Ecological Restoration: Nature-Based Solutions for Climate Mitigation and Engaging Canadians with Nature

Part 3 - Case Studies:

Garry Oak Ecosystem Restoration Report

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Middle left: Spring gold (Lomatium utriculatum) in Mt. Tolmie Park, Saanich BC. (© Sarah Bird)
Bottom left: Restoration in Summit Park, Saanich BC. (© Nancy Shackelford)
Bottom right: Greater bee fly (Bombylius sp.) at Mt. Tolmie Park, Saanich BC. (© Sarah Bird)

Executive Summary

Some of the last remaining patches of Garry oak ecosystems in Canada are found on southeastern Vancouver Island and nearby areas in British Columbia. These ecosystems are imperiled from habitat loss and degradation fueled by land-use-change, increased herbivory, reduction/removal of natural and cultural fire regimes, and invasive species. In Canada over 100 rare and at-risk species are supported by these ecosystems, whose value to the community has spurred dedicated volunteers, restoration practitioners, and academics to contribute to their protection and restoration for over 30 years.

We asked how restoration was being done in Canadian Garry oak ecosystems, and what potential opportunities existed to support restoration in this community. We used two approaches to address our question: developing a database of known restoration projects and searching available grey and academic literature for restoration methods and projects. We also conducted semi-structured interviews with restoration practitioners to access unpublished restoration details such as methodology and planning.

At least 100 restoration projects within Canadian Garry oak ecosystems were found, supported by restoration practitioners, municipal to federal government agencies, non-governmental organizations, and community volunteers. There are two main organizations (the Garry Oak Ecosystems Recovery Team and the Cascadia Prairie Oak Partnership) that collect and disseminate restoration knowledge within the community by publishing best practices, hosting conferences, and managing a listserv. While good information exists on best practices and ecological research supports these practices, formal restoration plans and reporting on restoration success were difficult to access or had not been created for many projects, making it difficult to assess the effectiveness of ongoing restoration efforts. To showcase a range of project types in this ecosystem, we highlight five restoration projects including a rare species introduction, a large urban park that is a hotspot for species at risk, and three park restoration projects that have be spearheaded and accomplished largely through the dedication of volunteers over many years.

Acknowledgements

We acknowledge with respect the Lekwungen peoples on whose traditional territory our work has been carried out, and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day. More fundamentally, we acknowledge that Garry oak ecosystems evolved in response to the care and stewardship of the local Nations. The relationship between the local peoples and nature has, and continues to, shape the landscapes we value and protect today.

We would like to thank the many busy restoration practitioners, government employees, and volunteers who took the time to share knowledge that supported this work. We also thank our research collaborators who provided guidance and feedback during the project: from the University of Victoria - Dr. Eric Higgs, Dr. Sarah Wilson, Alina Fisher, and Sonia Voicescu; from the University of Waterloo - Dr. Stephen Murphy, Dorian Pomezanski, and Tim Alamenciak; from Carleton University - Dr. Steven Cooke, Stephanie Cruz Maysonet, and John-Francis Lane; and from Laval University – Dr. Line Rochefort, Claire Boisemenu, and Gwendal Breton. Important feedback was also provided by Parks Canada and made for a much-improved document.

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1. Introduction

This case study is part of a larger research project supported by a Tri-Council Knowledge Synthesis grant, administered by the Social Sciences and Humanities Research Council (SSHRC): *Ecological Restoration: Nature-Based Solutions for Climate Mitigation and Engaging Canadians with Nature.* The overarching project includes interviews, a literature review, and three case studies to identify the state of restoration knowledge in Canada and opportunities for its development. The goal of this case study is to synthesize current knowledge about Garry oak ecosystem restoration in Canada. Although native plant gardens are excluded from this synthesis it is worth noting that gardeners, landscapers, and native plant nurseries in British Columbia are promoting gardening and landscaping with plant species from these ecosystems. Garry oak ecosystem restoration in Canada has a long history in modern land management and a strong community of practitioners across southern BC. Here we aim to summarize the scope and activities of the restoration community by reviewing current and previous projects, interviewing local practitioners and linking these results with existing best practices.

1.1. Garry Oak Ecosystems

Garry oak and associated ecosystems (Garry oak ecosystems) include a suite of ecosystems found in the dry rain shadow of the Vancouver Island mountain range. In these ecosystems Garry oak (*Quercus garryana*) is a dominant or co-dominant tree in the canopy, when present, and the understory is typically characterized by a diverse flowering forb and grass community (Figure 1). Garry oak woodlands can be divided into shallow-soil (more common) and deep-soil communities, and their associated ecosystems include maritime meadows, vernal pools, vernal seeps, and coastal bluffs (GOERT 2011). Many Garry oak ecosystems were established and maintained by traditional land management of Coast Salish Peoples, in particular practices such as intentional burns and the harvest of food plants like Camas (*Camassia* spp.*;* Pellatt & Gedalof 2014, Fuchs 2001). Intentional, controlled burns in Garry oak meadows contributed to increased productivity of traditional food plants for Coast Salish Peoples and helped maintain open meadows in the landscape (Turner 1999), while harvesting of root plants turned soils over and encouraged higher productivity due to selective harvesting practices (Turner, Ignace, & Ignace 2000).

Figure 1: Garry oak meadow (Gore Park) and examples of wildlife that can be found in Garry oak meadows. Bottom row L-R: Lotus micranthus, yellow-faced bumble bee on camas (Bombus vosnesenskii), and Anna's hummingbird on nest – (Calypte anna). Photos by Nancy Shackelford & Sarah Bird.

Seven plant associations were developed to describe Garry oak communities, with 17 plant communities and seven sub-communities described (Erickson & Meidinger 2007). At least 55 federally-listed species under the Species at Risk Act, and more than 100 of British Columbia's at-risk species live in these threatened ecosystems (GOERT 2011). Garry oak ecosystems are found only on Vancouver Island's southeastern coast and the adjacent gulf islands (and a few patches in the lower mainland of BC). The native range of Garry oak ecosystems extends south through western Washington, Oregon, and California in the United States (GOERT 2011).

1.2. The Need for Garry Oak Ecosystem Restoration

The most recent, best available estimate suggests that only 5 % of pre-European-contact Garry oak ecosystems remain in a relatively naturalized state (Lea 2006). Garry oak ecosystems are considered one of Canada's most at-risk ecosystems and face three major threats: habitat loss, fragmentation, and degradation. The native range of Garry oak ecosystems overlaps with the major areas of land development for human use in the Saanich Peninsula, so many patches have been lost to development (Fuchs 2001). Patches that remain are separated by an urban landscape, which inhibits the movement of plants and animals and contributes to the degradation of patches through increased introduction of invasive species. Additionally, most of these ecosystems have lost their traditional land management by First Nations as a result of European colonization and the forcible displacement of First Peoples (Pellatt & Gedalof 2014, Fuchs 2001). This loss of traditional management, coupled with the suite of exotic species associated with colonization, has led to new and different disturbance regimes impacting the landscape. Hyper-abundant herbivores, including deer *(Odocoileus hemionus columbianus*), and introduced goats, sheep, and rabbits that cause increased grazing pressure are an additional concern (GOERT 2011). Since many remaining Garry oak sites are present in urban parks, they are impacted by recreational use leading to compaction, trampling of native plants, introduction of invasive species, and exclusion of fire. Many of these threats interact and are interrelated, which can make restoration challenging.

For at least the last three decades, people have been restoring these ecosystems using collaboration, dedication, and hard work. A number of projects are looking to reconnect Garry oak ecosystems to the cultural landscape in which they developed, including through partnerships with First Nations and the re-introduction of intentional burns. There is also research into species biology, ecology, rare species, invasive species, and restoration treatment methods that supports restoration work being done in these ecosystems. The restoration of over 100 projects in remnant patches is important to limit further species losses, and to preserve these highly biodiverse landscapes.

1.3. Early Work in Garry Oak Ecosystem Restoration

For much of its recent history, Garry oak ecosystem restoration has often been spearheaded by community members and land managers in the interest of protecting species at risk and cherished landscapes (Figure 2). The Garry Oak Ecosystems Recovery Team (GOERT), a volunteer-based organization centered in Victoria, BC, and its legacy support ongoing work. When GOERT was established in 1999 its goal was “to provide a cooperative and coordinated long-term approach to conserving what is left of Garry oak and associated ecosystems and species at risk.” (Smith et al. 2006, pg.1). This group continues to be a central organizing force and has established a substantial base of knowledge on these ecosystems. GOERT has fostered partnerships and connections within the community for the last 21 years, with over 100 participating members since its inception, from a range of organizations, agencies, and institutions. They published native plant propagation guidelines for ~100 species, decision support tools and best management information for invasive species and species at risk, two books detailing restoration methods and practice, and countless other free resources publicly shared on their website to increase knowledge, foster community, and support Garry oak ecosystem conservation and restoration. Their annual research colloquiums bring together ~70-100 participants. Today they continue work that supports the implementation of the existing Recovery Strategies for species at risk in these ecosystems. The dedication of so many community members has ensured a strong theoretical and practical foundation for Garry oak ecosystem restoration in Canada.

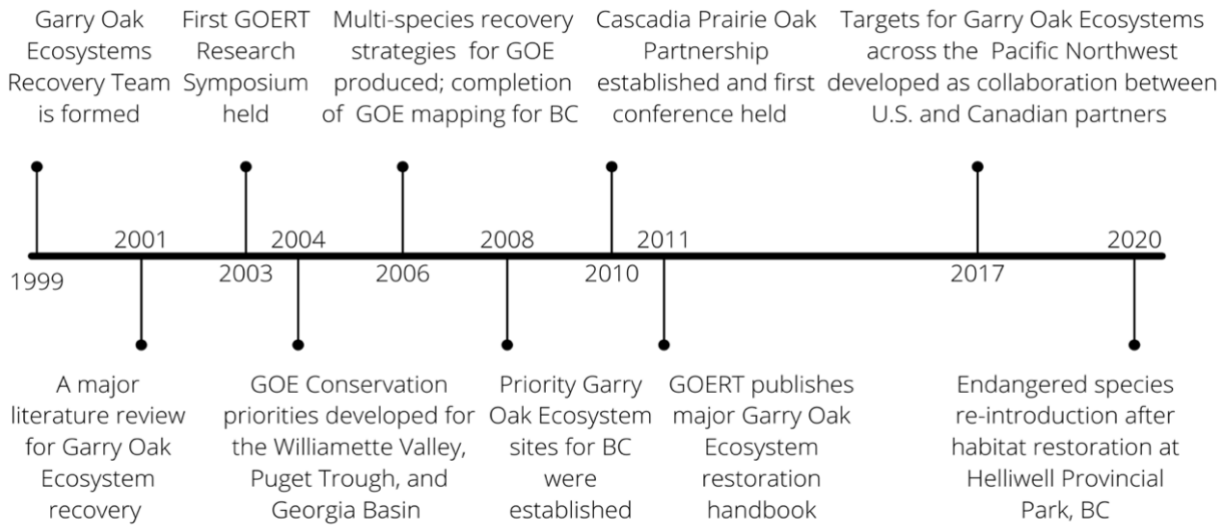

Figure 2: Major events in community organization to support Garry oak ecosystem restoration and conservation in Canada. Many restoration and conservation projects were initiated during this time, but are not shown.

The Cascadia Prairie Oak Partnership is a second organization that contributes to information sharing and community building within the Garry oak ecosystem restoration community in Canada. This organization was founded in the United States (US) in 2010 and connects practitioners across the full range of Garry oak ecosystems in Canada and the US through triennial conferences, a digital technical library, and a listserv that is actively used by Canadian and American restoration practitioners. The combination of local and regional organizations that create a community of practitioners facilitates knowledge-sharing at multiple scales and between diverse organizations.

2. Current Restoration Practices

2.1. Overview

A total of 102 restoration projects in Garry oak ecosystems within Canada were identified through online searches, e-mail and personal communications, and available public documents, 70 of which were identified from GOERT's list of restoration sites (Figure 3). Within the scope of the case study, we gathered and processed information on restoration actions and/or planning for 41 projects. The project list is likely incomplete, as we did not access reporting from some organizations known to be working on restoration in the area, and First Nations were not contacted due to the extractive nature of this particular research. The project is continuing to grow and will include deeper connections with First Nations partners as it develops. Some Nations are involved in cultural restoration projects which connect with Garry oak ecosystem restoration, and others are involved in some of the ongoing projects.

Of the projects for which we had information, current restoration projects are being completed largely within protected areas such as municipal and regional parks, provincial parks, and federal parks and park reserves. Many individuals engaging in restoration are federal and provincial parks biologists, regional/municipal biologists, and park managers. Project sites receive a significant contribution of effort from dedicated community volunteers, through "Friends of _____ Park" groups, municipal volunteer programs, and paid volunteer coordinators such as the Greater Victoria Green Team. Dedicated

volunteers include both community members and local environmental practitioners. In addition to projects on public lands, there are some projects occurring on private lands of homeowners and businesses. These projects were not included in this project. In the future, understanding the scope and scale of these projects would provide some information on the potential to use restoration on private land to address habitat fragmentation in this ecosystem.

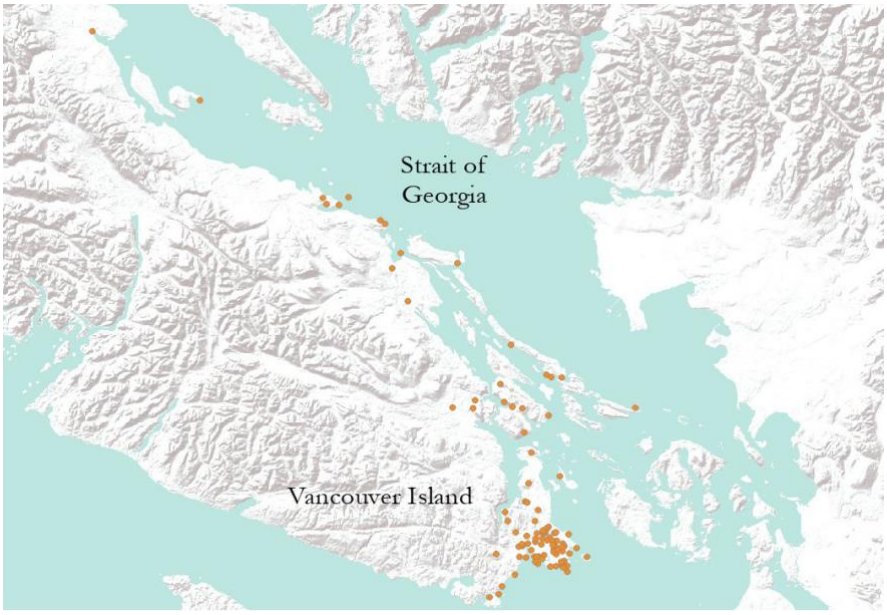

Figure 3: Map of 102 Garry oak ecosystem restoration projects located in Canada.

Partnerships and collaboration are common in Garry oak ecosystem restoration. For 50 projects for which we had some or all of the partnership information, there were at least 54 groups, organizations, or individuals involved in the restoration projects, many involved in multiple projects. Some projects included more than 10 partners. These numbers are an underestimate of the magnitude of groups participating in Garry oak ecosystem restoration in Canada. An annual highlight report from GOERT (2006-2007) indicated that in that year alone over 90 groups or agencies contributed to Garry oak ecosystem projects (conservation and/or restoration) through labour or funding (Appendix 1). Partners cover a wide range of organizational types including government agencies, First Nations, conservation organizations, businesses, academic institutions, community organizations, naturalist groups, and not-for-profit organizations.

In addition to the partnerships that facilitate on-the ground restoration projects, there is a large community of researchers from different institutions and public offices that collaborate to research both restoration techniques and important ecological and biological foundations within the ecosystem. A curated list of Garry oak ecosystem researchers from 2009 included 40 Canadian researchers who have worked in Garry oak ecosystem restoration specifically, and an additional 54 researchers in Canada focusing on ecosystem classification and function, rare species biology, disturbance regimes, invasive species, and fragmentation (GOERT 2009, unpublished document). Some of these researchers are associated with academia, but others yet are connected to local and federal governments, conservation agencies, or individuals privately conducting research. Additionally, 62 papers on ecology and 11 on restoration in these ecosystems were found in the literature search, published between 1972 and 2019.

2.2. Volunteer Contributions

Much of the restoration work in Garry oak ecosystems is supported and/or initiated by volunteers, and they play an integral part in managing persistent invasive species. In any given year, more than a thousand individuals may be contributing to Garry oak ecosystem restoration projects. For example, Highrock Park in Esquimalt hosted over 1000 students in a single event (pers. comm. 2020), and other events attract tens to hundreds of volunteers. In 2019, Friends of Uplands Park initiated 27 restoration events at Uplands Park contributing 546 hours from 300 individuals; this in-kind labour helped secure funding to support other restoration in the park (pers. com. 2020). The total reported hours from 14 projects included about 51 000 hours of volunteer work (~31 person-years of labour or $1.02 million CAD of labour at a $20/hour wage), roughly 22 % of which were reported from Uplands Park over a 6-year period, and 14 % from a single volunteer over a 10-year period. Additionally, in their annual reports GOERT reported a range between ~2.5 - 6 person years, per year, of volunteer work in their projects. From the existing and incomplete numbers available (from only 13.7 % of known projects, and records of volunteer hours available for some but not all years of each project), it is reasonable to assume these numbers vastly underestimate the hours dedicated to restoration projects by volunteers. It is clear that volunteers are an essential and valuable part of Garry oak ecosystem restoration.

2.3. Funding Sources

At a minimum, funding for Garry oak ecosystem restoration is provided by federal programs, local governments, not-for-profit organizations, businesses and private donors. Federal funding programs such as the Interdepartmental Recovery Fund (for Federally-managed lands) and the Habitat Stewardship Program (for non-federal lands) provide funding for the many project sites in Garry oak ecosystems that contain species at risk. Additionally, parks budgets contribute to funding, such as local governments (*e.g.* the District of Oak Bay for work at Uplands Park), Provincial Parks (*e.g.* Helliwell Provincial Park) and Federal Parks (*e.g.* Fort Rodd Hill Fisgard National Historic Site). Not-for-profit organizations such as Habitat Acquisition Trust and the Victoria Foundation, and private donors contribute funding which also supports restoration projects and activities. Some NGOs manage restoration projects as well, which contributes paid staff time to complete the projects.

2.4. Restoration Techniques

Common restoration treatments include invasive species management, fencing, conifer removal/girdling, and addition of native plants. Other treatments include prescribed fire, mowing, mulching, and species at risk re-introductions or supplementation. These treatments correspond to the main methods of restoration described in GOERT's 2011 "*Principles and Practices*…" publication. Many of these projects were started 15- 25 years ago (15 projects), many are ongoing (*e.g.* 17 confirmed within the assessed projects and ~40 projects within Saanich Parks, for which we did not access management information during the case study). Detailed restoration techniques were accessed for 40% (41 projects) of the 102 projects we identified. However, due to incomplete reporting in some cases, some of the current interventions for those 41 projects may not be captured in our synthesis. The projects for which detailed restoration methods are available are managed by a range of responsible organizations. About 22% of the projects we assessed for management actions are projects completed as part of the Restoration of Natural Systems Program at the University of Victoria, due to the availability of these reports.

a) Invasive Species Management

Management of invasive species was the most common technique among projects. Invasive species impact the health and persistence of native plants through competition for resources, altering the habitat (*e.g.* hydrology and thatch changes), and through predation/herbivory (GOERT 2011); they are thought to be the second greatest threat to these ecosystems. This result supports the findings of GOERT's 2011 publication indicating that invasive species treatment is a very common restoration action, and invasive species are a common threat in Garry oak ecosystems. Of the 41 projects we examined, only 33 had information about invasive species treatment, all of which reported some kind of invasive species management. Some reports noted that the GOERT decision-making tool for invasive species in Garry oak ecosystems (available here) helped with restoration planning. The main invasive species targeted for management in these projects are outlined in Table 1. For several projects, it was noted that consistent and persistent treatment of Scotch Broom (*Cytisus scoparius*), the most commonly managed plant, resulted in manageable populations during the project. For sites where a single year of Scotch Broom treatment was missed, there were noticeable setbacks to the management of the plant, and some individuals recommended securing long-term funds or volunteers before beginning treatment. In several projects it was also noted that native flowers grew from a seedbank once thickets of Scotch Broom were removed. In addition to the most common seven plants being treated, invasive species not in Table 1 are being treated in 13 of the ongoing projects. Both mechanical and chemical means were used to manage invasive plants; 25 projects confirmed using mechanical and 11 projects used chemical control for species such as holly, blackberry or invasive grasses. Some managers noted that there are new or less common invasive species, like crow garlic (*Allium vineale*), that require more research on best management practices.

Table 1: Percent of restoration projects (N=33) managing common invasive species.

Scientific name	Common name	%
Cytisus scoparius	Scotch Broom	81
Rubus armeniacus	Himalayan blackberry	52
Daphne laureola	Daphne	49
Hedera helix	Ivy	33
Ilex aquifolium	Holly	24
	Non-native grasses	24
Crataegus spp.	Hawthorn	18

b) Herbivory and Fencing

Additional stressors to Garry oak ecosystems include loss or change in disturbance regime. Increase in herbivory from overabundant native deer, and from introduced rabbits are contributing to changing vegetation dynamics. In order to address grazing pressure from deer, tall deer fencing has been used to keep deer out of restoration sites. The size of the fenced area impacts the function of the fencing, as at least one project reported small exclosures encouraged vole herbivory on native plants (this drawback is also reported by GOERT, 2011). Projects are also using cages around Garry oak saplings to protect against herbivory (Figure 4). Fencing is not just used to protect from herbivores; stacked cedar fencing is used in projects to help direct pedestrians within a park or to keep people and pets outside of patches of sensitive plants (Figure 6).

Figure 4: Metal cage to protect Garry oak seedlings from herbivory. Photo by Sarah Bird 2020

c) First Nations Partnerships and Fire Re-introduction

Figure 5: Prescribed burn at the Cowichan Garry Oak Preserve from 2020. Photo from Steven Godfrey, Nature Conservancy of Canada

Several restoration projects have prioritized reconnecting First Nations stewardship and traditional management practices to their historical landscapes. In the most developed examples, this effort has taken the shape of collaborative reintroduction of fire management. Fire can help maintain an open canopy, minimize thatch build-up from non-native grasses, and provides an opportunity to re-integrate the landscape into the cultural context in which they developed (Pellatt & Gedalof 2014). Returning fire to the landscape is difficult in many Garry oak sites because of their location in cities, and those projects that have been successful have been in relatively remote locations. The process involves cultivating trusting relationships between First Nations, and land managers from governmental and non-governmental organizations. Relationship-building can create the needed space for meaningful integration of traditional knowledge and land management practices that have co-evolved with these ecosystems. This is an ongoing process and several projects that are using prescribed fire have been working with First Nations to integrate traditional knowledge into the project planning, most notably Tumbo Island (Gulf Islands National Park Reserve) and the Cowichan Garry Oak Preserve (CGOP; Figure 6). The work on Tumbo Island by Parks Canada includes experimental plots looking at impacts of prescribed fire and herbivory on native and invasive vegetation, and a burn was conducted in 2016 in close partnership with the Penelakut Tribe on planning and implementation. At the Cowichan Garry Oak Preserve, the Nature Conservancy of Canada (NCC) has conducted at least three burns, which were developed as part of a research program. The NCC worked with members of the Cowichan Tribes to incorporate traditional knowledge into the burn planning, and continue to develop a relationship with Cowichan Tribes to support other traditional land management activities on site (Nature Conservancy of Canada 2020).

Figure 6: Stacked cedar fencing to keep pedestrians and pets outside of sensitive areas. Photo by Nancy Shackelford.

d) Other Restoration Treatments

There are several other methods of restoration that are less widespread, but still relevant in Garry oak ecosystems that were used in projects. These include: native species planting, conifer removal and girdling, re-introducing species-at-risk, mowing, and mulching. These techniques address some of the other factors that may limit the success of native plants: poor dispersal or patches separated by distances that limit dispersal; Douglas fir encroachment into meadows; invasive grass populations. For those projects that added native plants (15 projects) the numbers and selection of species varied widely. Camas and native grasses were often added, with anywhere from a few to over a hundred species of native plants being added. Most

commonly seeds were used to add native plant propagules to a site but plugs, pots and seedlings were also used. A few projects also reported using salvaged or transplanted plants for their restoration. At least 6 projects included some kind of Douglas fir removal, girdling, or limb-removal to help manage encroachment into Garry oak meadows. Re-introduction or augmentation of at-risk species was less common. Two projects included mowing as a restoration treatment, and one discussed mulching to manage invasive plants.

e) Planning and Monitoring for Restoration

Planning and monitoring information was less commonly available than restoration techniques. For many sites where it was available, it was in part because of the presence of species-at-risk and associated reporting requirements. We found that 27 projects included some kind of restoration goal associated with their project, but formal restoration plans were uncommon and/or difficult to locate. Only 10 projects of the 41 we reviewed had accessible and formalized (*i.e.* written) documentation of restoration outcomes, and these ranged from a single paragraph description to extensive multi-page reports. Some practitioners cited limited funding as a barrier to comprehensive planning.

Monitoring included a mixture of quantitative measures (13 projects), particularly for rare plant inventories, or in permanent vegetation plots, and qualitative measures (9 projects), often to assess invasive species persistence, or through photo monitoring. The frequency of monitoring efforts varied greatly between projects – some with a single quantitative monitoring event, others with permanent vegetation plots measured annually for 12 years. Some projects employed a mix of qualitative and quantitative measures. In total, documentation of monitoring was available and findable for 20 projects. Most commonly monitoring assessed invasive species, followed by species at risk. Some projects monitored vegetation change after conifer removal, success of native plantings or seedlings, and herbivory levels. The timing and duration of monitoring varied between projects and within a project occasionally changed based on available funding. This variation makes it challenging to compare outcomes across projects.

3. Project Spotlights

We are highlighting five projects in this report: restoration and butterfly reintroduction at Helliwell Provincial Park, rare species protection at Uplands park, and volunteer-coordinated projects including Playfair Park, Devonian Regional Park, and Trafalgar Park. These examples highlight some of the themes in Garry oak ecosystem restoration projects in Canada: repairing landscapes for at-risk species, community-driven projects, and highly dedicated and driven volunteers.

Helliwell Provincial Park is located on Hornby Island, south of Courtney BC. The park contains coastal bluff meadows (a Garry-oak-associated ecosystem), which historically supported Taylor's Checkerspot (*Euphydryas editha taylori*), an endangered butterfly. The park's meadows were threatened by conifer encroachment and plant invasions, in part due to a lack of fire regime (Hoffman et al. 2018). In 2005, the butterfly, thought to be extirpated from Canada, was found on the neighbouring Denman Island. At that time the Taylor's Checkerspot Recovery Project Team began planning for the species' recovery in Canada, and considered restoring habitat at Helliwell to support re-introduction efforts. After 15 years of hard work by 22 core project members, other volunteers, over 7 partnering organizations, and the support of 17 funders, the re-introduction project began. Starting in 2015, many participants, including students from the Hornby Island Community School, restored butterfly habitat in the coastal bluffs of Helliwell. In

the spring of 2020, to culminate years of planning, cooperation, and hard work, ~800 Taylor's Checkerspot caterpillars were re-introduced in Helliwell Provincial Park. Future monitoring will indicate if the re-introduction was a success, but early surveys indicated at least 25 individuals survived to become adults in 2020 (GOERT 2020).

Uplands Park is a large (31 ha) urban park located in Oak Bay, in the Greater Victoria Area. The park boasts one of the highest concentrations of rare and endangered plants in the region, providing habitat for 24 species at risk. The sensitive Garry oak ecosystems in the park are threatened by invasive plant populations including gorse (*Ulex europaeus*), Scotch broom (*Cytisus scoparius*), Himalayan blackberry (*Rubus armeniacus*), and English ivy (*Hedera helix*), with a total of 14 actively managed species and 80 invasive species within the park. Additional threats include the heavy recreational use that can lead to trampling of spring wildflowers and compaction of soils. Early efforts to restore the habitat focused on invasive plant removal and started as early as 1992 when Margaret Lidkea, a community volunteer, organized "Broom Bashes" with Girl Guides to remove invasive plants, notably Scotch Broom (pers. comm. 2020). She also organized the community group "Friends of Uplands Park" in 2010 with a friend, which now hosts regular restoration events in the park (169 events in 2019). In 2004, a park Stewardship Plan was prepared, highlighting the park's important role in providing habitat for at-risk species. This report spurred additional planning in 2005 (with updates in 2014 and 2018) to manage the park's invasive species. These plans prioritized invasive species management and some were developed with students from the Restoration of Natural Systems Program at the University of Victoria. Work within the park is supported by the District of Oak Bay and the Habitat Stewardship Program, and volunteers contribute at least 1600 hours every year to work in the park (pers. comm. 2020). The District of Oak Bay is also reducing recreational impacts on sensitive species by closing the central, iconic, Garry oak meadow in the winters (District of Oak Bay 2020).

In Playfair Park, located in the District of Saanich, volunteer Colleen O'Brien, has singlehandedly initiated and ensured the restoration of the park's Garry oak meadow, one of few remaining deep-soil Garry oak meadow sites (Acker 2018). She has contributed more than 7000 hours in 10 years of volunteering, usually working alone in the park. Ms. O'Brien has developed and tested various methods for invasive grass and other invasive plant removal, which have been quite successful at the scale of the park in supporting the return of Camas *(Camassia spp.)* and other native meadow wildflowers where invasive grasses once dominated (Acker 2018).

Devonian Regional Park is located in Metchosin and is managed by the Capital Regional District. The park has also had significant Garry oak ecosystem restoration that was initiated by a passionate councilor for Metchosin, Moralea Milne, in 2002. The work has largely been completed through the time of volunteers (3800 hours as of 2008; Milne 2008). The restoration project has been ongoing for 18 years and was started to manage the Scotch broom infestation in the Garry oak meadow and restore the native ecosystem there. The project was such a success at removing the scotch broom that the restoration efforts have expanded to include areas outside the meadow, covering most of the park. Recently, students from the RNS program at UVic developed a restoration plan to further the restoration work being doing in the park's meadow, in response to Ms. Milne's unfortunate passing in 2018, designating it a memorial meadow to honor Moralea's long-term dedication to the project (Catanzaro and Cotter 2020). The regular restoration work continues to be organized and completed by dedicated community volunteers.

Finally, Trafalgar Park, located within the District of Oak Bay, is notable due to the involvement of the local elementary school, Margaret Jenkins Elementary, in stewarding the park. The project was

developed as an environmental learning opportunity that got students out of the classroom and fostered local stewardship. The project was supported by Matt Fairbarns and Margaret Lidkea, but also included significant drive and enthusiasm from the parents, teachers, and administration at the school (pers. comm. 2020). In 2019, there were 26 classes of students from grades 3-5 helping to plant native species and remove invasive plants in the park. The school won a sustainability award as one of the top 10 "Eco-schools" in Canada because of the program (pers. comm. 2020). It is notable that other parks, including some in Esquimalt have significant contributions to restoration from local students, which can help build lasting stewards of these ecosystems.

The Garry oak ecosystem restoration projects in Canada have so many more associated stories that cannot be shared within the scope of this report. It is clear, however, that these ecosystems and their flora and fauna are cherished parts of the landscape. These ecosystems draw the focus and energy of many local practitioners and community members who will continue the ongoing work of restoring their beautiful biodiversity for future generations.

4. Opportunities in Garry Oak Ecosystem Restoration

Restoration projects in Garry oak ecosystems have several strengths: dedicated people, collaboration between many partners, and centralized knowledge. Across the projects we reviewed, it was clear that communities of land stewards will continue to push for the protection and restoration of these ecosystems and a passion for the ecosystem spurs many people to be involved in projects, either as a volunteer or through a paid position. Another prominent feature is the level of collaboration occurring during projects. Some sites are co-managed through complicated partnerships to address ecosystems spanning different land ownerships. Other sites, like urban parks, have parks staff, consultants, regular volunteers, not-for-profits, and researchers working together to conduct restoration projects. Finally, the Garry Oak Ecosystems Recovery Team has authored and curated dozens of documents aimed at a diverse audience involved in restoration, from practitioners to landowners. GOERT plays a critical role in collecting and sharing restoration knowledge for Garry oak ecosystems in Canada by providing a centralized resource.

Future opportunities include formalizing planning and monitoring, continuous knowledge capture, invasive species legislation, private gardens/projects, and creating more opportunities for cultural restoration. In addition, volunteer demographics regionally are dominated by retirees and older generations. Recruiting young volunteers can lead to longer persistence of projects and can re-energize ongoing work.

Few of the projects we reviewed had formal planning or ongoing monitoring efforts that were available. Formal restoration plans or follow-up reporting describing restoration activities and lessons learned were difficult to access, and it is unclear the degree to which they are unavailable versus non-existent. Those with written restoration planning tended to be student projects from the Restoration of Natural Systems Program at the University of Victoria and sites with high levels of species at risk. Additionally, many researchers in Garry oak ecosystem restoration were associated with government or other non-academic institutions, which increases the likelihood that research results would be maintained in unpublished internal reports. Clear restoration goals were available for 27 projects, with 20 of those completing some kind of monitoring, but written reporting of whether or not goals were being met were only available for 10 of those projects. Efforts should be made to ensure that both follow-up assessments of restoration outcomes and reporting of those impacts occur. Being unable to access information on

restoration outcomes makes it more challenging to learn from collective successes and failures, which is crucial to ensure future restoration is effective. Some of this work is already underway through the Cascadia Prairie Oak Partnership technical library. Regular updates to grey literature can be difficult to achieve in practice, in part because of time and funding limitations for practitioners and because of challenges to researchers accessing on-the-ground knowledge for synthesis.

Additionally, strong invasive species legislation that mobilizes resources for invasive species management may provide additional support to restoration in these ecosystems given that it is a major restoration activity. Landscape-level planning and coordination of invasive species efforts is a valuable tool, as well as pairing invasive species removal with other management activities. On its own, invasive species control may not lead directly to increases in native species cover or abundance (Shackelford et al 2019), and ecological benefits may be prevented by increasing cover of a different invader in response to the control efforts. Thus, management actions should focus on multiple strategies that clearly address well-articulated restoration goals.

Private gardens and other small-scale restoration projects can contribute to restoration at the landscape level. Private gardens were not included in the project map, but there is interest in native Garry oak meadow gardens throughout the range of Garry oak ecosystems in BC. A number of organizations including GOERT and Habitat Acquisition Trust have existing projects to develop knowledge and tools for native Garry oak ecosystem gardening. Given that much of the range covers dense urban areas that were previously meadows, continuing this work in home gardens may be an opportunity to expand Garry oak meadow restoration beyond park boundaries and into the city.

Finally, as culturally-derived ecosystems, it is appropriate to consider cultural restoration as a key part in restoring the ecological function of these ecosystems. For municipalities, building and fostering relationships with local First Nations would ensure opportunities are available to discuss cultural restoration within municipal sites, where much of the restoration is occurring.

5. Conclusion

For the last 30 years, Garry oak ecosystem conservation and restoration in Canada draws on the passion of concerned citizens and Garry oak ecosystem and restoration experts alike. Centralized knowledge-sharing and planning work through the Garry Oak Ecosystems Recovery Team has shaped and informed the restoration work being done across the landscape. Partnerships between community organizations, research teams, and government agencies strengthen the work being done. Dedicated volunteers provide long-term support to invasive species management, an inherently long-term commitment in this ecosystem, which supplements the funds available to work in Garry oak ecosystem. If these strong technical and community roots for Garry oak ecosystem restoration in Canada can be maintained and nourished, these ecosystems may yet have hope for recovery.

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Appendix 1: List of GOERT Collaborators (2006/07)

The Garry Oak Ecosystems Recovery Team 2006/2007 Annual Highlight report provided the following list of Garry oak ecosystem project supporters (this includes both restoration and conservation projects). The list has been grouped into similar organization types and simplified for presentation here:

Government		
Songhees First Nation	BC Gaming Commission	City of Colwood
Aboriginal Critical Habitat Protection Fund	BC Parks / Ministry of Water, Land and Air Protection / British Columbia Government	City of Courtenay
Canadian Coast Guard / Fisheries and Oceans Canada	Capital Regional District Parks (BC)	City of Langford
Canadian Development Services	Ministry of Environment / British Columbia Government	City of Nanaimo
Canadian Forest Service / Natural Resources Canada	Ministry of Forests / British Columbia Government	City of Victoria
Canadian Wildlife Federation	Ministry of Forests and Range / British Columbia Government	District of Central Saanich
Canadian Wildlife Service / Environment Canada (EC)		District of Highlands
CFB Esquimalt / Department of National Defense		District of North Cowichan
Department of National Defense		District of Oak Bay
Environment Canada (EC)		District of Saanich
Habitat Stewardship Program		Regional District of Nanaimo
Interdepartmental Recovery Fund		Saanich Community Matching Fund Program / District of Saanich
Pacific Forestry Centre / Canadian Forest Service / Natural Resources Canada		Town of View Royal
Parks Canada Agency		Township of Esquimalt
National Research Council Canada		
Natural Resources Canada		
WorkSource Wage Subsidy Program		

Community and Not-for-profit organizations		
Alberta Ecotrust Foundation Community Members / Volunteers (Time) District of Saanich Community Members / Volunteers (Time) Garry Oak Ecosystems Recovery Team Garry Oak Meadow Preservation Society Habitat Acquisition Trust Institute for Sustainability Education & Action Kaatza Foundation LifeCycles Project Society Nature Conservancy of Canada The Nature Conservancy in Washington Society for Organic Urban Land Care	Citizens Combating Ivy Growth and Spread Comox Valley Naturalists' Society Cowichan Valley Naturalists' Society Friends of Beacon Hill Park Society Friends of Brodick, Feltham and Bow Parks Nanoose Naturalists Swan Lake Christmas Hill Nature Sanctuary Tsolum River Restoration Society	Canadian Land Trust Alliance Comox Valley Land Trust/ Land Trust Alliance of British Columbia (LTABC) Cowichan Community Land Trust Society Galiano Conservancy Association Hornby Island Conservancy / LTABC Islands Trust Fund (BC) Nanaimo Area Land Trust Mayne Island Conservancy Association / LTABC Pender Islands Conservancy Association Salt Spring Island Conservancy The Land Conservancy of BC
Private enterprise, educational institutes, and neighbourhood associations		
Aruncus Consulting Individual Donor ($) Masselink Environmental Design Polster Environmental Services Ltd. Scotiabank Shell Canada Valley Environmental Windmill Development	Carleton University Gaia College Malaspina University-College Simon Fraser University Strawberry Vale School Trinity Western University University of British Columbia University of Guelph University of Victoria	Landowners Nanoose Property Owners and Residents Association Victoria Real Estate Board Victoria West Community Association

Appendix 2: Literature Search Methodology

Information was collected for this report in a number of ways: online searches for public reports, searches of available resources on the Garry Oak Ecosystems Recovery Team (GOERT) website and the Cascadia Prairie Oak Partnership (CPOP) website's Technical Library to identify specific restoration projects, e-mail communication with restoration practitioners to access unpublished grey literature, some unstructured phone conversations with practitioners (Ethics application #20-0425), and a brief academic literature search. A full, systematic review of the peer-reviewed literature was not conducted, as detailed information on restoration actions in these systems is often not published academically. This issue was identified in the 2011 GOERT restoration handbook as well (GOERT 2011). Grey literature on Garry oak ecosystem restoration was located to build a project database of Canadian restoration efforts.

First, the known range of GOE in Canada was used to identify the range within which to search for projects. Unstructured internet searches and the GOERT website were used to find preliminary information on ongoing projects and to identify people to contact for projects with limited or no readily available information. The GOERT website lists about 70 Garry oak ecosystem restoration projects, which provided a strong foundation for the database. Since it was unclear when the list was last updated, we also searched for projects from other sources. The initial unstructured searches were combined with existing information from the GOERT and CPOP websites. Then, an initial list of potential people and organizations conducting restoration was developed. The initial list included governments (federal, provincial, municipal/regional), community groups, and conservation organizations. By the end of the project 86 individuals from 74 groups/organizations had been contacted for information on Garry oak ecosystem restoration, and 54 individuals responded. Of those who replied, 27 were involved in restoration projects.

A search using the SCOPUS database was used to identify existing academic literature on Garry oak ecosystems in Canada to supplement the grey literature (either Canadian locations, or Canadian researchers involved with the project). Search terms are outlined in Appendix 3. The SCOPUS search returned 65 results, 58 of which met the criteria of research in Canadian Garry oak ecosystems or being conducted by Canadian researchers. It is worth noting that despite testing multiple search strings, at least 16 papers dealing with Garry oak ecosystems or restoration were missing from the SCOPUS search results. In total 74 papers relating to Garry oak ecosystem restoration and ecology were located from the SCOPUS search and other literature collected throughout the project. All relevant papers found during the project are listed in Appendix 3.

Appendix 3: Results from Academic Literature Search

Nov 30 2020 – SCOPUS Advanced Search: TITLE-ABS-KEY-AUTH ((Canada OR "British Columbia" OR "BC" OR "B.C.") AND ("garry oak" OR "quercus garryana"). Bolded papers were not captured by the SCOPUS search.

a) Restoration-/management-specific articles:

Clements, D. R. (2013). Translocation of rare plant species to restore Garry oak ecosystems in western Canada: Challenges and opportunities. *Botany, 91*(5), 283-291. doi:10.1139/cjb-2012-0269

Clements, D. R., Luginbill, S., Jordan, D. A., Dragt, R. V., & Pelant, R. K. (2011). Techniques to promote Garry oak seedling growth and survival in areas with high levels of herbivory and competition. *Northwest Science, 85*(2), 172-181. doi:10.3955/046.085.0208

Dennehy, C., Alverson, E.R., Anderson, H.E., Clements, D.R., Gilbert, E.R., & Kaye, T.N. (2011). Management strategies for invasive plants in Pacific Northwest prairies, savannas, and oak woodlands. *Northwest Sci. 85*, 329-351.

Frey, B., Kempler, C., & Ehret, D. L. (2007). Micro-propagation of white-top aster, *Sericocarpus rigidus*, a threatened species from the Garry oak ecosystem in British Columbia. *Canadian Field-Naturalist, 121*(1), 40-45. doi:10.22621/cfn.v121i1.391

Gomes, T. C. (2013). Novel ecosystems in the restoration of cultural landscapes of Tl'chés, West Chatham Island, British Columbia, Canada. *Ecological Processes*, *2*(1), 1–13. https://doi.org/10.1186/2192-1709-2-15

Gonzales, E. K., & Clements, D. R. (2010). Plant community biomass shifts in response to mowing and fencing in invaded oak meadows with non-native grasses and abundant ungulates. *Restoration Ecology, 18*(5), 753-761. doi:10.1111/j.1526-100X.2009.00535.x

Jones, T. G., Coops, N. C., & Sharma, T. (2011). Exploring the utility of hyperspectral imagery and LiDAR data for predicting *Quercus garryana* ecosystem distribution and aiding in habitat restoration. *Restoration Ecology, 19*(201), 245-256. doi:10.1111/j.1526-100X.2010.00684.x

MacDougall, A. S., & Turkington, R. (2007). Does the type of disturbance matter when restoring disturbance-dependent grasslands? *Restoration Ecology*, *15*(2), 263–272. https://doi.org/10.1111/j.1526-100X.2007.00209.x

MacDougall AS (2005) Response of diversity and invisibility to burning in a northern oak savanna. *Ecology 86*, 3354-3363.

Shackelford, N., Murray, S. M., Bennett, J. R., Lilley, P. L., Starzomski, B. M., & Standish, R. J. (2019). Ten years of pulling: Ecosystem recovery after long-term weed management in Garry oak savanna. *Conservation Science and Practice*, *1*(10), 1–11.

Ussery J.G. & Krannitz P.G. (1998) Control of Scot's broom (*Cytisus scoparius* (L.) Link.): the relative conservation merits of pulling versus cutting. *Northwest Science*, *72*, 268-273

b) Other Garry oak ecosystem articles:

Allen, G. B., Hebda, R. J., & Brown, K. J. (1999). Surface pollen spectra from southern Vancouver Island, British Columbia, Canada. *Canadian Journal of Botany, 77*(6), 786-799. doi:10.1139/b99-038

Arcese, P., & Rodewald, A. D. (2019). Predictors and consequences of earthworm invasion in a coastal archipelago. *Biological Invasions, 21*(5), 1833-1842. doi:10.1007/s10530-019-01942-w

Bennett, J. R., Vellend, M., Lilley, P. L., & Arcese, P. (2013). Abundance, rarity and invasion debt

among exotic species in a patchy ecosystem. *Biological Invasions, 15*(3), 707-716. doi:10.1007/s10530-012-0320-z

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Douglas, G. W., & Penny, J. L. (2004). Conservation evaluation of Howell's triteleia, *Triteleia howellii*, an endangered lily in Canada. *Canadian Field-Naturalist, 118*(2), 174. doi:10.22621/cfn.v118i2.906

Douglas, G.W. & Ryan, M. (1998). Status of the Yellow Montane Violet, *Viola praemorsa* ssp. *praemorsa* (Violaceae) in Canada. *Canadian Field-Naturalist, 112*(3), 491-495.

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Erickson, W. R. (2004). Bird communities of the Garry oak habitat in southwestern British Columbia. *Canadian Field-Naturalist, 118*(3), 376. doi:10.22621/cfn.v118i3.4

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