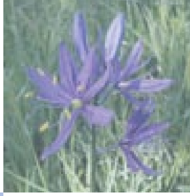

Restoring British Columbia's

Garry Oak Ecosystems

PRINCIPLES AND PRACTICES

Chapter 8
Restoration Strategies

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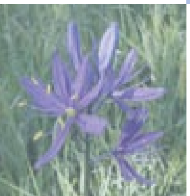

Chapter 8

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.

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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.

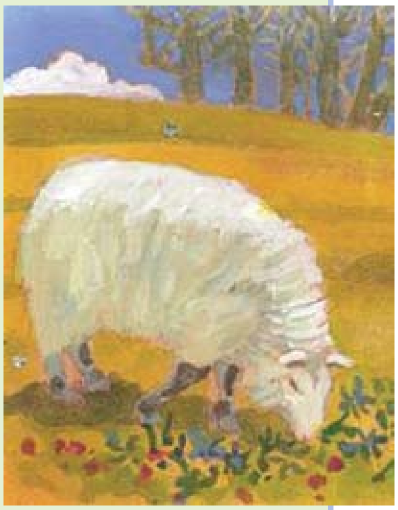
4 Successional status is an important factor to evaluate in ecological restoration; early successional communities tend to be dominated by pioneer plant species, often annuals or plants with rapid growth rates, that colonize an area immediately after disturbance or prefer regularly disturbed habitats, while later successional communities feature plants that grow more slowly and tend to be perennials.

CASE STUDY

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

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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.

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

Study of reference ecosystems provides ecological understandings that will allow selection of appropriate species for similar sites.

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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