Exploring the use of controlled burning in the Nuts'a'maat Forage Forest

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Abstract

Borrowing from Traditional Ecological Knowledge (TEK) and western science, this paper examines how prescribed fire can be used to manage the Garry oak meadow of the Nuts'a'maat Forage Forest (NFF), located at the Galiano Conservancy Association's Millard Learning Centre. By analyzing methods of burning and the effects of fire on introduced species, we found that the NFF was a unique garden-ecosystem, and therefore its response to fire would be difficult to predict. Additional factors such as the size of the area intended to be burned and the proximity of other plants do not make this site suitable for prescribed burning; however, the reintroduction of prescribed fire remains an important factor in Indigenous cultural revitalization and sustainable TEK-informed landscape management. As such, we propose the creation of a larger camas-exclusive meadow elsewhere on the property. In order to select an appropriate site, we propose community mapping as a way to identify areas of cultural importance.

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Introduction

This report is presented on behalf of the 2023 Advanced Principles and Practices of Ecological Restoration field school taught by Dr. Eric Higgs of the University of Victoria, and in partnership with the Galiano Conservancy Association (GCA). The authors position themselves as mixed-European settlers living and learning on the unceded and asserted traditional territories of the W̱SÁNEĆ, lək̓ʷəŋən, Penelakut, Hwlitsum, Lelum Sar Augh Ta Naogh, and other Coast Salish First Nations, as well as the ceded traditional territory of the Tsawwassen First Nation. The authors further acknowledge that the contents of this project frequently reference research on First Nations and Traditional Ecological Knowledge (TEK) written and published by majority non-Indigenous academics, and therefore the disclosed information is what the authors know to be true. We recognized also that, "TEK as a body of knowledge, and as a process, philosophy, and practice is inseparable from its cultural context" (Kimmerer, 2018, p.50).

The aim of this report is to address current gaps of knowledge and challenges brought forward by the GCA including the logistics of controlled burning, plant composition in the current camas meadow beds in the Nuts'a'maat Forage Forest (NFF), ethical considerations regarding community engagement and public safety, and climate change. The aggregate research resulted in a proposal for a new camas meadow site for prescribed fire demonstration. It should be further clarified that "prescribed burning is distinct from cultural burning primarily in the burn objectives, techniques used to burn, and who is conducting the burning" (Hoffman et. al, 2021, p.4). Therefore, this project encompasses two main goals that are further subdivided into four objectives.

Goals

I. Provide background information relevant to implementing prescribed burning in a restored camas meadow ecosystem;
II. Create the opportunity for community learning and engagement in Indigenous cultural revitalization.

Objectives

I. Engage with local Traditional Ecological Knowledge (TEK) on prescribed burning;
II. Synthesize applicable historical and contemporary accounts of prescribed burning for future reference;
III. Survey and assess plant composition in the four existing camas meadow beds in the NFF and their responses to fire;
IV. Provide information on provincial and regional prescribed fire management policy.

The first objective encompasses the ethos of *nuts'a'maat*, a word in the local Hul'qumi'num language meaning "working together with one heart, one mind" (Galiano Conservancy Association, n.d.). The NFF has been a community engagement-centered project from its conception and it is the intention of the authors to support this vision through the research presented here. Active and ongoing inclusion of local First Nations communities as well as the Galiano North Fire Hall, GCA, stakeholders and other community members is essential to successful restoration planning and monitoring of prescribed fire on GCA property. This report provides a comprehensive overview of key cultural and ecological considerations that sets the foundation for planning prescribed burning in a restored camas meadow ecosystem.

1. Background

1.1 Garry Oak Ecosystems in Canada

Garry oak (*Quercus garryana; P'hwulhp*) are broadleaved deciduous trees native to the Coastal Douglas-Fir biogeoclimatic zone on the southeastern tip of Vancouver Island and the adjacent Gulf Islands (GOERT, 2023; Charlie & Turner, 2022; Pellatt et al., 2021). Thriving on rocky slopes and in open savannah lands, Garry oak habitat varies in elevations from near sea level to approximately 200m (GOERT, 2023; Pellatt et al., 2021, p. 2055). Garry oak ecosystems (GOE) host more diverse plant species than any other terrestrial ecosystem in B.C. and supply important resources for animals, insects, and humans alike (GOERT, 2023). Threats to GOE include anthropogenic-induced climate change, habitat fragmentation, degradation, and invasive species (GOERT, 2023; Pellatt et al., 2021).

Radiocarbon dating and pollen analysis trace the presence of Garry oaks on SE Vancouver Island back to approximately 8,300 years before present (BP) when climate conditions were warmer and drier (GOERT, 2023; Pellatt et al., 2021). Frequent natural disturbances during warmer climate trends, likely fire, maintained GOE succession and was emulated through anthropogenic practices as coastal climate conditions began cooling (Pellatt et al., 2021). Extensive oral and written history confirms the deliberate use of fire by coastal Indigenous peoples as a tool for managing GOE succession to aid in the acquisition of culturally important plant (i.e. Camas) and animal (i.e. deer) resources (GOERT, 2023; Charlie & Turner, 2022; Turner, 1999). The perpetuation of culturally prescribed burning correlates with the continuation of fire adapted GOE in coastal B.C.

1.2 History of Indigenous Fire Stewardship

Indigenous Fire Stewardship (IFS) is defined as "routinely applying controlled fire to adapt to changing environments while promoting desired landscapes, habitats, and species and supporting subsistence practices and livelihoods" (Hoffman et al., 2021, p.1). IFS has long been confirmed to be ecologically and culturally beneficial and cultural uses of fire as a land management tool are extensively recorded in ethnographic literature (Barlow & Pellatt & Kohfeld, 2021; Berkes & Pellatt & Gedalof, 2014; Davidson-Hunt, 2006; Hoffman et al., 2021; Charlie & Turner, 2021; Turner, 1999). Although valuable case studies of IFS exist globally from the Americas (e.g. swidden agriculture) to Australia, this section deliberately focuses on examples with direct application to the NFF.

Although a vast majority of the literature on IFS pertains to cases on southeastern Vancouver Island, cases of IFS were present across B.C. from coastal communities such as Kwakwaka'wakw (Southern Kwakiutl), Nuu-chah-nulth (Clayoquat), Nuxualk (Bella Coola), Haisla, and Haida to interior First Nations such as the Stl'atl'imx (Lillooet), Nlaka'pamux (Lytton), Secwepemc (Turner, 1999) and beyond to the Anishinaabe of Shoal Lake (Berkes & Davidson-Hunt, 2006). Still, this is not an exhaustive list of all First Nations that utilized prescribed burning in Canada.

Though IFS practices were not universal, intentional burns were generally applied on a landscape scale "to clear vegetation and enhance the growth of certain plant and animal species, as well as for various other purposes…" such as "driving off mosquitoes and other insect pests, eliminating unwanted snakes, driving game in hunting, obtaining edible insects, clearing campsites and village sites of brush, clearing trails, improving communication, improving visibility, offense and defense in war, protecting forests from crown fires, and creating future supplies of dry fuel wood…" (Turner, 1999, p.187). Among the many applications of prescribed fire, its use as a tool to enhance the growth of favorable native plant species for subsistence practices is commonly recorded in ethnographic literature.

Numerous scientific studies conducted in B.C. confirm the use of IFS specifically in Garry oak ecosystems (GOE) (Barlow & Pellatt & Kohfeld, 2021; Berkes & Pellatt & Gedalof, 2014; Davidson-Hunt, 2006; Hoffman et al., 2021; Charlie & Turner, 2021; Turner, 1999). Oral and historical accounts of Indigenous prescribed burning describe its efficacy in managing plant heterogeneity and the growth of favorable edible and medicinal species, such as the culturally important common camas (*Camassia quamash*) and great camas (*C. leichtlinii; speenhw*) (Charlie & Turner, 2022). Prescribed low-intensity fire effectively reduces tree canopy cover in savannah grass ecosystems, creating the open structure that camas meadows require to thrive (Pellatt & Gedalof, 2014; Berkes & Davidson-Hunt, 2006). Specialized and adaptive knowledge of timing, camas' response to fire, harvesting, and the influence of abiotic factors (season, wind, tide, etc.) on fire behavior exemplifies the deeply instilled nature of Traditional Ecological Knowledge (TEK) in place-based practices (see Appendix 1 for further details).

Quantitative data further supports the direct link between TEK and prescribed burning. The study of historical ecological, paleoecological and stand dynamics in GOE offers insight into important shifts in land management and subsequent outcomes for IFS and GOE ecology (Pellatt & Gedalof, 2014, p.2054). It is well documented that the persistence of the GOE savannah structure on southern Vancouver Island and the Gulf Islands corresponds with Indigenous management of forest ecosystem succession through prescribed burning (Barlow & Pellatt & Kohfeld, 2021; Pellatt & Gedalof, 2014; Charlie & Turner, 2022; Turner, 1999).

Beyond the history of IFS, the history of fire governance in B.C. also contains important insight into how fire management has adapted and changed over time. These alterations have led to the present state of provincial and federal fire policies, as well as GOE ecology. In addition to climate change, the Canadian government's suppression of IFS and imposed colonial "command and control" worldview is having lasting impacts, especially on Indigenous communities who are disproportionately affected by environmental catastrophes (Copes-Gerbitz & Hagerman & Daniels, 2022; Hoffman et al., 2021; Pellatt, 2014).

A comprehensive study by Copes-Gerbitz, Hagerman & Daniels in 2022 (Appendix 2) expands on the history of fire governance in B.C. In this context fire governance is defined as the "attributes that influence environmental outcomes, including organizations or individual actors, objectives, legislation, decision-making processes and power, and worldview" (Copes-Gerbitz, Hagerman & Daniels, 2022, p. 2). The report outlines "five fire governance eras based on periods of stability and key moments of change defined by broad scale shifts in the suite of governance attributes" (Copes-Gerbitz, Hagerman & Daniels, 2022, p.4) that are summarized and illustrated below (Figure 1).

The study concludes with three relevant insights for future fire governance: diversify community involvement by decentralizing Canadian governmental bodies, address systemic constraints that maintain the status quo, and recenter First Nations in adaptive fire management planning (Copes-Gerbitz, Hagerman & Daniels, 2022, p. 10). In other words, recentering Indigenous-led approaches to restoration and landscape management (i.e. prescribed fire) challenges the status quo by acknowledging worldviews contradictory to the dominant order.

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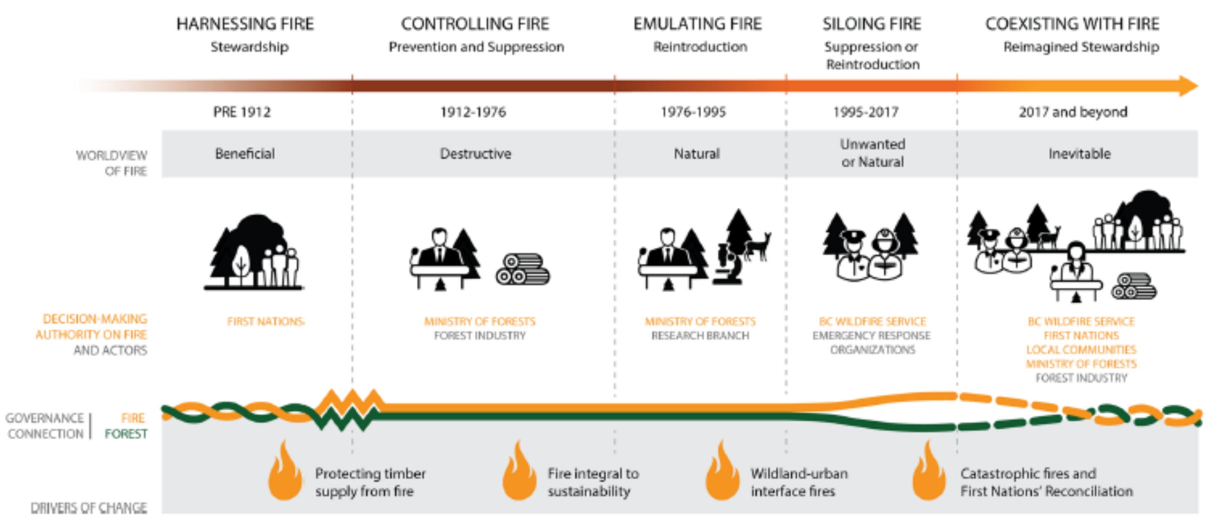


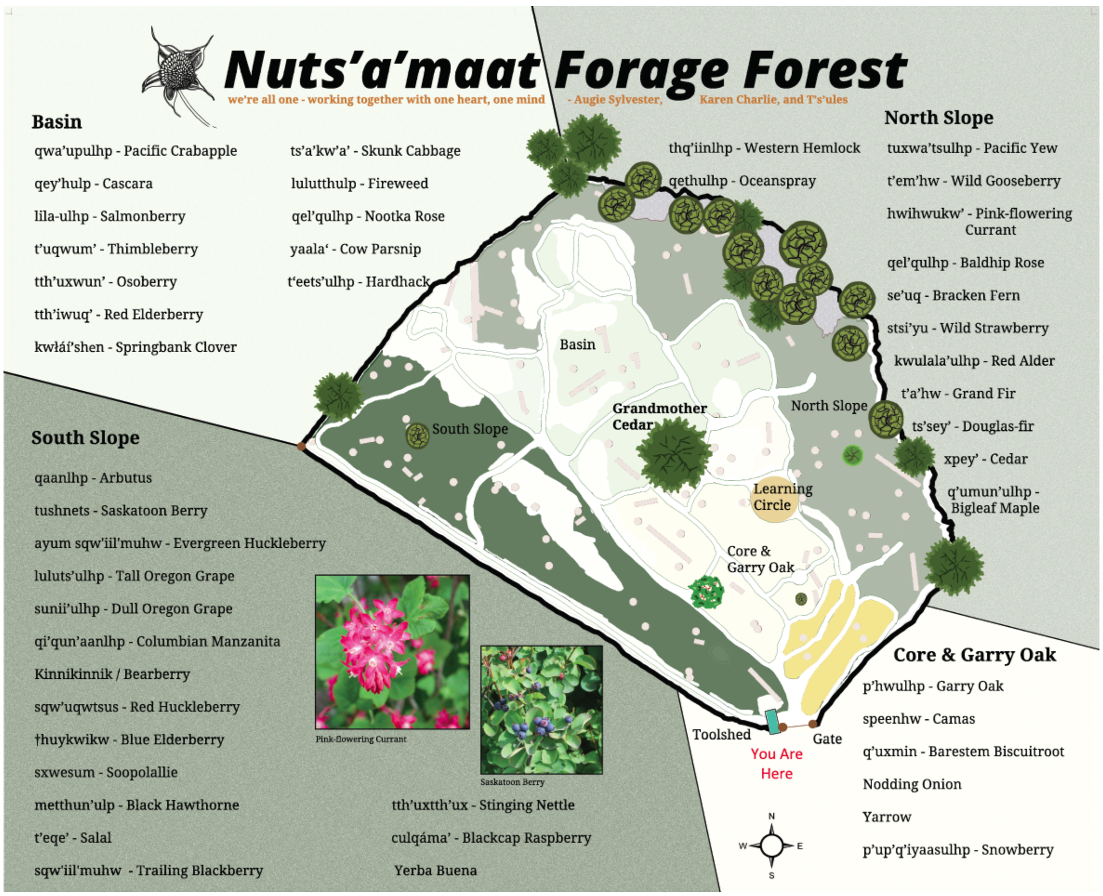
Fig. 3 Fire governance eras in British Columbia which were distinguished based on worldview of fire, actors with decision-making authority on fire, governance connections between fire and forestry, and key drivers of change between eras. Note the First Nations' decision-making authority and intertwined governance connection required for coexisting with fire in the *Coexisting with Fire* era

Figure 1. Fire governance in BC (Copes-Gerbitz & Hagerman & Daniels, 2022, p.5)

A closer look at historical eco-cultural relationships with fire reveals consequential shifts in worldviews and governance systems that correlate with the decline of IFS and fire-adapted ecosystems. Ample ethnographic and ecological studies on GOE support a shift towards reintegrating Indigenous fire stewardship. However, it is also necessary to examine potential limiting factors such as "risks associated with burning dead and dense fuels, the presence of highly flammable invasive species, laws prohibiting the cultural use of fire, and in some cases the loss of knowledge associated with cultural fire practices" (Hoffman et al., 2021, p.4). Beginning with a comprehensive overview of the Nuts'a'maat forage forest (NFF), the following sections aim to address some of the critical ecological and political considerations for reintroducing prescribed fire as a tool for landscape management in camas meadow ecosystems.

1.3 History of the Nuts'a'maat Forage Forest

The Nuts'a'maat Forage Forest (NFF) is a half-hectare native plant food forest and restoration site managed by the Galiano Conservancy Association (GCA) in collaboration with members of the Penelakut First Nation and the Galiano community. Home to more than fifty species of native edible and medicinal plants, the NFF functions as a "model forest, where native plant species traditionally used for food and medicine" are used to "restore a degraded area while also fostering a connection with the land and its people" (Boyd & Spencer, p. 3, 2018).



Map of the Nuts'a'maat Forage Forest (Galiano Conservancy Association)

Prior to intense human occupation, the NFF site was a western redcedar forest ecosystem, characteristic of the valley ecosystems of Galiano island that historically supported wetlands and wet cedar forests. The site was logged for several decades by its previous landowners, and by the time of its acquisition by the GCA in 2012, the site was bereft of trees except a large lone standing cedar which came to be known as the "grandmother cedar." Though the GCA had originally planned to establish a permaculture food forest on this site, soil acidity, exposure, and the standing cedar led the GCA to establish the food forest elsewhere (Huggins, 2017).

From its ideation onward, the NFF has been a community-focused project. Between 2015 and 2016, two University of Victoria student groups (Schiefelbein, Potts, Kathrens, 2015; Kucher, Drysdale, & Terris, 2016) created proposals for the design, implementation, and management of a native plant forage forest on the site. These proposals surveyed soil composition and vegetation, and designed the proposed forage forest, including educational and interactive elements. Concurrently, the CGA and Access to Media Education Society (AMES) facilitated projects and meetings with Penelakut First Nation community members and elders to share knowledge about traditional plants and provide feedback on the proposed forage forest (GCA "Nuts'a'maat Forage Forest").

In 2017, University of Victoria student (and now current CGA Restoration Coordinator) Adam Huggins created a restoration plan for the native plant forage forest that deepened this prior work and created a detailed design plan for its implementation. Early monitoring work was conducted by Sonia Voicescu, then a UVic co-op student and alumna of the Galiano field course. Restoration work began at the site at the end of 2017 with machinery work to decompact the soil, the removal of introduced species, consultation with and involvement of local Penelakut elders, and fencing to prevent aggressive deer browse (Huggins, 2017; Boyd & Spencer, 2018).

The southeast corner of the plot was chosen for a Garry oak meadow because of its drier microclimate. Though the site's original ecosystem was mixed cedar forest, Garry oak meadow ecosystems provide edible and medicinal plants, like *Camassia sp*., that are important to traditional Indigenous ways of life. These ecosystems are also critically endangered, with only a few small sites across the Pacific Northwest (GOERT, 2023). In this way, the NFF differs from traditional restoration in its departure from historical ecological fidelity and its focus on cultural connection and restoration, particularly of Indigenous peoples to their traditional food and medicine (Park 2018; Curran, 2013, in Kucher, Drysdale, & Terris, 2016; Higgs, 2013).

Restoration continued through 2018, with community and school volunteers working to remove introduced species and plant native species. Three local artists from Penelakut and Galiano were commissioned to create twin works of art throughout the NFF, symbolizing the collaborative nature of the forage forest.

The NFF's first community harvest was held in the winter of 2018, and May 2019 saw its first large-scale community harvest of yaala' (cow parsnip) shoots, nodding onion greens and bulbs, q'uxmin (biscuitroot) greens, and se'uq (bracken fern) fiddleheads. These were then prepared and served to a group of 70 leaders from across the Salish Sea at the Millard Learning Centre (GCA "Nuts'a'maat Forage Forest").

Photo: May 2019 community harvest (Galiano Conservancy Association, 2019)

Today, the NFF provides ingredients for teas and small medicinal products produced by the GCA. The GCA also hosts educational programs that invite school groups to learn how to grow, harvest, and use native plants. Its continued success–both as a restoration site, an agroforestry project, and a community and reconciliation-focused project–is measured annually using a monitoring framework developed between 2016 and 2018 by Master's student Hyeone Park (Park 2016; Park & Higgs, 2018). As the NFF grows and establishes, engagement is ongoing with local Penelakut families and the wider Galiano community to guide the future of the forage forest.

The NFF is open to the public year-round to be appreciated and harvested with care.

3. Current state of the Nuts'a'maat Forage Forest

One of the major catalysts for investigating the use of fire on the Garry oak meadow is the persistent weed pressure. Each year GCA staff and volunteers spend dozens of person-hours hand-weeding the beds to remove aggressive introduced grasses and forbs and to thin out aggressive native species like yarrow and trailing blackberry. Using fire to control existing weedy plants and destroy their remaining seed bank could save the GCA significant time and resources.

Though a monitoring system was established and has been implemented annually on the NFF since 2018, the Garry oak meadow portion has not been included in this monitoring (Boyd & Spencer, 2018; Huggins, personal communication, 2023). As such, the authors of this paper conducted a baseline vegetation assessment of the Garry oak meadow to assess how prescribed fire might affect these plant communities.

3.1 Vegetation Monitoring

To provide a baseline for our assessment of how fire might affect both desired and undesirable plant species in the beds, a vegetation assessment was conducted on July 13, 2023. The approximate length and width of each bed was measured and divided into quadrants. Percent cover of desired native plant species, bare soil, and stumps was recorded on diagrams corresponding to Huggins' diagrams of the beds and noted into a table of cover types (Table 1). For further details on vegetation monitoring methods and limitations, see Appendix 3.

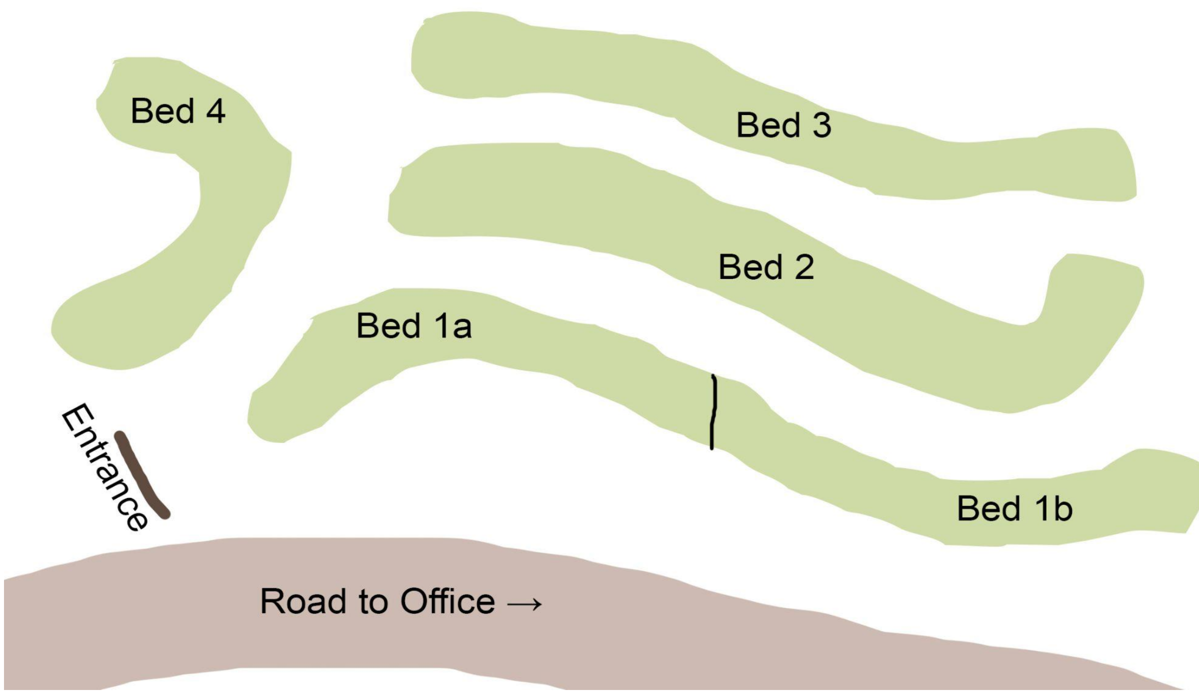


Figure 2. Bed layout of vegetation monitoring

Based on the vegetation monitoring conducted on July 13, 2023, each of the four Garry oak meadow beds varied significantly in native plant composition, undesirable plant pressure, and amount of bare soil (Figure 2; Table 1). In general, Bed 1 was the most diversely planted of all beds and most characteristic of a native Garry oak meadow; Beds 2 and 3 were similar in amount of bare soil and in their lower plant diversity; and Bed 4 had the unique characteristic of having only one species, *Epilobium densiflorum*, comprising the majority of its bed space; this species acted like a cover crop over dormant *Camassia*. Table 1, below, presents the detailed results of the vegetation monitoring.

Cover type		Percent cover of beds				
Species	**Common and (Hul'qumi'num) names**	**1a**	**1b**	**2**	**3**	**4**
Achillea millefolium	Yarrow	35	0	15	3	0
Allium cernuum	Nodding onion	15	0	10	15	0
Anaphalis margaritacea	Pearly everlasting	1	0	10	20	0
Aquilegia formosa	Red columbine	1	0	0	0	0
**Arctostaphylos uva-ursi*	Kinnikinnick (Tl'ikw'íyelhp)	0	0	0	0	3
**Arctostaphylos columbiana*	Hairy manzanita	0	0	0	0	10
Camassia leichtlinii / quamash	Great / common camas (Speenhw)	5	0	5	1	0
Clarkia amoena	Farewell-to-spring	1	0	0	0	0
Dodecatheon spp.	Shooting star	1	0	0	1	0
Epilobium densiflorum	Denseflower willowherb	0	0	0	0	65
Festuca roemeri	Roemer's fescue	1	0	3	2	3
**Gautheria shallon*	Salal (T'eqe')	1	70	0	20	0
Lomatium nudicaule	Barestem desert-parsley (Q'uxmin)	5	0	15	6	0
Lomatium utriculatum	Spring gold	2	0	2	2	0
Plectritis congesta	Sea blush	1	0	0	1	0
Quercus garryana	Garry oak (P'hwulhp)	0	5	0	0	0
**Rubus ursinus*	Trailing blackberry (Sqw'iil'muhw)	1	90	1	20	0
Sisyrinchium idahoense	Idaho blue-eyed grass	10	0	10	2	0
Symphoricarpos albus	Snowberry	0	1	0	0	3
Triteleia hyacinthina	Fool's onion	2	0	0	0	0
Bare soil		25	5	50	65	20
Stump		5	5	10	15	0

Table 1: Vegetation monitoring results.

3.2 Discussion

Bed 1a & 1b

Length: 25m

Width: 1.5m

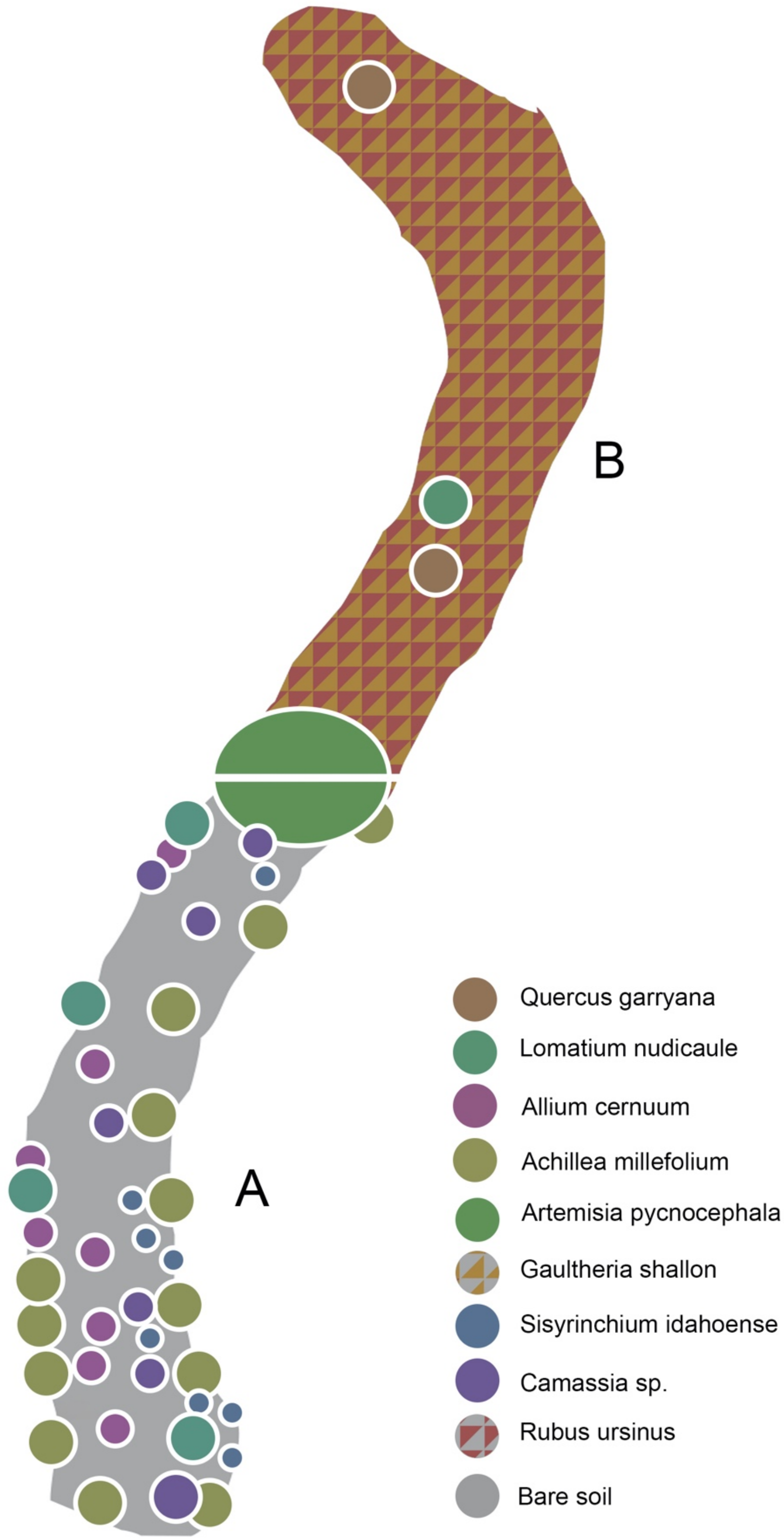
Major characteristics: Most plant diversity; dominated by *Achillea millefolium*; split lengthwise into two distinct floral communities.

Bed 1a contains by far the highest plant diversity of the four beds, with over fifteen native species and a relatively low percentage (20%) of bare soil. These plant species are almost all characteristic of Garry oak meadows. At the time of the survey, roughly 12 *Camassia* seed-heads were counted; other primary native species included *Allium cernuum* (15%) and *Sisyrinchium idahoense* (10%).

Though personal correspondence with Huggins indicated that *Achillea millifolium* (25%) had been transplanted from the middle of the bed to its edges to prevent it from overwhelming other native plantings, at the time of the survey it dominated the plot and would benefit from being thinned.

Bed 1b was characteristic of primary succession of the former *Thuja plicata* ecosystem, with dense *Gautheria shallon* covered by *Rubus ursinus*. Within this dense understory vegetation were two planted *Quercus garryana* saplings and a small *Symphoricarpos albus*.

Based on these results, Bed 1b is not a candidate for controlled burning, as its plant communities of *Gaultheria shallon* and *Rubus ursinus* are not the desired target species for the Garry oak meadow. These plants are both dense and



relatively fire-resistant, and tend to resprout well after fire (Fonda & Binney, 2011). Because increasing the cover of these species is not desired, burning would not have the intended effects of increasing Garry oak meadow plants.

Bed 1a is also unlikely to benefit from fire; though the planted species are characteristic of Garry oak meadows and likely co-evolved with fire, the plantings are extremely dense. These other native plants differ significantly from *Camassia.* Most are not graminoids (ie. they do not store their energy in bulbs, roots, or tubers), and have differing phenology (ie. they mature and flower at different times of the year), life cycles (ex. perennial or annual), and seed bank longevity (Mackinnon, 2014; Radosevich, Holt, & Ghers, 2007). This means that the traditional technique of burning Garry oak meadows when *Camassia* are dormant might kill other native forbs, or might not effectively target undesired introduced species. In native Garry oak meadows, *Camassia* are generally interspersed with native bunchgrasses, which provide fuel for fire, and only sparsely with other native forbs (Dunster, 2009).

Burning in Bed 1a would also not likely address the issue of overabundant *Achillea millifolium* or *Rubus ursinus*, as they tend to resprout well after fire (Aleksoff, 1999).

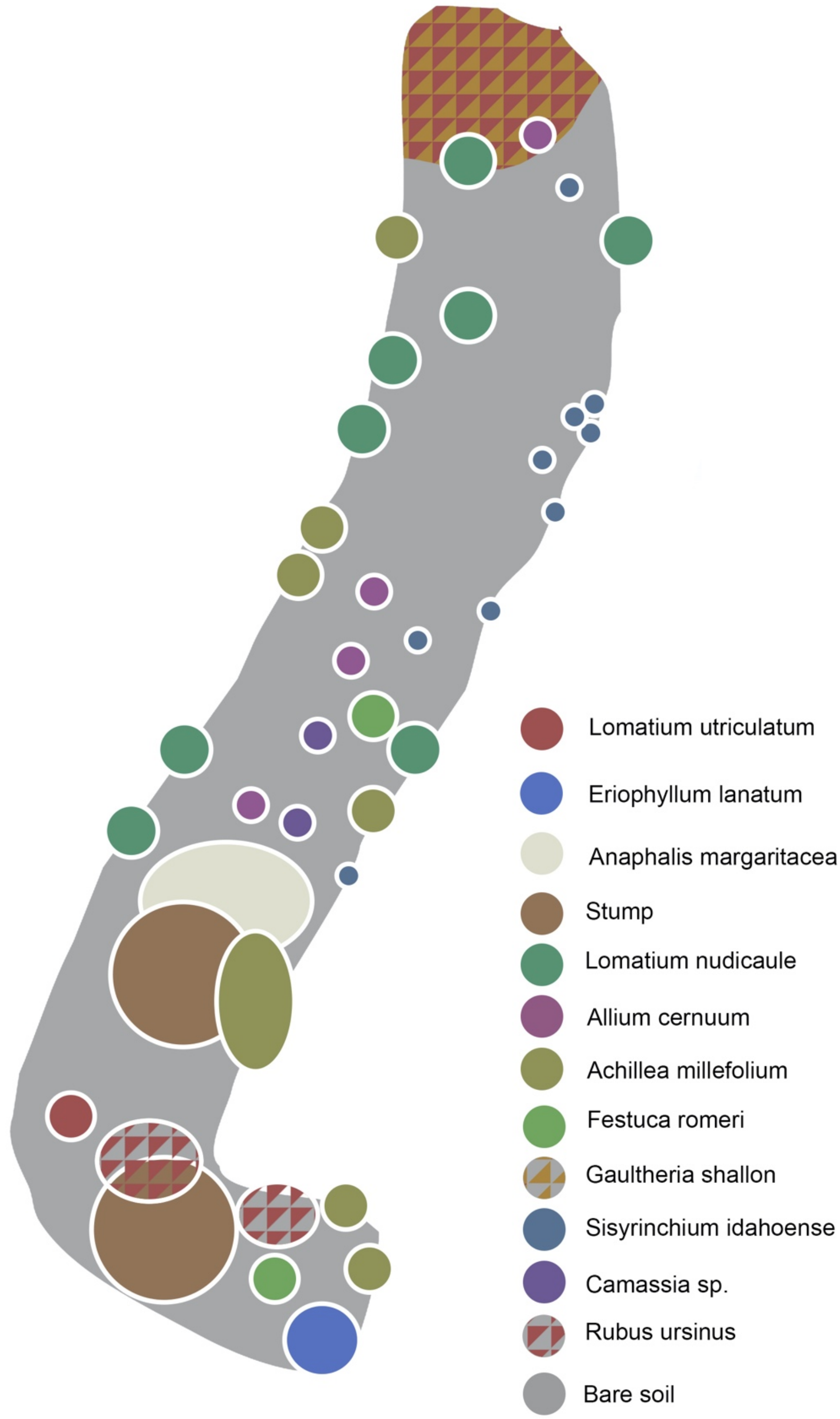
Bed 2

Length: 20m

Width: 1.5m

Major characteristics: Majority bare soil with a dominance of *Achillea millefolium* and some *Anaphalis margaritacea*; good health of *Lomatium nudicaule.* Two large stumps in bed.

Though bare soil accounted for roughly half the bed, plantings of healthy native species were dispersed evenly across the bed, with many individuals of *Lomatium nudicaule (15%), Allium cernuum (10%)*, and *Sisyrinchium idahoense (10%),* as well as a large patch of *Anaphalis margaritacea (10%)* and several patches of *Achillea millefolium (15%).*



Bed 3

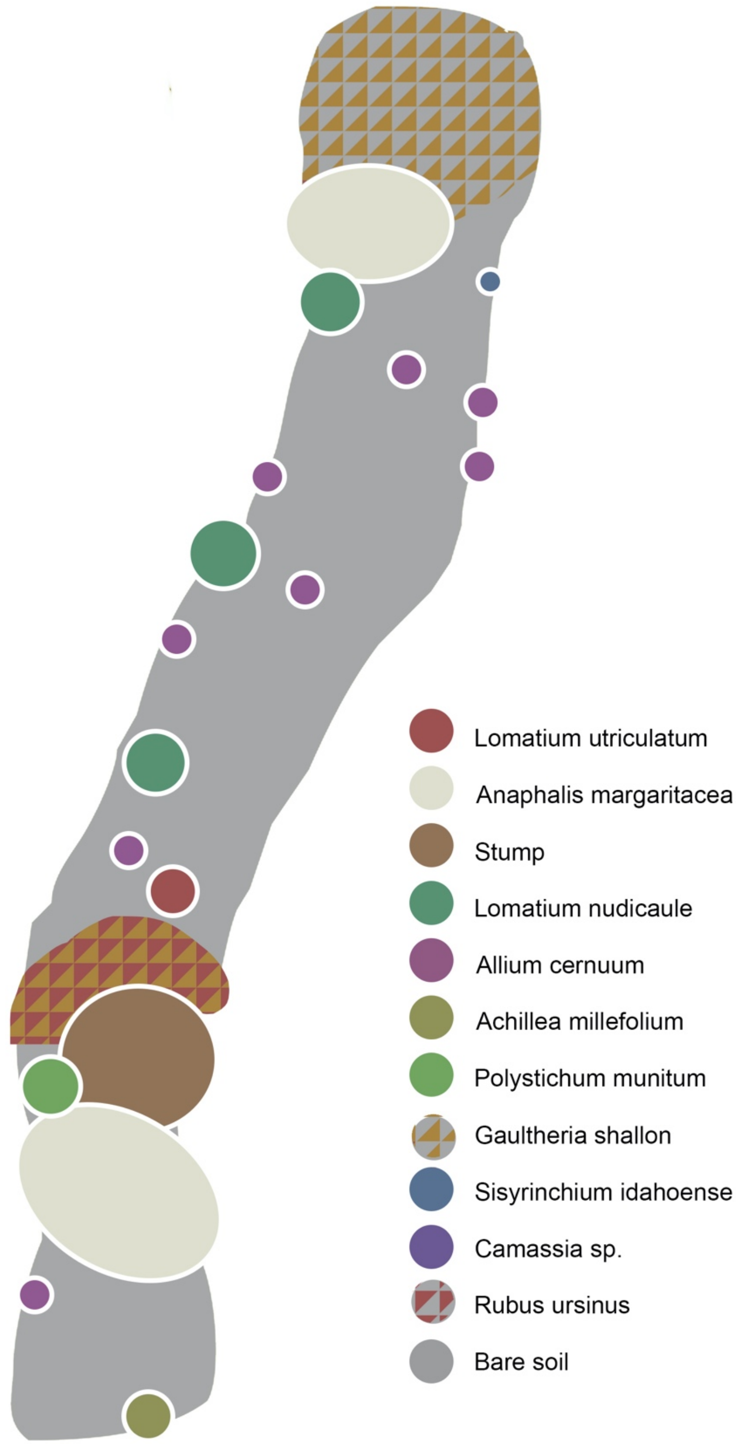
Length: 16m

Width: 1.5m

Major characteristics: Majority bare soil with a dominance of *Anaphalis margaritacea*; stump in middle of bed growing with thick *Gaultheria shallon* and *Rubus ursinus*.

Bare soil accounted for over half the bed (65%). As with Bed 2, plantings of healthy native species were dispersed evenly throughout, with many individuals of *Allium cernuum (15%)*, and *under 10% each of Lomatium nudicaule and Sisyrinchium idahoense.* A large patch of *Anaphalis margaritacea (15%) occupied the first quadrant of the bed*, and the second and third quadrants were dominated by a stump growing heavily with overlapping *Rubus ursinus* (20%) and *Gaultheria shallon* (20%).

As Beds 2 and 3 both have similar and relatively simple vegetation composition and a majority (>50%) of bare soil, these beds could potentially be used as a control and test plot, respectively, for a controlled burn. The beds are currently mulched with dry fern fronds, which would carry a flame well if the thatch layer was increased. However, both beds are affected by the relatively fire-resistant *Gaultheria shallon* and *Rubus ursinus,* and obstructed by large stumps. They also both have a relatively low abundance of *Camassia*, and diverse native forb species that may not respond positively to fire.



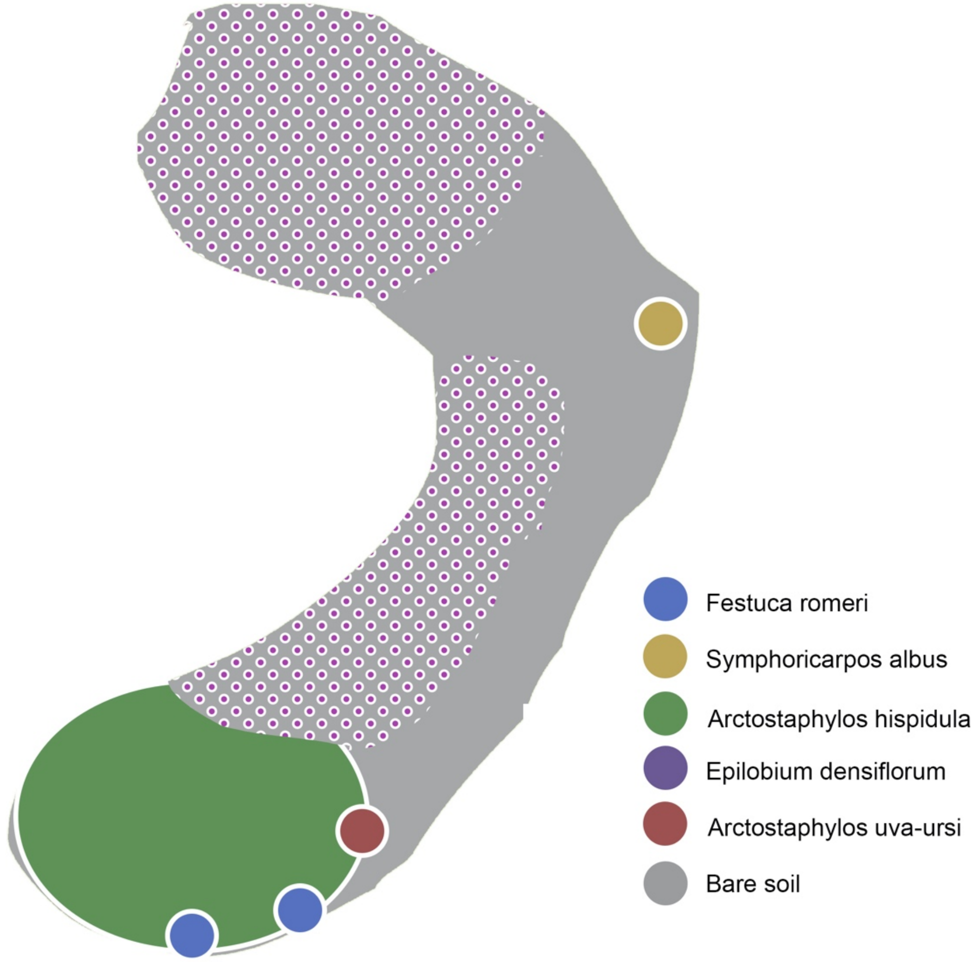
For a prescribed burn to be successful, these beds would likely need to be cleared of fire-resistant or obstructive material to better carry a flame. They would also benefit from a denser planting of *Camassia* and possibly other phenologically similar or annual Garry oak meadow plants that would take up the bare soil, out-compete introduced weeds, and provide more fuel for future burns. As they currently exist, they do not seem like ideal candidates for a prescribed burn.

Bed 4

Length: 6m

Width: 4m

Major characteristics: *Epilobium densiflorum* “cover crop” over *Camassia* bed; *Arctostaphylos Columbiana* near the entrance.



Bed 4 has a much simpler plant community; its central area comprises only *Epilobium densiflorum* (an endangered and red-listed species under the *Species at Risk Act*) at the time of the survey (65%), and would comprise *Camassia* earlier in the season. A small section of this area was burned using a flame weeder by Huggins earlier in 2023 at the suggestion of local Penelakut elders, before the *Epilobium densiflorum* emerged.

Personal correspondence from Huggins revealed the challenge of burning safely around small *Camassia* plants in the spring, which were easily charred by the flame weeder. Though this bed is much simpler in plant composition than the other beds, which would make the timing of a burn easier, the presence of this red-listed species, the bed’s relatively small size, and the proximity of the fire-adapted but rare *Arctostaphylos Columbiana* to the *Camassia* introduce more potential risks and fewer benefits to burning on this bed.

4. Planning for Prescribed Fire

4.1 Contemporary use of prescribed fire for introduced species management

The use of fire as a weed-management tool has been studied within the Western scientific paradigm for decades in two different contexts: agriculture and native ecosystems.

The majority of this research originates from the study of agriculture, specifically brush management and crop systems, where it is used effectively for removing vegetation, suppressing pathogens, and removing weeds (Radosevich, Holt, & Ghers, 2007).

Though more recent, studies on controlled burning in fire-adapted ecosystems have also shown that fire can be used in natural ecosystems to exhaust seed banks, destroy undesired mature plants, and encourage regrowth; however, these effects are much less predictable in complex natural ecosystems (Radosevich, Holt, & Ghers, 2007; Ditomassio et al., 2006). In both agricultural and native systems, fire often causes "flushes of germination," as many introduced plant species depend on disturbance to germinate; further, fire can damage natural systems when used improperly, or when the system's natural composition has been too altered by introduced species to respond as it would have in a pre-disturbed state (Radosevich, Holt & Ghers, 2007).

It is important to note that the NFF Garry oak meadow is a unique garden-ecosystem that likely has no precedent (Huggins, 2017). It is neither a natural ecosystem, nor agriculture, nor a garden, but a fusion of all three. As such, how it responds to fire is unknown; nevertheless, prior research can provide insights on the responses of both weed plant communities and desired plant communities of a similar nature to those in the Garry oak meadow of the NFF.

Ditomassio et al. (2006) provide an interesting comparison between agricultural and "wildland" use of fire. Their table is interpreted below, with an additional fourth column added by the authors of this paper to describe the Garry oak meadow of the NFF.

	Croplands	**Wildlands**	**NFF GoE**
Timing of fires	Preplant or postharvest	Varies with target species and ecosystem	Spring or autumn; varies with *Camassia* timing and fire risk
Fire types	Surface fire	Surface or crown fire	Surface fire
Integrated treatments	Chemical or mechanical weed-removal; cover-cropping	Chemical or mechanical treatments; revelation	Mechanical weed-removal; manual repainting and reseeding as needed
Targeted invasives	Typically herbaceous	Varies: grasses, forbs, shrubs, trees	Grasses and forbs
Ecological complexity	Low	High	Moderate

Table 2: Comparison of prescribed fire on different systems

A further important consideration to note is the history of the site. In “wildlands” or natural restoration sites, a native seed bank has often had thousands of years to establish. Further, sites are often surrounded by desired native plants in adjacent sites that can spread into the site through seeds or vegetatively. This means that native species will naturally colonize the site after a fire. In annual crop agricultural settings, the seed bank is largely undesired species. As the desired plants are removed and replanted seasonally, it is possible to burn the site aggressively without destroying the native seed bank or mature desired plants.

In the Garry oak meadow of the NFF, however, neither of these situations is the case. Its native seed bank is that of the former *Thuja plicata* ecosystem, in addition to introduced species that colonized the site after settler occupation over the last several decades, and a small seed bank from the native plantings established five years prior. Additionally, none of the desired species of the Garry oak meadow exist adjacent to it to recolonize the site. It also cannot be burned like an agricultural system, because it contains multiple perennials with varying phenologies that would be damaged by fire.

Despite these differences, the desired and undesired plant communities in the Garry oak meadow garden are likely to respond in predictable ways based on their morphology and evolutionary history.

DiTomassio et al.’s (2006) review provides a synthesis of plant communities’ responses to fire, and how best to apply fire for their management.

For all communities, burning should occur when the seeds of undesired species are still in the inflorescence and the desired species’ seeds have either been collected or have fallen to the soil, where they will experience less heat. The more effective phenological timing for destroying undesired seeds is before the seeds have cured and become viable, or before they have dispersed. As most species recover by the second or third year, it often takes several years of repeat burning depending on the longevity of the seed bank. For perennial and asexually reproducing plants, fire must be hot enough to prevent resprouting and deplete the seed bank.

Seed bank longevity is also a strong determinant in how introduced species respond to fire, and is strongly related to seed size, shape, and depth of distribution; smaller and more deeply buried seeds persist while larger, shallow seeds have a higher mortality rate (Radosevich, Holt, & Ghers, 2007). However, habitats where soil layers are deeply disturbed (as from tilling) are an exception to this rule.

With this information, it could be helpful in the future for the GCA to combine its current phenological calendar for its native NFF species with the phenology of its introduced species to determine the most effective and least damaging times of year to burn.

Below is a table (Table 3) of the responses of different plant communities to fire and protocol recommendations for controlling species with fire, summarized and interpreted from DiTomassio et al. (2006).

	Phenology	Timing	Frequency	Comments
Annual grasses	Kills seeds before they become viable or disperse	Early summer or spring; summer too dry (fire moves too quickly)	-	Because of their dependence of naimal dispersal, the seeds remain on the inflorescence longer than on desirable grasses
Annual forbs	-	-	Requires several years of burning	Most effective on late-season annual forbs; winter burning difficult because fuel hasn't accumulated
Biennials	Second-year plants that have bolted are susceptible but not 1st year plants	Later in spring before plants have set seed	At least two years in a row	More intense fires are more effective; damp thatch is ineffective
Perennial grasses	When tillers are elongated on target species but natives still dormant	Mid to late spring for Poa and late spring to summer for bromes	Biannually over several years	Requires heavy thatch layer
Perennial forbs	Species dependent	Timing might be critical: ex, Canada thistle controlled in May-June but earlier and later increased infestation	-	Fire usually promotes, not controls, perennial forbs. Unsuccessful against leafy spurge, dalmatian toadflax, sulfur cinquefoil, spotted knapweed
Woody species	Most species are hard to control with fire and resprout well.			

Table 3. Controlling introduced species with controlled burns (interpreted from DiTomassio et al., 2016).

4.2 Site design planning

There are many factors to consider in order to integrate fire into a site. First, it is important to understand fire behaviour and how it might move over a given landscape. Fire behaviour is influenced by three key factors: fuel, weather, and topography (Province of British Columbia, 2005). Fuel moisture, spacing, and loading will affect the intensity of a fire. For instance, fuel which is dry and abundant will be conducive to a much higher intensity fire than a sparser load of moist fuel (Province of British Columbia, 2005).

In the context of Nuts'a'maat, the proposed burn area is open, and does not contain a heavy fuel load. There is, however, forest surrounding the forage forest. Weather will have a greater impact on NFF. Therefore, wind, precipitation, relative humidity, and temperature must be taken into consideration when a prescribed burn is being planned. By looking at the topography of a site, one must consider slope, aspect, and elevation (Province of British Columbia, 2005). Fire moves upslope, and will move faster when there is little space in between the crowns of trees. This means that on steeper slopes, there is less distance between crowns as they make their way uphill and, as a result, less spacing that would act as a fire break. The area upslope of the Nuts'a'maat forage forest is characterized by forest which is drier uphill of the adjacent logging road. While this road would act as a good fire break, this drier section of forest could potentially burn if fire were to jump the road.

A good understanding of fire behaviour is crucial when designing for fire mitigation. In the context of climate change, permaculture design takes into account this behaviour and plans to include fire-resistant elements. For instance, Andrew Millison proposes the strategic use of permaculture zones when planning to mitigate fire: "Permaculture designed sites that use the concentric zone model have an advantage because the critical infrastructure is clustered in the inner zones that are the center of human activity" (2019, n.p.)

Millison explains the importance of a fire break situated between the likely direction of a fire and the important infrastructure of a site. For instance, roads, irrigated gardens and orchards, concrete slabs, wetlands, and ponds can act as fire breaks (Millison, 2019). Nuts'a'maat is surrounded by a few different types of fire break, including roads and wetlands. While the objective of this permaculture design is to have important infrastructure nested within layers of fire-resistant elements, it could also be used to contain fire within a protected perimeter. An added layer of firebreak within the boundaries of the forage forest would add additional "defensible space" to the site (Millison, 2019, n.p.) An irrigation system could be installed around the perimeter of the proposed burn site, or a physical break consisting of mineral soil around the site could be made. These precautions would make it much more difficult for fire to move out of the desired area.

In addition to the use of fire breaks, water storage structures are an important consideration. Fire suppression ponds are an example of an element which can be integrated into a site which can aid in mitigating fire (Millison, 2019) Such a pond would have to be full during the dry season, and if the topography of the site allows for it, should be located above the fire sector. The use of a manual valve to flood the site or of a gravity fed sprinkler system are ideal, according to Millison, as these can be used without having to be connected to a power grid. Finally, the incorporation of roads and turn-around areas are important, as they make the site accessible to fire trucks (Millison, 2019,) The proximity of Nuts'a'maat to the main road allows for emergency response vehicles to access the site with little difficulty.

4.3 Safety measures

Once the site has been prepared for a prescribed burn, there are many regulations which must be adhered to in order to ensure that the fire remains contained and to prepare an appropriate response should fire suppression become necessary.

The BC Wildfire Service *Standard Operating Procedure for Prescribed Fire* lists a series of pre-burn site preparation activities. These include: the construction of fire breaks, contacting all agencies and individuals that have values within or adjacent to the burn area, notifying the public, and obtaining a valid burn registration number (BC Wildfire Service, 2018).

In the case of the Nuts'a'maat Forage Forest, a potential controlled burn would be on a very small scale, and would be contained on private land. However, despite the small scale of the burn, it would still be considered an open fire as defined by the BC *Wildfire Act* (BC Wildfire Service, 2018). Therefore, the use of fire would have to be in accordance with these regulations. These requirements include the preparation of a "Burn Plan", which would need to be approved by an Official (BC Wildfire Service, 2018). On the day of a burn, firefighting equipment and sufficient water would need to be on site, as well as an individual responsible for managing the fire. Furthermore, post-burn requirements include monitoring the site to ensure that the fire does not escape the designated burn area (BC Wildfire Service, 2018).

Once a Burn Plan has been approved and all other preparations have been made, weather is a factor which will determine when the burn can take place. Appropriate weather conditions would be outlined in a Burn Plan and would need to be met before going forward with the prescribed burn (BC Wildfire Service, 2018). This limits the burn to a short time frame, which would most likely be in the fall. When outlining their approach to burn programs, York et al. examine the most feasible time to perform a prescribed burn. According to them, this would be in the fall, ideally following precipitation (York et al., 2021). This would ensure a more controlled burn.

While this is the safest option, especially in the context of hotter, dryer, and more unpredictable weather conditions, the authors state that this is not their ideal scenario. In fact, their preferred strategy would be "an initial entry burn during dry conditions, followed by repeat burns under slightly wetter conditions" (York et al., 2021, p. 106). This initial burn would be more intense, thus greatly reducing the fuel load. However, in the context of Nuts'a'maat, which is not heavily forested and does not contain a heavy fuel load, burning in wetter conditions would be appropriate.

In addition to the time of year during which a prescribed burn can be undertaken, frequency of burning should be considered for the purposes of long-term management. According to York et al., this can be determined in different ways. Firstly, range of natural variability (RNV) can be used to determine a maximum range of fire-return interval (York et al., 2021). This approach involves paleoecological investigations which would look for evidence of fire over a span of time. This approach is helpful, as it uses historical context to better understand a given ecosystem and its interactions with fire. However, the land on which Nuts'a'maat is situated was not historically a camas meadow and therefore past data might not be suitable in this situation. Another possible approach is fuel and fire hazard monitoring, which involves the close monitoring of fuels based on set management targets (York et al. 2021). This is a more feasible approach, given the context of the site, and would allow for adaptive management.

It is important to note that these measures may not be necessary if the fire is very small. In this case, supervision from the local fire department might be sufficient. However, such a small fire would not be effective for managing introduced species.

4.4 Revitalizing Indigenous fire stewardship: walking with community

In present-day Canada, the topic of fire has become increasingly sensitive due to the devastating effects of megafires sweeping across the country. Current data published June 29, 2023 by *The Guardian* reveals "the area burned by Canadian wildfires this year is 11 times the average for the same period over previous years" (Cannon & Cecco, 2023). Learning to coexist with fire in the midst of rapid climate change and intensifying megafires across B.C. requires a collective, communal approach to adaptive management.

Surmounting evidence within the literature resonates the need to revitalize TEK in GOE management. Implementing co-management frameworks that incorporate IFS in GOE restoration planning and management can empower local First Nations so long as respectful relations are maintained throughout the process (Berkes & Davidson-Hunt, 2006; Hoffman et al., 2021; Turner, 1999). Work by Higgs et al. (2014) on the role of history in future restoration introduces the concept of "Restoration v2.0" that includes redressing historical cultural damages within the pragmatic goals of restoration planning. This work provides a beneficial perspective that influenced one of the main goals of this project; to create opportunities for community learning and Indigenous cultural revitalization.

As a group of settlers conducting this research, it was critical to understand the historical and ongoing role that colonization has in the suppression of fire and IFS. Although this topic was touched on in section 1.2, it is worth reemphasizing here. Specifically, the disruption and loss of TEK due to the residential school, child welfare, and other systems of cultural oppression in Canada. Colonial systems of oppression forcibly Indigenous separated families, violently oppressing Indigenous ways of knowing and being that continues to impact Indigenous communities today (Corntassel & Bryce, 2012; Hoffman et al. 2021).

These impacts are necessary considerations when engaging with local First Nations and TEK in future planning for camas meadow restoration and prescribed burn planning. Ethical measures should be taken as not to appropriate TEK for settler gain and perpetuate harm against First Nations. One way this is exemplified is by "walking with community" (A. Huggins, personal communication, June 2023), a methodology that involves working respectfully and collaboratively with First Nations while accommodating community capacity, in other words, meeting people where they are at. This methodology is in accordance with ongoing relationship frameworks between GCA, Penelakut, and other stakeholders.

5. Proposal

Although this project began as an exploration of the use of fire within the NFF, it quickly became clear that this was not the best location to experiment with prescribed burns. First of all, the small and narrow beds are not conducive to the intensity of fire necessary to obtain the intended result of invasive species management. Secondly, this site's seedbank is that of a *Thuja plicata* ecosystem, with the addition of introduced species. Therefore, small-scale burns contained within the designated camas beds would not be effective.

In order to obtain the best results, we propose a new site location, which would provide better conditions for burning. A larger burn area would allow for more aggressive burning, followed by reseeding of desired species. In addition, control plots could be integrated in the site design in order to gather valuable data.

The exact location of this site depends on several factors. One consideration is community engagement and the use of community mapping to select a relevant site. Other physical factors to consider are the proximity to infrastructure, as well as access to roads and water. We suggest a design based on Andrew Millison's strategic use of permaculture zones (Millison, 2019). By nesting the camas meadow in between fire breaks, the GCA would reduce the risk of fire spreading.

Ideal site characteristics include:

I. A distance of at least 500 metres from infrastructure such as residences or businesses (*Environmental Management Act,* 2022).
II. Proximity to a logging road which would allow access to the site, while also serving as a fire break (Millison, 2019).
III. Access to water, for instance, a pond, which would be used for fire suppression (Millison, 2019; BC Wildfire Service, 2018).
IV. A relatively open area which would be conducive to the growth of *camassia*, and with a minimal fuel load.

In the spirit of "walking with community" we suggest that the GCA hold a community mapping event for Penelakut and other local First Nations to assist in choosing a suitable site for a new camas meadow. Community mapping broadens the scope for how landscape features are evaluated and subsequently utilized by different communities. In the context of engaging with First Nations, community mapping can help identify areas of cultural significance in which a restoration project would maximize benefit for the community. Author Wraspir consulted with the UVic Students of Geography Society (SOGS) Co-Chair on best practices to avoid extractivism (i.e. extracting TEK from its cultural context for personal gain). Their suggestions were as follows (S. Barratt, personal communication, July 23, 2023):

I. Host a community potluck at the GCA for Penelakut and other local First Nations to come discuss the proposal of a camas meadow restoration site. Offering food as an expression of gratitude as well as a conduit for conversation (e.g. sharing food and knowledge).
II. Define a clear intention for the map (e.g. to choose a camas meadow restoration site that community members can easily access/steward).
III. Instigate storytelling by creating an interactive element. For example, create cards with prompts about camas.

IV. Provide some guiding questions: What draws you to this place? What place do you feel is most impactful or significant and why? Do you remember camas here? Etc.

V. Ask how the community would like the information to be given back. Oftentimes, First Nations are given a visual representation of the knowledge they shared (e.g. a map with culturally significant locations and Indigenous place names) as a way of returning their contributions. However, different community values dictate what would be considered a valuable contribution in return for time and knowledge given.

Conclusion

Our goals in undertaking this project were twofold. First, we wanted to gather information on prescribed burning in order to explore whether this method could be implemented in the GCA's Nuts'a'maat Forage Forest (NFF). Our second goal was to create the opportunity for community learning and engagement in Indigenous cultural revitalization. This was done by learning from Traditional Ecological Knowledge (TEK) on prescribed burning.

Place-based TEK practices inform Indigenous Fire Stewardship (IFS) and adaptive strategies for climate change. The decline in IFS in coastal B.C. coincides with the onset of colonialism and subsequent encroachment of species maladapted to fire. Over a century of fire suppression has not only negatively impacted some of coastal B.C.'s most endangered ecology (i.e. camas meadow ecosystems), but the First Nations who have stewarded these ecosystems for millenia. Tracing back the history of fire governance in B.C. exemplifies how colonial worldviews of fire (i.e. command and control) influenced fire policy that impacts current provincial management strategies and First Nations communities across B.C. (Copes-Gerbitz & Hagerman & Daniels, 2022). Restoring a camas meadow ecosystem for prescribed fire demonstration grants an important opportunity to decolonize fire and assist in the revitalization of Indigenous culture.

An assessment of the NFF site revealed that the current Garry oak meadow beds in the NFF are likely not suitable for burning for several reasons. For instance, the new Garry oak meadow plant seedbank would likely be outcompeted by the seedbank of the prior *Thuja plicada* ecosystem and introduced plants that existed prior to the NFF's establishment, or colonized by the adjacent native and introduced plant species, resulting in more undesirable than desirable plant germination following a burn. In addition, the plant composition of the Garry oak meadow is complex; both the desired native plants and introduced grasses and forbs have varying phenologies and responses to fire. Coupled with the very short fire window, finding a time to burn that would not damage native plants, but that would adequately target introduced plants, would be extremely challenging. Furthermore, the existing beds are small and narrow, with relatively low densities of the main desired native plant, *Camassia sp*. Burning on these areas would likely not reach the intensity needed to control introduced plants, and the low density of *Camassia sp.* is likely not worth the possibility of damaging other desired native plantings.

Given this information, we propose the creation of a new camas meadow located elsewhere on the GCA property. This would allow for more suitable conditions, which could be identified by surveying potential sites and also through community mapping with the goal of identifying culturally significant areas. A new site would be designed with permaculture principles in order to incorporate multiple fire breaks which would help contain a fire within the desired area.

References

Aleksoff, K. (1999). Achillea millefolium. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Retrieved from https://www.fs.usda.gov/database/feis/plants/forb/achmil/all.html.

Barlow, C. M., M. G. Pellatt, & Kohfeld, K. E. (2021). Garry oak ecosystem stand history in Southwest British Columbia, Canada: implications of environmental change and indigenous land use for ecological restoration and population recovery. Biodiversity and Conservation.

BC Wildfire Service (2018). *Standard Operating Procedure for Prescribed Fire*. Ministry of Forests, Lands, Natural Resource Operations, and Rural Development. Retrieved on July 21, 2023, from https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/wildfire-status/prescribed-burning/prescribed_fire_-_standard_operating_procedure.pdf

Berkes, F., & Davidson-Hunt, I. J. (2006). Biodiversity, traditional management systems, and cultural landscapes: examples from the boreal forest of Canada. Revue Internationale Des Sciences Sociales : RISS., 58(187), 35–47. https://doi.org/10.1111/j.1468-2451.2006.00605.x

Bowman, D. M., et al. (2011). The human dimensions of fire regimes on Earth. *Journal of Biogeography*, 38(12), 2223-2236. https://doi.org/10.1111/j.1365-2699.2011.02595.x

Cannon, G., & Cecco, L. (2023, June 29). *'It burns wild and free up there': Canada fires force US crews to shift strategy.* The Guardian. https://www.theguardian.com/world/2023/jun/29/canada-wildfires-us-crews-shift-strategy

Charlie, L. A., & Turner, N. J. (2021). Luschiim's Plants: Traditional Indigenous Foods, Materials and Medicines. Harbour Publishing.

Copes-Gerbitz, K., Hagerman, S.M. & Daniels, L.D. (2022). Transforming fire governance in British Columbia, Canada: an emerging vision for coexisting with fire. *Regional Environmental Change,* 22(48). https://doi.org/10.1007/s10113-022-01895-2

Corntassel, J. & Bryce, C. (2012). Practicing Sustainable Self-Determination: Indigenous Approaches to Cultural Restoration and Revitalization. *The Brown Journal of World Affairs*, 18(2), 151–162. http://www.jstor.org/stable/24590870

Dunster, K. J. (2009). The Garry Oak gardener's handbook : nurturing native plant habitat in Garry Oak communities. Victoria, B.C: Garry Oak Ecosystems Recovery Team.

Environmental Management Act, S.B.C., c.53 (2003). https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/03053_00

First Nations' Emergency Services Society of British Columbia (FNESS). (n.d.). Fire Services. Retrieved on July 25, 2023, from https://www.fness.bc.ca/core-programs/fire-services/

Galiano Conservancy Association. (n.d.) Nuts'a'maat Forage Forest. Retrieved on July 24, 2023, from https://galianoconservancy.ca/nutsamaat-forage-forest/

Garry Oak Ecosystem Recovery Team. (2023). Why Are They Important? Retrieved on August 8, 2023, from https://goert.ca/about/why-are-they-important/

Hanley, M. (2009). Thermal shock and germination in North-West European Genisteae: implications for heathland management and invasive weed control using fire. *Applied Vegetation Science*, *12*(3), 385–390. https://doi.org/10.1111/j.1654-109X.2009.01038.x

Hayes, J. P. Fire Suppression and the Wildfire Paradox in Contemporary China: Policies, Resilience, and Effects in Chinese Fire Regimes. Hum Ecol 49, 19–32 (2021). https://doi.org/10.1007/s10745-020-00183-z

Higgs, E., et al. (2014). The changing role of history in restoration ecology. *Frontiers in Ecology and the Environment*, 12(9), 499-506. doi:10.1890/110267

Huggins, A. (2017). Restoration Plan: Native Plant Forage Forest. *University of Victori*a. Prepared for the Galiano Conservancy Association.

Hul'qumi'num Treaty Group. (2011). Ecosystem Guide: A Hul'q'umi'num' language guide to plants and animals of southern Vancouver Island, the Gulf Islands and the Salish Sea. Retrieved from https://nlpslearns.sd68.bc.ca/wp-content/uploads/Hul_Qum_Ecosystem_Guide.pdf

Hoffman, K., et al. (2021). Conservation of Earth's biodiversity is embedded in Indigenous fire stewardship. *Proceedings of the National Academy of Sciences*, 118(32), 1-6. doi:10.1073/pnas.2105073118

Kimmerer, R. W. (2018). *Mishkos Kenomagwen*, the Lessons of Grass: Restoring Reciprocity with the Good Green Earth. In M. K. Nelson & D. Shilling (Eds.), *Traditional Ecological Knowledge: Learning from Indigenous Practices from Environmental Sustainability* (pp. 27-56). Cambridge University Press.

Kucher, A., Drysdale, S. & Terris, N. (2016). Native Plant Forage Forest: Analysis, Design, and Educational proposal for the Galiano Conservancy Association. *University of Victoria*. Prepared for the Galiano Conservancy Association.

Millison, A. (2019). Permaculture Design: Tools for Climate Resilience. Oregon State University.

Pellatt, M. G., Gedalof, Z. (2014). Environmental change in Garry oak (Quercus garryana) ecosystems: the evolution of an eco-cultural landscape. *Biodiversity Conservation*, 23, 2053–2067. https://doi.org/10.1007/s10531-014-0703-9

Park, H., Turner, N., & Higgs, E. (2017). Exploring the potential of food forestry to assist in ecological restoration in North America and beyond. Restoration Ecology.

Pojar, J. & MacKinnon, A. (2014). Plants of the Pacific Northwest Coast. Vancouver, BC: Lone Pine Publishing.

Province of British Columbia (2005). *Basic Fire Suppression & Safety: Student Manual*. Province of British Colombia, Ministry of Forests.

Radosevich, S. R., Holt, J. S., & Ghersa, C. (2007). *Ecology of weeds and invasive plants: relationship to agriculture and natural resource management*. Wiley-Interscience. https://doi-org.ezproxy.library.uvic.ca/10.1002/9780470168943

Schiefelbein, T., Potts, E., & Kathrens, L. (2015). Native Forage Forest Implementation and Management Plan. *University of Victoria*. Prepared for the Galiano Conservancy Association.

Turner, N. J. (1999). "Time to burn:" Traditional use of fire to enhance resource production by Aboriginal peoples in British Columbia. I*ndians, Fire and the Land in the Pacific Northwest*, Boyd, R. (ed.), Oregon State University Press, Corvallis, 185–218.

Watson, B. L., Lukas, S. B., Morris, L. R., DeBano, S. J., Schmalz, H. J., Leffler, A. J., & Wagner, V. (2021). Forb community response to prescribed fire, livestock grazing, and an invasive annual grass in the Pacific Northwest Bunchgrass Prairie. *Applied Vegetation Science*, *24*(4). https://doi.org/10.1111/avsc.12619

Weber, M.G. & Taylor, S.W. (1992). The use of prescribed fire in the management of Canada's forested lands. *The Forestry Chronicle* 68(3): 324-334.

York, R. A., Levine, J., Foster, D., Stephens, S., & Collins, B. (2021). Silviculture can facilitate repeat prescribed burn programs with long-term strategies. California Agriculture (Berkeley, Calif.), 75(3), 104–111. https://doi.org/10.3733/ca.2021a0016

Appendix 1: TEK and prescribed burning

In an interview dated January 23, 2011, Cowichan elder Dr. Luschiim Arvid Charlie explained that his great-grandpa Luschiim shared that every few years prescribed burning, at what is now known as Somenos Lake, was applied during the winter to areas composed of camas (*Camassia. sp.; speenhw*), trailing blackberries (*Rubus ursinus*; *sqw'iil'muhw*), blackcaps (*Rubus leucodermis; tsulqama*) and strawberries (*Frugaria chiloensis*; *stsi'yu*) when the ground (soil) had become "sour", or *ni'sa'yum'thut tu tumuhw* in Hul'q'umi'num. Fire was believed to "sweeten the ground", referring to the addition of biochar which enhances soil nutrients (Charlie & Turner, 2021, p. 204). Luschiim describes the importance of timing in greater detail:

"The worst time to burn would be about one o'clock in the afternoon. Everything's dry by then, [it would burn] five acres, that's how hot it is. So if you burn early in the morning… Or, you can do the edges at different times, maybe when the first time it's dry, burn the edges [so] you're going to have a perimeter…so you're going to have a stopper. Keep track of the weather: how hot it's going to be. You can definitely do some in, maybe, in a shower. So you can burn it in a little shower, you can coax it along. Not in the summertime. Your fuel's going to be gone in by summertime. Any time now [January], winter, yeah winter; by the time spring's come around, you're too late. You're going to stunt the growth. So, springtime, you're much too late. This is January. But we have had some warm weather already, so I would say it's too late, because the tops [of the camas] will be coming up now…It'll be about two weeks ahead of here [in Victoria]. Still, this is mid-January, [it's] too late…[to burn]" (Charlie & Turner, 2022, p.207).

Variability in biotic and abiotic features on a landscape are deeply ingrained within TEK, forming the foundation for place-based landscape management. For contrast, the Anishnaabe (Ojibwa) people of Shoal Lake, northwestern Ontario carried out prescribed burning in the springtime to manage habitat for berries in the boreal forest (Berkes & Davidson-Hunt, 2006). For the people of Shoal Lake, springtime burning and planting was favorable for blueberries (*Vaccinium boreale*). Blueberry patches were burned depending on topographical features at a site (soil, slope, etc.), blueberry establishment, and succession rates of bush honeysuckle (*Diervilla lonicera*), varying three to five years between burn periods (Berkes & Davidson-Hunt, 2006). This study noted the integration of Ojibwe terminology in landscape planning and management. An illustration of the Shoal Lake people's perception of forest succession post-burn, alongside Ojibwe terms, are included in Berkes and Davidson-Hunt's work (2006, p.39) seen in Figure 1.

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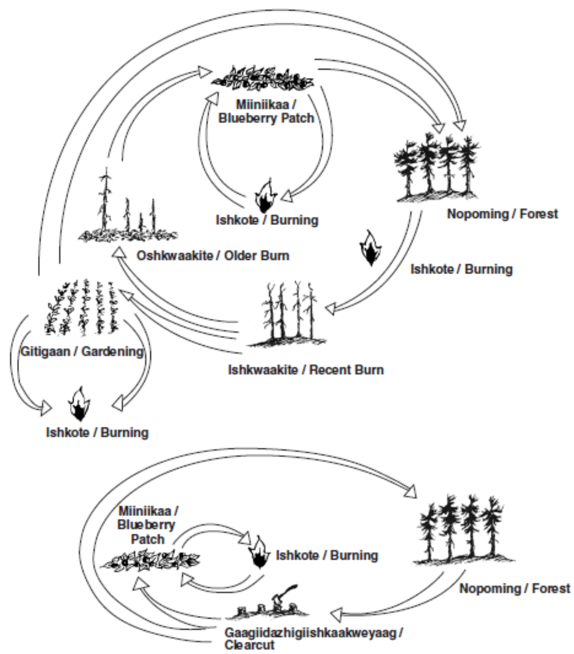

FIGURE 1. An Anishinaabe perception of forest succession following disturbance. The top cycle refers to fire as disturbance. The bottom cycle refers to foresty clearcuts as disturbance.

Berkes & Davidson-Hunt, 2006, p. 39.

In partnership with the Gulf Islands National Park Reserve (GINPR), an in-depth study of GOE stand history using dendroecological analysis, site classification, and site history contributed quantitative data to the better understanding of local IFS (Barlow & Pellatt & Kohfeld, 2021). Data was collected from three sites: Somenos Marsh, Vancouver Island; Tumbo Cliff, Tumbo (Temosen) Island; and Tumbo Marsh, Tumbo (Temosen) Island. Each stand site was classified by soil characteristics (saturation, depth, exposed bedrock, etc.), slope, and proximity to coniferous tree species. Paleoecological and stand dynamic data collected from this study correlated with the onset of European settlement and subsequent transformation of fire regimes in GOE (1850-1860's). Infilling of Garry oak (*Quercus garryana*) canopy and encroachment of Douglas fir (*Pseudotsuga menziesii*) is characteristic of these sites in present-day and is a testament of Indigenous dispossession (Barlow & Pellatt & Kohfeld, 2021). This study provides valuable quantitative data that implicates the negative impacts of European colonization on IFS and GOE species.

Appendix 2: Evolution of fire governance in B.C.

Prior to European settlement in coastal B.C. (pre-1850's) First Nations operated highly sophisticated systems of governance and land management that met corresponding cultural values of respect and reciprocity for the land. The Songhees First Nation, a lək̓ʷəŋən speaking peoples located in present-day in Victoria, B.C., are a prominent example of disrupted IFS. For millennia Songhees women have been the primary caretakers of camas (*kwetlal*) meadows in GOE and transferred the role intergenerationally between mothers and daughters (Corntassel & Bryce, 2012). Songhees women play a key role in maintaining GOE biodiversity through sustainable practices of planting, transplanting, harvesting, and burning the camas meadows (Bryce & Corntassel, 2012).

Despite settler adoption of fire to clear land after logging, create fuel wood, hunt, facilitate mineral exploration, agriculture, and to create pasture for grazing cattle (Pellatt & Gedalof, 2014; Turner, 1999), the Bush Fire Act was enacted in 1874. This legislation was influenced by the colonial perception of "fire as destructive to timber, in contrast to the worldview of fire as beneficially held by First Nations practicing fire stewardship for millenia prior" (Copes-Gerbitz, Hagerman & Daniels, 2022, p. 5). The "harnessing fire" period (pre-1912) thus marked the transition towards complete fire suppression and exile of IFS, coinciding with other governmental agendas (i.e. *Indian Act 1876*) that aimed to dispossess Indigenous peoples for land acquisition. After a century of enforced fire prevention strategies, such as financial penalties and propaganda (i.e. the "controlling fire" era), in 1976 the Royal Commission on Forest Resources acknowledged the ecological importance of fire and aimed to reintroduce the concept of fire as a "natural" component of forest ecosystems (Copes-Gerbitz, Hagerman & Daniels, 2022, p. 7).

However, the objective to reintroduce fire deteriorated as public concern increased around wildland-urban interface (WUI) fires and other hazards (e.g. climate change). In 1995, growing public concern about the social and economic impacts of reintroduced fire led B.C. Wildfire Service to become a separate entity from the Ministry of Forests due to lack of provincial oversight, creating a "siloing" effect between sectors with differing objectives. This separation of responsibility subsequently increased public recognition of the need to involve and support First Nations in strategic planning, marking an important shift in favor of "reinstating First Nations' decision-making power and sovereignty over land" (Copes-Gerbitz, Hagerman & Daniels, 2022, p. 8). Following the 2017 and 2018 catastrophic fire events in B.C. that resulted in the destruction of entire communities, including at least two fatalities, an emphasis was placed on transformative change and focused efforts on increased community collaboration with fire management planning (Copes-Gerbitz, Hagerman & Daniels, 2022). Further, reintroducing Indigenous fire stewardship aligned with B.C.'s recent legal commitment to the *United Declaration on the Rights of Indigenous Peoples* (Copes-Gerbitz, Hagerman & Daniels, 2022).

Appendix 3: Vegetation Monitoring

This method was adapted from the GCA's vegetation survey methods sites and from the NFF's current monitoring system. Plant list was taken from Huggins 2017 p. 80; field identification was confirmed using Pojar & MacKinnon (2014). Hul'q'umi'num' names were referenced from Charlie & Turner (2021), Hul'qumi'num Treaty Group (2011) and GCA publications.

It is worth noting that many species in the Garry oak meadow are seasonal, and thus some were inconspicuous or absent at the time and not represented in the survey. Because of its central importance to the garden, *Camassia* cover was estimated based on dried seedheads present.

Additionally, percent cover of weedy species was substantially lower in at the time of survey because of intense hand-weeding by GCA staff in preceding weeks and the seasonality of these plants. As such, the "introduced grasses" and "introduced forbs" sections of the vegetation monitoring survey were omitted. Their percent cover can be inferred by the percentage of bare soil cover.

As noted in Huggins (2017, p. 67) and one of the author's (Magusin) field experience, the most persistent introduced grasses include *Agrostis capillaris, Dactylis glomerata, Elymus repens,* and *Holcus lanatus;* pervasive introduced forbs include *Cirsium arvense, C. vulgare, Digitalis purpurea, Hypochaeris radicata, Mycelis muralis, Plantago lanceolata, Ranunculus repens, Rumex acetosella,* and *Vicia sativa*; and aggressive native plants include *Achillea millefolium, Rubus ursinus*, and *Gaultheria shallon*. In the future, noting the phenology of these species will be an important step in determining the most effective burning time and method, and whether or not controlled fire is an effective form of weed control.