automatically change to reflect the width. Click 'OK'. Go to *View/Show Grid* and turn that on. While you are there also turn on the *Snap to Grid.* The latter causes all pencil dots to snap directly to grid intercepts. The photo should now be covered with a calibrated fine grid overlay. You can turn the grid on and off from the main menu when needed. Reset the photo magnification to 100% or to whichever magnification allows you to determine where the Scotch Broom or *Camassia* spp. are located.

- **Tracing the Scale Pole:** Trace the height pole as a reference in the final map. To do this, make sure that the *Outline* layer is turned on. You might want to magnify the photo first. Use the pencil tool at brush size 01 set to black and with *Fade Out* turned off in order to outline the height pole and its increments. Do not trace the tripod. To make a straight line, first click at the top of the pole and release the mouse button; remember to turn off the *Snap to Grid* setting to ensure smooth tracing. Click and hold the Shift key while moving the mouse to the base of the pole. Click the mouse and let go of the shift button. You may need to move the line back and forth somewhat in order to get a straight line before you make the final click. Repeat this procedure to complete the pole and its increments. Use the *Bucket Fill Tool* set at red to fill in the increments.

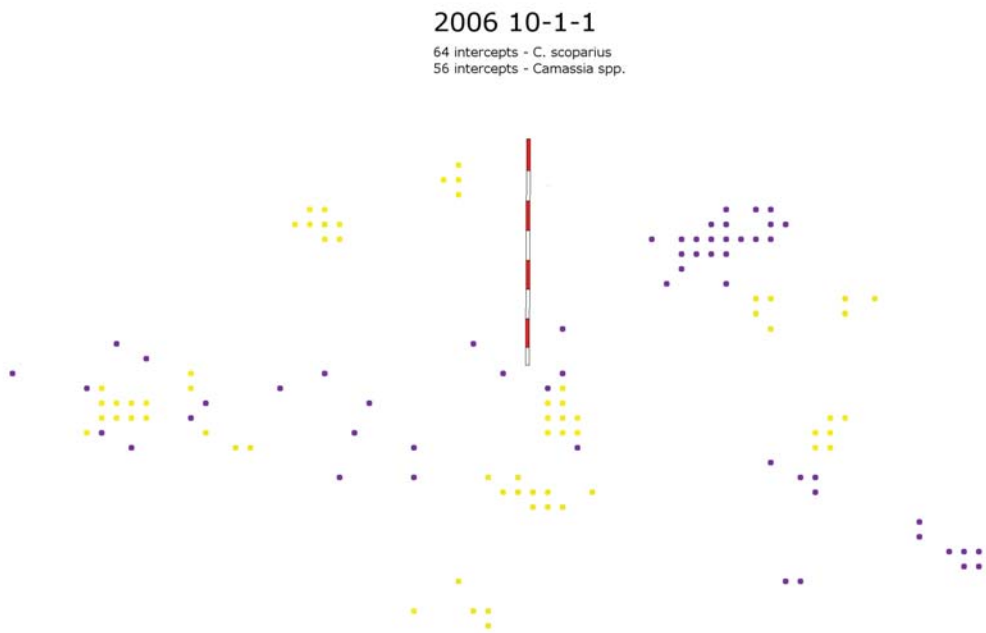

Figure A7.1. Example of final analysis map. Purple dots indicate grid intercepts with *Camassia* spp., and yellow dots indicate grid intercepts with Scotch Broom (*Cytisus scoparius*).

- **Selecting and Calibrating the Pencil Tool for Dots:** Go to Tools and click on the *Pencil Tool*. You will see two colour boxes. Change the top box to the appropriate colour: yellow for Scotch Broom and purple for *Camassia* spp. Once you have set the colour, it is available to you in the colour chart throughout the session. Under *Pencil Opacity*, leave the value at 100.0. You will have to experiment to find a suitable brush size for your photos. Brush sizes used for analyzing the Fort Rodd Hill photos are as follows: when analyzing photos from 2003 to 2006, use **brush size 11** (**pixel size 109**). When analyzing photos from 2007 onward, use **brush size 17 (pixel size 241).** Click on *Fade Out*. Turn on the *Outline* layer. It is very important for the next steps that all your coloured dots are the same size.

- **Adding Coloured Dots:** Make sure the grid is turned on and the *Snap to Grid* option is selected. Search the photo for any instance where a grid intercept is crossed by Scotch Broom or *Camassia* spp. Make sure the *Pencil Tool* is turned on and calibrated and that the *Outline* layer is activated. Create a dot on the intercept to mark where the plant crosses; flowers, stalks, and leaves can be counted when they cross an intercept. Make sure the dot snaps to the intercept (grid crossing). Remember, sometimes you have to increase the magnification or play with the lighting in order to more clearly see where the plants are located. Scotch Broom tends to have a characteristic shape and green shade and is typically distinguishable from other plants.

  TIP: Load the different exposures of the same photo-point photograph as layers. In some cases you might find it useful to add a photo from another season as a layer for reference.

- **Counting Pixels:** Once you have placed all the yellow and purple dots at corresponding intercepts, they can be counted. The program uses a histogram function that counts pixel colours. This saves you eye strain and time. The *Pencil Tool* makes it so that the dot you are using has a solid outline. This means that only pure yellow and purple dots are counted. Make sure you know the number of pixels within one dot of your chosen brush size. To do this you can use the *Fuzzy Select* Tool. Under the attributes of this tool change the *Threshold* to 0. Select one of the colour dots; the dot will be outlined. Go to the main menu and click on *Windows/Dockable Dialogue/Histogram*. To unselect dots go to the main menu *Select/None*. For example: Brush Size 11 (2003–2006) = 109 Pixels Brush Size 17 (2007–present) = 241 Pixels. If you already have all the dots placed and you know the pixel number per dot, then use the *Select by Colour Tool* located in the toolbox. Under the attributes make sure that the threshold is set to zero. Click one dot on the photo and all the dots of that colour will be highlighted. Go to *Dockable Dialogue/Histogram* again and note the number of pixels e.g. 3615 for a size 17 brush (241 pixels). Divide the total number of pixels by 241 and the final value is your relative abundance count for Scotch Broom or *Camassia* spp. for that photo. In this case, the count is 15. You can record these relative abundance counts in your spreadsheet and perform further analysis.

- **Final Touches:** You should now have an outline layer that shows all the Scotch Broom or *Camassia* spp. intercepts and the traced height pole with red increments. Create new text layers that specify the photo title (ex. 2011 10-1-4) as well as the intercept count number for Scotch Broom or *Camassia* spp. Make the 'photo' layer invisible. Make sure all text and number layers, as well as the outline layer, are turned on before you save this file. All layers will be saved in the program layer dialogue box so that you can go back and re-analyze later if needed. Save the file as a .xcf file in this format: *2011 10-1-4*. You can also save it as an exported jpg. Figure A7.1 shows an example of what the final map should look like. Make sure all final maps are well organized in the file directory.

A COMMON SOURCE OF ERROR: FOREGROUND VS BACKGROUND PLANT COUNTS

One obvious issue is that plants in the foreground of the picture will increase the intercept counts more so than those in the background, even if those in the background may be larger and/or more abundant. Due to the fact that we are analyzing a three dimensional representation as if it had only two dimensions issues will arise as varying depths of field and natural obstructions hinder the ability to accurately state the relative abundance of these plants. This is the primary downfall of this technique; however, when comparing individual photo-point views over multiple years this issue appears to be less influential as the obstructions in the individual views generally remain constant.

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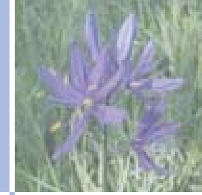

Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

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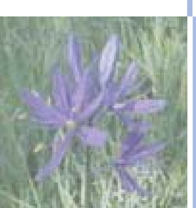


Chapter 8

Restoration Strategies

by Dave Polster

Community groups can remove large quantities of Scotch Broom (*Cytisus scoparius*) from invaded Garry Oak sites, allowing the herbaceous layer to recover. Here a team is removing broom from Beacon Hill Park. Photo: Dave Polster

8.1 Introduction

8.1.1 Holistic Ecological Restoration

Ecological restoration is defined by the Society for Ecological Restoration International as "the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed" (SERI 2004). Restoration therefore consists initially of identification and remediation of those elements that are causing the degradation. Although in some cases this may be all that is needed to re-establish the successional trajectory that provides a pathway to recovery (Walker et al. 2007), with Garry Oak ecosystems, degrading processes are complex and the degradation that has been caused is equally complex (See Chapter 3: Natural Processes and Disturbance, and

Holistic ecological restoration includes the social and cultural values that are essential for the recovery of a site.

Chapter 9: Alien Invasive Species). This chapter explores the various physical and biological attributes of Garry Oak ecosystems that have been degraded and the measures that are being used to address these issues.

Holistic ecological restoration has been described by Clewell and Aronson (2007) as including the social and cultural values that are essential for the recovery of the site. With Garry Oak ecosystems there are historical social and cultural values (Chapter 2: Distribution and Description) as well as contemporary values (Chapter 6: Outreach and Public Involvement) that influence restoration of these ecosystems. In addition, there are spiritual values (not religious, but spiritual *sensu* Henry David Thoreau or Aldo Leopold) that connect many people with Garry Oak ecosystems. Although social and cultural values are discussed in greater detail elsewhere in this publication, mention of them is made here to help provide the framework for the discussion of restoration strategies.

8.1.2 Role of Social and Cultural Attributes of Garry Oak Ecosystems

Garry Oak ecosystems were maintained by the activities of First Nations prior to the arrival of Europeans (Chapter 2: Distribution and Description and Chapter 3: Natural Processes and Disturbance). Complex social and cultural practices were responsible for creation of the ecosystems that greeted the European settlers. Although it is unlikely that these practices can be re-established on a landscape level, within specific sites knowledge of the historical practices can assist in creating the conditions of ecological disturbance (or suitable alternative processes carried out on the site) that maintained the pre-contact flora and fauna of these ecosystems.

Contemporary social and cultural values influence the ecological conditions of Garry Oak ecosystems. Although most (95%) of the pre-contact Garry Oak ecosystems have been lost to urban and suburban growth and agriculture, those that remain are treasured parts of the local landscape. Many local parks and ecological reserves protect fragments of former Garry Oak ecosystems. Most of these have been degraded to the point where restoration is essential if the values (spring flowers, species at risk, open landscapes, etc.) that comprise these favoured landscapes are to be retained.

The social and cultural aspects of Garry Oak ecosystems, both historical and contemporary, are important contributors to the development of ecosystem restoration strategies. Re-establishment of disturbance regimes (Chapter 3: Natural Processes and Disturbance) and the constraints that current ecosystem use places on restoration activities must be incorporated into strategies for restoration. Similarly, the pressures that society places on these ecosystems need to become part of the fabric of the ecosystem restoration designs. Therefore, the social and cultural aspects of Garry Oak ecosystems are interwoven with the ecological aspects in the discussions of restoration strategies presented below.

8.1.3 Structure of Chapter 8

Effective restoration strategies are founded on an understanding of the ecosystem in which the restoration is to occur. For this reason, the following section on the selection of reference ecosystems, and the Restoration Ecosystem Units that have been described in Chapter 2, play a pivotal role in the design of restoration strategies (see Section 8.2 below). Similarly, the features that constrain the recovery of the ecosystem must be addressed for effective restoration. These constraints are therefore discussed in Section 8.3. Section 8.4 describes strategies that have been applied to the restoration of Garry Oak ecosystems using the analogy of re-stitching the fabric of the ecosystem. This analogy provides a useful framework to understand how these complex ecosystems can be re-built, as well as the disturbance regimes that sustain them. The importance of disturbance elements is reflected in the fact that a specific section of this chapter (8.5) is devoted to discussing how the disturbance elements described in Chapter 3 can be incorporated into restoration strategies. Finally, as recognition of the complexity of the tasks associated with restoration of Garry Oak ecosystems grows, the need to measure where we are along the path becomes apparent. Section 8.6 provides a brief overview of monitoring systems that can be employed. This topic is more fully discussed in Chapter 7: Inventory and Monitoring.

8.2 Selection of Reference Ecosystems

Understanding how ecosystems are put together allows us to fashion strategies for restoration when the ecosystems become damaged. Reference ecosystems provide a roadmap that shows how the ecosystem is put together. Unfortunately, there are few Garry Oak ecosystems that have not suffered some form of degradation, from fire management to invasive species establishment (see Chapter 3: Natural Processes and Disturbance). The reference ecosystems for Garry Oak restoration therefore must be composed of a composite description (SERI 2004) derived from a wide variety of sources.

Historical photographs can be used to give us a "picture" of how Garry Oak ecosystems once looked. Similarly, historical mapping of the extent of Garry Oak ecosystems (Lea 2006) can be used to show the relationships of Garry Oak ecosystems to other landscape elements. Archaeological and ethnobotanical studies (Turner 1995, 1998; Beckwith 2005) can help us

Historical photos, such as this one taken in Beacon Hill Park circa 1890, can be used to help determine what Garry Oak ecosystems looked like in the past, or to help define restoration goals. Image G-01564 courtesy of Royal BC Museum, BC Archives understand the context in which Garry Oak ecosystems existed and the management elements that maintained them. These historical sources can help in the formation of a composite description of Garry Oak ecosystems for restoration purposes.

Ecosystem classifications (see Chapter 2: Distribution and Description) can be valuable as models of how the various Garry Oak ecosystems align themselves on the landscape. Eight Restoration Ecosystem Units (REUs) have been defined (Table 2.2 in Chapter 2). The processes that sustain these ecosystems differ, therefore restoration strategies differ among them. These different processes and strategies are discussed in the following sections along with examples of reference ecosystems.

8.2.1 Deep Soil, Average Moisture Garry Oak Communities (REU #1)

There are no ideal examples of mesic, deep soil Garry Oak ecosystems that we can use as reference ecosystems. However, historical photos, as well as some sites where alterations were relatively minor, can serve as references for these ecosystems. In some cases, native Garry Oak species may start to re-appear once grazing has been halted. In other cases, cultivation of these ecosystems has significantly altered the soils and replaced any native vegetation with agronomic hay and pasture species. Some of our most troubling invasive grasses (see Chapter 9: Alien Invasive Species) were introduced to “improve” deep soil Garry Oak ecosystems. There may have been sites where historical cultural practices created camas (*Camassia* sp.) gardens with limited inclusions of other species.

The structure of the vegetation in some of the deep soil Garry Oak ecosystems has shifted dramatically from an open grassy savannah to a shrub-dominated cover with Common Snowberry (*Symphocarpos albus*) in mesic areas and Nootka Rose (*Rosa nutkana*), Indian-plum (*Oemleria cerasiformis*) and Oceanspray (*Holodiscus discolor*) in wetter areas. These alternative more stable

A patchwork of vegetation conditions from open meadows to shrubby woodlands often characterizes deep soil Garry Oak ecosystems, like the ones that exist at the Cowichan Garry Oak Preserve’s lower camas meadow. Photo: Dave Polster states can be challenging to deal with (Hobbs and Suding 2009) as species compositional changes may have led to shifts in the soil mychorrizal conditions[1] that would be required for the historical ecosystem to re-establish. In some cases, historical management is thought to have created a patchwork of open savannahs coupled with sites where shrubby vegetation dominated. Although the assumed patchwork of deep soil Garry Oak sites may be largely conjectural, several existing sites show this patchy pattern of open meadows and shrubby woodlands, and it may be that re-establishment of patchy burning would allow this condition to be established.

8.2.2 Deep Soil, Wetter Garry Oak Communities (REU #2)

The deep soil, wetter (subhygric to hygric) Garry Oak sites become very shrubby in the absence of fire or other management treatments. Dense stands of Nootka Rose, Common Snowberry, Indian-plum and Oceanspray can form in these areas. Understorey species can include extensive stands of White Fawn Lily (*Erythronium oregonum*), Chocolate Lilies (*Fritillaria affinis*), Blue Wildrye (*Elymus glaucus*), and California Brome (*Bromus carinatus*). These sites will readily revert to very productive Douglas-fir (*Pseudotsuga menziesii*) sites where fire or other management techniques have been excluded. Historically, they would have been the very productive camas meadows cultivated by local First Nations. These stands tend to occur in areas adjacent to streams and water-ways where transportation would allow effective camas harvest. In some cases, such as at the Somenos Garry Oak Protected Area in the Cowichan Valley, this vegetation type can be flooded in the winter.

8.2.3 Shallow Soil Garry Oak Communities (REU #3)

Shallow soil Garry Oak ecosystems comprise the largest area of Garry Oak ecosystems at present due in no small part to the fact that they were not suitable for agriculture. In addition, because this type of ecosystem can occur in obscure locations such as the tops of mountains and on steep mountain slopes, some of the shallow soil, rocky Garry Oak ecosystems are relatively pristine.

It is fortunate that these ecosystems are relatively more common than their deep soil counterparts as the shallow soil sites are very complex with species compositional changes occurring over very small distances in relation to moisture gradients associated with the near-surface bedrock. This ecosystem complexity creates issues for restoration and in the formulation of reference ecosystems as the ecological processes that underlie the complexity may be equally complex. For instance, nutrient transfer and/or export would be expected to be complex where moisture flow patterns are complex. Issues associated with changes in nutrient status of Garry Oak ecosystems are discussed below.

8.2.4 Shallow Soil Seepage Communities (REU #4)

The seepage zones on rock outcrop sites have developed a unique flora of annual species such as Small-flowered Blue-eyed Mary (*Collinsia parviflora*) and Chickweed Monkey-flower (*Mimulus alsinoides*) that germinate and grow over the winter and early spring, setting seed prior to

1 Soil mycorrhizae are networks of underground fungi that have been shown to promote plant growth and soil health in many ecosystems.

The relatively pristine Eagle Heights grasslands are representative of the shallow soil, rock outcrop ecosystems. Unlike most rocky Garry Oak sites in more urban areas, this site has never been invaded by Scotch Broom. Photo: Dave Polster

summer drying, or species such as Common Camas (*Camassia quamash*), Fool's Onion (*Triteleia hyacinthina*), and Harvest Brodiaea (*Brodiaea coronaria*) that retreat to bulbs during the later summer dry period. These sites are found in close proximity to the rock outcrop sites and restoration treatments that are good for one are suitable to the other, such as removal of invasive species. Care should be taken to ensure that seepage zones are maintained; the water that feeds the groundwater system from slopes above these plant communities should not be diverted.

8.2.5 Maritime Meadow Communities (REU #5)

The maritime meadow communities and the coastal bluff communities (Section 8.2.7) share many of the same features although the maritime meadow communities are generally flat or gently sloping, while the coastal bluff communities are located on steep slopes. Both occur along the coastline and are influenced by saline sprays during winter storms. Species such as Tufted Hairgrass (*Deschampsia cespitosa*) that are salt-tolerant can be an important part of the fabric of these ecosystems which feature Common Camas, Barestem Desert-parsley (*Lomatium nudicaule*), and Woolly Sunflower (*Eriophyllum lanatum*) as common herbaceous species.

8.2.6 Vernal Pool Communities (REU #6)

Vernal pools can be important contributors to the rare species flora of Garry Oak ecosystems. Although these communities have no trees or shrubs, the presence of standing water during the winter and into the spring can be an important habitat in the life-cycle of a variety of plants and animals. One of the major threats to vernal pool communities is blasting for new home construction in adjacent areas that opens drains, reducing the water-holding ability of the pools.

8.2.7 Coastal Bluff Communities REU #7)

Coastal bluff communities are strongly influenced by their ocean-side location. They are similar to the maritime meadows communities but are found on steep either rocky or till slopes. The

Blasting adjacent to the Mount Tzuhalem Ecological Reserve may allow seepage water to drain more quickly than prior to the excavation, thus changing the ecological conditions of ephemeral pools in upslope areas. Application of bentonitic clay slurry can help to seal such sites although the ability of vernal pools to dry up later in the summer can be important. Re-establishing pre-disturbance hydrologic conditions may be very difficult. Photo: Dave Polster

active nature of these communities, due to winter storms, has resulted in a variety of rare species (see Chapter 4: Species and Ecosystems at Risk) occurring on these sites. The harsh physical conditions of the sites and fear of excessive erosion have prompted some well-meaning civic site managers to introduce invasive species such as Gorse (*Ulex europaeus*) and Tree Lupine (*Lupinus arboreus*) (see Chapter 9: Alien Invasive Species) to some of these sites. Recognition that it is the erosion that actually preserves the conditions required for the rare species may allow future acceptance of this natural process.

8.2.8 Douglas-fir Communities (REU #8)

In the absence of fire or other active management treatments (mowing or cattle grazing), deep soil Garry Oak sites can shift to become Douglas-fir forests. The Coastal Douglas-fir Biogeoclimatic Zone (CDF) is the smallest zone in British Columbia and is threatened by many of the same factors as the Garry Oak ecosystems. Restoration of CDF forests, however, is easier than Garry Oak ecosystems because successional processes can be used to restore CDF forests. If pioneering species such as Red Alder (*Alnus rubra*) and Bigleaf Maple (*Acer macrophyllum*) are planted in Garry Oak ecosystems, the Garry Oak stage of succession will be missed and the ecosystems will move directly to CDF forests. Natural successional models can provide an effective framework for the treatment of degraded CDF forests. Many of the alien invasive species that are a problem in Garry Oak ecosystems (broom, blackberry, Gorse, etc.) are not shade tolerant and will be immediately lost if a dense cover of pioneering Red Alder and/or maple (*Acer* spp.) is established. Similarly, although CDF forests can eventually move towards a later successional stage of Western Redcedar (*Thuja plicata*) and Western Hemlock (*Tsuga heterophylla*) in the absence of fire, this process takes many hundreds of years. By contrast, in a few decades many deep soil Garry Oak ecosystems will become CDF forests.

One of the most important components in the development of restoration strategies is to identify the constraints preventing recovery.

Removal of Scotch Broom in Mount Tzuhalem Ecological Reserve has allowed recovery of these beautiful flower meadows. Sites that have been heavily invaded by introduced species may have passed a threshold where recovery without significant interventions is improbable (Hobbs and Suding 2009). In these cases, restoration may take on the characteristics of agriculture using native Garry Oak species. This section reviews the common filters that limit the unassisted recovery of Garry Oak ecosystems. Photo: Dave Polster

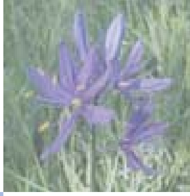
8.3 Constraints to Restoration

One of the most important components in the development of restoration strategies is to identify the constraints preventing recovery (Clewell and Aronson 2007). In some cases, the constraints act as ecological filters[2]. Where degradation is limited, removal of filters such as invasive species can allow Garry Oak ecosystems to recover most, if not all, of the features and functions of unimpaired reference ecosystems (see photo of Mt. Tzuhalem Ecological Reserve, above).

8.3.1 Invasive Species

The International Union for the Conservation of Nature (IUCN, www.iucn.org) has concluded that invasive species are the second most common cause of ecological degradation after habitat alienation. Within Garry Oak ecosystems, dealing with invasive species is commonly the major restoration activity. Chapter 9 provides details of invasive species management strategies for Garry Oak ecosystems. The following sections present considerations for dealing with invasive species, both native and introduced, within the context of restoration.

2 The term “filter” in ecological restoration is used to describe how ecological conditions allow certain species to thrive while filtering out others.



Native Invaders

The cessation of burning, both cultural burning and natural fires, has allowed a variety of native species to establish (see Chapter 3: Natural Processes and Disturbance). Similarly, pasturing of livestock on Garry Oak ecosystem sites can result in an increase in the cover provided by the native shrub snowberry. Where Garry Oak ecosystems have included a component of Douglas-fir, the cessation of burning allows the Douglas-fir to fill in the open areas and to choke out the Garry Oaks as well as to eliminate understorey species. Although removal of the Douglas-fir is a relatively simple procedure, cutting trees in protected areas can cause concern with local residents and natural history clubs (see Chapter 6: Outreach and Public Involvement). Also, large quantities of biomass must be disposed of if significant in-growth by Douglas-fir has been allowed to occur. Girdling the trees is an alternative to cutting them down (see photo below).

Where Garry Oak ecosystems have included a component of Douglas-fir, the cessation of burning allows the Douglas-fir to fill in the open areas and to choke out the Garry Oaks as well as to eliminate understorey species.

Alien Invasive Species

Alien invasive species can create significant obstacles to effective restoration. Chapter 9 provides a detailed discussion of alien invasive species; however, it is useful to consider this filter here in the context of restoration strategies. Changes in stand structure associated with the establishment of evergreen alien invasive shrubs such as Scotch Broom (*Cytisus scoparius*) may change ecological processes, such as spring soil warming, that influence native species germination and growth. Similarly, changes in nutrient status associated with broom growth can influence the species composition of Garry Oak ecosystems (Shaben and Myers 2009). Phytotoxins associated with Scotch Broom can also influence the species composition in areas where broom has established. These changes can make it difficult to restore sites that have been heavily invaded by broom.

The absence of fire in Garry Oak ecosystems is allowing Douglas-fir to establish to the exclusion of the ecosystems. Removal of the encroaching trees is the first step in reversing the degrading element. The photo shows girdled Douglas-fir trunks in Mt. Tzuhalem Ecological Reserve. Photo: Carolyn Masson

Introduced species such as Himalayan Blackberry (*Rubus armeniacus*) can create significant ecological changes by providing habitat for invasive animals, such as introduced Eastern Cottontail rabbits (*Sylvilagus floridanus*) and native Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*) (Gonzales and Clements 2010). These herbivores are protected from predation by the invasive shrubs while at the same time they reduce populations of native plants (e.g., spring forbs) through grazing. Similar problems can arise with snowberry and other native shrubs that have established in response to grazing and changes in fire frequency.

Alien invasive grasses can be the most perplexing invasive species to deal with in Garry Oak ecosystems. On rock outcrop sites, species such as Silver Hairgrass (*Aira caryophyllea*) and Early Hairgrass (*Aira praecox*) can germinate and occupy sites in the winter, thus precluding native winter annuals like Sea Blush (*Plectritis congesta*) or Small-flowered Blue-eyed Mary. Similarly, on slightly deeper soil pockets, invasive grass species such as Hedgehog Dogtail (*Cynosurus echinatus*) or Sweet Vernalgrass (*Anthoxanthum odoratum*) can compete with a wide variety of native Garry Oak ecosystem plants. In deep soil areas, Common Velvet-grass (*Holcus lanatus*), bluegrasses (*Poa pratensis* and *Poa compressa*), Red Fescue[3] (*Festuca rubra*), and Orchard-grass (*Dactylis glomerata*) can replace native grasses and forbs. The sod-forming bluegrasses and Red Fescue can create a dense turf that precludes growth of most other species. In addition to the physical space occupied by invasive grasses, changes in thatch accumulation can have a significant impact on the characteristics of fires (e.g., fires that burn faster and hotter) should these be re-introduced.

Management of Invasive Species

Management of invasive species may be one of the major restoration activities undertaken in Garry Oak ecosystems. Additional details on management strategies that can be applied to specific species within specific ecosystems are provided in Chapter 9: Invasive Alien Species. Within the context of restoration, the primary consideration is to deal with the invasive species without changing the ecological processes that are the focus of the restoration efforts. Opportunities to change the successional status[4] of the degraded ecosystem and thus avoid the conditions favouring invasive species are limited in Garry Oak ecosystems. Where burning is used to create early succession communities of camas and other spring flowers, successional distancing (Polster 1994) can be an effective management strategy. Successional distancing is the process of creating an early seral community such as a burned Garry Oak meadow, right next to a later successional community such as a Douglas-fir forest where there is no ecological space for the invasive species. In these situations, care must be taken to ensure that there are appropriate native species that can occupy the space opened by the burning, otherwise invasive species will re-occupy the sites (MacDougall 2002). Although species replacement (replacing the invasive species with appropriate native species) is critical to the success of any invasive species management efforts, the other key element for success is persistence. Plans should be developed for management efforts to be continued over many years.

3 There are both native and exotic forms of Red Fescue.

4 Successional status is an important factor to evaluate in ecological restoration; early successional communities tend to be dominated by pioneer plant species, often annuals or plants with rapid growth rates, that colonize an area immediately after disturbance or prefer regularly disturbed habitats, while later successional communities feature plants that grow more slowly and tend to be perennials.

Case Study 1. Restoration of Garry Oak Ecosystems Degraded by Invasive Grasses and Ungulates on Salt Spring Island

by David R. Clements

The 30 ha Crow's Nest Ecological Research Area (CNERA) on Salt Spring Island includes extensive shallow soil Garry Oak meadows. The meadows feature a diverse community of typical Garry Oak forbs such as Hooker's Onion (*Allium acuminatum*), Harvest Brodiaea (*Brodiaea coronaria*), Small-flowered Blue-eyed Mary (*Collinsia parviflora*), Common Camas (*Camassia quamash*), Chocolate Lily (*Fritillaria affinis*), Yellow Monkey-flower (*Mimulus guttatus*), Sea Blush (*Plectritis congesta*), and Fool's Onion (*Triteleia hyacinthina*). The Propertius Duskywing (*Erynnis propertius*), a butterfly that is Blue-listed in British Columbia, is also present.

Feral sheep. Painting by Briony Penn

However, the meadow forbs are sparsely distributed within abundant non-native grasses, particularly Sweet Vernalgrass (*Anthoxanthum odoratum*), Hedgehog Dogtail (*Cynosurus echinatus*), and Orchard-grass (*Dactylis glomerata*). Furthermore, selective grazing pressure by Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*) and feral sheep promotes dominance by these grasses (Gonzales and Clements 2010).

In 2003, a 5-year study was initiated at CNERA to examine three restoration techniques: grazing exclusion, mowing, and planting of native species. Fifty-six 1 m x 1 m plots were set up in the meadows, with half of them (28) enclosed to prevent grazing. The exclosures consisted of aluminum frames fitted with fishnet mesh that prevented grazing by ungulates but did not exclude light or small mammals. Half of the plots in each category were mowed to complete a two-factor factorial design. Plots were moved in the beginning (October/November) and end (July/August) of the growing season each year, with this timing designed to minimize disturbance to native plants, many of which are perennials that emerge from bulbs in the spring.

> Within the context of restoration, the primary consideration is to deal with the invasive species without changing the ecological processes that are the focus of the restoration efforts.

Four native plant species were planted in each of the 56 plots in 2003 (Gonzales and Arcese 2008): Garry Oak (*Quercus garryana*), Arbutus (*Arbutus menziesii*), Common Camas, and Sea Blush. Biomass of these and other plant species found in the plots was evaluated after three years along with other measures to evaluate responses to the treatments.

Ecologists have often theorized that competition by invasive species is the chief driver of habitat degradation in invaded habitats. From this presumption, a restoration prescription of mowing alone should provide substantial restoration benefits in Garry Oak ecosystems, by removing invasive grass biomass. Yet recent evidence, drawn chiefly from Garry Oak ecosystems, suggests that invasive species are not the drivers of degradation, but rather the passengers (MacDougall and Turkington 2005).

Indeed, results of the research at CNERA showed that herbivory was more limiting than competition on early and established native plants in invaded Garry Oak meadows (Gonzales and Arcese 2008). Thus, in this case mowing twice yearly over several years had some impact on the invasive grasses, but exclosing grazers had much more impact. The recommendation is therefore that the two restoration techniques be combined for maximum impact (Gonzales and Clements 2010). Just as mowing on its own did not produce the desired result for restoration, fencing alone also increased proportional biomass of non-native perennial grasses.

The third restoration technique attempted in this case study at CNERA on Salt Spring Island also provided promising results. Although the Garry Oak and Arbutus seedlings that were planted largely perished due to a drought year, Common Camas and Sea Blush responded favourably to the combination of mowing and fencing. Sea Blush densities increased greatly over three years within exclosed plots, reaching the highest densities where mowing also occurred. Common Camas bulb mass also increased in exclosed plots, in both mowed and unmowed exclosures.

The evident impact of grazing on Sea Blush and Common Camas substantiates the claim that deer and sheep selectively forage on Garry Oak meadow forbs, potentially reducing the diversity of the plant community. We further tested this selectivity by looking at herbivore forage preferences in 16 0.5 m x 0.5 m plots via stem counts (Gonzales and Clements 2010). Out of 9,307 stems counted, 12% were browsed. Relative to availability, native perennial forbs were more frequently browsed than any other plant group, with Harvest Brodiaea and Fool's Onion topping the list.

We also looked at the seasonal activity of ungulates in the meadows through a pellet census, and found that March was a peak period of pellet deposition, with more than twice as many pellets counted than in the other 4 months surveyed (November, February, July, and August). Most of the key meadow species flower in March-April, so they are particularly vulnerable to browsing during the time of peak activity by ungulates (Gonzales and Clements 2010).

On many of the islands where Garry Oak ecosystems occur, there is an absence of carnivores such as wolves, bears, and cougars that once regulated ungulate populations. Even though Columbian Black-tailed Deer are a native species, they may have a large impact on Garry Oak plant communities on islands where deer are extremely abundant. As this case study on Salt Spring Island has shown, restoration measures to exclude ungulates, at least seasonally (e.g., in spring) may represent a key component of restoration strategies. If populations of native forbs are relatively sparse, propagation of native species may also be a crucial element in diversifying plant communities dominated by invasive grasses (see Chapter 10: Species Propagation and Supply).

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Dogs walking along the edge of this coastal bluff ecosystem in Macaulay Park have created a worn trail, causing excessive erosion and opening the area to invasion by alien species. Photo: Dave Polster

8.3.2 Urban Settings

The fact that 95% of Garry Oak ecosystems in Canada have been lost to urban expansion and habitat alienation[5] creates various stresses on the remaining Garry Oak sites that largely exist within urban settings. This section presents some of the common constraints to recovery of these ecosystems as well as some strategies that can be applied to address them.

The fact that most Garry Oak sites are located in urban areas provides an opportunity for local stewardship groups to be involved in protection and restoration of these special areas (see Chapter 6: Outreach and Public Involvement). Inclusion of the local community in stewardship of the ecosystems is an important part of holistic ecological restoration (Clewell and Aronson 2007).

Human and Dog Use

Garry Oak ecosystems are often favourite places for people to walk with their dogs, leading to the potential for substantial ecological degradation. Degradation occurs because of physical trampling and, in the case of dog excrement, nutrient enrichment. Although many of the Garry Oak sites are protected from development as parks, ecological reserves, and in other ways, they may be subjected to inadvertent degradation by people, some of whom walk their dogs in these areas. Protection from development is no assurance that the flora and fauna will be un-impacted by visitors (Primack et al. 2009). Specifically, rare species (see Chapter 4: Species and Ecosystems at Risk) can be lost in protected areas through the degradation associated with human use of these areas (including dog walking); for example, increased use can cause an increase in the introduction of alien invasive species (Primack et al. 2009).

Management of human use of Garry Oak ecosystems is a complex issue. Garry Oak ecosystems are favoured habitats and people want to be able to visit these sites, often with their pets. Where these

5 Habitat alienation is a shift from, for instance, a Garry Oak ecosystem to a shopping mall: complete and irreversible loss.

This split rail fence in Macaulay Park is a simple way to restrict the movement of humans and their dogs into ecologically sensitive areas. Photo: Dave Polster

ecosystems are located on private land or on military reserves, access control is possible and these sites can be protected from degrading human influences. However, many of the remaining Garry Oak sites are on land that is open to the public, either officially as parks or unofficially as vacant Crown land, and therefore other solutions to human degradation of Garry Oak ecosystems must be sought.

Opportunities to protect Garry Oak ecosystems from the degrading effects of humans and their pets fall into two general types: sites can be fenced or otherwise blocked off to protect sensitive areas, or sites can be closed during sensitive times of the year (see Chapter 3: Natural Processes and Disturbance, Section 3.3.3 Herbivory). Both of these treatments have their advantages and disadvantages so care must be taken to ensure adequate monitoring (see Chapter 7: Inventory and Monitoring) accompanies any management efforts. This monitoring allows the implications of the management treatment to be identified early in the process, with opportunities for modification.

Fencing off sensitive areas can be an effective way of limiting the adverse effects of human access. Some fence types, for example cedar snake fences, can be relatively unobtrusive, although it should be recognized that fencing may not always prevent access. Logs along the edges of trails can be used to encourage people and dogs to stay on the trail. Where the impetus for off-trail traffic is access to a desired site such as a beach or a watercourse, construction of "official" access points with guiding fences will help relieve the pressure on other areas. In some cases, access can be re-routed so that access is still provided to certain areas, but the pressure on the sensitive habitats is reduced.

Timing Considerations

Many of the sensitive and unique Garry Oak ecosystem plant species are winter annuals (e.g., Dense-flowered Lupine (*Lupinus densiflorus*). In addition, most of the native Garry Oak ecosystem species complete their life cycle (flowering and seed set) before the ecosystems dry out in the mid- to late summer. Establishing access timing restrictions can protect these vulnerable species while allowing access at other times of year when the ecosystems are more robust. Timing considerations must also be addressed during restoration work so it is beneficial to understand the life cycles (phenology) of the species of interest.

Limitations on Use of Fire

Fire is an integral part of deep soil Garry Oak ecosystems and an occasional part of shallow soil rocky ecosystems (Chapter 3: Natural Processes and Disturbance). However, the urban location of almost all deep soil Garry Oak ecosystems can cause serious restrictions on the re-introduction of fire. Concerns about fire control, smoke, and seasonal burning restrictions in most areas limit the use of fire as a restoration tool. Efforts to change attitudes on ecosystem burning have gained some headway since the 2003 uncontrolled wildfires burned Kelowna, B.C., as people are recognizing that in some ecosystems frequent, low-intensity fires play a role in actually reducing the fire hazard (Taylor and Carroll 2003). Any use of fire in the restoration of Garry Oak ecosystems would need to be developed in conjunction with local fire control organizations.

People are recognizing that in some ecosystems frequent, low-intensity fires play a role in actually reducing the fire hazard.

Endangered Dense-flowered Lupine is a sensitive species at risk that occurs on coastal bluffs as a winter annual. Photo: Dave Polster

Case Study 2. Prescribed Fire at the Nature Conservancy of Canada's Cowichan Garry Oak Preserve

by Irvin Banman and Thomas Munson

All photos taken during prescribed burns at the Cowichan Garry Oak Preserve (CGOP), Nature Conservancy of Canada, July 2010. All photos: City of Victoria

The Cowichan Garry Oak Preserve (CGOP) near Duncan, B.C. is an 18 ha remnant of the highly fragmented Garry Oak ecosystem of southeastern Vancouver Island. The property is owned and managed by the Nature Conservancy of Canada (NCC). This site has an overstorey of Garry Oak (*Quercus garryana*), occurring at varying densities from sporadic to closed canopy. The most abundant native flora in the understorey include Common Camas (*Camassia quamash*), Great Camas (*Camassia leichtlinii*), Broad-leaved Shootingstar (*Dodecatheon hendersonii*), Spring Gold (*Lomatium utriculatum*), and Western Buttercup (*Ranunculus occidentalis*). However, the open meadows are dominated by invasive grasses, mainly Kentucky Bluegrass (*Poa pratensis*) and Orchard-grass (*Dactylis glomerata*) (MacDougall 2002).

A series of disturbance treatments was initiated at the CGOP in the year 2000, to determine the ecological relationship between invasive and native species on the site. One of these treatments involved re-introduction of fire to the ecosystem, on both spring and fall burn plots. One of the main objectives in re-introducing prescribed fire was to determine its impacts on introduced

Photo 1: Wetting down the fire guard.

Photo 2: Lighting the prescribed fire with a propane drip torch.

invasive grasses, which have come to dominate oak habitat. In addition, it was hoped that fire would have an adverse affect on other introduced species such as Scotch Broom (*Cytisus scoparius*) while increasing native species biodiversity and abundance (MacDougall 2002, 2005).

Restoration Treatments at Cowichan Garry Oak Preserve (CGOP)

Disturbance treatments which began in 2000 and have continued for 10 years include:

- Summer control, burning, mowing, and selective removal of invasive species
- Fall control, burning, mowing and selective invasive plant removal

All early treatments (2000–2002) were carried out on 1 m^2 plots. Above ground (50 cm) temperatures of these low-intensity, small-scale grass fires ranged from 133°C to 408°C. Ground level temperatures ran between 74°C and 213°C. No temperature increases were detected 5 cm below ground (MacDougall 2002).

In the last two seasons (2009, 2010), larger-scale experimental burns have been conducted involving burn plots of sizes ranging from 10 to 30 m^2. In preparation for burns on this scale, fire guards of mowed grass strips were cut around the burn plots and the fire guards wetted down immediately prior to burning (Photo 1). NCC staff and volunteers set the prescribed fire using propane drip torches (Photo 2), patrolled the burn plot with fire hoses during the burn, and wetted down any fire "hot spots" after the surface burn had been conducted (Photo 3). Fire results were sporadic, depending on micro-site conditions of species cover and moisture content (Photo 4).

Photo 3: Wetting down hot spots.

Photo 4: Variable fire effects on post-burn fire plot.

The preliminary results of burning in 2000-2002 showed that perennial grass cover and litter biomass dropped significantly in all plots over the first season. The removal of the dense grass thatch and exposure of bare soil stimulated native forb cover to increase significantly in species rich plots. Burning had a positive effect on seedling survival, especially when native seed was added after the burn. Native species added were Roemer's Fescue (*Festuca roemeri),* Poverty Oatgrass *(Danthonia spicata),* or California Oatgrass *(Danthonia californica),* Common Yarrow *(Achillea millefolium),* Woolly Sunflower *(Eriophyllum lanatum),* Spring Gold, Barestem Desert-parsley, also known as Indian consumption plant (*Lomatium nudicaule),* Sea Blush *(Plectritis congesta),* and Western Buttercup. Although non-native species were substantially reduced, native plants did not increase uniformly; the best gains were seen in sites with higher initial diversity of native species.

However, an increase in Scotch Broom and Canada Thistle (*Cirsium arvense*) germination was also evident. Exotic annuals also tended to increase sharply in germination after burning. Cryptogramatic mosses typically declined after burning. With fire, areas of low species diversity become illuminated with large areas of exposed mineral soil, facilitating invasion of shrubs and exotic forbs that otherwise may have difficulty establishing (MacDougall and Turkington 2004, MacDougall 2005).

Discussion

Fire suppression in Garry Oak ecosystems has been prevalent since the late 1800s, and these ecosystems have now evolved in the absence of fire. The result has been an increase in shrub cover and encroachment of Garry Oak seedlings and conifers (mainly Douglas-fir and Grand Fir (*Abies grandis*)) into formerly open Garry Oak woodlands (Smith 2007). The introduction of many European grasses for livestock forage in the 1800s has led to mostly exotic grasses dominating the few remnant Garry Oak habitat sites (MacDougall et al. 2004). Native plant species at risk in this ecosystem are limited in expansion by lack of bare soil, ground-level light, and available soil nitrogen. Many of these species at risk are small annuals and perennial forbs of short stature that perform poorly in dense thatch swards of exotic grasses and in the absence of disturbance to create sites for germination. Periodic surface fires would have eliminated grass litter and opened up possible recruitment sites for these subordinate native species at risk; the elimination of fire has likely contributed to their present-day displacement to mostly shallow-soil locations, where non-native grasses and shrubs form less densely (MacDougall et al. 2004).

One obvious step in restoration of Garry Oak ecosystems is the re-introduction of fire. However, fire re-introduction may have unwanted consequences if the timing of the burns is not carefully matched to the phenology of the native species and if native species are not added to the site following burning. Repeated burning in a particular season will select against those species that flower or set seed at that time. In Garry Oak ecosystems, most native species formerly escaped the effects of fire because their growing season (March–July) did not coincide with the timing of peak fuel combustibility (August–October). Combined with the knowledge that some of the most dominant invasive species are "summer species" (Kentucky Bluegrass, Orchard-grass), this implies that late summer or fall burning will benefit Garry Oak ecosystem restoration. However, not all Garry Oak ecosystem flora complete their annual life cycle by midsummer, or are, by implication, fire tolerant. This includes many species from the family Asteraceae. This reinforces the conjecture that former fire impacts probably varied across the landscape as a result of combinations of topography, soil depth, and cultural management practices. Present-day land managers using prescribed fire on small Garry Oak remnants must account for native species on site, particularly species at risk that are sensitive to fire, and must monitor the impacts of fire on invasive species that may flourish in its presence (MacDougall et al. 2004).

Research on fire and its impacts on non-native invasive species in Canada has been limited, with few studies covering more than one year after fire re-introduction. However, prescribed fire re-introduction has been practiced on a rotational basis on Garry Oak woodlands and prairies at Fort Lewis, Washington since 1978. Both spring and fall burns have been used, on plots ranging in size from 1 m^2 to 10 x 20 m. A review of results in 1999 (Tveten and Fonda 1999) found that prescribed fire had significantly reduced overstorey cover of Scotch Broom and Douglas-fir seedlings, and top-killed Garry Oak seedlings and saplings in open prairies. Invasive understorey grasses, forbs and Scotch Broom seedlings were not significantly reduced with one fire cycle—a fire rotation period of 3–5 years was most beneficial in managing invasive species. Supplemental seeding and planting of native species may also be needed to increase density of native vs. non-native species.

Fire researchers recommend that fire managers give priority to:

- controlling non-native species known to be invasive post-fire in the area burned and adjacent areas
- preventing new invasions through early detection and rapid eradication of likely invasive species
- long-term monitoring and adaptive management after fire on the burn areas to control or reduce invasive species (USDA Forest Service 2009)

Pacific Northwest Garry Oak meadows are severely seed limited. Planting native species is essential to increase abundance and diversity of desirable vegetation. Planting on bare soil following prescribed burning will allow the native species to compete against the dominant non-native invaders. As shown at the CGOP, without the experimental introduction of native seed on the burn plots, native plant recruitment was sometimes close to nil. Conversely, when native seed was added to burned and unburned plots dominated by invasive grasses, germination and initial native plant establishment levels were high (MacDougall 2002). Experimental treatments such as post-burn grazing with sheep or post-burn application of herbicides have also been used at the CGOP to further inhibit regeneration of the dominant invasive grasses.

Additional constraints on the use of fire in Garry Oak ecosystems are smoke and fire control concerns. Many oak woodlands are now part of, or adjacent to, urban and semi-rural environments. Although smoke is ephemeral, it is still a significant concern for traffic and local, smoke-sensitive citizens. The threat of damage to adjacent properties from a prescribed burn which is blown out of control can potentially shut down future controlled burn plans. It is incumbent on land managers to have smoke management plans and prescribed burn plans in place, and to inform and work cooperatively with local fire departments to conduct successful prescribed burns.

The use of fire as a restoration tool in Canada is in its infancy. For Garry Oak ecosystems, much can be learned from work being done in oak woodlands in eastern Canada (Toronto and Windsor) and for prescribed fires in other ecosystems, from researchers such as Stephen Barrett and Steve Arno in Montana, Henry Lewis and C.W. White in Alberta, Dana Lepofsky and Ken Lertzman in British Columbia, and Stephen Pyne (2007). In addition, experimental restoration incorporating fire in our area will provide valuable insights into timing, effects on species at risk, and effects on native species germination and invasive species.

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8.3.3 Social and Cultural Constraints

The position of many Garry Oak sites within the urban sphere creates a variety of social and cultural constraints to restoration. Tree removal in protected areas can raise concerns with local citizens and natural history clubs. Similarly, any change in the condition of a site that people have become used to, such as a shift from a shrub-dominated understorey to an open grass/forb understorey, can generate concern. It is essential to incorporate effective communication systems including information signs and pamphlets dropped in the mailboxes of local residents, to avoid delays and misunderstandings.

Where Garry Oak sites have significant cultural connections, inclusion of First Nations input in the restoration designs will be important. There may be opportunities to invite local First Nations to be part of the restoration or the ongoing management of the restored ecosystem. Fire and camas harvest have historically been part of the disturbance regimes associated with deep soil Garry Oak ecosystems (see Chapter 3: Natural Processes and Disturbance). Re-establishment of these disturbance elements is expected to be an important part of successful restoration of these ecosystems. Ideally, this re-establishment would happen with the involvement of local First Nations.

SOMENOS HISTORICAL VILLAGE SITE (YEY'UM'NUTS)

The Somenos Garry Oak area has a long history of human use. A gentle southwest-facing slope parallels Somenos Creek downstream of Somenos Lake to the confluence with the Cowichan River. Large specimen Garry Oak trees are found throughout this area, although the Garry Oak ecosystems mostly have been lost to housing developments. Continued expansion of the TimberCrest development in 1992 unearthed human remains and the development was halted. A detailed archaeological survey was conducted and additional burials were found along with evidence of a village site with occupation dating back 3750 years before present. It is clear from the scattered large old oak trees and the deep rich soil that this area has been cultivated for camas for many centuries.

Archaeological dig next to Somenos Garry Oak Protected Area. Remains were found at this site that date back almost 4,000 years. Photo: Dave Polster

The author next to one of the large Garry Oak trees in the Somenos area. Photo: Hans Roemer

8.4 Re-stitching the Fabric of the Ecosystem

Restoration of Garry Oak ecosystems generally entails removal of invasive species, replacement with appropriate native species, and the re-establishment of natural disturbance regimes. Removal of invasive species has been discussed above and is presented in greater detail in Chapter 9: Alien Invasive Species. Establishment of native species is discussed below while the recovery of historical disturbance patterns is presented in the following section. If invasion by alien species and the disruption of natural disturbance regimes are what have caused the degradation of Garry Oak ecosystems, then species and disturbance regime re-establishment are viewed as parts of re-stitching the fabric of the ecosystem. The assumption is that by re-establishing the appropriate species and disturbance elements, the natural processes of nutrient cycling and soil building will come along as well. If the ecological degradation has been extreme, then some form of soil amelioration through the use of appropriate mychorrizal inoculation may be required.

Study of reference ecosystems provides ecological understandings that will allow selection of appropriate species for similar sites.

8.4.1 Selection of Suitable Species

Selection of suitable species requires knowledge of the characteristics of the site in which the plants are to be established and the autecology of the plants to be planted. Study of reference ecosystems (discussed below) provides ecological understandings that will allow selection of appropriate species for similar sites. Sometimes selection of species can be based on remnant plants that have survived on the disturbed site, although care must be taken not to base species selection entirely on remnant plants as these may represent the species that were able to persist in the face of the degrading element, while other species might have been selectively lost. Camas is known to have been selectively grazed by cattle to the point where once-dense stands have been eliminated, while snowberry was released by cattle grazing to the point that when snowberry occurs extensively in Garry Oak ecosystems it can be a sign of former

Reference ecosystems such as the grasslands of Eagle Heights can be used to illustrate the distribution of species across the ecological gradients that occur in Garry Oak ecosystems. Photo: Dave Polster

heavy grazing. Knowledge of the ecology of the site being treated, including the successional status and trajectory (discussed in Successional Trajectories as follows), and the potential species that would be used for treatment, is essential for effective species selection.

Reference Ecosystems

Reference ecosystems (see Section 8.2 above) can be used to define the ecological conditions under which specific species grow. In addition, the relationships between species can be determined through careful study of reference ecosystems. Although we may not know why plants assort themselves the way that they do, repeating patterns found in reference ecosystems on the restoration sites will help to ensure that the appropriate species are planted together. Reference ecosystems also provide information on the way species arrange themselves along ecological gradients[6] so that, for example, species that are found in moist seepage areas are planted in seepage sites on the restoration area, and species that are found on dry rocky knobs are planted on the drier parts of the restoration area.

Unfortunately, there are few Garry Oak ecosystems that have not been impacted by something, even if only the absence of landscape burning. Therefore, selecting reference ecosystems for the purposes of determining species selection and planting locations should be based on a number of different sites. Visiting a variety of Garry Oak sites at various stages of recovery with an eye towards the species that are found on these sites and the arrangement of those species to each other and their environment can assist in selection of species for restoration. Looking at the relationships between species and the habitats in which they occur, as well as the relationships among various habitat types and the species that occupy the transition areas between habitats, will help in determining species for re-planting on degraded ecosystems.

6 Such as from dry to moist or nutrient poor to nutrient rich.

Hobbs et al. (2006) suggest that as species and ecosystems assort themselves under the conditions of changing climates, there may be situations where novel arrangements arise. The range of Garry Oak ecosystems may expand substantially and sites that were formerly mesic may end up being drier while wet sites may become wetter during periods of intense winter rains. Since our knowledge of how these novel ecosystems are put together will be imperfect it may be prudent to incorporate a range of species in restoration projects (Hobbs and Cramer 2008). Although the Garry Oak ecosystems of the future may be different than they are now, it is useful to have a good understanding of the ecology of our current ecosystems so that we may knowledgeably assist in their restoration as they change under a changing climate.

Successional Trajectories

Garry Oak ecosystems in their pre-contact state can be considered as edaphically controlled dis-climax ecosystems[7] (shallow soil rocky sites) or culturally maintained dis-climax ecosystems (deep soil sites). Since successional theory has undergone a substantial shift and the ideas of climax ecosystems have been displaced (Walker and del Moral 2003), it may be better to think of the successional status of Garry Oak ecosystems as one that in the absence of management or fire would shift towards a Douglas-fir dominated ecosystem, although on dry rock outcrops this may be a very slow process. Deep soil Garry Oak sites will be replaced in short order by Douglas-fir stands as is evident on many of the remaining sites.

Recognizing the transient nature of Garry Oak ecosystems requires that restoration activities remain active with interventions required to maintain these ecosystems in the face of ongoing successional changes. On deep soil sites, the re-establishment of camas harvest and regular burning will be needed to keep the Douglas-fir at bay. On shallow rocky sites, Douglas-fir encroachment was historically controlled by wildfires that would occur at 300 to 500 year intervals (Roemer 1972). Since landscape burning that maintained the Coastal Douglas-fir zone ecosystems (of which Garry Oak ecosystems are a part) are not expected to be re-established in the future, manual clearing of encroaching Douglas-fir will be required.

Some of the species that are currently found in Garry Oak and related ecosystems can be considered early seral[8]. Alaska Brome (*Bromus sitchensis*) has been identified as one such species (C. Maslovat, pers. comm. 2010). Other species associated with Garry Oak ecosystems might also be considered early seral as these ecosystems have been established with disturbance as a major ecological element. Species that produce large quantities of seed and establish easily, such as camas, make ideal candidates for restoration. Many early seral species possess such attributes. Incorporation of early seral species into repair of drastically disturbed sites has been cited as an effective strategy for restoration of these sites (Polster 1989).

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7 Dis-climax refers to a plant community that is maintained at some earlier successional state by some external factor. In this case, Garry Oak ecosystems would become Douglas-fir forests except for the dry conditions associated with rock outcrop areas and the fires associated with aboriginal burning of deep soil sites.

8 Early seral means the plants and communities that show up early in a successional sequence.

8.4.2 Propagation

Many of the species used in Garry Oak ecosystem restoration are easily propagated. Garry Oak grasses, Long-stoloned Sedge (*Carex inops*), and various lilies can be readily grown from seed. Species that are easy to grow can form the foundation for rebuilding species diversity in restored Garry Oak ecosystems. Standard nursery procedures using conventionally-sized containers have been shown to be effective for most species, although some tricks have been found for growing certain species. Chapter 10: Species Propagation and Supply and the Native Plant Propagation Guidelines prepared by the Native Plant Propagation Steering Committee of GOERT provide details for propagation of Garry Oak ecosystem species (see www.goert.ca/propagation).

8.4.3 Establishment Procedures

Most Garry Oak ecosystem species can be easily established by planting plugs using standard tree planting methods. In most cases where the aim is to re-build the fabric of the ecosystem, dense plantings are used. Grass plugs can be planted at 20 to 30 cm spacing to create a dense stand of native grasses that resists invasion by introduced species. Where the aim of the planting is to re-establish complexities of ecosystem structure, larger shrubs can be planted.

Although Garry Oak ecosystem species are adapted to growing in a climate with summer droughts, it may be prudent to provide some level of irrigation during the first year. Care should be taken to avoid over-watering as this can encourage establishment of alien invasive grasses. Fertilizer is generally not needed for Garry Oak ecosystem species when they are planted in reasonably intact ecosystems, as the mychorrizal and microbial communities will be in place to help provide nutrients to the newly-established species. On sites where degradation has been substantial, watering the plugs with a slurry of soil collected from intact ecosystems may help establish the appropriate soil flora and fauna.

Re-stitching the fabric of Garry Oak ecosystems may entail planting native grasses as well as the showier forbs. Photo: Dave Polster

8.5 Re-establishing Disturbance Elements

Garry Oak ecosystems rely on disturbance to perpetuate the species assemblages that make these ecosystems so special. On deep soil sites in the absence of fire, Douglas-fir trees will cover the oaks and the site will turn into a Douglas-fir forest. Encroachment can also happen on rock outcrop sites, but much more slowly. Re-establishment of disturbance elements can be difficult and in many cases surrogates such as mowing are used. Chapter 3 provides details of the natural processes and disturbance regimes associated with Garry Oak ecosystems.

8.6 Development of Monitoring Programs

Chapter 7: Inventory and Monitoring provides details of monitoring programs that can be applied to Garry Oak ecosystem restoration projects. Specifics of the monitoring program will depend on the site and treatments being monitored. In general, the ability to observe changes in the species composition and ecological conditions over extended periods of time should be included in all monitoring programs.

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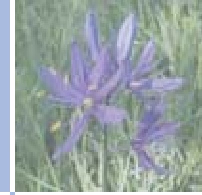

Restoring British Columbia’s

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 9
Alien Invasive Species

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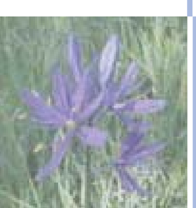

Chapter 9

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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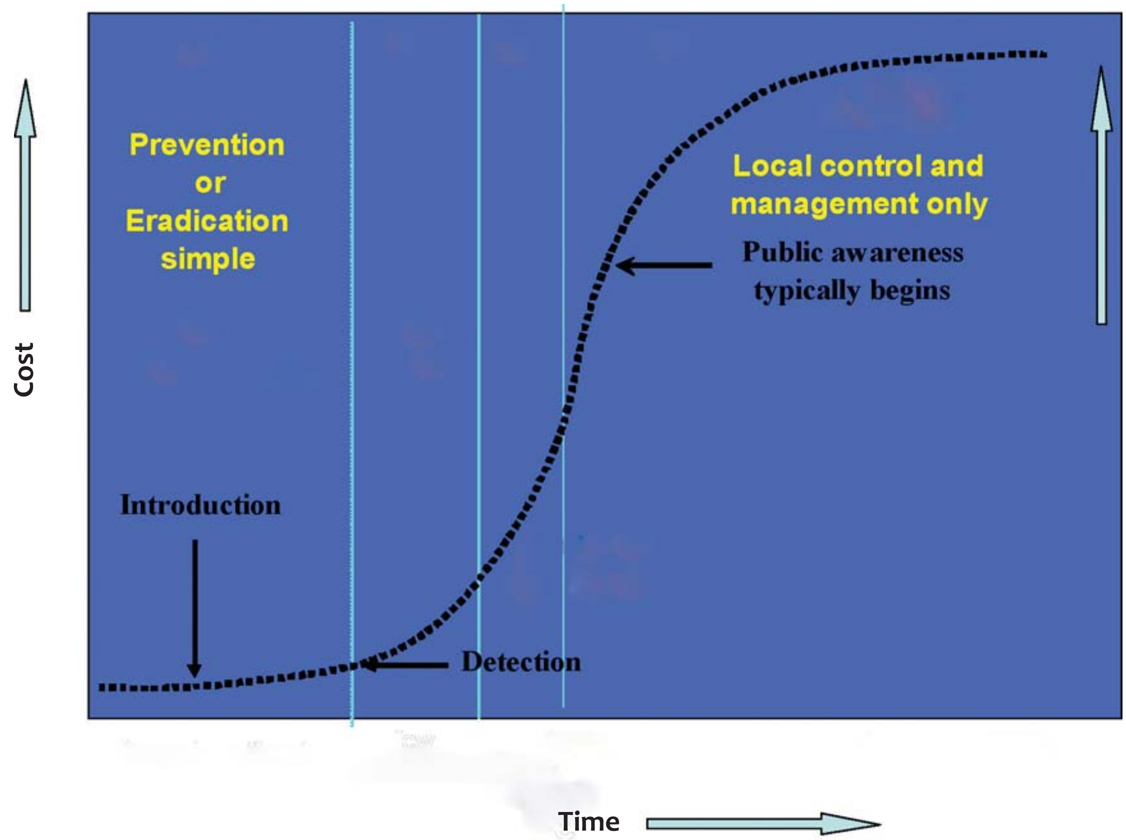


Figure 9.1 Typical invasion sequence for alien invasive species (after Hobbs and Humphries 1995).

- 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 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

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).

(continued on page 9-22)

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

by Aimée Pelletier

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

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*)

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

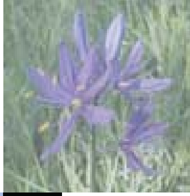
a. Site inventory for species at risk as well as the AIS

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.

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.

References

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Parks Canada Agency. 2006b. Recovery strategy for multi-species at risk in maritime meadows associated with Garry Oak ecosystems in Canada. In: *Species at Risk Act* Recovery Strategy Series. Parks Canada Agency, Ottawa, Ont. www.sararegistry.gc.ca/document/default_e.cfm?documentID=873.

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

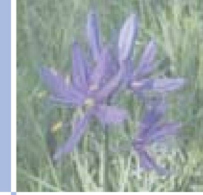
The role of non-governmental environmental organizations such as World Wildlife Fund, Sierra Club, and Ducks Unlimited, as well as local naturalists and interested community groups, in addressing issues related to invasive alien species can be valuable in invasive alien species detection and removal.

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.



Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 10
Species Propagation and Supply

Contents

Chapter 10

Species Propagation and Supply

by Fred Hook and Brenda Costanzo

Propagation of Common Camas (*Camassia quamash*) at Beacon Hill Park Nursery. Photo: City of Victoria

10.1 Introduction

In almost every restoration project, obtaining appropriate native species will be challenging. For example, many of the plant species of interest may not be in commercial production or available in the numbers needed; others will not be available at all. Vertebrate and invertebrate species, such as butterflies, may have to be captive-raised or collected under appropriate conditions, and permits may have to be obtained before those or other endangered species are re-introduced to a site (see Chapter 4: Species and Ecosystems at Risk).

Maintaining the genetic integrity not only of existing source populations but also of the resulting re-introduced populations must also be considered. Maintaining the genetic makeup of the material collected on your restoration site or from a nearby similar site is important for the longevity of the restoration project, especially in view of climate change and other types of environmental change. Additionally, budget concerns, availability of space for on-site propagation, availability of native plant nurseries, and availability of skilled staff can present challenges to restoration projects. Availability of plant material from salvage sites will have to be factored into the decision about whether to collect and propagate the plants yourself or to contract-grow all or part of the supply with commercial nurseries.

The restoration of animal populations through re-introduction or population enhancement requires consideration of similar factors.

Chapter 2: Distribution and Description describes the Restoration Ecosystem Units (REUs) that may be present in your restoration project area, or those that could be sustained on the project site. Refer to Table 2.2 (Chapter 2) and Appendix 4.1 (Chapter 4) to find the species that may have been present in your representative REU but which are currently absent from or present in reduced numbers on the site. Once you have determined your **restoration target** (what your site should look like and how it should function), you can generate a list of native species that you can attempt to re-introduce or enhance. Refer to Chapter 8: Restoration Strategies section 8.4, for further information.

10.1.1 Chapter Outline

Most of Chapter 10 deals with plant species but provides some references to other organisms. The overall outline of this chapter is as follows:

Section 10.1: Introduction—gives a brief overview of some of the challenges involved in carrying out a restoration project.

Section 10.2: Basic considerations for plant propagation with respect to restoration —considers questions regarding the ethical collection of plants and species at risk, and the maintenance of genetic integrity and species diversity.

Section 10.3: Captive rearing and plant propagation methods—provides general methods for propagating plants from seed, cuttings, and divisions. Appendix 10.1 indicates which methods are appropriate for species mentioned in this publication.

Section 10.4: Determining optimum techniques for propagation—discusses the advantages and disadvantages of different propagation techniques and when those techniques might be appropriate.

Section 10.5: Seed collection, extraction and cleaning, viability testing, and storage—provides a general discussion of seed collection, extraction and cleaning, viability testing, and storage methods. Moralea Milne's case study of seed collection at Camas Hill (p. 10–37) provides additional information on these topics.

Section 10.6: Selection and treatment of plant materials—discusses the selection of suitable, healthy material to produce vigorous, genetically diverse, but species-true plants for your project.

Section 10.7: Consideration of timelines—outlines considerations for planning the initiation of your restoration project, and the propagation, growing, and planting of material for it.

Section 10.8: Additional Suggestions

Section 10.9: References—lists references cited in this chapter plus those which provide additional information on species-specific propagation techniques.

Section 10.10: Related Websites—a compilation of additional information and suggestions for those starting to plan and implement a propagation program for restoration.

Section 10.11: Related Guides and Handbooks

In addition, the following case studies highlight propagation programs used in a number of restoration projects:

- Plant Salvage, Section 10.2
- Taylor's Checkerspot Captive Rearing (butterfly re-introduction), Section 10.3
- Fort Rodd Hill Garry Oak Ecosystem Restoration, Section 10.3
- Native Grass Restoration at Gonzales Hill, Section 10.3
- Native Meadow Restoration at Cowichan Garry Oak Preserve, Section 10.3
- Seeds—Collection, Storage, and Germination, Section 10.5
- Contract Growing for Outplanting—Considerations, Section 10.7
- Small Scale Native Plant Nursery Set-up and Operation, Section 10.7

10.2 Basic Considerations for Plant Propagation with Respect to Restoration

10.2.1 Ethical Guidelines

Various ethical guidelines have been developed for collecting native plant material for propagation. The Garry Oak Ecosystems Recovery Team's Native Plant Propagation Steering Committee has posted guidelines at: www.goert.ca/ethical_collection.

As well, there is the "1-in-20 rule", which refers to collecting no more than one-twentieth (5%) of a plant's parts, of a plant, or from a plant population in a particular site. So before collecting, there should be at least 20 plants within the population, and when collecting propagules, no more than 5% of the plant should be removed, or no more than 5% of the seeds or fruit should be taken.

For further information about considerations when collecting plant materials for propagation, refer to the Genetic Integrity section (10.2.3), and also Source Diversity section (10.6.2).

Salvage of plant materials should not be done unless the site is scheduled to be destroyed. See the following case study on plant salvage.

Salvage of plant materials should not be done unless the site is scheduled to be destroyed. See the following case study on plant salvage.

Case Study 1. Plant Salvage

by Nathalie Dechaine

Plant salvage tools and equipment ready for harvesting. Photo: Nathalie Dechaine

Introduction

Ideally, native plants would remain in their natural environment. Typically, native plant salvaging is a last resort to rescue plants that would otherwise be lost to site alteration, such as for housing developments (refer to GOERT's ethical collection guidelines: www.goert.ca/ethical_collection). Preferably, salvaging is conducted by an organized group for an established program rather than as an informal activity. Proper planning ensures that native plant salvage is done in such a way that it protects salvagers, landowners, infrastructure, and ultimately the native plants being salvaged. Native plant rescue is hard but rewarding work if done properly. Salvaging can provide an inexpensive source of locally adapted plants, but it is important to know what will be done with the plants after they are salvaged. Depending on circumstances, they may go directly to a restoration site, a native-plant demonstration garden, or a holding site, or they may be taken by individuals to enhance their own backyards. It is not appropriate to take plants from parks or protected areas. That is considered poaching.

Planning Prior to Salvaging

THE PEOPLE

It is important to consider who will organize and administrate the salvaging and who will help with it. In most cases, native plant rescue is undertaken by volunteers. Fortunately, most areas have local botany, naturalist, or gardening clubs from which the coordinator can recruit volunteers. People with some expertise in gardening and/or native plants can help train other interested but inexperienced volunteers. Preferably, the group can meet beforehand to sign any release of liability forms. Training can be done in a club or classroom setting prior to salvaging, or it can be done in the field. Suggested training topics include ethics, plant identification, salvaging techniques, care and maintenance of salvaged plants, and how to avoid transplanting pests, diseases, and invasive species.

THE SITE

Finding potential salvage sites can be made less challenging by considering the following. Each agency has different development approval processes, so it is important to become familiar with local requirements. Some agencies require publication of development applications, or in some states, an intention to clear land. These announcements can be found in local newspapers, on public websites, on signs on the site, or by notifying the local community associations. It is helpful to screen the salvaging potential of the site by speaking with local naturalist groups, neighbours, and the planning department responsible for processing the development application. It is equally important to build a good relationship with the applicant because they are usually responsible for project timelines and granting permission. Generally, supporting native plant salvaging is one way an applicant can help demonstrate their attempt to address environmental and social concerns, and to gain community support, all of which can be requirements for approval.

Once a site has been identified, there are several things to consider prior to salvaging. Permission to salvage must be granted from the appropriate landowner or agency, preferably in writing. The agreement should include terms, conditions, and logistics, such as liability issues (release disclaimer and whether or not insurance is required), how the salvagers will access the site and during which dates and hours, how adjacent property owners will be notified about the salvaging activities, and what will be done with the salvaged plants.

Once permission is granted, it is important to ensure that the area is appropriate. The following conditions should be met prior to salvaging:

- An inventory of the native and invasive plants has been conducted, as thoroughly as possible (seasonally dormant plants may present challenges).
- Legal boundaries are known and marked on-site.
- Underground utilities have been checked, and if present, marked on-site (this may be a legal requirement in some areas).
- Local authorities or naturalist clubs have been contacted for information about any species at risk that may be on-site.
- Any areas that are not appropriate for salvaging (e.g., that are protected for conservation or which pose safety risks) have been identified.

The Next Step: Opening the Site to Salvagers

Once all the background information has been compiled, a map and written instructions can be used to communicate that information to the salvagers. Email and blogs can be used to organize volunteers and share information, as long as there are measures in place to protect sensitive information. A site orientation is recommended for training volunteers on-site.

PLANT SALVAGING

Timing of plant salvaging can be challenging. Ideally, plants should be transplanted when they are dormant, yet dormant perennial plants can be difficult to locate and identify. Annual plants may also be present but not obvious because they can remain ungerminated (dormant) in the soil (a seed bank) until conditions become favourable. Salvaging opportunities are generally the result of the development process, which does not necessarily align with the most opportune time to salvage. It is important to remember that salvaging can be successful at any time of year if the plants are properly cared for.

GENERAL TIPS FOR SUCCESSFUL PLANT SALVAGE

- **Protect the roots.** This is key to successful salvage.
- **Smaller is better.** Smaller plants (especially shrubs and trees) adjust to disturbance better than larger, more established plants (with the exception of bulbs).
- **Dig around and under, not through plants.** This method avoids “collateral damage”.
- **Care for the plants immediately after salvaging them.** If possible, transplant plants directly into containers on-site, especially if they are to be stored for a period of time. Plants seem to adjust

better if they rest in containers for a short period of time. In addition, unwanted transplants like weeds or invasive species can be removed, which prevents them from being unintentionally introduced on the new site. Allow for as much time to process and transplant items as it took to dig them up.

- **Keep all plants well watered.** Even though some native plants may be drought tolerant, they will need extra care to help them through the upheaval. For at least the first year of being transplanted, plants should be kept well watered.
- **Salvage components as well as plants.** Salvage other habitat components such as woody debris, rocks, mosses, and soil, which contain mycorrhizal fungi and other beneficial biota.
- **The right plant in the right place.** When replanting the salvaged plant, consider the conditions where it was growing (aspect, drainage, sun or shade, etc.) to ensure conditions in its new spot are appropriate.
- **Dig deep.** Depending on the habitat, some plants, especially bulbs, are quite deep in the soil.

Tips for Salvaging Specific Types of Plants

PERENNIALS: BULBS

A transplant spade can wedge up a clump of soil, and bulbs can be pulled from the bottom of the clump. This is easier and protects the bulbs much better than trying to dig them out from the top of the soil. If bulbs are dormant, keep them covered in loose soil and try to bury them as close as possible to the same level as where they were found (to be conservative, bury them a bit deeper than they were found). If the bulbs are flowering, cut off the bloom to preserve the bulb's energy before burying them. Most native bulbs do not do well when left to dry like horticultural bulbs.

PERENNIALS: ROOT WADS

Dig around root wads carefully. Try to keep the roots as intact as possible. Some native perennials can be divided like horticultural varieties if they appear to be crowded, and may prosper from being separated. Carefully replant the root wads near the soil surface but ensure they are covered with enough soil or mulch to protect them from the elements.

Salvaged plants potted for growing on and re-planting. Photo: Nathalie Dechaine

ANNUALS

Annuals generally do not transplant well but will continue to grow if well cared for. The goal is to keep the plant alive long enough so that it can set seed. Sometimes annuals will appear around other salvaged plants because they came from the seed bank in the soil. It is always recommended to transplant native soil for this and many other reasons (unless there are known diseases or pests present).

SHRUBS

Choose as small a shrub as possible. Get as much root ball as possible, and when necessary, cut roots with a sharp instrument so they heal along clean lines. Prune the top growth so that is it smaller than the underground root ball. More roots than shoots will give the plant enough energy to adjust to being transplanted. Most shrubs are fairly resilient.

TREES

Choose as small a tree as possible. Get as much root ball as possible, and when necessary, cut roots with a sharp instrument so they heal along clean lines . A transplant spade can dig through roots cleanly and can dig deeper than a conventional shovel. Depending on the type of tree, pruning may help or hinder the tree's success. Hardwood trees generally tolerate and in some cases benefit from pruning. Prune the top growth so that it is smaller than the underground root ball. This is generally not recommended for most conifer species. Trees will not survive if their roots dry out, so transplant them immediately and water well.

Sources

Personal experience, The District of Saanich's Native Plant Salvage program, other experienced salvagers.

Useful Links

Indiana Native Plant and Wildflower Society—Native Plant Rescue Protocol www.inpaws.org/INPAWS%20Native%20Plant%20Rescue%20Protocol.pdf.

King County Native Plant Salvage Program www.kingcounty.gov/environment/stewardship/volunteer/plant-salvage-program.aspx.

Mason & Grays Harbor Counties – Native Plant Salvage Program http://graysharbor.wsu.edu/NativePlant.

Native Plant Salvage Alliance www.ssstewardship.org.

Native Plant Study Group (Victoria, British Columbia) www.npsg.ca/index.shtml.

Saanich Native Plant Salvage Program www.gov.saanich.bc.ca/resident/environment/salvage.html.

Thurston County – Native Plant Salvage Project http://thurston.wsu.edu/NPS.htm.

Nathalie Dechaine *is a member of the Native Plant Study Group in Victoria and formerly worked as Environmental Education Officer for the District of Saaanich.*

10.2.2 Species at Risk

If species at risk are going to be restored to a site, permits are required if the species are listed on Schedule 1 of the federal *Species at Risk Act* (SARA) on the SARA registry website.

For provincial Red- and Blue-listed species (listed by the BC Conservation Data Centre) that occur in a Provincial Park or Protected Area, permits must be obtained through the Permit Bureau website.

For information on species at risk and recovery planning, refer to these websites:

- BC Species and Ecosystems Explorer: www.env.gov.bc.ca/atrisk/toolintro.html
- NatureServe: www.natureserve.org
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC): www.cosewic.gc.ca/eng/sct5/index_e.cfm
- Species at Risk Public Registry – Recovery Planning: www.sararegistry.gc.ca/default_e.cfm
- Ministry of Environment – Recovery Planning in British Columbia: www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm

See also Chapter 4: Species and Ecosystems at Risk, for further guidance on restoration involving species at risk.

10.2.3 Genetic Integrity

When selecting plant material for propagation, it is recommended that the ecoregion characteristics of the collection site be considered (e.g., the amount of rainfall, including winter precipitation, and the soil types). As well, plants propagated for outplanting should be field tested to assess the adaptive abilities of each provenance.

If possible, determining the type of breeding system and whether the plants cross-pollinate is also useful to know (genetic composition of the species), but in reality, we know little about our native plant pollinators. Individuals that cross-pollinate produce populations that are genetically different and therefore more adaptable than self-pollinating individuals, which are more genetically homogenous (Jones 2005). Self-pollination can lead to inbreeding and potentially weaken the populations' ability to adapt to different environmental stresses and/or climate change. A plant that is endemic, ephemeral (as are many of the Garry Oak associated species in B.C.), and self-pollinated will have greater genetic variation between populations, whereas a plant that is wide-spread, long-lived, and cross-pollinated will have greater genetic variation within the population and greater ability to adapt to changing conditions.

To preserve the genetic integrity of plant material that will to be restored to a site, it is recommended plants not be used if they are genetically similar to those that were initially (or still) on the site. If seeds are used from plants that were located far from the restoration site, outbreeding depression and swamping could result (Booth and Jones 2001). However, this takes time to assess; therefore, most projects do not have the budget to do field trials and genetic studies. To minimize problems of inbreeding and outbreeding depression, plant material from adjacent or nearby sites can be used for propagation (refer to Species Diversity Section 10.2.4 and Selection and Treatment of Plant Materials, Section 10.6).

If the site where the propagules were collected was already disturbed, the plants will also need resilience and adaptability, which may be found in non-local genotypes (Johnson and Mayeux 1992). The flip-side is that these genotypes may contaminate the local gene pool through hybridization, which is more common in annuals and short-lived perennials (a large number of Garry Oak associated plant species hybridize readily).

10.2.4 Species Diversity

Along with the genetic considerations above, appropriate plants need to be chosen according to the microhabitats occurring on the restoration site. If it is not possible to define or use a reference ecosystem you could instead consider the ecological processes that build communities. Refer to the Restoration Ecosystem Units described in Chapter 2: Distribution and Description, Table 2.2, and in particular, the plant species column for plant communities. A target plant community/subcommunity needs to be selected for the restoration site, and an assemblage of plants chosen for propagation. These species assemblages will naturally change and evolve with time, as influenced by climate change, natural succession, and effects of species already present. Depending on how rigorous the restoration target is, there may be a need for ongoing culling and additions to the restoration site.

Questions to Ask About Species Diversity

How many individuals are used, which individuals, and collected from where?
How do the species and their numbers relate to community structure and viability?
Will we be able to ensure species diversity in our restoration?

10.3 Captive Rearing and Plant Propagation Methods

This chapter deals mainly with plant propagation methods; however, a brief case study on the captive rearing of Taylor's Checkerspot butterfly (*Euphydryas editha taylori*) is also presented. For information on propagating other animal species, GOERT may be able to refer the reader to appropriate experts.

10.3.1 Captive Rearing of Vertebrates and Invertebrates

See Case Study following.

CASE STUDY

Case Study 2. Taylor's Checkerspot Butterfly Captive Rearing

by Brenda Costanzo and Jennifer Heron

Captive rearing of several butterfly species found in Garry Oak ecosystems has been ongoing in the United States. Species reared include Zerene Fritillary (*Speyeria zerene bremnerii*), Fender's Blue (*Icaricia icarioides fenderi*), and Taylor's Checkerspot (*Euphydryas editha taylori*, a.k.a. Edith's Checkerspot var. *taylori*). The most recent captive-rearing research has centred on Taylor's Checkerspot.

Taylor's Checkerspot is listed as Endangered in British Columbia. There are records from southeastern Vancouver Island and the Gulf Islands, and the species' global range extends southward west of the Cascades into Oregon's Willamette Valley. Denman Island currently supports the only known population in B.C.

Captive rearing of Taylor's Checkerspot has been ongoing since 2003 at the Oregon Zoo in Portland Oregon, in conjunction with butterfly reintroduction projects in Washington State.

The captive-rearing project at the Oregon Zoo involved collecting Taylor's Checkerspot eggs from the wild (eggs are laid from mid-May to early June), collecting wild females for egg production, and using captive-reared females for egg production. The first two methods of egg production have provided the greater percentage of hatched eggs. The larvae are reared in small plastic containers that are lined with paper towels and closed with a clear perforated lid. The lid is then covered with fabric to prevent the larvae from escaping because they tend to crawl to the top of the containers. Leaf material (Ribwort, *Plantago lanceolata*) is placed in the containers to provide the larvae with food. In order to keep the humidity high, the containers are placed on damp towels inside a large open bin. Light is also provided by UV fluorescent tubes above the bins.

Pre-diapause larvae enter diapause anytime from mid-July until mid-February. Once molting is completed, the larvae are placed in clean, small plastic containers. These containers have inverted terra cotta plant pots placed over top of them, and they are moved to an outdoor location that is protected from wind and rain. They are checked weekly, and any larvae that have died are removed. After diapause, the small containers are removed from the plant pots, placed back into large open bins, and again provided with fresh host plants, high humidity, and exposure to light. The larvae may enter the pupal stage by early March, and are then ready for release into the wild.

The Oregon Zoo has had increasing success with their captive-rearing projects. For example, 490 eggs were collected in 2005, and 29 larvae were released in 2006. In 2006–2007, 930 larvae were hatched, and 726 (or approximately 78%) were released into the wild.

References

Oregon Zoo: www.oregonzoo.org/Conservation/Butterflies/checkerspot.htm.

Linders, M.J. 2007. Development of captive rearing and translocation methods for Taylor's checkerspot (*Euphydryas editha taylori*) in south Puget Sound, Washington: Washington Department of Fish and Wildlife, Wildlife Program, Olympia, Wash. 2006–2007 Annual Report. www.southsoundprairies.org/documents/LindersTCSTransAnnReport07.pdf.

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10.3.2 Plant Propagation Methods

This section details the methods for plant propagation through sexual methods (fertilized seed) and asexual or vegetative methods (plants produced using material from a single parent with no exchange of genetic material). Vegetative methods include herbaceous cuttings, stem cuttings from shrubs, and division. Required supplies, materials, equipment, and techniques are given for successfully starting and growing native plants in the nursery.

Supplies, materials, and equipment needed for seed sowing and growing

GROWING MEDIA

- mix for starting seed – commercial seed starter
- mix for plug propagation – soilless Sunshine Mix #4
- mix for potting on – sterilized soil:peat moss:perlite mixed at a 2:1:1 ratio and add 30 ml (2 tbsp) of 2-13-0 bonemeal to each 10 litres (2.6 gal) of mix
- mix for growing on – perlite or sawdust:sand:peat mixed at a 1:1:1 ratio.

Note: Moisten the peat/sawdust before mixing. If using perlite, use a dust-mask and dampen to avoid dust inhalation.

Vegetative methods include herbaceous cuttings, stem cuttings from shrubs, and division.

CONTAINERS

Pots

- small pots – 2" or 4" (5 or 10 cm)
- plastic cell packs or plugs in trays with drainage; use nursery trays with drainage holes for cells/plugs
- deep boxes 24" x 12" x 4" (60 x 30 x 10 cm) with slats in the bottom for bulbs e.g., Fawn Lilies (*Erythronium oregonum*) or camas lilies (*Camassia* spp.); or, for less time to flowering, use shallow plastic trays with no more than 1" (2.5 cm) of soil. Note: A good watering regime is required and trays must not be allowed to dry out during the growing season.
- open nursery flats with drainage for direct sowing of herbaceous perennials

Root trainers

- Hillson root trainers (for larger plants such as rose, Saskatoon (*Amelanchier alnifolia*), Alder (*Alnus* spp.), Common Snowberry (*Symphoricarpos albus*)
- Smaller root trainers for grasses/perennials
- Tinus containers for Garry Oak (*Quercus garryana*) seedlings (these are approximately 1 litre, or .26 gal)

Note: Root trainers[1] are plastic containers with ribbed sides and an open bottom. The ribs are designed to encourage deep growth rather than circling and the containers are hinged to open so that plants can be removed without root disturbance.

1 All root trainers are supplied by Spencer-Lemaire Industries Limited, Beaver Plastics Ltd Head Office: 7-26318-TWP RD 531A, Acheson, Alberta, Canada T7X 5A3, phone 1-888-453-5961, Fax: 1 780 962 4640,
E-mail: growerinfo@beaverplastics.com

Plugs

Plug trays are generally 11" x 21.5" (28 x 55 cm) with between 36 and 522 cells from 1/2" to 3" (1.3 to 7.5 cm) deep. They are designed to be used with mechanical seeders and must be matched to the specific requirements of each machine. Plugs can be seeded by hand and some large, commercial growers will sow trays on contract.

Garry Oak (*Quercus garryana*) seedlings in a 112 plug styroblock. Photo: City of Victoria

- Plug tray sowing is used where large numbers of plants are required. Plants are usually moved from cells into larger containers after germinating and establishing but some species may be planted out directly as plugs.
- It will be necessary to determine the appropriate number of seeds per cell for each species and the appropriate size and depth of cell. As this information is not generally available for Garry Oak ecosystem restoration species, it may be necessary to acquire extra seed to do trial sowings.
- Individual cells are open at the bottom to allow watering by placing on wick mats, reducing the incidence of seedling damage through overhead watering. Their advantage over open sowing (where seeds are scattered on trays of soil) is that roots don't intertwine with those of other plants in the tray and so little disturbance takes place when they are pricked out and potted on.
- Due to the limited volume of medium in each cell, plants are especially vulnerable to damage through insufficient or excess watering or fertilizing, and accumulation of salts. The number of plants in a small space makes them susceptible to insect attack or fungal growth.
- For species where limited seed is available, the use of root trainers which hold more soil can allow for growing seedlings larger, which may be advantageous.
- Plug trays are usually only used once but can be recycled. Root trainers, if treated carefully, can be re-used for 5 years before recycling.

Plastic cell packs – 21" x 11" (55 x 28 cm)

- plastic tray with or without perforations for drainage, and containers that fit inside the tray in range of sizes with various cell sizes
- trays can be re-used; cells will last about two seasons and then can be recycled

Styro blocks[2]

- usually for forestry trees but can used for vigorous shrubs and grasses (Case Study 4) and come in a variety of sizes
- common block formats are 200 and 112 plugs; cavity volumes of 2.4–6.6 cu inch (40–108 ml)

2 Supplier: Beaver Plastics Ltd., 7-26318-TWP RD 531A, Acheson, Alta, Canada, T7X 5A3, 1-888-453-5961, techsupport@beaverplastics.com

Sexual Propagation

Seed dormancy is the mechanism that prevents seeds from germinating until conditions are appropriate. There are two basic types of seed dormancy:

- **Seed coat dormancy** – The seed coat is impermeable to water
- **Embryo dormancy** – The seed embryo must undergo physiological changes, usually under cool, moist conditions. This process, known as stratification, is a method of simulating the natural conditions under which the seed would normally germinate: a period of cool, moist weather for plants that germinate in the spring in our climate; a period of warm, moist weather for those that germinate in summer or early fall.

Seed dormancy is the mechanism that prevents seeds from germinating until conditions are appropriate.

METHODS FOR OVERCOMING DORMANCY

- **Seed coat** – The most common way to overcome seed coat dormancy is to scarify the seed coat to allow water to pass through. This can be done mechanically by rubbing the seeds with sandpaper, nicking with a file or knife, or, in a few cases, chemically by acid etching. In any case it must be done in such a way that it does not damage the embryo.
- **Embryo** – Seeds may be sown outside in the fall and overwintered outside, or stratified by placing the seeds between damp paper towels in an airtight plastic container, and storing in the refrigerator at 2–5°C (36–40°F) for 1–3 months. The same result can also be achieved by covering seeds in damp peat moss in plastic bags and storing them in the refrigerator. Time will vary for stratification within the same seed lot and it is possible to do several seed lots for one, two, and three months, starting in January/February so that seeds are ready to be sown outside in spring. Check containers for mold and germination, and remove any seeds that show either. Pot up germinating seeds (see below).

SEED SOWING METHODOLOGY

- Refer to the previous section to determine the time and method of sowing for their dormancy type. This information can be found in a variety of places including the propagation guidelines on GOERT's website (www.goert.ca/propagation) and the USDA Fire Effects Information Database.
- Clean your pots/flats just prior to using them by soaking in a solution of 10% household bleach for 20 minutes, and then dry.
- Determine which seeds will be sown at what quantity in what container. Sowing density may need to be determined through trials but some information can be extrapolated from rates for similar species that are in commercial production. See also section 10.4.3 on determining quantities of seeds to be grown.
- Use cleaned seed (see section 10.5 for information on seed collection, cleaning, storage).
- Fill containers with appropriate medium and lightly tamp down. The planting mix should be moderately moist (i.e., not running with water when squeezed).
- Place small seeds on the top of the medium and separate as best as possible; press slightly into the soil medium; lightly cover with dry, clean, washed sand, forestry sand, or crushed granite (crushed granite is an Imasco product sold in agricultural supply stores for use as poultry grit) and bottom water, or gently mist using a watering rose (fine watering roses are sold in some garden supply stores, from specialist greenhouse suppliers, and from outlets like Lee Valley

Tools). You can mix the smaller seeds with fine sand before sowing as this makes it easier to handle the seeds and spread them into the containers by using a salt shaker with appropriate sized holes (this works best for sowing into open flats).

- Very fine seeds and spores can be sown on top of the topping grit. The pots are then set in a tray of water until the medium pulls water up to the surface of the soil. The same capillary action will pull the fine seeds or spores down to the medium's surface.
- Plant larger seeds at a depth of 1–2 times the diameter of the seeds, cover with medium, then pea gravel or clean washed sand (to help with drainage and prevent damping off), and gently water with a fine mist nozzle. Cover and maintain moisture levels as with small seed.
- Label (using a permanent, waterproof, fade-resistant marker (pencil works the best!)) the flat/container with the plant name and date of sowing. Record this information with the amount of seed sown, source of seed, seed treatment, medium type, in nursery records (templates for nursery records are given in the appendices). Cover with a sheet of glass, Plexiglas, or plastic wrap, or layers of moistened newspapers to retain the moisture.
- Place flats outside. If necessary cover with screen door mesh stapled to the edges of the flats to deter insects/pests from removing seeds. Germinating seeds need to be moist and may need to be checked twice a day, or be watered on a timed system.

POST-GERMINATION CARE

- Move seedlings into semi-shaded location or one with morning sun/dappled sun only.
- Monitor moisture; do not overwater or allow the seedlings to dry out.
- Once the seedlings have their first true leaves, prick or plant them out into a nutrient-rich potting mix. Make your own mix: sterilized soil:peat moss:perlite in a 3:2:1 ratio and add 30 ml (2 Tbsp) of 6-8-6 fertilizer to each 10 litres (2.6 gal) of mix. You can water with a weak liquid form of transplanting fertilizer (4-10-2) weekly, but ensure that the soil is moist before applying any fertilizer.
- Seedlings should be acclimatized in a shade house or lath-covered cold frame for a few weeks until they are set out in longer-term storage areas. Fertilize every 7–14 days from spring until late July.
- In the fall, pot up seedlings that have sufficient root mass into larger pots. Check the size of the root balls to determine the next pot size that should be used (see "Potting On" below). Do not use a pot that is too large or too small.
- Overwinter in a cold frame, sunk in sand, sawdust, or soil in nursery beds (to retain moisture and protect from frost), in a cool greenhouse, or in a place that is protected in some way (such as by using Remay cloth or shade cloth) from fluctuating temperatures and wind.

POTTING ON

- Moving seedlings to a larger pot size may be required the following spring, which will vary with the species growth rate, but this should be done before the plant is pot-bound.
- Move up one container size (pots are usually in 2" (5 cm), 3" (7.5 cm), 4" (10 cm), 6" (15 cm), 8" (20 cm), 1/2 gallon (2 litres), 1 gallon (4 litres) sizes).
- Put some potting mix in the bottom of the container, place the plant in the centre of the new pot, and make sure it is at the same height as the previous pot.

- Add potting mix around the plant and firm gently around the edges of the pot and next to the stem.
- Water and re-label.
- Record the date of transplanting and numbers of species in nursery records.

Asexual or Vegetative Propagation

Herbaceous cuttings are of three types: ***tip, root,*** *and* **rhizome.** *See also stem cuttings below.*

TIP CUTTINGS

> Herbaceous cuttings are of three types: tip, root, and rhizome.

- Tip cuttings are taken from early spring to early summer from herbaceous perennials.
- Choose cuttings from healthy, vigorous plants. Remove the top 3–6" (7–15 cm) with at least two leaf nodes.
- To ensure that there will be enough cutting material, shear back the stock plants repeatedly in the spring/summer, and keep them well fertilized. The stock plants will bush out and there will be a succession of tip cuttings available.
- Take the cuttings on a cloudy, humid day with no wind and have the potting mix and pots ready for insertion of the cuttings.
- Place at least one leaf node or axil well into the potting mix. Remove any leaves that will be below the soil, and pinch out any growing tips and buds.
- For a good potting mix use seed starting mix and coarse perlite at a 2:1 ratio; peat moss and coarse perlite mixed at 1:1 ratio, or a 1:1 mix of sharp sand and perlite.
- Strike cuttings into containers using 16"x 16" x 3" (40 x 40 x 7.5 cm) flats, or 11" x 21" (28 x 55 cm) flats, or plugs.
- Keep air around cuttings humid with a mist system or enclose in a plastic bag using small sticks to keep the bags open, or use the domed plastic lids that fit over standard flats.
- The cuttings should receive only morning light until they are rooted, then should be hardened-off gradually (in the spring) in a cold frame over a 2-week period before placing outdoors.

ROOT CUTTINGS

Examples of root types: Small roots: Woolly Sunflower (*Eriophyllum lanatum*) (REU#3, 5), Common Yarrow (*Achillea millefolium*) (REU#1, 3, 5), Shootingstar (*Dodecatheon* spp.) (REU#1)Medium-sized roots: Rough-leaved Aster (*Eurybia radulinus*) (REU#3)

- Root cuttings can be taken for the propagation of some shrubs and herbaceous perennials.
- Use healthy root pieces in late winter or early spring prior to the start of new growth, but when the roots have a supply of stored foods.
- Wash roots and choose firm, fleshy roots about the thickness of a pencil.
- Choose sections that are as close as possible to the root crown of the plant. Dispose of any weak, damaged, or diseased roots.
- Use sterilized secateurs or knives to cut roots into short sections. Cut the root tip end on an angle, and straight-cut the end nearest the root crown (this will make it obvious which end goes up when striking the cutting).

- Dibble a hole with a pencil approximately 1–2" (2.5–5 cm) deep. Place cuttings vertically or at 45° angle into a soil-less potting mix of coarse sand, a 2:1 mix of sand and peat moss, or a mix of equal parts vermiculite and perlite (use a dust mask) with the root tip end placed down into the pot.
- Cover the medium's surface with fine sand or pea gravel.
- Water the cuttings in gently to ensure good contact with the medium and cover the container with plastic, glass, or Plexiglas.
- Label the containers and enter the name of the plant, its source, the number of cuttings, the date they were collected and the type of medium used in your nursery records (see appendices).
- Place pot in a warm but shaded place. It may take 6–8 weeks before new shoots and roots have developed.
- Cuttings can be potted up when they have 2–3 sets of leaves, or sooner, depending on the size of the container in which they have been started.

RHIZOME CUTTINGS

Examples: Perennials: Long-stoloned Sedge (*Carex inops*) (REU#1, 2, 7).
Shrubs: Saskatoon (REU#7), Nootka Rose (Rosa *nutkana*) (REU#1, 2, 5), snowberry (REU#1, 2, 3, 5, 7)

- Divide rhizomes with at least 2–3 buds or nodes in each section.
- Lay the section on the top of soil-less potting mix so that it is in contact with the soil. You may want to anchor the sections with opened up paper clips or some other type of anchor.
- Water and cover with glass or Plexiglas.
- Label the containers and enter the name of the plant, its source, the number of cuttings, the date they were collected and the type of medium used in your nursery records.
- Place in the shade until new shoots have developed.

Stem cuttings taken from shrubs are of three types: *softwood, semi-hardwood*, and *hardwood* cuttings. Use potting medium of equal parts sand:peat moss (or peat substitute if peat from a renewable source is not available), perlite:peat, or vermiculite:sand.

Stem cuttings taken from shrubs are of three types: *softwood, semi-hardwood,* and *hardwood* cuttings.

SOFTWOOD CUTTINGS

Examples: Dull Oregon-grape (*Mahonia nervosa*) (REU#8), Indian-plum *(Oemleria cerasiformis)* (REU#1, 2), Mock-orange (*Philadelphus lewisii*)

- Take these in early morning during spring or early summer, using new growth when deciduous shrubs are first leafing out.
- Take the growing tip plus two to three nodes (3" (75 mm) in length).
- Cut beneath a leaf node.
- Trim large leaves to reduce moisture loss.
- Place rooting medium in 4" (10 cm) pot. Press firmly down leaving approximately 3/8" (1 cm) at the top.

- Use a pencil or dowel to make holes in the medium.
- Dip the root ends of cuttings in rooting hormone #1.
- Insert cuttings into the holes in the medium and firmly press media around the edges so cuttings remain upright.
- Gently water and label the containers and in your nursery records enter the name of the plant, its source, the number of cuttings, the date they were collected and the type of medium used.
- Provide mist and bottom heat if it is available. If not, cover the container with clear plastic bags (support bags with small sticks such as chopsticks or bamboo skewers), clear plastic domes (ones that fit over flats), or cut open large, clear pop bottles and use them as domes. Check for condensation build-up and vent the cover.
- Place in a semi-shady location (cuttings will need filtered light such as under deciduous trees) and check for mold and monitor moisture levels.
- Check for rooting in 6–8 weeks by gently tugging on the cuttings. Knock out the cuttings and check the roots, which should be 1/2–3/4" (1.5 to 2.25 cm) long.
- Pot up rooted cuttings in 4" (10 cm) pots and place in a shade house or sink into sand or soil in a cold frame over the winter.

SEMI-HARDWOOD CUTTINGS

Examples: Saskatoon (REU#7), Tall Oregon-grape (*Mahonia aquifolium*) (REU#1, 3, 5, 7), Western Trumpet Honeysuckle (*Lonicera ciliosa*) (REU#1, 2)

- Take these cuttings in early morning in mid to late summer (early June to August).
- Use the current year's growth, approximately 4-6" (100–150 mm) in length including the softer top growth and the slightly hardened older growth.
- Remove any developing buds or blooms.
- Use steps iv–xiii in Softwood cuttings, except use rooting hormone #2.
- Use a mist system and bottom heat, if available.

HARDWOOD CUTTINGS

Examples: Oceanspray (*Holodiscus disolor*) (REU#1, 2, 3, 7), Indian-plum (*Oemleria cerasiformis*) (REU# 1, 2), Nootka Rose (REU#1, 2, 5)

- Take these in mid-winter, usually from deciduous trees and shrubs once their leaves have dropped.
- Use previous season's growth—about the thickness of a pencil.
- Take long lengths, about 12" (0.3 m), bundle together with elastic bands or string, and dip the root ends in liquid hormone #3.
- Place the bundles in boxes filled with damp peat moss or sharp sand and plunge up to ¾ of their length into the medium.
- Cover bundles with Garry Oak leaves, burlap, or Remay cloth, and store over the winter (2–3 months) in cold frames while the callus forms.
- Plant the rooted cuttings out in nursery beds in spring, or pot them up into the rooting medium. Remember to label the containers and enter the name of the plant, its source, the

number of cuttings, the date they were collected and the type of medium used in your nursery records.

Division

DIVISION OF HERBACEOUS PERENNIALS AND SHRUBS

Examples of herbaceous perennials: Yarrow (*Achillea millefolium*) (REU#1, 3, 5), Thrift (*Armeria maritima*) (REU#6), Rough-leaved Aster (*Eurybia radulinus*) (REU#3?), Pearly Everlasting (*Anaphalis margaritacea*) (REU#5?)

- Divisions can be made of fibrous-rooted herbaceous perennials, fleshy crowned perennials, and some multi-branched woody shrubs, which form dormant buds at the base of the stems.
- Cuttings are best done when the plant is dormant in early winter or late fall.
- Ensure the plant material is moist before dividing.
- Prepare either a transplanting bed or pots with soil mix.
- Divide the crown by cutting around the perimeter of the perennial or shrub with a sharp shovel.
- Split the crown of herbaceous perennials by slicing with a sharp transplanting shovel or a knife into pie-shaped wedges (about 2–3 only), ensuring there is sufficient root material attached to the crown. Remove any dead material from the centre of the plant.
- For shrubs, cut back the tops of the shrub and slice off the outer sections with adequate roots at the base of the stems (e.g., Nootka Rose (REU#1, 2, 5), Oceanspray (REU #1, 2, 3, 7)).
- Keep the material moist while the sections are out of the ground, and water in once transplanted or potted up.
- Perennials that are kept as stock plants should be divided every 2–3 years following the guidelines for dividing in the fall for spring/summer bloomers, and dividing in the spring for late summer/fall bloomers.

DIVISION OF BULBOUS PERENNIALS

For more information, please see "Propagating Flowering Bulbs, Corms, and Rhizomes: Some shortcuts from the Beacon Hill Nursery Experience", Appendix 10.1.

Examples of bulbous perennials: Bulbs: Nodding Onion (*Allium cernum*) (REU#7), Hooker's Onion (*A. acuminatum*) (REU#5), camas spp. (REU#1, 3, 4, 5), Chocolate Lily (*Fritillaria affinis*) (REU#4)
Corms: Harvest Brodiaea (*Brodiaea coronaria*) (REU#4), Fawn Lily (REU# 1, 2), Fool's Onion (*Triteleia hyacinthina*, White Triteleia) (REU#4)

- Using stock plants, lift and divide bulbs.
- Bulblets can be removed from the edges of the basal plate (camas spp.) or at the leaf bases (onion spp.).
- Divide stock plants every 3–4 years in the fall by lifting and separating bulblets.
- Pot the bulblets up into flats or pots, water in, and label.
- Corms can be divided in the fall by removing the old inner corm and separating the outer smaller cormels from the base of the new corm.

- Place the dry new corms and smaller cormels in a paper bag or box in a cool area that will not freeze.
- Plant these in pots, flats, or nursery beds in the spring.

SUCKERS

Examples of plants that produce suckers: Saskatoon (REU#7), Nootka Rose (REU#2), Mock-orange (*Philadelphus lewisii*), Common Snowberry (REU#1, 2, 3, 5, 7)

- Take side shoots from shrubs that arise from below the ground.
- Make cuttings when the shrub is dormant.
- Dig out the suckering shoots with roots intact and separate from parent plant.
- Pot up or transplant the rooted suckers into nursery bed.

LEAF PETIOLE CUTTINGS

Examples: Broad-leaved Stonecrop (*Sedum spathulifolium*) (REU#3,7).

- Leaves can be used to propagate perennials vegetatively.
- Take leaf cuttings in spring when the leaves are plump, but prior to flowering, or in early fall.
- Using a sharp knife, remove the leaf near the base of the plant.
- Insert the leaf base into the rooting medium; water and label the containers and enter the name in your nursery records of the plant, its source, the number of cuttings, the date they were collected and the type of medium used.
- Place the pot in a warm place with diffused light.
- Repot into individual pots after about four months.

Case Study 3. Fort Rodd Hill Garry Oak Ecosystem Restoration—Parks Canada Agency

by Conan Webb

The objectives of this project at Fort Rodd Hill (FRH) were to:

a. test the efficacy of cutting out mature Orchard-grass (*Dactylis glomerata*) by removing only the root crown
b. test the feasibility of removing Orchard-grass by hand on a small scale (four 6 m x 6 m deep-soil plots (7.17 sq. yds.) and two shallow soil plots on rocky slope areas: one approximately 10 m x 10 m (10.95 sq. yds.); the other 10 m x 20 m (10.94 yds. x 20.87 yds.)
c. test the feasibility of removing Orchard-grass by hand on a medium scale (1.3 ha rock outcrop (3.21 acres))
d. investigate the feasibility of converting an herb layer dominated by Orchard-grass into one dominated by native grasses by removing mature Orchard-grass and planting native grasses at both a small (0.04 ha (0.098 acre)) and medium (0.5 ha (1/24 acres)) scale.

The study site is located in Victoria, on the west side of Esquimalt Harbour, and is in the Nanaimo Lowlands Ecosection and the Coastal Douglas-fir biogeoclimatic zone. Most of the area is underlain by Wark gneiss, a coarse to medium-grained metamorphic rock that outcrops extensively. Glacial deposits overlay bedrock throughout much of the study area, and deep-soil pockets occur within many bedrock exposures. Due the large number of deer present on the site, a fence was installed prior to planting. The study site is on the slopes and toe of a wooded (Garry Oak and Douglas-fir, *Pseudotsuga menziesii)* rock outcrop. The outcrop has been surrounded by a deer fence 2.1 m high and 400 m long (2.29 yds. x 437.45 yds.), which encloses approximately 1.3 ha (3.21 acres).

The grass species that were outplanted were selected based a number of factors:

a. common native species found growing in similar habitats around the Orchard-grass field
b. common native species found growing in similar less-invaded habitats at FRH
c. how robust native species were, which was presumed to correlate with their ability to compete with Orchard-grass
d. ease of growing
e. availability of local seed sources (at FRH)

As well, the native Blue Wildrye (*Elymus glaucus*), Alaska Brome (*Bromus sitchensis*), Columbia Brome (*Bromus vulgaris*), and Alaska Oniongrass (*Melica subulata*) were selected as species to plant in the study site. The study site already contained individuals of all of these species.

The wildflower species selection was based on the same criteria as those for grasses, except for criterion (a). Wildflower species planted were Spring Gold (*Lomatium utriculatum*), Harvest Brodiaea (*Brodiaea coronaria*), and Fool's Onion (*Triteleia hyacinthina*, White Triteleia).

Seed was collected on-site within the 54 ha (133.43 acres) of land managed by Parks Canada Agency. Seed was collected by University of Victoria co-op students who had been hired annually as part of the larger Garry Oak restoration project at this site. When grass seed was naturally dispersing, it was collected by using the thumb and forefinger to pinch the stem firmly below the inflorescence, then drawing the hand down the inflorescence to collect the seed in the palm of the hand. Collecting sites were visited weekly over the seed-ripening period, and plants were tested to determine when most of the seeds from any given inflorescence would detach easily. Regular visits ensured that a site was not left so long that no mature seeds were left on the plants.

The amount of time needed to collect seed was highly dependent on:

a. the overall plant density and number of inflorescences per plant: low plant density (or few inflorescences per plant) increases the time to search for and travel between plants
b. the number of seeds collected per plant (this is also affected by seed readiness: if too early, few seeds can be collected from each plant)

It took approximately 50 hours to collect 1.1 kg (2.43 lbs.) of seeds from the species at FRH, and more time if species identifications had to be confirmed. Grass seed generally was ready for harvesting from mid-June to mid-July; however, there were also yearly variations of approximately two weeks. To obtain a broad genetic mix, seed should be collected from tall, medium, and short plants in equal amounts, as well as from plants growing in different microhabitats. Because seed at different sites ripens at different times, collections have to be made over a number of days.

The collected seed was sent to Yellow Point Propagation[1] for cleaning. Airflow was used to blow away the chaff and unfilled florets. Only a few hours were required to clean the 1.1 kg (2.43 lbs.) of grass seed.

Seed storage was not necessary as grass plugs could be sown and outplanted in the same year, and seeds could also be broadcast in the fall. The seeds underwent a simple germination test prior to sowing: seeds were counted out; placed on a moist paper towel and sealed in a jar; the jar was placed on a windowsill; and the number of germinates were counted over a set period of time (two weeks) to estimate percent germination.

Seeds that were to be grown as plugs were sent to the nursery shortly after being collected and sown in early August. Seed to be broadcast was kept in a dry place until early fall when it was scattered after the fall rains began.

Seed was sown in 310 styro block at the beginning of August (310 Beaver Styro blocks have 160 cells, each holding 60 ml (2.03 oz.) and are about 10 cm deep (4")). Originally, 410 styro blocks (112 cells each holding 80ml (2.70 oz.) and are 10 cm deep (4")) were used; however, the smaller 310 size allowed the roots to fill the cavity quicker and were also easier to plant. The number of seeds planted per cavity was generally 3, but this may well vary based on the results of standard germination tests conducted in a growth chamber, the state of the seed, and the growing time (plugs can be ready sooner if more seeds are sown).

Some species exhibited dormancy while others did not. No dormancy was found in Blue Wildrye, Alaska Brome, or Columbia Brome. It was found that Alaska Oniongrass needed a cold stratification

1 Yellow Point Propagation, 13735 Quennell Road, Ladysmith, B.C. V9G 1G5 Phone: 250-245-4635. Email: ypprop@shaw.ca

period prior to germination. The seeds at FRH were stratified naturally over the winter by leaving them in mild weather in the unheated greenhouse (with the polyethylene walls removed). If colder weather or snow was in the forecast, the greenhouse walls were put on. This needs to be considered during the planning stage as it can drastically affect the sowing time, or the seeds will require artificial stratification.

The growing medium was peat-based with other components: vermiculite, perlite, and bark mulch to a ratio of 2:1 (peat:other components). This ratio gives a porous mixture that drains quickly and allows for frequent misting without over-watering. A slow release 14-14-14 fertilizer was used in the mix (100 day release) along with the other soil amendments of: 2 kg (4.40 lbs.) of lime and 500 grams (17.64 oz.) micronutrients in approximately 1 1/2 yd. mix. Dolomite lime was added to adjust the pH to approximately 6.

The greenhouses were kept at 15° to 25°C (59°F to 77°F) until the seeds germinated, and then the temperature was allowed to drop to 10°C (50 °F) at night. During the day, the greenhouse vents opened automatically at 20°C (68 °F), and were closed at night.

After the plants germinated, a 20-8-20 forestry water-soluble fertilizer was applied at a rate of 150 ppm of nitrogen at each watering. During the rapid period of growth the plants were given a water-soluble fertilizer at each watering.

A block weight difference between dry and wet weight was used to determine when to water. The difference from saturation to dry was approximately 2 kg (4.40 lbs.) and depending on the temperature and growth, it would take from a few days to over a week between fertilization.

The grass plants were allowed to reach approximately 25 cm (10") in height and then cut back to 15 cm (6"). This procedure produced a bushy plant with a good root for transplanting. The best plugs resulted from two shearings before outplanting, and shearing done in the spring. A good plug from spring planting would take about 8 weeks, whereas in the fall it would take about 11 weeks.

The plugs are ready when they can be removed from the styroblock cell cavity and have a good tight bundle of roots. Care must be taken that the plants are not grown too long or they will become root-bound. At this time, the seedlings were extracted from the styroblocks, bundled, and then placed in boxes for shipping. The plugs are able to stay in the boxes for 7–10 days if kept in a cool, shady place. If they are to be held for a longer period of time, the boxes need to be opened and watered. Outplanting can begin soon after the first soaking fall rain, usually around mid-October, and can continue throughout winter and early spring.

The site must be prepared prior to planting. This was initially done in September, however, preparing in June prior to Orchard-grass seed set proved to be better. No new weeds will germinate after this time due to the summer drought conditions. Preparation entails removing Orchard-grass by cutting out the root crown with a hooked knife (e.g., carpet knife). This method was chosen because it created minimal soil loss and disturbance compared to pulling out the entire root system. It took two people approximately a week to clear 444 metres^2 (531 sq. yds.), and the grass had covered 100% of the area.

Since 2005, 4000-5000 plugs have been planted into the study site annually. Grass plugs are trimmed to about 10 cm (4") in height before planting. A planting hole is created by cutting into the soil with a tool and the plant is inserted with the top of the plug being level with the soil that is then packed back around the plug. This method is quicker and creates less soil disturbance than digging does. All species were planted 25 cm to 30 cm apart (10" to 12") (~ 13 plugs metre^2 (1.2 yds.^{2})). No aftercare is generally needed if the plugs are planted in the fall after the first heavy rains. The first year planting was done using inexperienced staff and took 7 days for two people. In subsequent years a professional planter was contracted and planted approximately 4000 plugs in two days.

Two methods of monitoring have been used for this project: 1) recording percent cover of all species in the planting sites before and after treatment and annually since, and 2) photo monitoring of the sites (see Chapter 7, Case Study 1 and Appendix 7.1 for photo monitoring techniques). Orchard-grass has declined from an average of 16-30% percent cover in 2005 to less than 5% in 2008. Percent cover for Blue Wildrye has increased from less than 5% to 31-50% cover. No change was detected for California Brome, which was not detected in pre-treatment surveys, but is now at less than 5% cover. Columbia Brome was planted in one area, and has now increased to 6-15% cover. Alaska Oniongrass was a minor component planted in each area: its cover has not changed since the study began in 2005, and the study is ongoing.

Costs were highly variable and depended largely on how much of the work was contracted, however the main steps and their costs are:

a. Collecting the seed (a few hours to a couple of days of work) was done by staff. Cost per square metre is negligible.
b. Seed-cleaning cost is negligible compared to the other costs. If care is taken in collecting seeds using the method described, you may not have to clean the seed further.
c. Nursery cost has proven to be the most variable: from $0.15 per plug up to $0.75 per grass plug.
d. Planting the plugs generally costs around 4 cents per plug or around $5.59 per square metre at our planting density of about 13.7 per square metre (16.4 yd^2)

Conan Webb *is a Species at Risk Recovery Planner for Parks Canada Agency at Fort Rodd Hill National Historic Site.*

CASE STUDY

Case Study 4. Native Grass Restoration at Gonzales Hill

by Tara Todesco

The objectives of the restoration at Gonzales Hill Park were to remove non-native species from two fairly highly disturbed areas and replant with native grasses, grown by local community members from seed harvested within the park. TLC The Land Conservancy of B.C., along with other partners, has been working to restore the Garry Oak ecosystem in the park. The goals of the project were to improve the ecological integrity of Gonzales Hill Regional Park, to use an adaptive management strategy in the restoration plan for the park, and to encourage community participation.

Gonzales Hill Regional Park is located on Denison Road just off Beach Road in Victoria. Gonzales Observatory, built on the summit of the hill in 1914, was a weather station for 75 years, and the building is a heritage building. The 1.8 ha (4.45 acre) park was established in 1992 and is a small fragment of Garry Oak habitat located within a residential area. Due to its location, the site is subjected to a high degree of recreational use. Soil compaction, site disturbance, and lack of active management have resulted in the establishment of a high proportion of non-native invasive species.

The elevation at the summit of the park is 67 m (220 ft.). The site is ridged, with elongated hillocks of metamorphic rock (Wark Gneiss) that run in an east/west direction with pockets of soil in the rock indentations and in low-lying areas. In the five areas surveyed, there was a top layer of organic material 2–10 cm (3/4"–4") deep. The aspect of the soil pockets is approximately westward with a slope between 0 and 15°. Water is from precipitation, and the site drains rapidly. Surrounding vegetation includes patches of Douglas-fir (*Pseudotsuga menziesii*) and Shore Pine (*Pinus contorta* var. *contorta*).

Native grass plantings were carried out in two main areas near the observatory on sites that had been impacted by both the construction of the building and the development of a small, ornamental garden during the 1950s and ’60s. Both areas were covered primarily with non-native grasses, cotoneaster (*Cotoneaster* sp.), and English Ivy (*Hedera helix*). Both sites, except for a few rocky sections, had deeper soils than most of the rest of the park, probably due to past gardening activities and the subsequent decomposition of ivy leaves.

With the help of biologist James Miskelly (CRD Parks), two grass species were identified for propagation and replanting in the park: Blue Wildrye (*Elymus glaucus*) and California Brome (*Bromus carinatus*). These two species were chosen because they are both native and common within the park. Collections were made when grass seeds could easily be pulled by hand from the heads during a period of relatively dry weather (late July). No cleaning was required. Seed collection took less than 1 hour in each season, and both harvests in 2007 and 2008 took place in late July.

Seeds were counted and packed by hand for distribution to volunteers within a few weeks of harvesting. Seeds were then stored in paper envelopes in a dark, dry place. Volunteers were given seeds and supplies and looked after sowing and growing-on of grass plugs, which took a few hours each season. The volunteers grew the grass plugs at their homes.

A propagating plan was designed to allow the planting-out of the grass plugs in late September or early October to take advantage of the start of the fall rains. During the first two weeks of August,

Outplanting of grass plugs at Gonzales Hill Regional Park. Photos: Tara Todesco and Kathryn Martell

volunteers sowed the seeds into plastic planting trays that each contained 50 cells (54 cm x 27 cm (22" x 10"). Four seeds were sown in each cell, and moist peat was used as the planting medium. Seed trays were placed in a sunny location and kept moist until germination occurred. The trays were then moved to a semi-shaded location and were watered as required (i.e., not allowing the plants to be flooded or dry out completely). No fertilizer was added.

The grasses remained in the trays for an average of eight weeks. Planting-out of the plugs, using approximately 5 cm (2") of space between plugs, was carried out in late September and early October. A full day each year was required for two volunteers to complete the planting. The plugs were watered for the first two weeks after planting, or until consistent rainfall occurred.

During the growing period, the two target sites were cleared of all non-native grasses and any remaining roots. Removal techniques were based on best practices outlined on the GOERT website at www.goert.ca/invasive, and clearing was carried out by volunteers. There was no over-digging of the soil, and planting was carried out in the resulting open soil. This was to minimize opportunities for re-invasion by non-native species.

The grass growing project attracted a different set of volunteers to The Land Conservancy. These volunteers were interested in growing plants for the park's restoration but were not necessarily interested in other types of volunteering. To attract volunteers, local advertisements were placed through Volunteer Victoria, The Fairfield Community Organization, and the Garry Oak Ecosystems Recovery Team. In addition, volunteers were recruited from TLC's on-call volunteers. Each volunteer came in ahead of time to discuss the project and fill out volunteer application forms. As well, volunteers were encouraged to come by individually to take a look at the park and to review the growing instructions when they picked up their seeds and supplies.

Volunteers were used whenever possible in all stages of the project in order to develop a core of local community members with a sense of stewardship for the park. Ongoing communication with volunteers, including asking for follow-up phone calls and emails to track when the grasses were sown and how growth progressed, was important for keeping the volunteers' interest and commitment.

The costs involved with the restoration of the park were minimal: they covered the costs of planting trays and peat. In-kind costs included the staff hours from TLC and CRD staff, including the transport of the debris from the site by CRD Parks.

References

Bonenfant, N., L. Kwasnicia, and A. Smith. 2007. Gonzales Hill Regional Park: study site—restoration of Garry Oak ecosystem. University of Victoria, Restoration of Natural Systems Program, Student Technical Series No. STS0710-311.

Tara Todesco *formerly worked at Gonzales Hill for TLC The Land Conservancy as Volunteer Management Coordinator.*

English Ivy (*Hedera helix*) growing at Gonzales Hill Regional Park before clearing, September 24, 2007 (left) and ivy partially cleared at Gonzales Hill Regional Park, September 27, 2007 (right). Photos: Tara Todesco

Case Study 5. Native Meadow Restoration at Cowichan Garry Oak Preserve—Nature Conservancy of Canada

by Irvin Banman and Tim Ennis

The main objective of the restoration conducted at the Cowichan Garry Oak Preserve (CGOP) by the Nature Conservancy of Canada (NCC) is to restore the native deep-soil Garry Oak ecosystem grasses and camas on a site that was formerly dominated by introduced agronomic grasses. A second objective is to establish a native Garry Oak nursery comprised of grasses for the purposes of seed harvesting.

Sedges (*Carex* spp.) and camas growing in old farm fields at the Cowichan Garry Oak Preserve. Photo: Irvin Banman

The non-native grasses that dominated the site are well-established forage and hay grasses, mainly Meadow Foxtail (*Alopecurus pratensis*) and Timothy (*Phleum pratense*). The rich dark topsoil extends to a depth of 1 m (3 feet) (an average depth of .4-.6 m or 1-2 feet), under which lies a layer of heavy clay, then bedrock and shale. Historically, CGOP may have been a Qggc plant association – Garry Oak – Great Camas (*Camassia leichtlinii*) – Blue Wildrye (*Elymus glaucus*), according to the Erickson and Meidinger Classification Guide of 2007 (www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr040.htm).

Native grass seedlings planted out in an old hayfield at the Cowichan Garry Oak Preserve. Photo: Irvin Banman

The site is part of the extensive deep-soil camas meadows that were maintained by the Cowichan First Nations in the lower Cowichan River watershed before European settlement. The field in which the study is being conducted still contains the historical Garry Oak ecosystem deep soil savannah structure with very large old Garry Oak (*Quercus garryana*) trees spaced far apart (anywhere from 50 m (55 yds) to distances of hundreds of metres). The terrain slopes very gently to the west. The field is moderately wet during the winter months and retains moisture until late May to early June depending on the amount of winter and spring precipitation, after which time the ground becomes very dry until the arrival of the fall rains.

The species planted were Blue Wildrye (*Elymus glaucus*), California Brome (*Bromus carinatus*), California Oatgrass (*Danthonia californica*), Junegrass (*Koeleria macrantha*), Roemer's Fescue

Junegrass (*Koeleria macrantha)* and California Oatgrass (*Danthonia californica*) seed stock plantings at Cowichan Garry Oak Preserve. Photo: Irvin Banman

Propagation frames at the Cowichan Garry Oak Preserve. Photo: City of Victoria

(*Festuca roemeri*), and Great Camas (*Camassia leichtlinii*). Seed was collected at the Cowichan Garry Oak Preserve and several other local areas with permission and under permit where required, and ethical seed collection guidelines were followed. These species were chosen partially to serve as a supply of native seed for further restoration. As well, they were chosen in order to observe which native grasses would perform the best in competition with each other and the non-native species, the seed of which is still in the seed bank. It is expected that the tall stature grasses, Blue Wildrye and California Brome, will out-compete the other grasses over time.

The site for the nursery is situated along a main access road into the preserve. The area chosen was in very poor condition, having been heavily disturbed and dominated by introduced grasses, Oxeye Daisy (*Leucanthemum vulgare*), Scotch Broom (*Cytisus scoparius*), and thistles (*Cirsium* spp.) The site is exposed to full sun and was enclosed with fencing to keep out deer and rabbits. Water is supplied by garden hose from the house on-site which is 200 m (218 yards) upslope from the nursery. A frame was constructed over the nursery for the installation of shade cloth in the spring until September.

The nursery has 20 cold frames, 2.5 metres x 1.5 metres (8 feet x 4 feet), for starting grasses and forbs. Some of these accommodate pots and trays; others are filled with soil and hold plants grown from seed. Three cold frames have been filled with salvaged camas, and there is open ground covered with landscape fabric for more mature plants, as well as trees and shrubs. Raised tables were constructed outside of the fenced area to accommodate additional potted plants when more space was needed. There is also a small greenhouse, which is being used on a trial basis for growing grass plugs. Mixed ready-to-use soil is stored under tarps next to the nursery.

Currently, two staff are employed at the site. Volunteers assist mainly during the winter months when youth programs are up and running and when community members are available. Volunteers contributed 500–600 hours to the nursery and out-planting program from October 2009 to April 2010. In addition, casual volunteers put in approximately 50 hours assisting with weeding and watering during the summer months.

All seed is locally collected in the Cowichan Valley area. Care is taken to collect no more than 5% of seed in any given population, and only up to this amount if the species are common and abundant throughout the region.

All plants for the restoration are propagated at the nursery except for salvaged plants like Common Camas (*Camassia quamash*), Spring Gold (*Lomatium utriculatum*), and Broad-leaved Shootingstar (*Dodecatheon hendersonii*). Trees and shrubs are salvaged from construction sites in the immediate vicinity, usually within a couple of kilometres of CGOP.

Seed collection occurs between the beginning of June and the end of September. Timing depends on the species collected and when the seed is ripened. Collection takes place during a warm and dry portion of the day, never after a rain or heavy dew, so that the seed is as dry as possible when going into storage. Most (95%) of the seed is collected on-site at CGOP. Some common forb and grass seed is collected at Mt. Tzuhalem Ecological Reserve under a permit issued by BC Parks for the purposes of Garry Oak ecosystems restoration. Seed collection is done mainly by NCC staff, and occasionally by volunteers.

The seed collection method is basic. Seed is collected by hand and several plastic yogurt containers wired together are used so that seed from numerous species can be collected at once. Seed is always transferred to breathable paper bags for storage so that it can continue to dry if there is any moisture left.

Seed collection from the grass nursery is carried out by cutting the grass stalks and taking them in bundles to the work shed. The stalks are spread out on the floor of the shed and the seed is separated by either shaking the seed off the stalk or combing it into plastic tubs. The time spent on grass seed collecting is approximately 80 hours per year. The amount of seed that can be collected from the grass nursery is far greater than what can be collected from the field in the same amount of time.

Seed cleaning, if necessary, is done by hand by rolling the seed to remove the husks and/or by winnowing (blowing off the chaff). Berries from shrubs and tree species like Saskatoon

Weeding in the propagation area at Cowichan Garry Oak Preserve. Photo: Irvin Banman

Grass seedbed at Cowichan Garry Oak Preserve after seed harvest. Photo: Irvin Banman

CASE STUDY

Grass plugs growing in root-trainers at Cowichan Garry Oak Preserve. Photo: Irvin Banman

Potted seedlings growing in frames at Cowichan Garry Oak Preserve. Photo: City of Victoria

(*Amelanchier alnifolia*) are macerated, washed, hand-rubbed over screens and then air-dried. Visual inspections are done to ensure that non-native seeds do not contaminate the mix. In total, 16 hours are spent annually cleaning seed at CGOP by NCC staff.

All seed is stored in the uninsulated work shed, which allows it to undergo natural temperature fluctuations and humidity levels until it is planted in the nursery. So far, no seed has been lost to mold or rot. This may be due in part to the fact that seed is not stored for very long periods (it is generally used within a year).

The standard soil blend used for all species grown in pots and trays is:

- 45% native soil (from what was once a hay field and is now cultivated to make way for native grasses)
- 45% sterilized fish compost*
- 5% Garry Oak soil (to inoculate the mix)
- 5% perlite

For most of the 45 species grown at the CGOP nursery, planting is initiated in the fall and continues into early- or mid-winter. Grasses are sown into plug trays; bulbous species (e.g., camas) and longer rooted species (e.g., Spring Gold) are sown in longer open trays. Tree and shrub species are sown in one-gallon pots. On average, 3–6 seeds per cell or pot are sown to ensure that each container has one plant in it. If more than one seed germinates, plants are separated into their own containers unless the roots are too intertwined. Almost all of the seedlings are subsequently replanted into larger containers for further development.

All plants remain exposed to the elements, and since the growing environment is not controlled, there is no need to harden-off the plants prior to outplanting in the field. No fertilizer is used, and watering is done only when required, which depends on the weather.

*certified organic fish and forest fines with neutral pH, heat treated to eliminated weeds; made on Vancouver Island and obtained from a local nursery.

Grasses started early in summer that have had sufficient warm weather to develop adequately go into the field 2 months after sowing. If the grasses are sown in the fall, they go into the field up to 8 months later. Some grass plugs are replanted first into one-gallon pots to grow larger because they not only survive better but also will then produce seed in the field in the first season. Bulb and perennial species are planted out after a minimum of 3 years in the nursery; trees and shrubs, anywhere from 2 to 3 years. Almost all species stand a much better chance of surviving if they have well developed deep root systems, which enable them to draw enough water to make it through the summer drought.

A variety of preparation techniques is used on planting sites. For grass species, the location is either on tilled ground or ground that is plant-free after having been covered with ground fabric for a couple of seasons (study plot). When grasses are planted out in ecologically sensitive areas at CGOP, they are placed into holes left from the removal of introduced species. In general, outplanting for all species takes place during the fall and winter months when soil moisture levels are high so that plants do not suffer from lack of water. On sites that are easy to water, outplanting is done at any time of year. Camas bulb planting is usually done in the fall and winter, but this is not absolutely necessary as the bulbs are very resilient, even when planted in spring and summer (as long as they are at least 2 cm (3/4") in diameter).

During the course of a year, 6000 grass plugs are started. It takes approximately 7-person hours to outplant 1000 grass plugs, not including preparation time and moving the plugs and supplies to the site. If plugs are planted into untilled areas, it may take 14–20 hours to plant 1000 plugs.

Suggestions/Pit-falls

- Frost may sometimes push plugs up and out of the ground if planted in bare cultivated soil, so care must be taken to plant the plugs as deep as possible.
- Sometimes too many plugs were grown and there was insufficient time to plant them all out.
- Herbivory is an issue and deer had a significant impact in the study plot on species they favour; they browsed heavily on California Oatgrass and Great Camas in particular.
- Fencing has been installed to keep out the native Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*) and non-native Eastern Cottontail (*Silvilagus floricans*) rabbits that have impacted the plantings. Additional 300 cm (9 feet) high exclosures have been installed around the outplantings to minimize losses.
- Ensure that plants are well-watered at all stages of growth and when they are re-potted, and that enough time is budgeted for weeding.
- If at all possible, allow plants to develop good root systems by keeping them in the nursery for as long as possible before outplanting, otherwise they may easily be overwhelmed by competition or die from lack of moisture.

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Tim Ennis *is the Director of Land Stewardship for NCC (B.C. Region).*

10.4 Determining Optimum Techniques for Propagation

10.4.1 Direct Seed Sowing vs. Container Seed Sowing

Direct seed sowing generally requires more work than container seed sowing because the site has to be prepared ahead of time and any germinating weed seeds have to be removed. In addition, seeds that are direct sown may not find the appropriate germination site if they are scattered, and/or they may be eaten by animals or insects.

It is easier to control the growing environment and track seed germination and rooting of any type of cuttings if they are in containers (e.g., you can control watering/media during the growth/fertilization schedule). Seeds started in plugs or containers will be able to obtain sufficient root development before outplanting. The exception will be when using whip cuttings, such as those used in bioengineering projects (Polster 2009). Starting seedlings in containers will give them a competitive advantage over other plants, especially weeds.

Container seed sowing also enables development to be monitored and provides consistent growing conditions, especially during the vulnerable seedling stage. Record keeping is easier with this method of sowing (e.g., you can determine the known number of propagules to outplant), as is the automatic application of water and fertilizer. A greater number of propagules will also reach maturity and therefore will be available for outplanting.

10.4.2 Nursery Bed vs. Containers for Vegetative Propagation

Deciding on using either nursery beds or containers for vegetative propagation depends on the growth type of the species to be propagated. Nursery beds are traditionally used for shrubs and trees, but they can also be used for perennials and grasses.

> It is easier to control the growing environment and track seed germination and rooting of any type of cuttings if they are in containers.

Some advantages of using nursery beds are as follows:

- They are less costly than containers.
- Less water is used (containers can dry out faster).
- There is greater root development for larger shrubs and trees; however, you may need to ball or burlap them for transportation which will require equipment to lift the plants, supplies, and the correct timing to be arranged for this process.
- Using nursery beds may allow the plants to stay in the beds longer than if in containers since they will not need to be repotted, as their roots are not constrained by a container. Beds may be used for trials, and plants can be maintained for future stock production (e.g., shrubs can be cut back to generate long stems to use as whip cuttings for bioengineering).
- Perennial plant materials in beds can be used for division and for taking root cuttings.

Some disadvantages of using nursery beds are as follows:

- Plants in nursery beds are hard to move around in the nursery and containers also facilitate taking plants directly to the outplanting site.

- The need to weed the nursery beds, which will have more ground surface area for weeds to grow in than containers.
- When the plant material develops through rhizomes, it is possible that the material will become too large and difficult to divide.
- Nursery beds require an initial investment to prepare the soil, which is costly.

10.4.3 Number of Propagules Needed (Estimation of Numbers for Outplanting)

When estimating the numbers of plant materials required for outplanting at a specific site consider the following:

- spacing (width and height considerations of the mature plant)
- percentage germination for species (each collection of seeds will differ)
- the plant composition (matrix) of the landscape microsite (refer to Table 2.2 in Chapter 2) that you want to restore to
- guidelines for spacing and numbers per species (e.g., one bunchgrass per m^2 for woodland and up to $5/m^2$; 4-8 herbaceous perennials/m^2; one shrub every 5 m^2; one tree every 50 m^2).

10.5 Seed Collection, Extraction and Cleaning, Viability Testing, and Storage

10.5.1 Seed Collection

When collecting seeds for native plant propagation, ethical collection guidelines should be followed. The GOERT website provides an example of such guidelines (www.goert.ca/ethical_collection). Additional guidelines can be found at the florabank website (www.florabank.org.au).

When collecting seeds for native plant propagation, ethical collection guidelines should be followed.

Seeds must be collected when they are ripe, which depends on the type of seed. For example, capsules must be dry and papery, and the seeds usually become brown to black when ripe. Berries or drupes normally turn red to dark purple when ripe. Banerjee et al. (1998) provide collection guidelines for woody plant seeds.

Collection methods for fruits vary depending on the type of fruit and the volume needed. Methods include simple hand-picking, removing entire fruit clusters, raking naturally fallen fruit from the ground, or flailing branches to cause fruit to fall onto tarps.

Collect only what you need for your project, and be prepared to properly store the cleaned and dried seeds for future use.

Record-keeping is extremely important in the propagation of native plants (refer to Section 10.7.3 and appendices); records can be referred to in subsequent years for guidance. The types of information that should be recorded are: species name, collection site, site description, date of collection, elevation, aspect, etc. You may want to use a specific code and a unique number for each record (see Appendix 10.2 for a seed collection record template).

10.5.2 Considerations for Collecting in Adjacent Sites

Before collecting seed from sites adjacent to the restoration site, a microhabitat assessment of these sites (refer to Table 2.2 in Chapter 2) should be completed to improve compatibility of propagated plants with the restoration site. This will increase the chance that the gene pool is maintained for those species collected.

When considering whether or not to collect from a site adjacent to the restoration site, determine if the species are the same (by identifying them correctly to species, variety, or subspecies), and if the genetic diversity of the resulting restoration planting will be increased by collecting at this site. It is also important to obtain written permission from the landowner to access the land, and to have the appropriate liability insurance (see Case Study 1). You should also ensure that there is minimal damage to the site and propagule sources.

Case Study 6. Seeds – Collection, Cleaning, Storage, and Germination

by Moralea Milne

One of the most enjoyable aspects of restoration is the collection of propagules for your project. After you have surveyed your site and reference sites, and determined which species are most likely to have been present and which species you will spend your efforts on replanting, you have the opportunity to search for these species.

Plant Identification and Locating Plants in the Field

If you are in any doubt as to plant identification, it is best to locate promising populations with the help of an expert, preferably during the flowering season because many vascular plants are easier to identify when they are in bloom. *You will need to receive permission to hike in and collect from these areas.* Identify the healthiest and most vigorous plants; they will likely produce the highest quality seeds. Mark their exact locations so when you return you can identify the plants in their new, less obvious stage as seed containers. The best way to record their locations is with a GPS device, but a little brightly coloured tape (that is removed later) can also be used to narrow down the location to the last few metres. It is also useful to collect or photograph representative seedheads and mount them so they can be used as a learning/identification tool.

Step lightly through these Garry Oak and associated ecosystems; disturbances, especially in sensitive rocky bluffs, can facilitate the spread of invasive species. It is best to collect seeds on dry days so that you do not have to worry about wet seed heads and subsequent mold problems.

It is most important to collect propagules from within your restoration site or from the nearest populations. Researchers are discovering new information on species every day. Some species that have been identified as a single species are in fact separate species with different ecological preferences.

Seed Collection

Refer to GOERT's ethical guidelines (www.goert.ca/ethical_collection) on the number of propagules that you should collect from species, populations, and locations. As well, consult with local knowledgeable sources as to the appropriate time to collect seeds.

Many factors can influence when seeds are ripe and the quantity of seeds you might find: early and late seasonal changes, moisture and drought, browsing by predators, elevation and geographic variations, disturbance regimes, the plants' own individual requirements, and other vagaries of which we have no or incomplete knowledge. For example, Garry Oaks are mast-fruiters—plants that produce acorns in abundance only irregularly—but the acorns are predated by Band-tailed Pigeons (*Columba fasciata*), Steller's Jays (*Cyanocitta stelleri*), and Eastern Grey Squirrels (*Sciurus carolinensis*), and are vulnerable to infestations by various weevils.

Consider when you are harvesting in lean years that you are decreasing the quantity of seeds available for natural reproduction and for food for some native species. Also, a population might have been decimated already; therefore, find and mark more sites than you think you will need.

CASE STUDY

Seed collection supplies include paper and plastic (Ziploc) bags, or small plastic storage containers; a small, waterproof booklet and additional waterproof paper; indelible writing implements; a GPS unit; and field guides for identification. Use paper bags when collecting dry seeds to reduce the possibility of mold. Soft-bodied seeds, such as berries, are better collected in plastic bags or plastic storage containers.

On each seed container, record the date, plant name, location, and any other relevant information (e.g., plant colour and vigour, associated plant species, recent weather conditions (dry year, wet year), a note to try collecting two weeks earlier, later, etc.). You may want to use a code for each collection and record the code and its corresponding information in a field notebook (see also Section 10.7.3 and appendices).

Directions for Cleaning Dry Seeds

by Heather Koni-Pass (from Jan 2007 NPSG News: www.npsg.ca)

FLUFFY SEED HEADS (e.g., Yarrow (*Achillea millefolium*), Oceanspray (*Holodiscus discolor*)): You will need sturdy gardening gloves, a sieve that will allow seeds to pass through, an ice cream bucket, newspaper, small plastic bags, and labels. With gloves on, take small handfuls of seedheads and rub them between your hands over a newspaper to separate the seeds and chaff. Place the broken seedheads into the sieve and sift. Save and label the seeds after discarding the chaff.

CAPSULES and PODS (e.g., Nodding Onion (*Allium cernuum*), camas spp., shootingstar spp.): You will need sturdy gardening gloves, a rolling pin, a large screen with mesh that will let seeds pass through, newspaper, small plastic bags, and labels. With gloves on, put a handful of capsules or pods on the newspaper. GENTLY crush the capsules or pods with the rolling pin. Take the resulting mixture and place it over a small mesh screen to separate out the chaff. Save and label the seeds; discard the chaff. Many pods curl open when dry; therefore, it is just as easy to flick the seeds out with your fingers or a thin probe.

CONES (for Grand Fir (*Abies grandis*)): You will need a face mask, paper grocery bag, blank newsprint, and a sieve that will allow the seeds to pass through. Put the cones in the paper bag and shake vigorously. Pour the contents into the sieve and sift the seeds through. Dry the seeds on the blank newsprint.

WINNOWING (e.g., grasses, sedges, and rushes): Winnowing is best for separating heavier seeds from the chaff. This is easiest done by working at a large table. You will need a broom, a dust pan, a large plastic sheet, newspaper, a fan, two deep buckets of the same height, and an ice cream bucket. Cover the table with the plastic sheet and cover the plastic with newspaper. Place one deep bucket at the end of the table, upside down, and stand a fan on the bucket with its head in a fixed position, facing down the length of the table. Turn the fan on low speed. Hold your hand in front of the fan so you can judge where the airflow is not too strong. Position the second deep bucket, right-side up, at this point in front of the fan.

Put the seeds and chaff into the ice cream bucket and hold that bucket above the second bucket that is in front of the fan, slowly pouring a little of the contents into the second bucket. If positioning is correct, the heavier seeds will fall into the deep bucket and the chaff will blow onto the table. If the air current is too strong and everything blows onto the table, simply scoop up the mixture, move the deep bucket a little further away from the fan and try again. With some experience, it becomes easy to judge the distance from the fan.

NUTS (e.g., Garry Oak (*Quercus garryana*)): You will need seeds, a bucket of water, two screens of the same size with two pieces of black landscape cloth to match the screens, and weights or clamps to hold the screens together. For acorn sowing: use 1-gallon pots full of leafy compost.

Put all seeds in the bucket of water and soak overnight. Seeds that sink are viable; discard any ones that float.

PLANTING OAK SEEDS: Place a layer of landscape cloth on a screen, spread the acorns over the cloth, and cover with a second layer of landscape cloth. Place the second screen on top and weigh or clamp all together. This is to ensure that rodents or birds do not eat the seeds. Place this package on a table in a greenhouse or in a shady spot outdoors, and water 3–4 times a day. As the acorns sprout, transfer them individually to deep, narrow pots containing good leafy compost that has been gently tamped down. Water in and continue to water regularly. Seedlings should remain in this pot until sold or ready to plant out. Take care not to damage the long root.

If you have only a handful of acorns, sprouting can be done in a canning jar with a screen on top. The cupboard under the kitchen sink is a good, dark, warm spot for sprouting the acorns.

Directions for Cleaning Soft-Berried Seeds

by Heather Koni-Pass (from May 2006 NPSG News: www.npsg.ca)

EXAMPLES: Saskatoon (*Amelanchier alnifolia*), Salal (*Gaultheria shallon*), honeysuckle (*Lonicera* spp.), Oregon-grape (*Mahonia* spp.), Indian-plum (*Oemleria cerasiformis*), Nootka Rose (*Rosa nutkana*), Common Snowberry (*Symphoricarpos albus*)

EQUIPMENT: Waterproof apron, water source at work table, several buckets, food processor, duct tape, large sieve, clean stir stick, several cleaning rags, fine-meshed screens, clean newspaper, fan, small plastic flower pots.

- Put one or two layers of duct tape on the blades of the food processor—one layer for small seeds (e.g. *Rubus*-raspberries), two for larger seeds (e.g. Indian-plum).
- Put a small number of berries in the food processor; fill with cool water.
- Holding your hand over the spout, pulse several times until a slurry forms.
- Fill a bucket 1/2 full of cool water. Pour the slurry into the bucket of water and swirl around. Unviable seeds and berry mush will float to the surface. Viable seeds will sink to the bottom of the bucket. Set the sieve over another bucket.
- Slowly pour swirling water through the sieve, stopping before the clean seeds are poured out of the first bucket. If cleaning fine seeds, line a screen with clean newspaper. Omit newspaper for large seeds. Retrieve clean seeds from the first bucket and spread on the screen.
- Examine the remains that are left in the sieve. If you feel there are enough seeds remaining in the slurry dregs, repeat processing.
- Repeat this process until all fruits are seeded.

When you have completed the screening process, put the screens of cleaned seeds in a well-ventilated space to dry. Stand a flower pot under each corner of the screens to ensure good ventilation. Cover with a second screen so the seeds are not eaten by rodents. Stir gently several times a day while drying, or gently run a fan in this area to help the drying process. If seeds stick together while drying, simply rub them through your hands occasionally to separate. When sufficiently dry, the seeds can be sown, or stored in the refrigerator.

Seed Storage

from: www.jvk.net/pdf/drk_seed_storage_and_handling.pdf

Check the Garry Oak Ecosystems Recovery Team's (and other) propagation guidelines (www.goert.ca/propagation) for information on seed storage times. Some species will keep for decades. Others will keep for only months or a few years, with decreasing germination success as time goes by.

Generally, seeds should be dried to 5–8% relative humidity (RH) and then stored at 5°C (41oF) to retain optimum seed quality. Seed quality will be affected when moisture content falls below 5% RH (vigour declines) or above 8% RH (seeds deteriorate); above 12% RH, fungi can grow. Refrigerators are the right temperature for seed storage but have approximately 40% RH. To ensure proper drying, seal the seeds in a jar (wide mouth canning jars work well) with a desiccant such as silica gel.[4] The amount of silica gel placed in the jar should equal the weight of the seeds. Storing the seeds for 7–8 days in a tightly sealed container along with the silica gel should bring the seeds down to approximately 8% RH. Once this is done, remove the seeds, repackage/label, and store in an airtight container. Seeds should be stored in a cool, dark, dry place such as an unheated basement room or the refrigerator.

If silica gel is not available, powdered milk or cornmeal, tied in a small breathable fabric such as cheesecloth, can be used. Small seeds will dry sufficiently overnight; larger seeds may take several days. If dried seed packets are opened and left unsealed for several hours, the seeds' moisture content will increase rapidly. They will have to be dried again to ensure continued vigour and viability.

Some seeds have short lifespans and can be stored only a short while. Garry Oak acorns should be planted almost immediately. They should be kept cool and moist until planting because they will not tolerate being dried out.

Seed Scarification

In order to propagate plants at our convenience, it is sometime necessary to artificially induce germination. One technique for doing so is seed scarification (see page 10–17). It is used on many tree and shrub species that have developed hard seed coats for protection. In their natural environment, the seeds might sit for one, two, or more seasons until their seed coats have deteriorated enough to allow moisture and air to access to the embryo and initiate the germination process. Hairy Manzanita (*Arctostaphylos columbiana*) and Kinnikinnick (*Arctostaphylos uva-ursi*) are two species that can be forced into an earlier germination by using various means of seed scarification. Mechanical treatments involve gently rubbing the seeds with sandpaper or a nail file, nicking them with a sharp implement, or cracking them with a hammer. Chemical treatments include immersing the seeds in vinegar for periods of time, or covering them with boiling water and leaving them to sit until the water has cooled. Whichever method is used, it is important to open the seed coat without harming the embryonic plant. Scarified seeds do not store well and should be planted as soon as possible.

4 Silica gel can be purchased at scientific supply stores. It comes as a coloured product. A pink or red colour means the product is still working; blue means it has ceased to be useful. The gel can be reinvigorated by heating to 110–180°C.

Seed Stratification

Many seeds need stratification. This involves manipulating the seeds' environment by providing moisture and alternating cold and warm temperatures, which simulates seasonal changes. For example, Saskatoon seeds will germinate after a cool, moist stratification period. This can be done by placing cleaned seeds in a sealable plastic bag along with some slightly moistened peat moss, and keeping the bag in the refrigerator for approximately three months. After this time, the seeds can be sown. Alternatively, the seeds can be planted directly into their container and left outdoors for the winter. Common Snowberry seeds are more particular; they first require a warm, moist, 60-day period of stratification followed by 180 days of cool, moist storage before planting. The seeds should be checked regularly as they stratify to monitor for signs of mold or dryness.

Some seeds need both scarification and stratification to germinate. Check propagation guidelines for individual species' requirements.

Whether for large-scale production or your own satisfaction, proper seed collection, storage, and germination technique is an important consideration in any project. Enjoy the process!

Moralea Milne *is a graduate of the Restoration of Natural Systems Program at the University of Victoria, and a member of GOERT's Native Plant Propagation and Invasive Species Steering Committees.*

10.5.3 Seed Extraction and Cleaning

Cleaning and extracting seeds can be done on a small scale, as described below. See also Case Study 6, and Young and Young (1986).

Dry, dehiscent capsules (fruits which spontaneously open to release the seeds within) can be placed upside down, while still attached to the main flowering stem, into large paper bags and allowed to dry until the seeds are released (e.g., camas spp., shootingstar spp., Small-flowered Alumroot (*Heuchera micrantha*), Chocolate Lily, Fawn Lily). Note that not all seeds will mature in the capsules if collected while still immature. This method is mainly for capsules that have maturing seeds but are not quite open yet.

Dry, indehiscent fruit (fruits which don't spontaneously release their seeds) should be separated from the stalk or capitulum of the plant; e.g., Western Buttercup (*Ranunculus occidentalis*), *Lomatium* spp., Woolly Sunflower, *Aster* species. It may take some time to hand-remove the seeds from the stem.

Fleshy fruits can be hand-mashed or lightly macerated in a blender with water. The remaining pulp is floated off, and the filled seeds (ones that sink to the bottom of the container) are then laid out to dry on newsprint or paper towels.

For record keeping purposes, record the genus and species, date of collection, source of seed, approximate numbers or weight of seed, method of cleaning, seed production per kilogram of initial fruit collected, and any associated costs. Refer to Section 10.7.3 and record-keeping templates Appendices 10.2–10.4.

10.5.4 Seed Viability Testing

Seed germination testing is performed to generate an estimate of the viability of the seed lot. A sample of 100 seeds per seed lot is used to determine the percent germination under a controlled experiment (e.g., germination in a growth chamber). Appropriate temperature and light conditions are employed over a set time period. The standard is 15/20°C (59/68°F) alternating for 16 hours in the light and 8 hours in the dark (Baskin and Baskin 1998). This method requires some controlled environment conditions and a replication of samples.

It is also possible to X-ray seeds (using a subset of the seedlot) to see if the embryos are filled, but this requires access to a seed testing lab. Another standard viability test is the tetrazolium test, which is performed on a subset of the seed lot (Baskin and Baskin 1998). The embryo can also be excised from a subset of the seed lot, and should be white and firm (Baskin and Baskin 1998).

All of these methods will provide an indication of how many seeds are needed to be sown in order to produce the required number of propagules for the project.

10.5.5 Seed Storage

Seed viability depends on the general health, age, and maturity of the seed, and on preventing deterioration while in storage. The latter depends on providing the optimal temperature and humidity conditions for the seeds when they are in storage.

In general, the smaller the seed, the less time it remains viable in storage; therefore, some species are best sown as soon as they are ripe. Garry Oak acorns are recalcitrant, meaning they are meant to germinate soon after ripening, and therefore do not store well. Seeds that have embryo dormancy can be stored for only 2–5 years (grasses); seeds with seed coat dormancy could remain viable for 15–20 years under optimal storage conditions.

Storage Conditions

- Dry seeds to 4–6% moisture content. This is the most important factor in determining the viability of stored seed.
- Seal in paper packets in moisture-proof containers.
- Add a silica desiccant or a twist of cornmeal in wax paper to maintain low moisture content while in storage.
- Maintain an ideal storage temperature of 3–5ºC (37–41ºF).
- Maintain an ideal relative humidity of 20–25%.

10.6 Selection and Treatment of Plant Materials

10.6.1 Stock Plants *in situ*

Propagules can be collected from the restoration site and then grown in a nursery setting for outplanting in one to two seasons' time. However, it is important not to inadvertently select the propagule in a way that will potentially decrease the genetic diversity of the resulting plant material and its adaptability to the restoration site (see Reichard 2001; Dunwiddie and Delvin 2006). For genetic considerations, refer to Basic Considerations for Plant Propagation with Respect to Restoration, Section 10.2. Also, refer to Determining Optimum Techniques for Propagation, Section 10.4, and to Case Studies 3 and 5 for more examples.

Plant material must be collected properly, the species identified correctly, and complete records kept. Seeds and cuttings should always be kept in separate containers and labelled with the scientific name, collection date, and collection site (provenance), using a code, if necessary. Seeds and cuttings that have been collected from different microsites but are of the same species should also be kept separate and labelled. Following the ethical collection guidelines of GOERT (www.goert.ca/ethical_collection) will increase the chances that a wide variety of propagules are collected which contain genotypic and phenotypic diversity.

Plant material must be collected properly, the species identified correctly, and complete records kept.

If stock plants are continually grown on a nursery site for propagule collection, they may hybridize with wild species and other native species (particularly grasses). Therefore, it is recommended that multiple generations of propagules not be produced from nursery stock plants. Instead, the nursery stock plants should be renewed frequently from appropriate local sources (Dunwiddie and Delvin 2006).

10.6.2 Source Diversity

As mentioned above, collecting from a wide variety of parent stock material on the site will increase the likelihood that broad genetic diversity is represented within the propagules, and thus also in the restored population. One way this can be ensured is to collect propagules from the site to be restored as well as at adjacent sites (see Section 10.4).

Additionally, plants that are close to one another at the collection site will likely have a similar genetic make-up (Millar and Libby 1989; Rogers 2004). Therefore, material should be collected from plants that are farther apart, and the 1-in-20 rule should be used (see Section 10.2). Also, since there may be genetic variation in germination, growth patterns, and development, the best seedlings or the first to root should not be the only ones selected. It is essential to have a broad window of time for germination and growth in order to allow a variety of propagules with a full range of characteristics to develop (Campbell and Sorensen 1984; Meyer and Monsen 1993). In this way, the selection of resulting materials for restoration will have included consideration of the geographic, genetic, and adaptation diversity of those materials (Jones 2005).

For further information on retaining a broader source diversity including genetic composition, refer to the section on stock plants *in situ* 10.6.1, and the genetic integrity section 10.2.3. As well, following the ethical collection guidelines (www.goert.ca/ethical_collection) provided on the GOERT website will also provide a wider variety of parent stock for the restoration site.

10.6.3 Monitoring Program

To monitor outplanting success, it is essential that accurate and complete records are maintained during the production stages (see Section 10.7). As well, monitoring the outplanting success of each species relative to its source (provenance) data will provide useful information for future restoration projects. Additionally, the number of propagules that survive at the restoration site over a certain time period should be measured. This may aid in evaluating whether or not the species becomes a self-sustaining population. Refer to Chapter 7: Inventory and Monitoring for full details on monitoring a restoration site.

10.7 Consideration of Timelines

10.7.1 Production Schedules (Planning Ahead for Outplanting)

In order to develop production schedules for the species, type, and number of propagules to be used in restoration, the time-frame for outplanting must be known. The production schedule is then based on the length of time required for the seedlings and cuttings to develop, and is planned backwards from the outplanting time.

Garry Oak species should be planted in the late fall to late winter when the ground is already moist.

Garry Oak species should be planted in the late fall to late winter when the ground is already moist. Early spring may also be an optimal time if there are spring rains in late May to early June; however, with climate change, this may not necessarily be a reliable time for outplanting unless irrigation is used on site.

Timelines need to be determined for collecting cuttings, sowing seeds, potting-up cuttings, and potting-on seedlings/plugs. As well, time for acclimation will also be necessary, and will require the use of a shade or lathe house, or a cold frame to overwinter and/or harden plant material off before planting out the following spring. Other temporal considerations will depend on the species and the growth habit. For example, there may be a need to pot-on larger shrubs that are slower growing and require a longer (2–3 years) period to mature before being outplanted.

When planning the production schedule, also consider the following:

- Determine which species are going to be propagated.
- Determine the numbers of species required.
- Determine what locality the species will be collected from.
- Maintain records of the provenance of the propagules for all species.
- Determine how these species will be propagated (vegetatively or by seed) and how much stock material or what volume of seed is required.
- Determine the size of the propagated material required to ensure optimal outplanting survival (this will vary with the species and propagation method).
- Determine the date by which the site should be prepared so it is ready to receive the materials. Coordinate this date with the delivery of the materials.
- Ensure adequate numbers of staff are available to organize and load the materials for delivery.
- Create an outplanting schedule that is somewhat flexible to ensure the weather is appropriate for outplanting (preferably a non-windy, overcast morning).

10.7.2 Contracting-out Growing for Restoration Projects

If the materials are to be grown by a wholesale nursery, then the considerations listed in Section 10.7.1 have to be coordinated with the grower. As well, a budget has to be developed for the grower's costs. These include costs for labour; materials and supplies such as containers, soil media, water, and fertilizers; collection of seeds and cuttings and preparation of propagules; and maintaining the resulting seedlings and cuttings as well as the plants and stock plants. (See Case Study 7 following.)

Case Study 7. Contract Growing for Outplanting—Considerations

by Siriol Paquet, Sylvan Vale Nursery

Sylvan Vale Nursery Ltd. is a located in Black Creek on Vancouver Island, B.C. The nursery was established in 1980, has 200,000 sq feet (18,580 sq metres) of growing space, and remains a family-run business. It maintains a custom program, and currently grows forest seedlings, Christmas tree seedlings, native plants, ornamentals, berry plants, and grasses, as well as plants for restoration, agroforestry, hedging, and many other applications. Services include on-site seed stratification, cold storage, and delivery. Over the years, modern techniques and automation have been incorporated along with many new buildings and equipment.

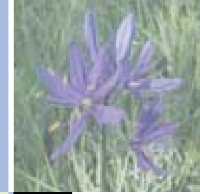
The number of propagules per species that are required to meet plant orders is based on historical data of the number of recoveries (successfully germinated and grown plants) per container type. The length of time to produce each species is also determined by historical data, and is species-dependent. For example, grasses tend to have fairly high recovery per block; approximately 80–90% of plants per container are grown to shipping size. Bulbs tend to be more problematic because consistent production of a set amount of shippable plants per container is not possible; therefore, more seed is needed.

Facilities include greenhouses, cold frames, mist bench/heated benches for rooting, and nursery fields. The different facilities' use is determined by the species to be propagated and the needs of clients. Seed storage is a minor consideration at the nursery and does not normally factor into pricing. Supplies needed are based on the volumes of each container type and include soil and other media, potting supplies (pots, flats, labels, cells, plugs, fertilizers, and/or growth hormone). Other costs factors include labour, energy, packing supplies, and sometimes shipping. Staffing is required in the greenhouses and office throughout the year and 24-hour computer monitoring of greenhouse environmental conditions is also used. A seasonal crew is employed for sowing, harvesting, etc.

Scheduling seeding, division, and growing-on to ensure that plants are ready for the project is determined by the client's requested delivery date. Scheduling is also determined by the overall production demands at the facility, seed availability, and stratification times.

Large-scale production is more economical for the nursery; however, small numbers of plant species can be produced, with the smallest amount being 100 plants. Price is determined by volume of plants required. Plants are held up to two years from sowing. After that time, the maintenance cost far outweighs the price received for the plant. The ideal production time in a business context is from four months to one year.

The nursery tries to use a seed source that is located near the project planting site, and seed is collected from a variety of plants to maintain genetic diversity. Planning is necessary, and timing is dependent on when the seed is ready for collection, when it is viable, and whether or not there is an accessible seed source location. As well, it may be determined that it is not economical to collect seed. Instead, seed may be purchased from a reputable seed dealer.



For some of the most commonly ordered plant species, the nursery maintains stool beds, which are nursery beds of plants for cutting stock. Where possible, vegetative material (twigs, roots, and divisions) is also collected or purchased for production of plant material.

Once the plant material is deemed to be extractable from the container, shipping can be done on very short notice; however, the usual required notice is 48 hours. When shipping, consideration as to the time of year and seasonal weather patterns is necessary to ensure optimal survival of plant material.

One challenge for nursery growing of native plants is obtaining enough information about producing plant material. There is a limited amount of knowledge on the species-specific methods of seed stratification, length of time to produce plant material, scheduling production of materials, seed availability, and budget considerations. Another problem for growers is that the market is currently depressed, so it is not economical to retain a large volume of plant material on hand. As well, for some requests, the time it takes to produce material may not meet clients' needs.

References

GOERT (Garry Oak Ecosystems Recovery Team) Native Plant Propagation Guidelines: www.goert.ca/propagation.

U.S. Department of Agriculture Forest Service Fire Effects Information database: www.fs.fed.us/database/feis/plants/index.html.

Native Plant Network Propagation Protocol database: www.nativeplantnetwork.org/network .

Siriol Paquet *is co-owner of Sylvan Vale Nursery, Ltd., in Black Creek, B.C.*

10.7.3 Post-propagation Records

Record-keeping is essential to monitor the progress of the restoration project and to find efficiencies in techniques, methodology, and budgets. All stages should be documented, from the initial collection stage through all growing phases to outplanting. The success of the restoration project should also be monitored. By compiling this knowledge through the use of templates, the restoration practitioner will be able to fine-tune or adapt certain techniques or budgets for the next project. This body of knowledge will also allow the sharing of information for other restoration projects during the planning phase.

Examples of post-propagation records include:

- dates and numbers/species by provenance for pricking-out of seedlings
- date and numbers/species by provenance of seedlings or cuttings potted up
- number of seeds or cuttings required to produce required amount of material for outplanting
- overall timeline of when seedlings or cuttings are ready for outplanting relative to method of propagation
- final production characteristics (e.g., size, age, height, pot size)
- costs of labour, equipment, materials, and supplies to produce each species
- final destination of the plants produced
- survival numbers after one, two, three, and five years at the site

> Record-keeping is essential to monitor the progress of the restoration project and to find efficiencies in techniques, methodology, and budgets.

See record-keeping templates Appendices 10.2–10.4 and Chapter 7: Inventory and Monitoring for more information.

10.8 Additional Suggestions

A compilation of additional information for those starting to plan and implement a propagation program for restoration.

1. Track species, seed source (provenance) and performance (monitor on a yearly basis) including outplantings, and any nursery trials.
2. Maintain detailed and complete records (label materials using a code if necessary to help with tracking).
3. Confirm the taxonomic identification of difficult species (e.g., grasses, sedges, rushes) for all seed lots, and check after they mature.
4. Determine the amount and type of materials needed (e.g., start planning 1–3 years ahead of outplanting).
5. Schedule propagation to correspond with outplanting deadlines so that the appropriate numbers of propagules are produced and are ready to leave the nursery.
6. Collect species from on-site and adjacent to the site, but not too far away.

7. Use your records to continue to learn about each species and methods of propagation (i.e., use adaptive management).
8. Have a goal even if you cannot rely on a reference ecosystem for the site, and inventory and classify the site (refer to Table 2.2 in Chapter 2 on Restoration Ecosystem Units).
9. Try to avoid decreasing the gene pool for the species (e.g., avoid inbreeding or repeatedly using the same stock material for different outplanting sites).
10. Publicize both the failures and successes of your project (i.e., share your information!).
11. Publicize the work that will be done ahead of time (before collecting propagules) in order to engage the neighbours, naturalist groups, environmental non-governmental organizations, and other stakeholders.
12. Recognize both the ecological and cultural significance of the site to be restored and plant appropriate species.

Case Study 8. Small-scale Native Plant Nursery Set-up and Operation

by Carrina Maslovat

Small-scale nurseries can provide stock to individual areas, which ensures there is a supply of plants grown from local genetic stock material. Most nurseries will collect from material close at hand, and very few projects are able to request contract-grown local plant material. However, because land costs are extremely high, particularly in urban areas, it may be cost-prohibitive to purchase land for a nursery. Efficiency of scale is also a consideration for nurseries. A small nursery, such as one that is less than 0.4 ha (1 acre), can be maintained by hand rather than with equipment. Larger-scale nurseries are more efficient but require a greater land base.

Choice of nursery location is related to the site-specific requirements of the plants that will be grown (e.g., level ground, sun exposure, soil quality unless growing strictly in containers, access roads, quality and cost of water). Each site will naturally be better for growing some species rather than others—for example, hot dry sites are potentially better for growing Garry Oak ecosystem species.

Determining which species to grow for restoration purposes is difficult unless the nursery grows for a specific project. It is almost impossible to determine what the demand will be for restoration and to have the right plants in the quantity and size required for a project. Large restoration projects generally happen sporadically and require large volumes of plants. As plants continue to outgrow their pots, they have to be potted up into larger pots; however, larger sizes of some species are not desired for some restoration projects. Some restoration practitioners prefer to purchase local stock from a supplier that they know will provide healthy material. This will ensure a higher success rate of survival in the long term, rather than requesting specific species that have not been field-tested and therefore may not perform as well.

The initial budget for set-up of a small nursery is usually for infrastructure, such as cold frames and an irrigation system, plus the cost of supplies such as containers, hoses, soil media, etc. For Garry Oak species, a heated greenhouse is not necessary, but a cold frame to protect small and newly rooted plants from the wind is essential. As well, a mist bench with a heating coil is essential for propagation by rooting. A small bar fridge can be adequate for seed storage. Soil and associated amendments are also essential. Storage areas may include simple open-ended, 3-sided cinder block containers. A shade/lathe house or shade cloth in part of the nursery is useful especially for protecting plants during more sensitive stages of development.

Staffing for a small nursery is mainly seasonal, with additional staff required in early spring and fall for propagation, pricking-out, and potting-on. Summertime labour is needed mainly for maintenance, watering, and pruning. Seeding can be done outdoors in the fall, so stratifying the seed ahead of time in refrigerators is not necessary. Hardwood cuttings can be taken in the fall; softwood cuttings can be taken in the spring. Using nursery field plots instead of containers to grow plant material will be impractical unless the soil is amenable; using nursery field plots can be costly, and for a small nursery, not possible due to size constraints. Seed collecting following ethical guidelines can also be done by nursery staff in the summer and fall.

Carrina Maslovat *is a consulting biologist, Salt Spring Island, B.C.*

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Appendix 10.1

Propagating Flower Bulbs, Corms, and Rhizomes: Some Shortcuts from the Beacon Hill Nursery Experience

The staff of the City of Victoria Nursery at Beacon Hill Park have grown native bulbs and perennials for use in the park for several years. The following observations come from that experience.

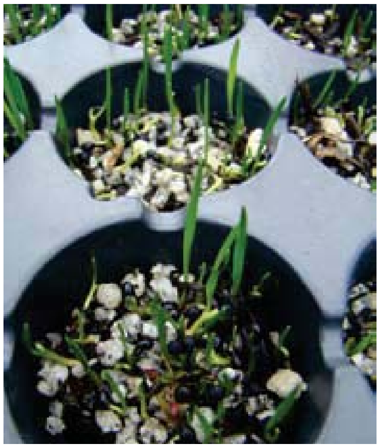
With an understanding of native species' adaptations to environmental patterns, growers can use knowledge of plant characteristics to take shortcuts in producing plants. The Garry Oak ecosystems of southern Vancouver Island share a relatively common pattern of long, dry summers and warm, wet winters. The response of many plants to that pattern is to go into some form of resting state in the hottest, driest part of the year. Seeds rest on the soil and many of them germinate in fall as rains begin and while temperatures are still warm enough for growth. Bulbs, corms, and rhizomes rest below the surface, insulated from the heat by a blanket of soil, until fall rain spurs them into new root growth. Some bulbs move themselves down into the soil to a point where temperature and moisture levels remain relatively constant.

Extending the pre-drought growing season, adding nutrients, and keeping roots cool can help to produce blooming size perennial plants earlier than by following natural growth patterns. The tendency of some bulbs to work their way down through the soil to a level where they remain cool and slightly moist can be exploited by growing in shallow containers to produce larger bulbs sooner.

For some other plants exploiting their natural tendency to multiply can be used to produce moderate numbers of useable size plants faster than growing from seed.

Camas – Greater and Common (*Camassia leichtlinii* & *C. quamash*)

In nature, camas is reported to take 5 to 7 years to flower from seed. This time can be shortened to between 2 and 4 years by taking advantage of their natural growing patterns.



Left: Camas seed germinating in plug trays. Photo: City of Victoria

Right: Blooming size camas in open flats. Photo: City of Victoria

Much of the time from seed to flower for camas in relatively deep soil sites in our region is the time it takes for the bulb to find its proper level in the soil—anywhere from 15 to 30 cm (6" to 12") below soil surface. In nature camas seeds germinate in the fall and begin to put a root down. In the next spring they put up a leaf and begin to form a bulb during the brief growing season before the summer drought sets in. The next fall roots begin to grow again and the small, new bulb elongates down into the soil, reaching for the depth that stays cool through the summer. It may extend as much as 2 cm (3/4") each year and the energy needed for that limits the increase in the size of the bulb until the appropriate depth is reached.

In the nursery it is possible to grow camas in shallow flats, reducing the energy loss from the bulbs working down through the soil. Both Great Camas and Common Camas benefit from being sown thickly. Fill normal 25 x 50 cm (10" x 20") plastic plant trays that have some drainage holes with a sterile mixture of sharp sand and horticultural peat or sterile potting soil to a depth of approximately 4 cm (1 1/2"). Sprinkle freshly collected seeds in late summer over the surface at the density that would be appropriate for grass seed: a coverage of about 1 seed per centimeter (per 1/2"). If seeding must be done later in the season and the seeds are no longer round and smooth, they can be moistened by spreading on moist paper towels until they plump. In either case, cover them thinly enough with medium grit or forestry sand to still be able to see the seed through the cover. Place the flats in a cool, shaded area until rains begin in the fall. Once the rain begins and the air cools, germination will begin. Place the flats where they will be exposed to the weather and in the sun. Put them on a surface such as large crushed rock or a mesh top bench. If the trays are placed on soil or on a flat surface, the camas roots will move out through the drainage holes and bulbs will form under the flats. An air gap is essential during the growing season to prevent this. The germination rate of camas sown in this way will be very high (close to 100%).

As soon as leaves begin to show in the following spring, begin to fertilize the camas with a balanced, liquid fertilizer (any soluble plant fertilizer with a number like 20-20-20 will do) at approximately 1/2 the rate recommended on the label at each watering. Water and fertilize, being careful not to overwater, through the summer, moving the flats into partial shade when temperatures are at their hottest. The leaves will die down on their own, some weeks later than those growing in the wild, and at that time stop watering and put the flats aside in a cool spot to wait for the fall rains begin again and restart growth. Repeat the treatment.

In the summer of the second year, after the leaves have died down and before the rains begin, screen the bulbs out of the sand/peat/soil mixture. Some will be the size of grains of rice and some the size of peas. Screen or sort the larger bulbs from the rest and plant them into a flat of the same mix as before: put a 2 cm (3/4") deep layer of the mix in the bottom of the same kind of plant tray and spread the larger bulbs over the surface, about 2 cm apart (3/4"). Cover with another 2 cm of sand/peat/soil mix and then with a thin layer of grit. Do the same with the smaller bulbs but at about 1 cm (1/2") spacing. Once again put them in a cool spot until fall and then continue to fertilize and water. Some will bloom in the third summer and most will do so by the fourth.

Bulbs can be left in the flats for several years as long as they are watered and fertilized during the growing season. They should be screened out of their flats during their summer dormancy for planting in the following fall. Plant out as soon as the soil is moist more than a few centimetres (~1") down but be sure to plant at least 15 cm (6") down—if not you'll wait a few years before you see a bloom as the bulb spends energy finding its preferred depth.

Onions (*Allium acuminatum* & *A. cernuum*)

The onions take 2 to 3 years from seed collected in the summer and sown that fall. Like camas, they like to be crowded in their pots and their growing season can be extended by watering and fertilizing through the dry part of early summer. Sow them in the same way as camas, thickly in shallow flats, and screen and thin them in their second summer.

If you take the largest bulbs in the second year and pot them into 10 cm (4") pots in a good potting soil in clusters of 5 or 6, they will begin to divide and multiply on their own, giving you a good pot-full after another growing season.

Nodding Onion (*Allium cernuum*) seedlings from a 10 cm pot. Photo: City of Victoria

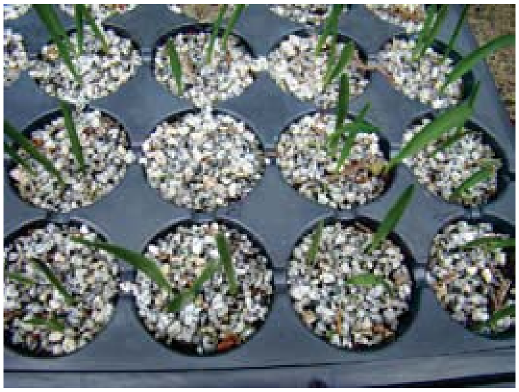
Harvest Brodiaea (*Brodiaea coronaria*)

Harvest Brodiaea take 2 to 3 years to flower from fresh seed planted in the fall immediately after collection. They, too, can be sown thickly in flats but aren't as sensitive as camas to soil depth—corms will stay relatively near the top of the pot.

Pot them on 2 or 3 to a 10 cm (4") pot but not in a clump—separate them and they will spread to fill the space.

Chocolate Lily (*Fritillaria affinis*)

Chocolate Lily (Southern Rice-root) will bloom from seed in 3 to 4 years from fresh seed, sown in the fall of the year in which it is collected. Sow thickly but not so thick that the flat, papery seeds overlap, on the surface of a good, sterile potting soil mixed with about half the volume with sharp sand and just cover with a very thin layer of the same mix. Water and fertilize as long as the leaves remain green in the spring and summer after sowing and leave them untouched in the flat until some begin to flower.



Left: Chocolate Lily (*Fritillaria affinis*) seeds germinating in a plug tray. Photo: City of Victoria

Right: Chocolate Lilies blooming in propagation flats. Photo: City of Victoria

In the driest part of the summer during flowering, very carefully lift the bulbs out of the mix. The largest will have already begun to produce the rice-grain-like bulb scales that give them the name 'rice-root'. They are very easily knocked off at this stage. Collect any that have been knocked off and replant them in the flat with the smaller, non-flowering bulbs for harvest in the following years. Most will have reached flowering size by their fourth growing season.

A slightly quicker way to grow Chocolate Lily is to harvest the rice-grain bulb scales from large, mature plants. Take a Chocolate Lily that is several years old out of its pot and it will have a large number of bulb scales around a central bulb. Harvest those scales and sow them like seeds into flats of potting soil, just covering them with more soil, and they will reach blooming size at least one year ahead of those grown from seed. They can be left in crowded flats for 4 to 5 years but will then begin to self-thin—the smallest will die off.

White Fawn Lily (*Erythronium oregonum*)

Fawn Lilies in nature take 4 to 5 years to bloom from seed. Sown in shallow flats, in an equal parts sharp sand/peat/soil mixture, and watered and fertilized to extend their growing season, they will bloom in 2 to 3 years.

They should be treated in the same way as camas seed but care should be taken to provide them with some shade and to grow them in the coolest spot possible.

Like camas, they will mature at different rates but, unlike camas, they cannot be left for more than 3 to 4 years in crowded flats. As soon as some plants begin to grow large and produce multiple leaves they will crowd each other out and many of the smaller plants will die.

Fawn Lily (*Erythronium oregonum*) seeds germinating in a plug tray. Photo: City of Victoria

Fawn Lily bulbs are more fragile than camas and so it is necessary to be gentle in the screening process. The bulbs are starchy and so attractive to slugs and other creatures in the soil. Care must be taken to prevent them from entering through the drainage holes in the flats. Fine screening is a useful preventative measure.

Satinflower *(Olsynium douglasii)*

Satinflower is fast-growing from seed, flowering often in its second year, but the seed is difficult to collect as it is flung out from the capsules as soon as it ripens. It won't germinate well unless the seed is ripe and so collecting the pods early requires sacrificing a part of the stem to ensure that there is enough energy for the seeds to ripen.

Satinflower is in the iris family and, like most members of this family, it produces rhizomes that are easy to divide. Each grassy stem in a clump can be divided off as a separate plant. The division needs to be done while the satinflower is in active growth as the tiny, spider-like rhizomes are very hard to find in the soil after they plant goes dormant in early spring. Just after flowering is a good time to work on them. Wash the soil off the roots of the clump and tease the individuals apart. Pot them into individual 10 cm (4") pots in any good potting mix. Fertilize well through the following spring, keeping them as cool as possible to extend the season. There should be a new crop of divisions by the next season.

Broad-leaved Shootingstar (*Dodecatheon hendersonii*)

The shootingstars are relatively quick from seed—2 to 3 years from fresh seed sown in the fall of the year it is collected.

Seed is the fastest way to propagate shootingstars but if there is some reason to propagate a specific plant—for instance if its colour, form, or leaf is exceptional—it can be propagated successfully from divisions. Shootingstars are in the primrose family and, like most of the family, root divisions with a bud attached will grow well. A mature plant that is growing in rich soil or is fertilized well will often divide on its own, producing extra leaf crowns in its second year and more in subsequent years. Separating those from the main plant will produce good plants. More can be produced by carefully slicing roots with crown buds from around the edge of the original plant.

Appendix 10.2 Seed Collection Record Template

SEED COLLECTION FORM

Basic Information	**Collection Number:**
Genus and species	
English name	
Date collected	
Collection site name	
Number of seeds	
Extended data	
Subspecies or variety	
Number of plants	
Seed maturity	
Weather at harvest	
Street address/site description	
GIS/Lat.&Long. coordinates	
Slope/Position	
Aspect	
Soil texture	
Soil moisture	
Sun/Shade	
Notes: (Plant community, tree cover/species, # of plants sampled, seed state, etc.)	

Appendix 10.3 Nursery RecordTemplate (full)

NURSERY SOWING RECORD **SEED COLLECTION NUMBER:**

Genus & Species:

English Name:

Seed Collection Site:

Seed Year:

Germination Data

Number of Seeds:

Chill Germ %:

No Chill Germ %:

Purity %:

Seed Weight:

Store Moist %:

Total Germinants:

NURSERY SOWING RECORD **SEED COLLECTION NUMBER:**

Genus & Species:

Total Germinants:

Stratification Data

Date Received:

Soak Date:

Hours Soaked:

Chill Date:

Days Chilled:

Dry Date:

Seed Treatment (scarify, nick, etc.):

Problem/Comment:

(i)

Nursery Record Template

Sowing Data

Sowing Date:

Container:

Medium:

Sowing method (scatter, place, etc.):

Density:

Cover material:

Cover depth:

Number sown:

Seed Grow Location

Greenhouse/Frame/Outside:

Exposure/Protection:

Light/Shade:

Temperature Range:

Moisture Regime:

Fertilizer (type, concentration):

Post Germination

Pot up/Re-pot Date:

Seedling Stage:

Container:

Medium:

Number of Seedlings:

Mulch:

(ii)

Appendix 10.4 Nursery Record Template (brief)

NURSERY SOWING RECORD **SEED COLLECTION NUMBER:**

Genus & Species:

Seedling Grow Location

Greenhouse/Frame/Outside:

Exposure/Protection:

Light/Shade:

Temperature Range:

Moisture Regime:

Fertilizer (type, concentration):

NURSERY SOWING RECORD **SEED COLLECTION NUMBER:**

Genus & Species:

Growing Record					
Year					
Potting Date					
Pot Size					
Medium					
Grow Location					
Quantity					
Notes:					

Appendix 10.5

List of Garry Oak ecosystem plants and animals used in this publication, with REU and propagation method information

by Brenda Costanzo, with contributions from lead authors

1. "*" means the species is an invasive alien species; propagation is inappropriate (X)
2. Propagation methods are for **plant species only**, and are only for the native species that are not federally (SARA) listed as Endangered, Threatened, or Special Concern.

English Name	Scientific Name	Restoration Ecosystem Unit[1]	Propagation Method[2]
Trees			
Arbutus	*Arbutus menziesii*	1; 3	1
Douglas-fir	*Pseudotsuga menziesii*	1; 2; 3; 5; 8	1
English Holly*	*Ilex aquifolium**	--	X
European Elm*	*Ulmus* spp.*	--	X
Garry Oak	*Quercus garryana*	1; 2; 3; 5; 7	1
Grand Fir	*Abies grandis*	7; 8	1; 2.2.3
Oregon Ash	*Fraxinus latifolia*	2	1; 2.2.3
Seaside Juniper	*Juniperus maritima*	7	1; 2.2.2; 2.2.3
Shore Pine	*Pinus contorta* var. *contorta*	3; 7	1; 2.2.3
Western Hemlock	*Tsuga heterophylla*	8	1
Western Redcedar	*Thuja plicata*	8	1; 2.2.3
Shrubs/Vines			
Common Hawthorn*	*Crataegus monogyna**	--	X
Common Snowberry	*Symphoricarpos albus*	1; 2; 3; 5; 7	1; 2.1.3; 2.2.1; 2.2.2; 2.2.3; 3; 5.1
Cotoneaster*	*Cotoneaster* spp.*	--	X
Dull Oregon-grape	*Mahonia nervosa*	8	1; 2.1.2; 2.2.1; 2.2.3; 3
English Ivy*	*Hedera helix**	--	X
Gorse*	*Ulex europeaus*	--	X
Hairy Honeysuckle	*Lonicera hispidula*	1;3	1
Hairy Manzanita	*Arctostaphylos columbiana*	3	1; 2.2
Himalayan Blackberry*	*Rubus armeniacus**	--	X
Indian-plum	*Oemleria cerasiformis*	1; 2	1; 2.2.1; 2.2.2; 2.2.3; 3; 5.1
Kinnikinnick	*Arctostaphylos uva-ursi*	3; 7	1; 2.2
Mock-orange	*Philadelphus lewisii*		1;2.2.1;2.2.3; 5.1
Nootka Rose	*Rosa nutkana*	1; 2; 5	1; 2.1.3; 2.2.3; 5.1
Oceanspray	*Holodiscus discolor*	1; 2; 3; 7	1; 2.2.2; 2.2.3; 3; 5.1

Poison Oak	*Toxicodendron diversilobum*	3	1; 2.2.1; 2.2.3 (wear protective clothing and face masks)
Red Huckleberry	*Vaccinium parvifolium*	8	1; 2.2.3
Salal	*Gaultheria shallon*	8	1; 2.2.2
Saskatoon	*Amelanchier alnifolia*	7; 8	1; 2.1.2; 2.1.3; 2.2.1; 2.2.2; 3; 5.1
Scotch Broom*	*Cytisus scoparius**	--	X
Spurge-laurel*	*Daphne laureola**	--	X
Tall Oregon-grape	*Mahonia aquifolium*	1; 3; 5; 7	1; 2.1.2; 2.2.1; 2.2.2; 2.2.3; 5.1
Trailing Blackberry	*Rubus ursinus*	3; 5	1
Tree Lupine*	*Lupinus arboreus**	--	X
Western Trumpet	*Lonicera ciliosa*	1; 2	2.2.2
Forbs			
American Vetch	*Vicia americana*	2	1
Barestem Desert-parsley	*Lomatium nudicaule*	5	1
Bearded Owl-clover	*Triphysaria versicolor* ssp. *versicolor*	5; 6	N/A
Bear's-foot Sanicle	*Sanicula arctopoides*	1; 3	N/A
Blinks	*Montia fontana*	4; 6	1
Bog Bird's-foot Trefoil	*Lotus pinnatus*	6	N/A
Bracken Fern	*Pteridium aquilinum*	5; 8	3
Broad-leaved Shootingstar	*Dodecatheon hendersonii*	1	1; 2.1.2
Broad-leaved Stonecrop	*Sedum spathulifolium*	3; 7	1; 5.2
Brook Spike-primrose	*Epilobium torreyi*	5; 6	N/A
Bull Thistle*	*Cirsium vulgare**	--	X
Bur Chervil*	*Anthriscus caucalis**	--	X
California Buttercup	*Ranunculus californicus*	5	N/A
California Hedge-parsley	*Yabea microcarpa*	3; 4	N/A
California-tea	*Rupertia physodes*	3	1
Camas	*Camassia* spp.	1	1; 4
Canada Thistle*	*Cirsium arvense**	--	X
Carpet Burweed*	*Soliva sessilis**	1	X
Chickweed Monkey Flower	*Mimulus alsinoides*	4	1
Chocolate Lily	*Fritillaria affinis*	2; 4; 5	1; 4
Cleavers	*Galium aparine*	1; 2; 3; 5	1
Coast Microseris	*Microseris bigelovii*	6; 7	N/A
Coastal Scouler's Catchfly	*Silene scouleri* ssp. *grandis*	5	N/A
Coastal Wood Fern	*Dryopteris arguta*	7; 8	N/A
Common Bluecup	*Githopsis specularioides*	4	1
Common Camas	*Camassia quamash*	1; 3; 4; 5	1; 4
Common Chickweed*	*Stellaria media**	1	X

Common Vetch*	*Vicia sativa**	1	X
Common Yarrow	*Achillea millefolium*	1; 3; 5	1; 2.1.2; 3
Creeping Buttercup*	*Ranunculus repens**	--	X
Cup Clover	*Trifolium cyathiferum*	6	1
Death-camas	*Zigadenus venenosus*	1; 5; 7	1; 4
Deltoid Balsamroot	*Balsamorhiza deltoidea*	1; 3; 5	N/A
Dense-flowered Lupine	*Lupinus densiflorus* var. *densiflorus*	5	N/A
Dense Spike-primrose	*Epilobium densiflorum*	2; 5; 6	N/A
Dwarf Owl-clover	*Triphysaria pusilla*	6	1
Dwarf Sandwort	*Minuartia pusilla*	6	N/A
Elegant Rein Orchid	*Piperia elegans*	5	1
English Daisy*	*Bellis perennis**	1	X
Erect Pygmyweed	*Crassula connata* var. *connata*	5	N/A
Farewell-to-spring	*Clarkia amoena* var. *lindleyi*	5	1
Fern-leaved Desert-parsley	*Lomatium dissectum* var. *dissectum*	3; 5	N/A
Field Chickweed	*Cerastium arvense*	5	1
Fool's Onion	*Triteleia hyacinthina*	4	1; 4
Fragrant Popcornflower	*Plagiobothrys figuratus*	5; 6; 7	N/A
Geyer's Onion	*Allium geyeri* var. *tenerum*	5	1; 4
Goldback Fern	*Pentagramma triangularis*	1; 3	spores
Golden Paintbrush	*Castilleja levisecta*	5	N/A
Grass Peavine*	*Lathyrus sphaericus**	--	X
Grassland Saxifrage	*Saxifraga integrifolia*	4	1
Gray's Desert-parsley	*Lomatium grayi*	3	N/A
Great Camas	*Camassia leichtlinii*	2	1; 4
Hairy Cat's-ear*	*Hypochaeris radicata**	1	X
Hairy Hawk-bit*	*Leontodon taraxacoides**	1	X
Harvest Brodiaea	*Brodiaea coronaria*	1; 4	1; 4
Hawksbeard*	*Crepis* spp.*	1	X
Heterocodon	*Heterocodon rariflorum*	4; 5	1
Hooded Ladies' Tresses	*Spiranthes romanzoffiana*	6	1; 2.1.2
Hooker's Onion	*Allium acuminatum*	5	1; 4
Howell's Triteleia	*Triteleia howellii*	5	N/A
Howell's Violet	*Viola howellii*	5	1; 3; 5.2
Jeffrey's Shootingstar	*Dodecatheon jeffreyi*	2; 5; 7	1;2.1.2
Lace Fern	*Cheilanthes gracillima*	3	spores
Large-flowered Blue-eyed Mary	*Collinsia grandiflora*	3; 4	1
Licorice Fern	*Polypodium glycyrrhiza*	1; 2	3
Lindley's Microseris	*Microseris lindleyi*	3	N/A
Little Chickweed*	*Cerastium glomeratum**	--	X
Little Hop-clover*	*Trifolium dubium**	1	X
Lobb's Water-buttercup	*Ranunculus lobbii*	6	N/A
Long-spurred Plectritis	*Plectritis macrocera*	6	1

Lowland Cudweed	*Gnaphalium palustre*	5; 6	1
Macoun's Groundsel	*Senecio macounii*	3	1
Macoun's Meadowfoam	*Limnanthes macounii*	6	N/A
Macrae's Clover	*Trifolium dichotomum*	7	1
Manroot	*Marah oreganus*	7; 8	N/A
Menzies' Larkspur	*Delphinium menziesii*	1; 7	1
Miner's Lettuce	*Claytonia perfoliata*	1	1
Mountain Sneezeweed	*Helenium autumnale* var. *grandiflorum*	5	1; 3
Muhlenberg's Centaury	*Centaurium muehlenbergii*	5; 6	N/A
Narrow-leaved Montia	*Montia linearis*	4	1
Needle-leaved Navarretia	*Navarretia intertexta*	5 & 6	1
Nodding Onion	*Allium cernuum*	7	1; 4
Nuttall's Quillwort	*Isoetes nuttallii*	6	N/A
Olympic Onion	*Allium crenulatum*	3	1; 4
Oregon Lupine	*Lupinus oreganus* var. *kincaidii*	5	N/A
Oxeye Daisy*	*Leucanthemum vulgare**	1	X
Pacific Sanicle	*Sanicula crassicaulis*	5; 7	1
Pearly Everlasting	*Anaphalis margaritacea*	5	1; 3
Pine Broomrape	*Orobanche pinorum*	3	1
Poverty Clover	*Trifolium depauperatum* var. *depauperatum*	5	1
Prairie Lupine	*Lupinus lepidus* var. *lepidus*	3	N/A
Pretty Shootingstar	*Dodecatheon pulchellum*	5	1; 2.1.2
Puget Sound Gumweed	*Grindelia stricta*	5; 6; 7	1
Purple Sanicle	*Sanicula bipinnatifida*	5	N/A
Pygmyweed	*Crassula aquatica*	6	5.2
Ribwort Plantain*	*Plantago lanceolata**	--	X
Rosy Owl-clover	*Orthocarpus bracteosus*	6	N/A
Rough-leaved Aster	*Eurybia radulina (Aster radulinus)*	3	1; 2.1.2; 3
Satinflower	*Olysinium douglasii*	3	1; 3
Scalepod	*Idahoa scapigera*	5	1
Scouler's Popcornflower	*Plagiobothrys scouleri*	6	1
Sea Blush	*Plectritis congesta*	1; 3; 7	1
Seaside Birds-foot Lotus	*Lotus formosissimus*	5	N/A
Slender Popcornflower	*Plagiobothrys tenellus*	5	N/A
Slender Woolly-heads	*Psilocarphus tenellus* var. *tenellus*	6	N/A
Slimleaf Onion	*Allium amplectens*	5	1; 4
Small-flowered Alumroot	*Heuchera micrantha*	7	1; 3
Small-flowered Birds-foot Trefoil	*Lotus micranthus*	3	1
Small-flowered Blue-eyed Mary	*Collinsia parviflora*	3	1

Small-flowered Catchfly*	*Silene gallica**	--	X
Small-flowered Godetia	*Clarkia purpurea* ssp. *quadrivulnera*	5	1
Small-flowered Tonella	*Tonella tenella*	3	N/A
Small-fruited Parsley-piert*	*Aphanes occidentalis**	--	X
Small-leaved Montia	*Montia parvifolia*	4	1
Small-headed Tarweed	*Madia minima*	3	1
Small-headed Clover	*Trifolium microcephalum*	1	1
Smooth Fringecup	*Lithophragma glabrum*	4	1
Smooth Goldfields	*Lasthenia glaberrima*	6	N/A
Spanish-clover	*Lotus unifoliolatus* var. *unifoliolatus*	5	1
Spring Gold	*Lomatium utriculatum*	1	1
Sword Fern	*Polystichum munitum*	8	3
Stonecrop	*Sedum* spp.	3; 7	1; 2.1.1; 5.2
Strawberry	*Fragaria* spp.	5; 7	1; 3
Tall Woolly-heads	*Psilocarphus elatior*	3; 6	N/A
Texas Toadflax	*Nuttallanthus texanus*	3; 5	1
Thistle*	*Cirsium* spp.*	--	X
Thrift	*Armeria maritima*	6	3
Tiny Mousetail	*Myosurus minimus*	6	1
Tiny Vetch*	*Vicia hirsuta**	--	X
Tomcat Clover	*Trifolium willdenowii*	4	1
Victoria's Owl-clover	*Castilleja victoriae (old name: C. ambigua ssp. ambigua)*	6	N/A
Wall Speedwell*	*Veronica arvensis**	--	X
Wallace's Selaginella	*Selaginella wallacei*	3; 7	2.1.1; 4
Water-starwort	*Callitriche* spp.	5; 6	1
Water-plantain Buttercup	*Ranunculus alismifolius* var. *alismifolius*	6	N/A
Western Buttercup	*Ranunculus occidentalis*	1	1; 2.1.2; 3
White Fawn Lily	*Erythronium oregonum*	1; 2	1; 4
White Meconella	*Meconella oregana*	5	N/A
White-lip Rein Orchid	*Piperia candida*	1; 8	1
White-tipped Clover	*Trifolium variegatum*	5; 6	1
White-top Aster	*Sericocarpus rigidus (old name: Aster curtus)*	2; 3	N/A
Wild Strawberry	*Fragaria virginiana*	5; 7	3
Woolly Sunflower	*Eriophyllum lanatum*	3; 5	1; 2.1.1; 2.1.2
Winged Water-starwort	*Callitriche marginata*	5; 6	N/A
Yellow Monkey-flower	*Mimulus guttatus*	6	1; 2.1.1
Yellow Montane Violet	*Viola praemorsa* ssp. *praemorsa*	5	N/A

Graminoids/Sedges/Rushes			
Alaska Oniongrass	*Melica subulata*	1; 8	1; 3
Alaska Brome	*Bromus sitchensis*	7	1; 3
Barren Brome*	*Bromus sterilis**	--	X
Barren Fescue*	*Vulpia bromoides**	--	X
Blue Wildrye	*Elymus glaucus*	1; 2; 3; 5	1; 3
California Brome	*Bromus carinatus*	1; 2; 3	1
California Oatgrass	*Danthonia californica*	1; 5	1
Canada Bluegrass*	*Poa compressa**	--	X
Carolina Meadow-foxtail	*Alopecurus carolinianus*	5	1
Creeping Bentgrass*	*Agrostis stolonifera**	--	X
Cheatgrass*	*Bromus tectorum**	--	X
Colonial Bentgrass*	*Agrostis capillaris**	--	X
Columbia Brome	*Bromus vulgaris*	1	1; 3
Common Timothy*	*Phleum pratense**	1; 2; 5; 7	X
Common Velvet-grass*	*Holcus lanatus**	--	X
Densetuft Hairsedge	*Bulbostylis capillaris*	4	1
Dune Bentgrass	*Agrostis pallens*	5	1
Early Hairgrass*	*Aira praecox*	--	X
Foothill Sedge	*Carex tumulicola*	5	N/A
Green-sheathed Sedge	*Carex feta*	5; 6	1
Hedgehog Dogtail*	*Cynosurus echinatus**	--	X
Junegrass	*Koeleria macrantha*	1	1; 3
Kellogg's Rush	*Juncus kelloggii*	5; 6	N/A
Kentucky Bluegrass*	*Poa pratensis**	--	X
Long-stoloned Sedge	*Carex inops ssp. inops*	1; 2; 7	1; 2.1.3; 3
Many-flowered Wood-rush	*Luzula multiflora*	1; 3	1
Meadow Foxtail*	*Alopecurus pratensis*	1; 2; 5; 7	X
Orchard-grass*	*Dactylis glomerata**	--	X
Pacific Woodrush	*Luzula comosa*	5	1; 3
Perennial Ryegrass*	*Lolium perenne**	--	X
Red Fescue[3]	*Festuca rubra*	5; 7	1; 3
Poverty Oatgrass	*Danthonia spicata*	3;	1; 3
Ripgut Brome*	*Bromus rigidus**	--	X
Roemer's Fescue	*Festuca roemeri*	1; 3; 7	1; 3
Sharp-pod Peppergrass	*Lepidium oxycarpum*	2(?); 5 (?); 6	1
Silver Hairgrass*	*Aira caryophyllea**	--	X
Soft Brome*	*Bromus hordeaceus**	--	X
Sweet Vernalgrass*	*Anthoxanthum odoratum**	--	X
Toad Rush	*Juncus bufonius*	6	1
Tufted Hairgrass	*Deschampsia cespitosa*	5	1; 3
Western Rush	*Juncus occidentalis*	5; 6	1

Mosses			
Red Bryum	*Bryum miniatum*	*4*	N/A
Banded Cord-moss	*Entosthodon fascicularis*	*3*	N/A
Broom Moss	*Dicranum scoparium*	*3; 7*	?
Electrified Cat's-tail Moss	*Rhytidiadelphus triquetris*	*2; 8*	?
Flat Moss	*Plagiothecium undulatum*	*8*	
Grey Rock-moss	*Racomitrium* spp.	*1; 3; 4*	?
Juniper Hairy-cap Moss	*Polytrichum juniperum*	*1; 3*	?
	Polytrichum piliferum	*3 (?)*	?
Lanky Moss	*Rhytidiadelphus loreus*	*8*	?
Oregon Beaked Moss	*Kindbergia oregana*	*8*	?
Rigid Apple Moss	*Bartramia stricta*	*3*	N/A
Small Flat Moss	*Pseudotaxiphyllum elegans*	*8*	?
Step Moss	*Hylocomium splendens*	*8*	?
Twisted Oak Moss	*Syntrichia laevipila (old name: Tortula laevipila)*	*1; 2*	N/A
	Syntrichia ruralis (old name: Tortula ruralis)	*1; 2*	?
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Ascomycota			N/A
None	*Coccomyces arbutifolius*	*Unknown*	N/A
None	*Coccomyces quadratus*	*Unknown*	N/A
None	*Cytospora* spp.	*Unknown*	N/A
None	*Diplodia maculata*	*Unknown*	N/A
None	*Erysiphe graminis*	*Unknown*	N/A
None	*Fusicoccum arbuti*	*Unknown*	N/A
None	*Hyponectria lonicerae*	*Unknown*	N/A
None	*Lophodermium cladophylum*	*Unknown*	N/A
None	*Microsphaera berberidis*	*Unknown*	N/A
None	*Microsphaera penicillata*	*Unknown*	N/A
Oak Leaf Curl	*Taphrina caerulescens*	*Unknown*	N/A
Basidiomycota			
Armillaria Root Disease	*Armillaria gallica*	*Unknown*	N/A
None	*Ganoderma* spp.	*Unknown*	N/A
None	*Hericium erinaceus*	*Unknown*	N/A
None	*Hymenochaete tabacina*	*Unknown*	N/A
None	*Inonotus dryadeus*	*Unknown*	N/A
None	*Laetiporus gilbertsonii*	*Unknown*	N/A
None	*Phellinus ferreus*	*Unknown*	N/A
None	*Phragmidium fusiforme*	*Unknown*	N/A
None	*Phragmidium rosae-californicae*	*Unknown*	N/A
None	*Puccinia crandellii*	*Unknown*	N/A
None	*Puccinia recondita*	*Unknown*	N/A

None	*Puccinia striiformis*	*Unknown*	*N/A*
None	*Puccinia symphoricarpi*	*Unknown*	*N/A*
None	*Pucciniastrum goeppertianum*	*Unknown*	*N/A*
None	*Pucciniastrum sparsum*	*Unknown*	*N/A*
None	*Urocystis colchici*	*Unknown*	*N/A*
None	*Uromyces heterodermus*	*Unknown*	*N/A*
None	*Ustilago heufleuri*	*Unknown*	*N/A*
Birds			
Band-tailed Pigeon	*Columba fasciata (Patagioenas fasciata)*	*8*	*N/A*
Barn Owl	*Tyto alba*	*1; 2*	*N/A*
Great Blue Heron, *fannini* subspecies	*Ardea herodias fannini*	*1; 5*	*N/A*
Horned Lark, *strigata* subspecies	*Eremophila alpestris strigata*	*5*	*N/A*
Lewis's Woodpecker (Georgia Depression population)	*Melanerpes lewis* pop. 1	*1; 2; 3; 5; 7; 8*	*N/A*
Northern Pygmy Owl, *swarthi* subspecies	*Glaucidium gnoma swarthy*	*1; 2; 3; 5; 7; 8*	*N/A*
Peregrine Falcon, *anatum* subspecies	*Falco peregrinus anatum*	*7*	*N/A*
Purple Martin	*Progne subis*	*Unknown*	*N/A*
Short-eared Owl	*Asio flammeus*	*1*	*N/A*
Vesper Sparrow, *affinis* subspecies	*Pooecetes gramineus affinis*	*3*	*N/A*
Western Bluebird, Georgia Depression population	*Sialia mexicana* pop. 1	*1; 2; 3; 5; 7*	*N/A*
Western Screech Owl, *kennicottii* subspecies	*Megascops kennicottii kennicottii (Otus kennicottii kennicottii)*	*8*	*N/A*
Yellow-billed Cuckoo	*Coccyzus americanus*	*Extirpated species*	*N/A*
Insects (non butterfly)			
Blue Dasher	*Pachydiplax longipennis*	*Unknown*	*N/A*
Black Slug*	*Arion ater**		
Blue-grey Taildropper	*Prophysaon coeruleum*	*3*	*N/A*
Jumping Gall Wasp*	*Neuroterous saltitrius**	*--*	*X*
(leaf bug)	*Ceratocapsus downesi*	*Unknown*	*N/A*
Oak Leaf Phylloxera*	*Phylloxera glabra**	*--*	*X*
(plant bug)	*Clivenema fusca*	*Unknown*	*N/A*
(robber fly)	*Nicocles rufus*	*1; 2; 5; 8???*	*N/A*
(robber fly)	*Scleropogon bradleyi*	*3*	*N/A*

(scentless plant bug)	*Harmostes dorsalis*	*Unknown*	N/A
(seed bug)	*Scolopostethus tropicus*	*Unknown*	N/A
(shield-backed bug)	*Camirus porosus*	*Unknown*	N/A
Western Pondhawk	*Erythemis collocata*	*Unknown*	N/A
Butterflies			
Autumn Meadowhawk	*Sympetrum vicinum*	*Unknown*	N/A
Boisduval's Blue, *blackmorei* subspecies	*Icaricia icariodes blackmorei (Plebejus icarioides blackmorei)*	4?	N/A
Cabbage White*	*Pieris rapae**	--	X
Common Ringlet, *insulana* subspecies	*Coenonympha california insulana (Coenonympha tullia insulana)*	5; 7	N/A
Common Woodnymph, *incana* subspecies	*Cercyonis pegala incana*	5; 7	N/A
Dun Skipper	*Euphyes vestris*	4?; 6?	N/A
European Skipper*	*Thymelicus lineola**	--	X
Great Arctic	*Oeneis nevadensis*	3	N/A
Gypsy Moth*	*Lymantria dispar**	--	X
Island Blue	*Plebejus saepiolus insulanus*	4?; 6?	N/A
Island Marble, *insulanus* subspecies	*Euchloe ausonides insulanus*	1; 2	N/A
Large Yellow Underwing*	*Noctua pronuba**	--	X
Lesser Yellow Underwing*	*Noctua comes**	--	X
Moss' Elfin, mossii subspecies	*Incisalia mossii mossii (Callophrys mossii mossii)*	3	N/A
Propertius Duskywing	*Erynnis propertius*	1; 2; 3; 5; 7	N/A
Taylor's Checkerspot	*Euphydryas editha taylori*	5	N/A
Western Branded Skipper, *oregonia* subspecies	*Hesperia colorado oregonia*	5; 7	N/A
Western Meadowlark, Georgia Depression population	*Sturnella neglecta* pop. 1	1	N/A
Western Sulphur	*Colias occidentalis*	3	N/A
Winter Moth*	*Operophtera brumata**	--	X
Zerene Fritillary, *bremnerii* subspecies	*Speyeria zerene bremnerii*	3	N/A
Mammals			
Columbian Black-tailed Deer	*Odocoileus hemionus columbianus*	1; 2; 3; 4; 5; 6; 7; 8	N/A
Eastern Cottontail*	*Sylvilagus floridanus**	5	X
Eastern Grey Squirrel*	*Sciurus carolinensis*	1; 2; 3; 5; 7	X
Ermine, *anguinae* subspecies	*Mustela erminea anguinae*	8?	N/A
European Rabbit*	*Oryctolagus cuniculus*	--	X

Roosevelt Elk	*Cervus canadensis roosevelti*	*1; 2; 8?*	*N/A*
Townsend's Big-eared Bat	*Corynorhinus townsendii*	*1; 3*	*N/A*
Reptiles			
Gopher Snake, *catenifer* subspecies	*Pituophis catenifer catenifer*	*Extirpated species*	*N/A*
Sharp-tailed Snake	*Contia tenuis*	*1; 2; 3; 5; 7; 8*	*N/A*

1 Refer to list of Restoration Ecosystem Units in Table 2.2 in Chapter 2: Distribution and Description
2 For vascular plants, refer to "Key to Propagation Methods" below
3 There are both native and introduced forms of Red Fescue.

Key to Propagation Methods

1. Seed
2. Vegetative Propagation
    - 2.1 Herbaceous cuttings – tip, root and rhizomes
        - 2.1.1 Tip cuttings
        - 2.1.2 Root cuttings
        - 2.1.3 Rhizome cuttings
    - 2.2 Stem cuttings – softwood, semi-ripe and hardwood cuttings
        - 2.2.1 Softwood cuttings
        - 2.2.2 Semi hardwood cuttings
        - 2.2.3 Hardwood cuttings
3. Division of herbaceous perennials and shrubs
4. Division of bulbous perennials
5. Other methods
    - 5.1 Suckers
    - 5.2 Leaf petiole cuttings

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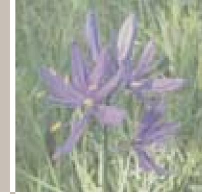
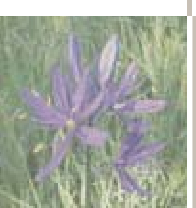


Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 11
Conclusion and Glossary



Chapter 11

Conclusion

Brittany Dewar, GOERT co-op student, cuts Scotch Broom (*Cytisus scoparius*) out of the vicinity of rare plants.
Photo: Chris Junck

Garry Oak ecosystems are among the rarest in Canada, and because the area that they occupy continues to decline, their loss adversely affects many animal and plant species. In addition, the loss of these beautiful ecosystems has degraded quality of life for many people. While the need for restoration of Garry Oak ecosystems is urgent, caution is warranted. Before the restoration process can be initiated, an understanding (to the extent possible) must be gained regarding the ecosystem, the species that it supports, and the associated natural processes. This knowledge can then be used to create a clear and consensus-based restoration plan.

Garry Oak ecosystems are among the rarest in Canada, and because the area that they occupy continues to decline, their loss adversely affects many animal and plant species.

Garry Oak (*Quercus garryana*), or Oregon White Oak, is restricted to the western portion of North America, generally along the Pacific coast. In British Columbia, the natural extent of Garry Oak and associated ecosystems has been greatly reduced due to agricultural and urban development. Garry Oak ecosystem plant communities in B.C. include Garry Oak woodlands, maritime meadows, vernal pools, vernal seeps, coastal bluffs, and Douglas-fir plant communities. Several authors have described ecosystem classification of Garry Oak in B.C.; however, not all plant communities in associated ecosystems have been classified. In this publication, **Restoration Ecosystem Units** were developed to help restoration practitioners create new plant communities on sites that no longer have a significant cover of native flora. These units provide information that can be used at a broad scale; for further details, the other classification systems can be referenced (e.g., Roemer 1972, Erickson 1998). As well, successional information can be used to determine which vegetation communities or stages could occur on the site that is undergoing restoration. Various successional stages often exist in mosaics across the landscape, depending on disturbance history. Because Garry Oak communities are dynamic, considering processes and stages of succession can shed much light on the restoration process for these ecosystems.

Dynamic natural processes and disturbances such as fire, disease, herbivory, and climate change are important to consider when restoring a Garry Oak ecosystem site. The first step towards integrating natural processes and disturbances into restoration is to **understand the processes** that affected the site historically, and those that are currently occurring. Since the present conditions and community composition differ from the historical state, re-introducing disturbance may not produce the desired restoration results. Garry Oak ecosystems are defined largely by their open savannah structure, which historically was maintained by a variety of disturbances, including fire, harvesting of bulbs, disease, weather events, and environmental conditions. Tree and shrub encroachment on deeper soil Garry Oak habitat in Canada has been linked to a disruption in the historical fire regime, which has led to an increase in Garry Oak and Douglas-fir (*Pseudotsuga menziesii*) trees, and both native and introduced shrubs. However, re-introducing fire will not produce the same results as it would have historically because the current conditions and plant community composition are different. Understanding the important role of natural processes and disturbances will improve the success of your project by helping you develop a restoration goal that is well-suited to the site and its conditions.

Long-term commitment and planning are required for all ecological restoration. This maxim is especially true when restoration efforts could affect species or ecosystems at risk. Species at risk, where present on federal lands, are protected under the federal *Species at Risk Act* (SARA). Although the Province of British Columbia provides some protection, no single piece of **legislation** protects species at risk or their habitats. Municipal or regional government legislation for the protection of species at risk may also exist. **Permits** are likely required when conducting work in the vicinity of species at risk. **Expert advice** should be obtained from a qualified specialist when planning any restoration project. A **detailed species inventory** should be conducted and completed by a qualified biologist. All threats to the rare species or ecosystems, and other special considerations (e.g., natural limitations on the species) should be identified. Moreover, species and/or ecosystem monitoring protocols should be considered right from the planning stage and should reflect the goals of the restoration project. Restoration goals should fit with the long-term goals and/or objectives of the recovery strategy for the species. Recovery actions should include mitigating threats to the species and to suitable available habitat.

Every restoration project can benefit from having a plan; a **restoration plan is essential** for medium- to large-scale projects. To be effective, a restoration plan needs to be developed before any on-the-ground work is performed but after the goal is identified. This allows time to fully establish the context, goals, and objectives for the site in consultation with any interested parties. Setting **clear and realistic goals** for the restoration project is essential for success because these goals will set the direction for the project. Once the direction is established, information about the site should be gathered through **site inventories**. The data collected during these inventories will inform the next stage of restoration planning: writing the plan. The plan will serve as the basis for further discussion with any interested parties. There may be further refinements prior to conducting on-the-ground work. The restoration plan will consist of a list of **goals, objectives, and tasks** to be carried out; **a schedule; a budget; and a monitoring plan**. Once the restoration plan is written and agreed upon, the on-the-ground work can begin with clear direction.

Successful restoration depends on the **support and values of the public and community**. A project that includes the community in its vision, goals, and objectives from the start is much more likely to have success and long-term stability. The benefits of public involvement are many: stewardship, funding, volunteers, environmental education opportunities, efforts on adjacent properties. To capitalize on this involvement, it is important to build a **strong communications/ outreach strategy** into the restoration plan from the very beginning. In preparing this strategy, you must carefully consider the desired and possible level of public participation; do not offer participation opportunities you are not prepared to follow up on. Once the level of participation has been decided upon, there are a variety of tools and approaches to use in gaining that participation. **Engaging youth** is particularly important because restoration is a long-term process which must involve the next generation. It is important to **celebrate successes** because this reaffirms the reasons for conducting the restoration and builds strong community support, which is essential to the long-term success of the project.

Inventory and monitoring are other keys to long-term success in restoring Garry Oak ecosystems. Inventory **documents the current status of a site** and identifies what species are present and their abundance. Inventory is also the essential first step in the monitoring process: without a baseline, change cannot be measured. Inventory is important for characterizing reference ecosystems, which allows the specification of restoration targets and assessing restoration progress. Monitoring is the process of making repeated measurements of habitat metrics **to detect change over time**; this data allows progress to be measured and is the foundation of adaptive management. Four key principles guide inventory and monitoring: (1) setting clear objectives, (2) ensuring reliability, (3) matching effort with outcomes, and (4) adopting an ecosystem-based approach.

Ecological restoration is the process of assisting the recovery of ecosystems that have been degraded, damaged, or destroyed. How can we assist the recovery of Garry Oak ecosystems? The first step in the development of an **effective restoration plan** is to determine the factors that have caused, or continue to cause, the degradation or damage. In simple cases, this might entail removal of alien invasive species. However, most Garry Oak sites are suffering from a variety of degrading elements: in particular, the loss of fire used in the traditional management of these ecosystems has had a profound effect. Some alien invasive species may have changed soil chemistry and micro-biota. Creating conditions that reverse these changes can be difficult. In fact, even identifying all of the ecological, social, and cultural attributes that have contributed to the development of Garry Oak ecosystems can be difficult. However, recognizing that there is a variety of elements that influence these ecosystems, and that these elements may change across a site, allows us to establish restoration treatments that re-create the conditions that initially allowed these ecosystems to develop.

> We hope that this will be a living document that is updated with new information as the practice of restoration within Garry Oak and associated ecosystems continues.

With the increase in international trade, world travel, and a changing climate, new alien species will continue to enter Garry Oak ecosystems. The management of alien invasive species in Garry Oak ecosystems tends to revolve around alien invasive plants; however, alien species consist of a wide variety of organisms. **Alien invasive species management** strategies focus on **preventing** the introduction of such species, **early detection of newly introduced** alien species, **developing a rapid response** to eliminate these species, and **managing** those species that become established.

Obtaining appropriate native species for restoration can be challenging because many species may not be available. Maintenance of **genetic integrity** is important when planning the restoration project, and **ethical guidelines** are available for collecting native plant materials. Most native plant species can be propagated readily through either standard sexual or asexual propagation methods, and with enough lead time, will be ready for outplanting on the restoration site in less than a year or two. Along with the establishment of production schedules, overall record keeping is an important aspect of species propagation and supply. Record-keeping should begin at the initial collection stage, and continue through all growing phases to outplanting and afterwards for monitoring of the success of the restoration project.

This publication is meant to be a comprehensive, clear, and reliable source of information that will assist restoration practitioners in the process of restoring Garry Oak ecosystems. It is intended to provide a synthesis of current knowledge and practice that will contribute to the successful restoration of these endangered ecosystems. However, restoration is large field of study which is rapidly growing and quickly evolving; therefore, no document can cover all topics or remain current for long. We hope that this will be a **living document** that is updated with new information as the practice of restoration within Garry Oak and associated ecosystems continues. We can all make a difference! Let us know how your restoration project has progressed, how this publication has assisted you in your project, and how it could be improved (send an email to info@goert.ca).

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Partial Glossary of Terms as used in this Publication

ACCLIMATION: physiological adaptation of plant material to a new climate or environment

ADAPTIVE MANAGEMENT: a problem-solving approach which takes existing knowledge, explores alternatives, makes predictions of their outcomes, selects actions to implement, and monitors to determine if the outcomes match the predictions; these results are then used as a learning exercise and a basis to adjust future management plans and policy.

ADJACENCY ARRANGEMENTS: configuration of a patch of habitat and its adjoining elements

AFTERCARE: any cultivation requirements such as watering or fertilizing once young plants or seedlings have been removed from their growing containers and planted in the ground

AGRO-FORESTRY: land-use involving the integrated production of trees, other forest plants, agricultural crops, and animals, usually in a manner compatible with the cultural patterns of the local population

AGRONOMIC: pertaining to agriculture

AIRFLOW: speed of air over a surface

ALIEN SPECIES: species that have been moved outside of their natural home range (= non-indigenous species)

ALLELE: a discrete form of a gene due to a mutation

ANTHROPOGENIC: caused by humans

APICAL MERISTEM: a meristem is the tissue in most plants consisting of undifferentiated cells (meristematic cells), found in zones of the plant where growth can take place. An apical meristem is in the buds and growing tips of roots in plants. Its main function is to begin growth of new cells in young seedlings at the tips of roots and shoots (forming buds, among other things).

ASEXUAL [PROPAGATION]: propagation of plants or animals without a sexual phase. For plants, vegetative method of propagating by non-sexual means and from a single parent that does not involve the exchange of genetic material, e.g., cuttings or division.

ASPECT: facing in a particular direction

AUTECOLOGY: the study of relationships of individual organisms or species to environmental conditions

AXIL [LEAF]: angle formed by a main stem and the leaf that is borne on it

BALLAST WATER: water taken on by ships and used for stability during a voyage, usually purged upon reaching destination

BASAL PLATE: bottom part of a bulb (base of the modified stems) that growth originates from

BASELINE STUDY / SURVEY: an inventory of the flora, fauna, and other components of a site's ecosystems before a project begins, to serve as a benchmark against which trends and changes in the site's characteristics can be measured

BASIDIOCARP: fruiting body with basidia (clublike structure that produces spores) in fungi belonging to the family *Basidiomycotina*

BEDROCK: solid rock, either exposed at the land surface or underlying surficial deposits

BEST MANAGEMENT PRACTICES [BMPS]: methods, measures, or practices designed to prevent or reduce damage or harmful alteration to species or ecosystems. Usually, BMPs are applied as a system of practices.

BIODIVERSITY: the variety, distribution, and abundance of different plants, animals, micro-organisms, the ecological functions and processes they perform, and the genetic diversity they contain at local, regional, and/or landscape level

BIOENGINEERING: a multi-disciplinary, applied science that uses living plant material as a component of site engineering and landscape construction in order to stabilize and conserve soils

BIOGEOGRAPHY: the study of the geographical distribution of living or dead organisms

BIOGEOCLIMATIC ZONE: the Biogeoclimatic Ecosystem Classification (BEC) is a land classification system that groups together ecosystems with similar climate, soils, and vegetation. This classification was developed in British Columbia and is widely used as a framework for resource management as well as for scientific research. In British Columbia, there are 14 biogeoclimatic zones identified, which are further refined into subzones and variants.

BIOLOGICAL DIVERSITY: (see biodiversity)

BIOMASS: total dry weight of biological matter on a site

BIOTA: all living organisms

BIOTIC AGENT: a living organism

BENTONITIC CLAY SLURRY: a slurry of bentonitic clay that expands when wet to seal cracks and seepage in bedrock

BILTMORE STICK: metre stick marked with approximate diameter of a circle when held against a tree approximately 60 cm from the observer's eye. [Observer lines "0" end of stick on one edge of stem and reads the number on the stick best matching the other edge. Developed and named by the Biltmore Forestry School in the U.S.A.]

BLUE LIST: a listing of elements of special concern, as determined by the BC Conservation Data Centre. The Blue List includes any ecological community, indigenous species, and subspecies considered to be of special concern (formerly vulnerable) in British Columbia. Elements are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed elements are at risk, but are not Extirpated, Endangered or Threatened.

BOLE: the stem of a tree

BONEMEAL: ground animal bones used as a plant fertilizer

BOTTOM HEAT: propagation heating mat used to increase germination of seeds as well as rooting of stem cuttings

BROADCAST: a technique for sowing seeds which involves scattering or spreading the seeds widely, with or without the use of a mechanical spreader

BROWN ROT: wood decay caused by fungi that utilize cellulose and hemicellulose for food leaving brown-coloured lignin compounds in the remaining wood

BRYOPHYTES: e.g. mosses, hornworts, and liverworts; primitive plants in the plant phylum *Bryophyta*, lacking a vascular system (the xylem and phloem that transport water, nutrients, sugars, and minerals)

BULBLETS: small bulbs produced between the stem and top of the soil

BULBOUS: having a bulb

BUNCHGRASS: grasses that grow as singe plants with several stems clustered from one root system in clumps, tufts, or bunches, rather than forming a sod or lawn

CALLUS: mass of unorganized plant cells usually formed after injury (such as at the base of a stem cutting) to seal off the wound; this area eventually gives rise to organized cells such as roots in the case of a stem cutting.

CANKERS [FUNGAL]: an area of diseased cortical (bark) tissue with a sharply delimited margin on a branch or the stem of a tree

CAPILLARY ACTION: attraction of water in to soil pores, causing the water to move through the soil

CAPITULUM: a flowering inflorescence with sessile (stalkless) flowers

CAPSULES: dry fruit of angiosperms (flowering plants) that open up (dehisce) when ready to release seeds

CAPTIVE-REARED: the collection of animals or insects from the wild to produce offspring that will be returned to the wild; a method sometimes used for the recovery of endangered species

CELLULOSE: the complex carbohydrate that is the principal chemical constituent (with lignin and hemicellulose) of the cell walls of higher plants

CLAYPAN: a layer of clay (fine-textured material less than 0.002 mm) that is nearly impermeable, formed by the cementation of soil particles, which holds water at or near the surface of the soil

CHAFF: thin membranous parts surrounding seeds, such as wings, husks, etc., separated from seeds during processing of collecting seed

CHEESECLOTH: loosely woven gauze-like cotton cloth

CLIMAX ECOSYSTEM / COMMUNITY: the culminating, self-perpetuating seral stage in plant succession that is relatively stable and persists for long periods relative to other seral stages.

[COARSE] PERLITE: a natural soil amendment used to hold water; derived from volcanic glass which is heated to expand; can be used for starting horticultural cuttings

COARSE SAND: sharp sand derived from non-saline environments used in horticulture as a soil amendment or propagation medium

COLD FRAME: small roofed structure built low to the ground and having either a glass or plastic cover that is used to protect plants from winter conditions

COLLUVIAL: pertaining to colluvium, which are materials that have reached their present position as a result of direct, gravity-induced mass movements

COMMUNITY COMPOSITION [PLANT]: proportion of species relative to total in a given area; can be expressed as a percentage of relative cover, or cover and frequency of occurrence

CONKS (FUNGAL): the spore-producing structure of a fungus, causing wood decay

COSEWIC: Committee on the Status of Endangered Wildlife in Canada; a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada

CORM(S): type of underground plant storage organ that is composed of swollen stem bases

CORMELS: small corms produced from the basal area of new corms

CRITICAL HABITAT: according to the *Species At Risk Act*, critical habitat is the habitat that is necessary for the survival or recovery of a listed species and that is identified in the recovery strategy or action plan for the species

CROSS-POLLINATE: pollination between two genetically-different plants of the same species; transfer of pollen from the anther (male reproductive organ) of one plant to the stigma (female reproductive organ) of another plant

CRYPTOGAMIC: cryptogams include fungi, lichens, mosses, liverworts and algae; a cryptogamic crust is a thin layer consisting of these nonvascular species that forms on soil in dry grasslands

CULTURALLY MAINTAINED DIS-CLIMAX ECOSYSTEMS: ecosystems that are maintained in a specific condition by some cultural activity. Deep soil Garry Oak ecosystems were maintained as camas harvest meadows by First Nations burning, preventing them from shifting to Douglas-fir (*Pseudotsuga menziesii*) forests.

DAMPING-OFF: fungal-induced death of seeds or seedlings

DECIDUOUS [TREES AND SHRUBS]: shedding leaves; usually meaning all leaves each year, in the autumn season

DEGRADED ECOSYSTEM: an ecosystem that has suffered a degrading activity (e.g. cattle grazing or control of fire or ploughing) that has led to a decrease in natural composition, structures, and processes such that population levels, structural complexity, and diversity of organisms have been changed in an unnatural manner

DENDROCHRONOLOGICAL ANALYSIS [DENDROCHRONOLOGY]: the study of growth ring patterns in trees to determine the age and prevailing environmental factors (e.g. drought, fire) that affected the specimen during its lifetime

DEHISCENCE: natural opening of a fruit or other seed-bearing structure of a plant to release seed

DIS-CLIMAX ECOSYSTEMS: ecosystems that are maintained at an earlier seral (successional state) by some activity, either natural or cultural (see culturally maintained dis-climax ecosystems). Areas along rivers that are subjected to flooding and ice scouring or ocean shorelines that may show a particular vegetation cover (e.g. Sitka Spruce) due to salt spray are examples of dis-climax ecosystems.

DESICCANT: drying agent used to remove humidity; used to keep seeds at low moisture content during storage (e.g. silica gel)

DIAPAUSE [INSECT]: suspended growth in response to adverse environmental conditions

DIBBLE: pointed garden tool used to make holes in the soil for seeds or seedlings

DIRECT SOWING: the sowing of seeds, by hand or with machinery, directly onto a substrate instead of into containers

DISTRIBUTION [SPECIES]: the spatial arrangement of a species within its range; the manner, pattern, or relative frequency with which individuals and populations of a species are distributed over the landscape

DISTURBANCE [ECOLOGICAL DISTURBANCE]: any relatively discrete event in time that disrupts ecosystem, community or population structure and changes resource, substrate availability, or the physical environment. (Pickett and White 1985). Disturbance can be from natural causes (e.g. fire, wind, earthquake, insect outbreak) or can be human-caused (e.g. invasive species, a bulldozer, or preventing a natural disturbance such as fire).

DISTURBANCE-BASED ECOSYSTEM: an ecosystem that exhibits high levels of disturbance and in which disturbance is critical to the system

DISTURBANCE REGIME / PATTERN: the spatial and temporal arrangement of disturbances

DIVIDE/DIVISION: the propagation of plants by separating the parent plants (i.e. not by seed or cuttings) such as through simple dividing of herbaceous perennials

DORMANCY/DORMANT[OF SEED]: method by which a plant storage organ, in this case the seed, fails to grow even though environmental conditions are favourable; for seeds there are two types: physical and embryo dormancy; [of plant] period when a healthy plant is not growing

DRAINAGE HOLES: containers for plant propagation need holes in the base to provide drainage for water

DRUPES: a fleshy fruit usually with a hard stone inside, e.g. plum or cherry

EARLY SERAL: ecosystems that establish soon after a disturbance. These may consist of herbaceous species in ecosystems that would eventually become forests, e.g. Fireweed (*Epilobium angustifolium*) after a forest fire.

ECOLOGICAL DISTURBANCE: see Disturbance

ECOLOGICAL FILTERS: the things that prevent the full establishment of the ecosystem. Compaction or excessive erosion may serve as filters that prevent ecosystem recovery.

ECOLOGICAL GRADIENTS: ecological gradients occur along transitions from dry areas to wet areas or from areas with sandy soil to areas with silty soils

ECOLOGICAL RESTORATION: the process of assisting the recovery of ecosystems that have been damaged, degraded or destroyed

ECOLOGICAL SUCCESSION: a series of dynamic changes in ecosystem structure, function and species composition over time as a result of which one group of organisms succeeds another through stages leading to a potential natural community or climax stage. Primary succession (pioneering) occurs when organisms colonize a previously empty area (e.g. bare soil) and secondary succession occurs on sites that had previously been colonized but then disturbed in some manner. Note that succession theories are still being debated by ecologists.

ECOREGION [ECOLOGICAL REGION]: an ecologically and geographically defined area that is smaller than an ecozone and larger than an ecosystem

ECOSYSTEM: a complex system of living organisms (plants, animals, fungi, and microorganisms), together with their abiotic environment (soil, water, air, nutrients) that function together to circulate nutrients and create a flow of energy which creates biomass, structure in the living community, and a change in ecosystem form and function over time

ECOSYSTEM-BASED APPROACH: a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way

ECOSYSTEM ENGINEER: an organism that creates or modifies habitats (alien invasive species are often ecosystem engineers)

EDAPHIC FACTORS: edaphic pertains to the biological influence of soil conditions, such as moisture or texture, on the surrounding natural plant community

EDAPHICALLY CONTROLLED DIS-CLIMAX ECOSYSTEMS: dis-climax communities that arise because of soil conditions; soil salinity may cause an edaphically controlled dis-climax community

EMBRYO: dormant immature plant within a seed, or earliest diploid stage of an animal post sexual combination

ENDANGERED: a species facing imminent extirpation or extinction

ENDEMIC: native; indigenous to a particular area, and often with a restricted geographic range

ENCROACHMENT (FOREST/CONIFER): progressive expansion of plant species into another ecosystem, e.g. Douglas-fir expansion in to a Garry Oak woodland, converting an open ecosystem into a closed forest

EPHEMERAL: lasting only a short time; in the case of streams or ponds, flowing or full only briefly in direct response to recent precipitation

EXCISE [EMBRYO FROM A SEED]: method by which the embryo within a seed is carefully removed to determine the viability

EXOTIC SPECIES: exotic species are those that have been moved outside of their natural home range (= alien or non-indigenous species)

EXTIRPATED: a species that no longer exist in the wild in Canada, but does occur elsewhere

EXTINCT: a species that no longer exists anywhere in the world

FACULTATIVE [PARASITE]: a species that lives under certain conditions or in certain habitats, but does not require them; that is, it could also live in other conditions or habitats. A facultative parasite can live either as a parasite or not. In fungi, it is a fungus which can develop in living host tissue but is capable of spending part of its life cycle in dead host tissue.

FILTER: (see Ecological filter)

FIBROUS-ROOTED [PERENNIALS]: plants that have small fine roots that are easily divided and lack major structural roots (e.g. grass vs. oak tree)

FIRE-ADAPTED VEGETATION: plants that evolved and persisted in fire-maintained ecosystems and possess various structural adaptations and life history strategies that enable them to tolerate frequent, low-intensity fires

FIRE REGIME: the pattern of fire that occurs over time e.g., the average interval between fires and/or fire severity when fires occur

FIRE SUPPRESSION: active human intervention to prevent fires from occurring or at least restricting them to small areas through fire fighting activities

FLAILING: a method to collect fruit, usually from trees or shrubs, whereby the branches are struck with a stick so that the fruit falls onto tarps spread underneath

FLAT: a type of container used for plant propagation that is usually made of black plastic and measuring 25 by 50 cm and 6 cm deep [10" by 20" and 2.4" deep]

FLORETS: a small or reduced flower such as in grasses

FORB: an herbaceous plant with broad leaves, excluding the grasses and grass-like plants

FRAGMENTED LANDSCAPES/ FRAGMENTATION: alteration or breaking up of the landscape into discrete or tenuously connected 'islands' as a result of modification or conversion of the landscape by management activities (e.g. logging, development)

GENE POOL: the collective genetic information within a population, that is, the totality of genes and alleles in an organism's local population

GENETIC INTEGRITY: the ability of a breeding population or group of breeding populations to remain adapted to its natural environment

GENETICALLY HOMOGENOUS: all individuals of a population containing the same genetic information (i.e. not genetically diverse)

GENOTYPE: the entire genetic constitution, expressed or latent, of an organism (which differs from the physical appearance)

GERMINATE: emergence of plant part(s) from a seed; when the dormant seed begins to grow, eventually producing a seedling

GIRDLING: a technique used to kill live trees without cutting them down, by cutting a continuous all the way around the trunk, thus preventing the movement of fluids and causing death

GLACIOMARINE CLAY: fine-textured sediments pertaining to processes, sediments, and landforms associated with glaciers developed in marine waters. Marine shells or shell cast may be present.

GLACIOMARINE CLAY-LOAM: processes, sediments, and landforms associated with glaciers developed in marine waters containing between 28 and 40 percent clay mixed with 20 and 45 percent sand

GRAMINOID: grass-like plants including grasses, sedges, and rushes

GROWTH CHAMBER [PLANT GROWTH CHAMBER]: temperature, light, and humidity controlled environmental chamber

HABITAT: the specific environmental conditions which an organisms needs, either directly or indirectly, to survive and carry out its life processes

HABITAT FRAGMENTATION: alteration or breaking up of habitat into discrete or tenuously connected 'islands' as a result of modification or conversion of the landscape by management activities (e.g. logging, development)

HAND-MASHED: manual method for removing the seeds from fleshy fruits by simply crushing or macerating the fleshy pulp off the seeds vs. a mechanical method such as a household blender

HAND-PICKING: removing fruits from a plant by hand, as opposed to flailing or mechanical methods

HAND-RUBBED: manual method to remove the seeds from macerated fleshy fruits by placing the pulp and seeds on a screen and then pressing down and rubbing to force the seeds through a screen and leaving the pulp on top

HARDEN-OFF [PLANTS]: method by which young plants or seedlings that have been propagated in cold frames or greenhouses are gradually exposed to the outdoor elements. This is usually over a week to two weeks whereby the plants are given a short time outdoors each day, and returned to the cold frame, gradually lengthening the time outdoors each day.

HARDPAN: a distinct layer of soil, nearly impermeable, formed by the cementation of soil particles with organic matter, silica, calcium carbonate, or iron oxides

HEMICELLULOSE: a carbohydrate constituent (with cellulose and lignin) of woody cell walls

HERB LAYER: the herb layer includes all herbaceous species, regardless of height, and some low woody plants less than 15 cm tall

HERBACEOUS: vegetation that is usually forbs, grasses, or leafy plants

HERBIVORY: consumption of plants or parts by grazers, e.g. deer

HISTORICAL RANGE: range of a species at a point in time in the past; in Garry Oak ecosystems this often refers to the period immediately prior to settlement by Europeans

HOLISTIC ECOLOGICAL RESTORATION: Defined by Clewell and Aronson (2007) as restoration programs that include personal and cultural values as well as ecological and socio-economic values.

HOLOPARASITE: parasitic plants which lack chlorophyll and are therefore wholly dependent on their host plant for the supply of water, nutrients, and fixed carbon

HOST PLANT: plants used by butterflies (and other insects) for laying eggs which then provide food for the larvae after hatching

HUMUS: well-decayed organic matter near the soil surface (beneath the litter layer but above the mineral soil)

HYDROLOGY: the study of water, its properties and movement (cycling), over and under land

HYDROLOGIC REGIME: changes with time in the rates of flow of rivers and in the levels and volumes of water in rivers, lakes, reservoirs, and marshes. The hydrologic regime is closely related to seasonal changes in climate.

HYGRIC: wet

[IMPERMEABLE] SEED COAT: the outer covering of a plant seed, that has become hardened so that it is impermeable to water (which is needed for germination to occur); type of physical dormancy in seeds

INBREEDING DEPRESSION: reduced reproductive success resulting in a decreased ability [of a population] to adapt to environmental stress; may be caused by a reduced genetic diversity within the population

INCREMENT BORER: a mechanized or hand tool for removing a small diameter core of wood from the stem of a tree for measuring of growth or assessing soundness of the wood

INDIGENOUS SPECIES: species that occur naturally in an area

INFLORESCENCE: flower cluster or the arrangement of flowers on a stem

INGROWTH (FOREST/SHRUB): gradual increase in numbers of a species on a site, filling in an opening

INVENTORY: generally, the collection (as a verb) or a collection (as a noun) of information to describe the state of an ecosystem or ecosystem characteristics at a particular point in time. Typically includes a list of organisms and/or their numbers and health, vigour, etc.

INOCULATE: deliberately placing a pathogen in contact with a host; trees are sometimes inoculated with fungal pathogens to create wildlife trees

INVASIVE SPECIES: invasive species are those whose introduction or spread threatens the environment, the economy, or society; invasive species can be either alien (exotic) or indigenous

LADDER FUEL: fuel that provides a vertical connection between surface fuels and crown fuels in a forest stand (e.g. tall shrubs, small trees, branches, tree lichens), thus potentially enabling a ground fire to rise and become a crown fire

LANDSCAPE CLOTH/FABRIC: weed barrier usually made of woven polypropylene

LATH HOUSE: type of wooden-open screened house used to provide shade for protecting new plants

LEAF NODE: location on the plant stem from which the leaves originate

LEAF PETIOLE: leaf stalk; “stem” of a leaf, which attaches it to the branch

LITTER: the top layer of the forest floor that is composed of relatively undecomposed organic material in the form of leaves, twigs, and branches shed from plants and below-ground inputs from the death of fine-root material

LIGNIN: one of the principal constituents (with cellulose and hemicellulose) of woody cell walls

LOAM: a soil containing a mixture of sand, silt, and clay

MACERATE: make soft and separate into constituents by soaking. Seeds of fleshy fruits are separated from the pulp by soaking to soften, then mashing and squeezing by hand, or machine, or rubbing through a screen, or floating (seeds sink and pulp rises to the surface).

MALAISE TRAP: a large, tent-like structure used for trapping flying insects

MAST-FRUITER: plant that produces seeds in abundance at irregular intervals of more than a single year. Garry Oaks are mast-fruiters.

MATRIX OR FABRIC: the background ecological system of a landscape with a high degree of connectivity. The dominant component in the landscape.

MESIC: a term meaning intermediate; describes an environment that has moderate moisture levels, neither too wet nor too dry. Water removed somewhat slowly in relation to supply; soil may remain moist for a significant, but sometimes short period of the year. A plant requiring a moderate amount of moisture.

MICROHABITAT: an small, identifiably different portion of a larger discrete habitat. A small, localized habitat within a larger ecosystem used by an organism.

MICRONUTRIENTS: seven nutrients essential to plant growth and health that are only needed in very small quantities. These are manganese, boron, copper, iron, chlorine, molybdenum, and zinc.

MICROSITE: an area where very local conditions—moisture, temperature, light exposure, or nutrients—create suitable habitat for species not found in the wider habitat type

MINERAL SOIL: any soil composed of mineral materials. Mineral soil characteristics reflect their creation by weathering processes rather than biological processes.

MIST/MIST BENCH/MIST NOZZLE: An intermittent mist system will, in many cases, speed up the rooting process and allow the rooting of normally difficult-to-root species. Mist is used to maintain a film of water on the cuttings without saturating the medium. System requirements vary in the size of desired droplets, amount of water used, mist pattern, duration of intermittent spray, and maintenance needs. The droplet size should be in the range of 0.002 to 0.004 inch. Small droplet size allows the mist to remain suspended as a cloud for a few seconds before landing on the surface of the cutting.

MOISTURE REGIME: the aggregate of phenomena responsible for the entry, movement, consumption, and utilization of soil moisture by plants. It is the most important factor in soil formation and fertility.

MONITORING: the systematic collection of ecological data in a standardized manner at regular intervals over time designed to provide information on the characteristics of the ecosystem and their changes with time.

MYCELIAL STRANDS: Mycorrhizal fungi often produce mycelial strands which grow out from the root into the surrounding soil. Rootlike strands of the diffuse, indefinite body of a multicellular fungus, which is composed of many fine, branching tubes called hyphae.

MYCORRHIZA: a mutualistic association between a fungus and a plant, occurring primarily in the roots. A mycorrhiza is a symbiotic association between a fungus and the roots of a vascular plant allowing nutrient exchange between plant roots and fungi.

NATURAL PROCESSES: dynamic interactions between abiotic and biotic elements

NECROTIC (AS IN NECROTIC SPOTS REPRESENTING FUNGAL DISEASE SYMPTOMS): prematurely dead cells and living tissue. Necrosis is caused by factors external to the cell or tissue, such as infection, toxins, or trauma.

NICKING: mechanical breaking of the seed coat to overcome physical seed dormancy by cutting, drilling or filing a small hole in the coat of each seed before sowing. Usually applied to large, hard-coated seeds.

NON-LOCAL GENOTYPE: natural selection, driven by local conditions, can determine which genotype is successful and can change the makeup of the local population gene pool. A non-local genotype is one that has developed over time in a different geographic location.

NON-INDIGENOUS SPECIES: species that have been moved outside of their natural home range (= alien, exotic)

NOVEL ECOSYSTEMS: ecosystems that, due to invasive species or some level of intervention, have not occurred before

NUTRIENT-RICH: nutrient rich growing medium contains an adequate supply of all the macro and micro nutrients in the correct balance required for the successful production of plant life

NUTRIENT TRANSFER AND/OR EXPORT: movement of nutrients from one ecosystem to another. Salmon bringing marine nutrients to the forests along spawning rivers would be one example of nutrient transfer.

OBLIGATE [PARASITE]: A species that is restricted to a very narrowly defined environment. An obligate parasite can only be a parasite and often only on one host species. An obligate fungal parasite can live and complete its life cycle only in the living tissues of the host. See also Facultative

OUTBREEDING DEPRESSION: decreased reproductive success due to introducing plants of the same species from different populations [e.g. through seed collection] resulting in less genetically adapted offspring than either parent and than offspring of crosses between individuals from the same population

OUTPLANTING: refers to planting of propagated stock into a restoration site

OVIPOSIT: the process of laying eggs.

PACKRAT MIDDEN: nest of a packrat, often built in small caves, which may contain organic material that can provide clues about an ecosystem in the past

PARENT MATERIAL: the unconsolidated and more or less weathered mineral or organic matter from which a soil profile develops

PATCHINESS: a characteristic of discontinuous and heterogeneous environments consisting of a 'patchwork' of rather different habitats, resources, and ecosystems, as opposed to homogeneous or uniform environments

PATHOGEN: a biological agent that causes disease or illness to its host or range of hosts

PATHWAYS ANALYSIS: identifying the main pathways that facilitate a pest's movement and dispersal

PATHWAYS OF INVASION: the ways in which alien invasive species are introduced or spread

PERENNIAL: lasting more than one year; of plant duration, a plant whose life span extends over more than two growing seasons

PERLITE: volcanic glass that expands greatly when heated. It is an industrial mineral and a commercial product useful for its light weight after processing. In horticulture perlite is used in soilless growing mixes for aeration and retention. For rooting cuttings, 100% perlite is used.

PETIOLE: the stalk of a leaf, i.e. that part below the blade or, if the leaf is compound, below the point of insertion of the leaflets

PHENOLOGY: the timing of developmental events such as flowering, germination, seed set, etc.

PHENOTYPE: the physical appearance of an organism (morphology, physiology, biochemistry, behaviour) due to both underlying heritable genetic variation and variation driven by environmental conditions

PHYTOTOXIN: refers to a substance that is harmful or lethal to plants

PINCH: to pinch the growing tip, which will include the terminal set of leaves, between thumb and forefinger twist, and remove it. It will then branch from below.

PLANT ASSOCIATION: a plant community represented by areas of vegetation occurring in places where environments are so closely similar that there is a high degree of floristic uniformity in all the layers—that is, the same species are present in similar proportions and age/size classes

PLUNGE: for cuttings, to thrust into rooting medium to ensuring firm contact of the stem to the medium without leaving gaps or pockets under the surface

POPULATION: refers to all of the organisms that both belong to the same species and live in the same geographical area such that inter-breeding is possible between any pair within the area

POPULATION VIABILITY: the probability that a population will persist across its range despite normal fluctuations in population and environmental conditions

POROUS MIXTURE: porosity is a measure of the void (i.e., “empty”) spaces in a material. A porous growing medium has empty spaces that allow for the movement of water and air.

POT-BOUND: a pot-bound or root-bound plant is one whose roots have filled all of the available space in its container. A pot-bound plant will be unable to properly take up moisture and nutrients.

POTTING-UP: the action of re-potting a plant into a larger container once its root system has grown to the maximum capacity of its present one.

PRE-CONTACT: prior to European settlement in North America

PRE-DIAPAUSE: the developmental stage of an insect immediately before a normal suspension in growth in response to adverse environmental conditions (diapause)

PRE-TREATMENT: treatment of seeds prior to sowing in order to improve germination. The condition of a site prior to restoration treatment.

PRESCRIBED BURNING: fires deliberately set by managers to produce disturbances or conditions that are beneficial to an ecosystem or that achieve management objectives

PRICKING-OUT: the transplantation of seedlings from germination trays to containers for growing on. Seeds germinated in open flats may need to be separated to allow room for them to grow. Pricking out is done just as seedlings develop first true leaves and before root development is too tangled together.

PROPAGULE: any structure with the capacity to give rise to a new plant, e.g. a seed, a spore, or part of the vegetative body capable of independent growth if detached from the parent.

PROVENANCE: the place of origin of a plant or propagule

PUPA: the life stage, following larva and before adult, of those insects that undergo a complete metamorphosis—four life stages.

QUARANTINE: compulsory isolation, typically to contain the spread of something considered dangerous. There are three quarantine Acts of Parliament Acts_of_Parliament in Canada: *Quarantine Act* (humans) and *Health of Animals Act* (animals) and *Plant Protection Act* (vegetations). The first legislation is enforced by the Canada Border Services Agency after a complete rewrite in 2005. The second and third legislations are enforced by the Canadian Food Inspection Agency. If a health emergency exists, the Governor in Council can prohibit importation of anything that it deems necessary under the *Quarantine Act*.

RANDOM SAMPLING: sampling without bias by, e.g., using a random-number generator to choose among items or locations to assess or measure; every possible sample has an equal probability of being selected

RANGE: of a species—the geographical area where a species occurs

RECONNAISSANCE SURVEYS: quick surveys that proved initial data that can be used for planning more in comprehensive surveys

RECOVERY STRATEGY: Canada's *Species at Risk Act* requires recovery strategies for all endangered species. A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the subsequent action plan stage.

RECOVERY TEAM: a technical committee charged with developing a national recovery plan for nationally threatened and endangered species

RECRUITMENT: generally, the addition to a population from all causes (reproduction, immigration, stocking). Recruitment may refer more specifically to numbers born, hatched, germinated, or sprouted but may also refer to non-living components, e.g. recruitment of snags or of coarse woody debris.

RED LIST: listing of elements of special concern, as determined by the BC Conservation Data Centre (www.env.gov.bc.ca/atrisk/red-blue.htm). The Red List includes any ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in British Columbia. Extirpated elements no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered elements are facing imminent extirpation or extinction. Threatened elements are likely to become endangered if limiting factors are not reversed. Red-listed species and sub-species may be legally designated as, or may be considered candidates for legal designation as Extirpated, Endangered or Threatened under the *Wildlife Act* (see www.env.gov.bc.ca/wld/faq.htm#2). Not all Red-listed taxa will necessarily become formally designated. Placing taxa on these lists flags them as being at risk and requiring investigation.

REFERENCE ECOSYSTEMS: an ecosystem that can serve a reference for restoration activities

REEMAY CLOTH: a proprietary brand name for thermally spunbond, non-woven polyester fabrics used as covers in horticultural applications for their ability to transmit light, insulate, allow air circulation, and stop insect and weed-seed intrusion

RESILIENCE: refers to the ability of a plant or community to withstand environmental stresses such as drought, disease, and herbivory

RESISTOGRAPH INSTRUMENT: An instrument that measures and records the resistance to penetration of a small diameter drill as it passes through wood. Resistance decreases when decay is encountered.

RESTORATION [ECOLOGICAL]: the process of assisting the recovery of ecosystems that have been damaged, degraded or destroyed

RESTORATION TARGET: the prescription for what your site should look like and how it should function after restoration

RHIZOME: a root-like stem in the ground: a slender to much swollen underground stem that grows more or less horizontally

RHIZOMORPH: a compact strand of fungal hyphae with a dark outer coat that is capable of apical growth through soil and assists in spread of the fungus from a host to a suscept

RIPARIAN: pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water

RISK ASSESSMENT (OF INVASIVE ALIEN PLANTS): the process by which potential alien invasive plants and plant pests are identified and evaluated. It includes pathways analysis and pest risk assessment

SARA: Canada's federal *Species at Risk Act* (2003). SARA is the federal government commitment to prevent wildlife species from becoming extinct and secure the necessary actions for their recovery. It provides for the legal protection of wildlife species and the conservation of their biological diversity. The purposes of the *Species at Risk Act* (SARA) are to prevent wildlife species from being extirpated or becoming extinct, to provide for the recovery of extirpated, endangered and threatened species, and to manage species of special concern to prevent them from becoming endangered or threatened. The Act establishes Schedule 1, as the official list of wildlife species at risk. It classifies those species as being either extirpated, endangered, threatened, or a special concern. Once listed, the measures to protect and recover a listed wildlife species are implemented.

SALVAGE: salvage plants are those recovered for translocation from a site which is to be destroyed by construction or development to another site undergoing restoration

SAMPLING: the collection of material or data about a portion (the sample) of a population for measurement in order to make estimates or inferences about the entire population

SAPROPHYTE: a fungus that obtains its nutrients by decaying dead organic matter

SATURATION: the point at which all pore spaces in a growing medium are filled with water and no air remains

SAVANNAH: generally classified as a state between open prairie or meadow and closed-canopy woodland

SCALE: bulb scales are the reduced leaves that make up the layers of bulbs such as Lilies and Alliums

SCARIFICATION: the process of pre-treatment of seeds to overcome physical seedcoat dormancy by softening, puncturing, wearing away or splitting the seedcoat in order to render it permeable, without damaging the embryo and endosperm within. Includes physical and biological methods, dry heating and soaking in water or chemical solutions. Destruction of impermeability at a single point in the seedcoat is normally sufficient to allow imbibition and gas exchange and hence embryo growth (germination).

SEASOIL: a proprietary name for a composted fish and forest fines soil from Vancouver Island, created by composting a mixture of fish (waste product) and forest fines (a logging industry term for bark and the organics that fall off of logs during the sorting process); contains abundant amounts of macro-nutrients, micronutrients and trace elements to produce healthy plants; has weed-free status.

SECATEURS: a small pair of shears for pruning, designed to be used one-handed, having a pair of pivoted handles, sprung so that they are normally open. Usually compose of a either a single cutting blade that closes against a flat surface (anvil pruners—used for hard, woody stems), or one blade that crosses another fixed blade, with a scissor action (scissor or cross-cut pruners—for general use and soft stems)

SEEDCOATS [SEED COAT DORMANCY/EMBRYO DORMANCY ARE DEFINED IN THE TEXT]: outer protective covering of a seed. The seed coat develops from the integument of the ovule. Also called testa.

SEEDLOT: refers to seeds of a particular crop gathered at one time and likely to have similar germination rates and other characteristics

SEEP: an area where minor groundwater flows out onto the land surface or into a stream channel. Seeps do not produce runoff at a visible rate.

SEEPAGE ZONES: areas where water seeps from the slope causing a specific vegetation assemblage

SELF-POLLINATION: refers to the transfer of pollen from a male reproductive structure (an anther or male cone) to a female reproductive structure (a stigma or female cone) of the same plant or of the same flower

SELECTIVE SAMPLING: samples are deliberately chosen by using a sampling plan that screens out materials with certain characteristics and/or selects only material with other relevant characteristics; for example, a sampling plan that selects certain microhabitats for sampling, e.g. vernal pools, to ensure that they are not over-looked by a random or stratified sampling technique

SEMI-HARDWOOD: mature stems from the current season's growth of a woody plant collected before the plant goes dormant. Semi-hardwood cuttings are still flexible, bending before breaking. Hardwood cutting snap if bent.

SEMI-SHADE: refers to dappled sunlight, where the full force of the sun is broken by a partial canopy of overhead foliage or screening but not all direct light is absent

SENESCENCE: generally, the process of ageing; in deciduous plants, the process preceding leaf shedding

SERAL COMMUNITY: a stage in a successional sequence

SHADE/LATH HOUSE: a constructed shelter which screens part of the sun from plants held within. In older structures the shading is provided by a grid of wooden lath. In new structures shading is usually provided by a synthetic 'shade cloth' which can be purchased in different weaves which provided specific percentages of shade.

SILT: a soil textural class (between 0.004 and 0.062 mm in diameter) in which silt particles are very abundant

SOIL AMENDMENTS: refers to a substance added to soil to increase its nutritive value, friability, moisture retention, or some other aspect

SOILLESS: a growing medium that uses sand, bark, and/or other ingredients, but not any actual soil. Soilless mixes are usually sterile and free of weed seeds

SOIL HORIZON: a layer or zone of soil or soil materials lying approximately parallel to the land surface with physical, chemical, and biological properties or characteristics that are distinct from the adjacent, genetically related layers

SPECIAL CONCERN: a species that may become threatened or endangered because of a combination of biological characteristics and identified threats

SPECIES DIVERSITY: the fundamental unit in which to assess the homogeneity of an environment; refers to both a) the number of different species found on a site, and b) diversity within a species, both phenotypic and genetic

SPECIES' RESIDENCE: according to Canada's *Species At Risk Act*, the specific dwelling place, such as a den, nest or other similar area or a place that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding, or hibernating

SPECIES-TRUE: plants which are genetically the same as plants in your target restoration area/ reference site. Hybrids are not species-true; selections and cultivars may be.

SPOROPHORE: a fungal structure producing and bearing spores

STAND DYNAMICS: both apparent changes in plant population over time AND factors affecting the preceding

STOOL BED: refers to a nursery bed where stock plants are held for the production of cuttings. Plants are 'stooled' back, cut back annually to near the crown to force production of new wood suitable for use as cuttings in the next season.

STRATIFICATION: a method of artificially overcoming seed dormancy by placing seeds in layers of moisture-retaining media and keeping under generally cool and moist conditions for a period of time (or alternating cold and warm conditions), so as to simulate winter conditions.

STRATIFIED SAMPLING: samples are selected after the population has been divided into parts (stratified); stratification is usually done by dividing the survey area into sub-areas on a map or through on-site interpretation and classification

STRIKE CUTTINGS: a cutting 'strikes' when it grows roots. By extension, to strike cuttings is to prepare and place them in a rooting medium

STYROBLOCK: a proprietary name for Styrofoam growing containers, primarily used in forestry. The blocks are approximately 600 x 350cm and vary in depth from 50mm to 200mm. Blocks have from 8 to 540 cylindrical cells, partially open at the bottom depending on the species to be grown. They allow for relatively easy removal of seedlings with minimal root damage.

SUBHYGRIC: moist or imperfectly drained; water removed slowly enough to keep soil wet for a significant part of growing season; some temporary seepage and possibly mottling below 20 cm. Water source is from precipitation and seepage

SUB-POPULATION: a definable subdivision of a population, whether created artificially or naturally, with common, distinguishing characteristics

SUBSPECIES: a naturally-developed and recognised division of a species, either morphologically or genetically, that usually arises as a consequence of geographical isolation within a species

SUCKER: a secondary shoot produced from the base or roots of a woody plant that gives rise to a new plant

SUCKERING SHOOT: a strong shoot that arises in a mature plant from a root, rhizome, or the base of the main stem

SUCCESSION: a series of dynamic changes in ecosystem structure, function and species composition over time as a result of which one group of organisms succeeds another through stages leading to a potential natural community or climax stage. Primary succession (pioneering) occurs when organisms colonize a previously empty area (e.g. bare soil) and secondary succession occurs on sites that had previously been colonized but then disturbed in some manner. Note that succession theories are still being debated by ecologists.

SUCCESSIONAL STAGES: see Seral Communities

SUCCESSIONAL TRAJECTORY: the pathway an ecosystem takes from a bare site (pioneering) to a late successional (mature) state. This pathway is considered to occur within a defined framework of seral stages for a particular disturbance regime and ecosystem type, that is, it is a mostly predictable sequence of communities.

SUITABLE HABITAT: habitat that meets the species' requirements but does not contain the species

SWALE: a slight depression in generally level ground that may be slightly swampy

SWAMPING: a) suppression of a species by rapid invasion by one or more other species; b) [genetic]domination of introduced genetic material into a natural population, potentially causing outbreeding depression and reduce genetic diversity in the original (smaller) population.

SWOT ANALYSIS: a strategic planning method used to evaluate the **S**trengths, **W**eaknesses, **O**pportunities, and **T**hreats involved in a project. It involves specifying the objective of the project and identifying the internal and external factors that are favorable and unfavorable to achieve that objective.

TALUS: angular rock fragments accumulated at the foot of a steep rock slope and being the product of successive rock falls; a type of colluvium

TAMP: to pack down [soil media] with repeated, even blows to firm before sowing seeds or inserting cuttings

TETRAZOLIUM TEST: a chemical test which provides a quick estimate of seed viability by staining with tetrazolium chloride. Viable embryos will stain reddish in colour.

THREATENED: a species that is likely to become endangered if limiting factors are not reversed

TILL: material deposited by glaciers and ice sheets without modification by any other agent of transportation

TOLERANT: able to withstand stress and function suitably

TRANSECT: a line followed across a study area while assessing its attributes

TRANSITIONAL ECOSYSTEM: a) a geographic boundary or transition zone between two different ecosystems. The term has been used to denote transitions at different spatial scales or levels of analysis, and may refer to any one of several attributes of the organisms involved. Also called an 'ecotone'; b) a mid-successional state or ecosystem (i.e., between two seral stages)

TRANSLOCATION [including augmentation, introduction and re-introduction]: the capture and/or collection, transport and release, or introduction or reintroduction of plants, animals, or habitat from one location to another

TRANSPLANT: to lift and reset a plant in another soil or situation

UNDERSTOREY: canopies of trees and other woody species growing under larger adjacent trees and woody growth

UNFILLED SEED: a seed that is lacking an embryo and so cannot grow. Usually resulting from not being fertilized.

UNGULATE: hoofed grazing animals

UTM: Universal Transverse Mercator, a geographic coordinate system that is based on a 2-dimensional Cartesian coordinate grid used to specifying locations on the surface of the Earth

VARIANCE: numerical expression of variability in a data sample

VASCULAR: those plants that have lignified tissues for conducting water, minerals, and photosynthetic products through the plant. Vascular plants include the clubmosses, horsetails, ferns, gymnosperms (including conifers) and angiosperms (flowering plants).

VEGETATION STRUCTURE: the various horizontal and vertical physical elements of the community, i.e. the different sizes, branching structures, shapes

VERMICULITE: a natural mineral that expands with the application of heat and used in horticulture as a soil conditioner for its ability to increase porosity of a growing medium

VERNAL POOL: small pools appearing in the winter or early spring caused by winter rains, that dry out later in the summer

VIABLE: capable of sustaining life; in plants, viable seed has the ability to germinate; see also Population viability

VIGOUR: the capacity for survival or strong healthy growth in a plant or animal

VIRULENCE: a quantitative measure of the amount of disease caused by a parasite

VOUCHER SPECIMEN: a specimen that serves as a basis of study, for expert identification, and is retained as a reference; a voucher specimen should be archived in a permanent collection (usually in a museum, an institution with a mandate to preserve materials indefinitely). It serves as physical evidence of occurrence at time and place and of any identifications and descriptions based on it, always assuming that it is archived with adequate collection data. (Even if it is not stored in an accessible, permanent collection, a specimen collected for identification or analysis remains a voucher specimen).

VULNERABLE: a vulnerable species is one that may be close to extirpation or extinction

WHITE ROT: wood decay caused by fungi that utilize mainly lignin, leaving white cellulose compounds

WHIP: a slender, unbranched shoot or plant used to vegetatively propagate deciduous woody shrubs

WHIP CUTTINGS: dormant cuttings taken from slender, straight, unbranched stems of deciduous woody shrubs

WHOLE TREE FAILURE: the tree is alive, with foliage, but because many of its structural roots are dead and decayed, there are not enough roots to support the weight of the above-ground parts. The tree falls over with or without help from wind.

WILDLIFE HABITAT AREAS: In British Columbia, the Identified Wildlife Management Strategy (IWMS) establishes two categories of wildlife which require special management attention to address the impacts of forest and range activities on Crown land. These two categories are the Category of Species at Risk and the Category of Regionally Important Wildlife. Wildlife habitat areas (WHAs) are mapped areas that are necessary to meet the habitat requirements of an Identified Wildlife element. WHAs designate critical habitats in which activities are managed to limit their impact on the Identified Wildlife element for which the area was established.

WINNOWING: to clean debris (chaff) from seed by a current of air; to blow seed coats, remains of flowers, and other light debris from heavier seed

WINTER ANNUAL: a plant that germinates in autumn or winter, lives through the winter, then blooms in winter or spring

WOODY CUTTING: cutting taken from a mature, woody stem

WOODY DEBRIS: a term used for fallen dead trees and the remains of large branches on the ground in forests

WOODY PLANT: with the stems and limbs containing lignin

WOODY STEM: mature stem, hardened and usually with bark

XERIC: Water removed very rapidly in relation to supply; soil is moist only for brief periods following precipitation. For a plant, of, or adapted to, an extremely dry habitat.

YELLOW LIST: species and ecosystems in British Columbia that are considered secure as determined by the BC Conservation Data Centre

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