# CONNECTIVITY CONSERVATION *for* GARRY OAK *Ecosystems*

***Planning an ecosystem-based green infrastructure network***

**written 2013, revised 2018**

A Lifeline for Our Rarest Species

Garry oak ecosystems recovery team

*www.goert.ca*

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## Executive Summary

Our homes, our jobs, and our cars that allow us to get from one to the other are important parts of community life. Unfortunately, routine planning for these can easily lead to habitat loss, fragmentation and degradation. Building communities and transportation infrastructure in ways that conserve imperiled biodiversity and ecosystem connectivity takes effort.

Once a prominent feature on the islands of BC's south coast, less than 5% of Garry Oak and associated ecosystems remain in near-natural condition. With so little remaining, the corridors, stepping stones, and other connections among remnant ecosystems and habitat patches have become increasingly important. They help sustain endangered and vulnerable species populations, ecosystem processes such as nutrient cycling, and ecosystem services such as pollination of crops and gardens.

In 2012 and 2013, the Garry Oak Ecosystems Recovery Team (GOERT) led landscape connectivity planning for southeast Vancouver Island and the Gulf Islands with the Connectivity Conservation project, building on the experiences of connectivity initiatives elsewhere in British Columbia (BC), Washington State, and California. The project was technical in nature, developing tools to identify natural connections for species movement and ecosystems processes. It was also exploratory in the social realm, assessing and building capacity for managing connectivity among community networks separated by jurisdiction and landownership.

Together with partners at Vancouver Island University, we created a Geographic Information System (GIS)-based connectivity prototype, a model that would show how rare and sensitive ecosystems and habitat fragments could best be linked. Datasets were amalgamated from GOERT, senior and local governments for a pilot area in the Cowichan Valley and on Saltspring Island. A list of approximately 1600 vertebrates, invertebrates, and plants known to live in BC's Garry Oak and associated ecosystems was pared down to a manageable suite of 16 representative, or 'focal' species. These would be used to test a future, more sophisticated model on the premise that, If the connected landscape can support these focal species, it would likely sustain the full range of species. Perhaps most importantly, we discovered a promising new way of mapping ecosystems and their linkages more precisely than ever before. With two advanced remote sensing technologies - LiDAR and hyperspectral, it is possible to identify and map individual Garry Oak trees and sensitive ecosystems directly, rather than relying on coarse-scale air photo interpretation products such as the Province's Sensitive Ecosystems Inventory.

To assess their capacity to plan for and map ecological connectivity, local governments and First Nations were surveyed. In subsequent meetings and dialogue sessions, we explored the challenges and opportunities associated with incorporating connectivity into community planning. Almost all local governments but very few First Nations had the capacity to run their own GIS-based connectivity models. Pilot area participants appreciated that once a baseline model was provided, they would have the flexibility of enhancing and updating their own, sometimes confidential datasets, together with the ability to plan for connectivity with neighbouring jurisdictions using a standardized framework.

Many local governments within the range of Garry Oak and associated ecosystems had already taken the first steps to address ecological connectivity, by including the concept in higher level plans such as

Official Community Plans or Parks and Trails Plans. For most governments however, connectivity planning, if it occurred at all, relied on visual assessments of maps or digital map layers. For some local governments, preserving natural areas for conservation was still perceived as less important than protecting parkland for recreation. Some had acquisition lists to guide decision-making with respect to the procurement and protection of lands, but these were derived from public surveys or have been populated as a result of public pressure, rather than from a science-based selection process. For many local governments, in practice the protection of natural areas was most often ad hoc, as opportunities arose to secure small portions of parcels awaiting development.

For First Nations, connectivity planning may help plan housing developments on reserve lands, as housing is a critical need and without careful planning, some Garry Oak ecosystems could be lost. They also saw its potential to conserve increasingly rare cultural resources outside of reserve lands, on landscapes over which they had little control. There was a common belief among First Nations that everything is connected, people are part of the natural landscape, and we all need to be competent guardians of that landscape.

By promoting the idea of a permeable landscape, and the need to support connectivity across our collective backyards, connectivity planning was perceived by project participants as having a more positive, cooperative flavour when compared with other, sometimes conflict-laden processes designed to avert development in Garry Oak and other imperiled and sensitive ecosystems. Still, public education was identified as a prerequisite to connectivity planning, as local government planners anticipated push-back from landowners when linkages were identified and conservation measures introduced. The notion of climate change adaptation through biodiversity conservation and ecological connectivity was virtually unknown, and will need to be explained and promoted to enable widespread support. However, many project participants supported and none disputed the importance or value of this concept.

While the project gained momentum, the GOERT society was winding down and transferring its important obligations to others. In these pages, we have documented our methods and findings in great detail, to facilitate continued connectivity planning for rare and sensitive ecosystems. Section 7.3, The Future of Connectivity Conservation, identifies interested parties and their recommendations to move forward.

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## 1.0 Introduction

Connectivity is everywhere. There are flows and linkages in and among food webs, water cycles, economies, governments, and so on. Yet we categorize and partition, sometimes quite arbitrarily. We sever natural connections and create new ones. We pipe rainwater to the ocean. We build roads, design property lines, and erect fences across once-continuous ecosystems. Incrementally, more species are affected, and ecosystems must function differently. As the landscape becomes more fragmented, remaining connections among ecosystems grow in importance.

Connections are particularly significant for BC's Garry Oak and associated ecosystems. Naturally rare, they are found only on southeast Vancouver Island, adjacent Gulf Islands, and two locations on the nearby mainland. They are believed to support some 1,600 species, many found nowhere else in Canada. Yet, in the decade preceding 2013, despite concerted efforts to protect species and habitats, the number of species-at-risk (SAR) climbed from 91 provincially listed species and 21 species listed federally, to 113 and 52, respectively. This is largely attributed to urban and rural development and the spread of invasive species. Of their pre-colonial extent, less than 10% of Garry Oak *(Quercus garryana)* ecosystems remain in BC, and less than 5% remain in near-natural condition (Lea, 2006). However, reduced connectivity among habitat fragments is also playing a role in the decline of Garry Oak and associated ecosystems and the species therein.

**Associated Ecosystems**
"Associated" ecosystems support many of the same species as Garry Oak ecosystems, but may have fewer or no Garry Oak trees. Associated ecosystems include maritime meadows, grasslands, seasonal vernal (spring) pools, rocky habitats such as coastal bluffs, and former oak ecosystems now dominated by other tree species.

A suite of ecological theories explain the need for functionally-connected ecological networks. Island biogeography theory is foundational, in asserting that the number of species and the size of their populations decrease with the size of the island (or habitat islands and patches) and with distance from sources of in-migrants, such as the mainland or other islands (MacArthur & Wilson, 1967; Harris, 1984). Meta-population theory maintains that the ability of species to move between habitat patches helps them persist on fragmented landscapes. With linkages, smaller, spatially-separated 'meta'-populations interact and function as larger, more resilient populations (Levins 1969; Wahlberg, Moilanen, & Hanski, 1996; Doerr, Doerr, & Davies, 2010). This concept of detached connectedness has evolved to encompass biotic and abiotic flows, landscape-level processes, and the spatial pattern of habitat fragments. Species and ecosystems are connected as meta-ecosystems, meta-communities, and meta-landscapes

(Loreau, Mouquet, & Holt, 2003; Wilson, 1992; With, Schrott, & King, 2006). While larger habitat patches are preferred, small, healthy patches in close proximity may be very important for the persistence of species and functioning of ecosystems.

In practical terms, this means developing communities and building transportation infrastructure in ways that conserve ecosystem connectivity. Consider a new road proposed through a natural area. It will destroy and fragment habitat and create edge effects that often lead to exotic species invasions. For an animal, crossing the road may be risky; to move to a distant habitat, too costly energetically (Eycott et al., 2008). For a plant population, there may be insufficient gene flow within the fragmented habitat to sustain future offspring (Heller & Zavaleta, 2009). Yet, the community is growing, the streets congested, drivers are frustrated, pedestrians are unsafe. The new road will improve community life. Typically, such projects are approved, planners work to limit habitat loss, and incrementally, ecosystems are diminished and degraded.

This project was designed to help conserve the connectivity and integrity of Garry Oak and associated ecosystems, by 1) developing tools to more easily identify, map, and model important links among ecosystems so they can be protected (and restored, if necessary), and 2) fostering social connections to enable planning and management of links across jurisdictional boundaries. We emphasize the important role of ecosystem connectivity in adapting to climate change.

### 1.1 Vectors, Corridors, Stepping Stones, and the Matrix

The connectivity of Garry Oak and associated ecosystems such as maritime meadows and coastal bluffs has been top of mind for ecologists since at least the late 1990s, when mapping comparing pre-colonial and contemporary ranges indicated these habitats were greatly reduced and fragmented (Figure 1). A report prepared for the Canadian Wildlife Service, *Towards a Recovery Strategy for Garry Oak and Associated Ecosystems in Canada*, dedicated a full ten pages to spatial integrity (Fuchs 2001). Fuchs' 1998 master's thesis had investigated the dispersal of Garry Oak acorns by their primary vector, the Stellar's Jay *(Cyanocitta stelleri)*. To protect Garry Oak ecosystems, she noted, would require safeguarding Stellar's Jay habitat - pointing to the importance of maintaining species connections to ensure ecosystems are still able to function.

The first recovery strategy developed by Garry Oak Ecosystems Recovery Team (GOERT) endeavoured to establish a network of Garry Oak and associated ecosystems sites and landscape linkages (GOERT 2002). It outlined the need for linkages between protected areas along streams and shorelines, recreational trails and greenways, and hydroelectric and transportation corridors. The 'matrix' - the landscape between patches of natural habitat, would play an important role in helping support viable populations of species, allowing wildlife to travel between habitat patches and supporting ecological processes at a landscape scale. For example, control of invasive species in the matrix would help sustain Garry Oak ecosystems by discouraging their encroachment into prime habitat areas for rare species.

Maintaining functionally connected ecological networks includes ensuring there are corridors and stepping stones between habitats, managing and restoring habitats, and improving matrix permeability (Eycott et al., 2008; Krosby et al., 2010). These are particularly important in the context of a rapidly changing climate, since heavily fragmented habitats may be most vulnerable (Walther et al., 2002).

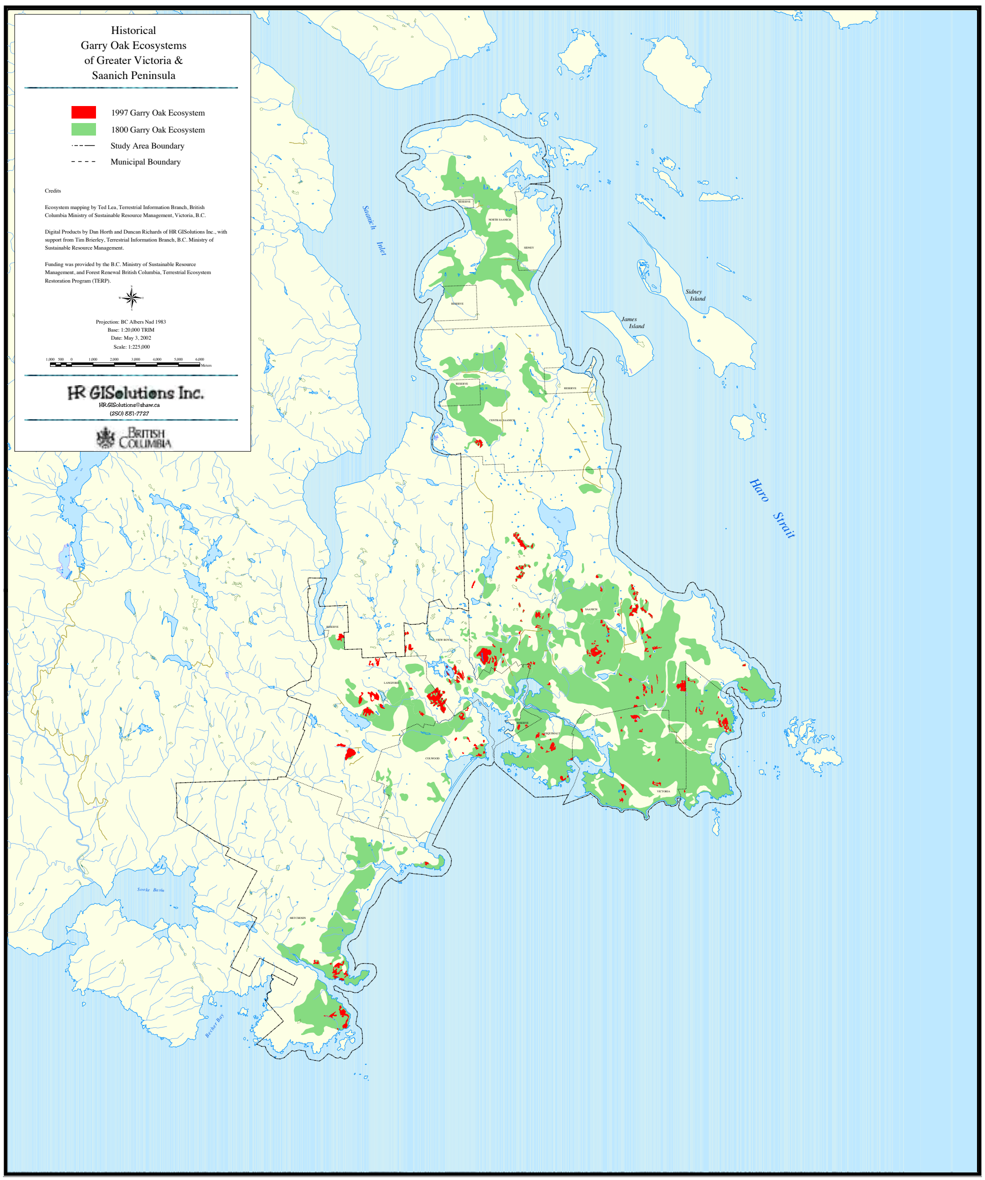


Figure 1. The extent of Garry Oak ecosystems in 1800 (in green) and in 1997 (in red) in Greater Victoria and on the Saanich Peninsula (Lea, 2006)

### 1.2 Connectivity and Climate Change Adaptation

Ecosystems are already disaggregating and re-assembling in response to climate change (Parmesan, 2005; Walther et al., 2002). Changes in the dominance and density of particular species or structural components (e.g., woody shrubs) increasingly occur (Brown, Valone, & Curtin, 1997; Walther, 2010). Spatial fragmentation is one of many factors that contribute to these transformations.

To the extent that the landscape has allowed, many species are tracking the changing climate, shifting their distributions poleward in latitude and upward in elevation (Breshears et al., 2008; Kelly & Goulden, 2008; Parmesan & Yohe, 2003; Walther et al., 2002). Range changes have tended to be episodic rather than gradual or constant (Walther et al., 2002). Where there have not been range changes, distributions of species in unfragmented landscapes have 'leaned upslope', with new and enhanced growth at higher elevations and decline and mortality at lower ones (Breshears et al. 2008; Kelly & Goulden, 2008). In a fragmented landscape, this type of shift is less likely to occur, and species with low adaptability and/or dispersal capabilities are more likely to face extinction (Kelly & Goulden, 2008; Walther et al., 2002).

Maintaining or increasing ecological connectivity at a landscape level is an important strategy to reduce climate change impacts on biodiversity (Krosby et al., 2010). Pellatt, Goring, Bodtker, and Cannon (2012) used bioclimate envelope models to show where Garry Oak habitat might be through 2099 with appropriate mechanisms in place to facilitate range expansion through protected connectivity corridors. They urged public and private protected area organizations to work cooperatively in the development of corridors in climatically suitable areas.

Wilson and Hebda (2008) recommended protecting ecological linkages as a key adaptation strategy to climate change - to reduce the loss of species, enable migration, and reduce the risk of fire and other accidental events. *Climate Change Adaptation and Biodiversity: Transitioning to an Ecosystem-based Economy in British Columbia* suggested adaptation policies focus on maintaining ecosystem resilience and connectivity (O'Riordan (Simon Fraser University), 2008). O'Riordan identified a variety of ways to pay for protection of corridors, including carbon offsets, a Public Land Trust-style entity to leverage matching funds from conservation organizations, and tax credits for participating landowners. Although BC Ministry of Enviroment's 2010 climate change adaptation strategy did not mention connectivity, it was a central tenet of a national 'priorities plan' developed by researchers and partners at University of Waterloo (Feltmate & Thistlethwaite, n.d.). They suggested creating more protected areas to strategically enhance connectivity; identifying and protecting climate refugia where climate shifts are expected to be minimal; restoring habitat corridors; and developing economic incentives and policy frameworks to encourage protections and restoration on private lands.

## 2.0 Project Goals and Objectives

Goal 1: Develop tools to identify, map, and model important links among Garry Oak ecosystems.

Objectives:

1) Create a Geographic Information System (GIS)-based connectivity model linking Garry Oak ecosystems with one another and with other sensitive ecosystems, that local governments, First Nations and others could use themselves;

2) Compile focal species information to test the model and augment landscape-focused connectivity planning; and

3) Explore the use of hyperspectral imaging to map remnant Garry Oak ecosystems and document channges

Goal 2: Foster social connections to enable planning and protection or management of links across jurisdictional boundaries.

Objectives:

1) Assess the capacity of local governments and First Nations to plan and manage for ecological connectivity; and

2) Facilitate dialogues across jurisdictional boundaries to explore how connectivity plans might be developed and implemented.

# 3.0 Creating a Connectivity Prototype

### 3.1 Connectivity Projects Elsewhere

A literature review was conducted to gather information about ecological connectivity and connectivity models. Then, jurisdictions with connectivity projects were contacted to discuss how their models were developed and used. In developing the model for Garry Oak ecosystems, we considered connectivity projects that had been completed or were underway in BC's Okanagan Valley, the Lower Mainland municipalities of Surrey and Richmond, the Islands Trust area, Washington, and California. In general, similar, yet distinct methodologies and mapping inputs were used by each jurisdiction, and no one model was superior to the others. A brief discussion of each is provided below.

### 3.11 Okanagan

In 2012, South Okanagan-Similkameen Conservation Program (SOCSCP) published *Keeping Nature in our Future: A Biodiversity Conservation Strategy for the South Okanagan Similkameen,* available at http://www.soscp.org/biodiversity/. The strategy, developed in collaboration with local and senior governments and others, was based largely on a series of maps: 13 source data layer maps, 10 derivative map products, and 4 decision support tools (i.e., Habitat Connectivity, Relative Biodiversity, Land Management Classes, and Conservation Opportunity) (Figure 2). (Caslys Consulting, 2011).


Figure 2. An overview of the Biodiversity Conservation Analysis in the South Okanagan-Similkameen region (Caslys Consulting, 2011).

There were at least three other connectivity initiatives in the Okanagan region. *Managing Connectivity in the Okanagan Landscape* - in draft form at the time of this writing, was a Best Management Practices-style document written for regional and community planners in the

Central Okanagan. It held that a connectivity strategy is achieved by identifying and comparing the quality of habitat patches, selecting priority patches for retention, and planning to maintain and facilitate connections to support movement of wildlife between these priority patches of habitat. University of BC (Okanagan) was beginning a multi-year connectivity research project that would build upon previous work undertaken in the region. The use of connectivity mapping in decision-making, and the role of focal species in modelling were to be examined, among other things. The Washington Connectivity Transboundary Working Group was conducting a connectivity analysis for the Okanagan-Kettle region, as part of a larger initiative led by the Washington Habitat Connectivity Working Group (WHCWG).

**Focal Species**

In conservation planning, it is important to ensure that the needs of all species within management areas in question are met. However, it is not feasible to expect that all of these species be included in models used to inform planning decisions, due to the sheer number of species present within different ecosystems. A suite of focal species is used to represent the others.

### 3.12 Lower Mainland

On BC's Lower Mainland, connectivity had been considered in a variety of ways. *Corridors of Green and Gold*, a project of the Fraser River Action Plan, documented the impact of riparian suburban greenways on property values in four study areas (i.e., Sturgeon Banks, Richmond; Cougar Creek, Delta; Kanaka Creek, Maple Ridge; and Colquitz Creek in Victoria on Vancouver Island) (Quayle & Hamilton, 1999). The *Green Links Project* endeavored to address habitat fragmentation by planting trees, shrubs and perennials in existing and new corridors in Coquitlam (Schaefer, 2003). Baseline inventories and a community survey were conducted, and targets were set using Simpson's biodiversity index for birds. Some 50,000 trees were planted, and hundreds of pounds of seeds were sown.

In developing its Official Community Plan (OCP) and *Environmentally Sensitive Area Management Strategy* (2012) (see http://www.richmond.ca/__shared/assets/esamgmtstratbtr33976.pdf), the City of Richmond identified an Ecological Network (HB Lanarc-Golder & Raincoast Applied Ecology, 2012). The network included hubs, sites, corridors, foreshore and riparian areas, parks and greenways. Hubs were larger, intact patches of naturally functioning ecosystems (generally >10 ha). Sites were smaller, non-linear stepping stones between hubs (0.25-10 ha). Corridors were linear connections between hubs. The matrix included 'permeable' green and open space in backyards and cultivated fields. Roads and other such features were considered barriers. Land cover types, roads and other components were assigned resistance values and a GIS-based least cost analysis was conducted to find paths of least resistance between hubs.

The paths determined by least cost analysis were manually reviewed and modified, for example by removing long corridors with low restoration potential, or by adjusting corridors to follow nearby greenways and riparian corridors. Then, each component of the network was ranked for biodiversity (e.g., hub size), water management (e.g, percent impervious surface area within the hub), and recreation (e.g., number of dwellings within a 10 minute walk of a hub or site). The sum of these rankings provided an overall ecological significance score. The scores and maps were used to develop Richmond's Environmental Sensitive Area (ESA) management guidelines and actions, and as well as its OCP.

**Least Cost Analysis**

To visualize least cost analysis, imagine pouring water through a steep landscape. The water will follow the paths of least resistance, quickly finding its way along roadways and barren areas, and around buildings. Where there is more vegetation, it will be absorbed and slow down.  Now, picture a terrestrial animal, one that is sensitive to human disturbances, trying to find its way across a landscape. It will avoid roads, seeking vegetated habitats that it considers to be of suitable to high quality. As long as the distance between these patches of habitat is less than the maximum distance that the animal can physically travel, it is more likely to safely satisfy its nutritional and other needs.

Least cost analysis uses a raster model base, or grid, combined with resistance values assigned to each square on the grid, to assess how easily the animal can move across it. A square on a highway will have a larger resistance value and a higher cost than one with a rural road, for example. Many authors have contributed to the development of least cost analysis (Husdal, 2001). Singleton, Gaines, and Lehmkuhl (2002), Adriaensen et al. (2003), and Beier, Majka, and Spencer (2008) are frequently cited in ecological connectivity documents.

Surrey's Green Infrastructure Network (GIN) was outlined in the *City of Surrey Ecosystem Management Study,* available at http://www.surrey.ca/files/Surrey_EMS_Final_Repor_Consolidated__April_2011.pdf (HB Lanarc & Raincoast, 2011). Similar to Richmond's ecological network, the GIN ranked hubs and corridors later in the project, after least cost analysis. A series of maps was published as part of the report; these included Aquifers, Slope, Watersheds and Sub-watersheds; Sensitive Species Occurrences and Habitat; Vegetation Inventory;Naturalness; Relative Impedance; Green Infrastructure Opportunities; Ecological Significance of Hubs; Sites Inside and Outside of Corridors; Ecological Significance of Potential Corridors; and Ownership of Network. A detailed Biodiversity Conservation Strategy was expected to build upon the GIN and Ecosystem Management Study.

### 3.13 Islands Trust

The Islands Trust was developing a spatial decision support system (SDSS), a map-based model to assist land use and management decisions. It identified lands with the highest biodiversity values and where biodiversity was under threat, determined high priority areas for land securement, and incorporated information on the probability of securement success. It used least cost analysis to identify important habitat linkages between pairs of core reserve areas. It also examined contiguity, a measure of importance based on adjacency to existing protected areas (Islands Trust Fund, 2012).

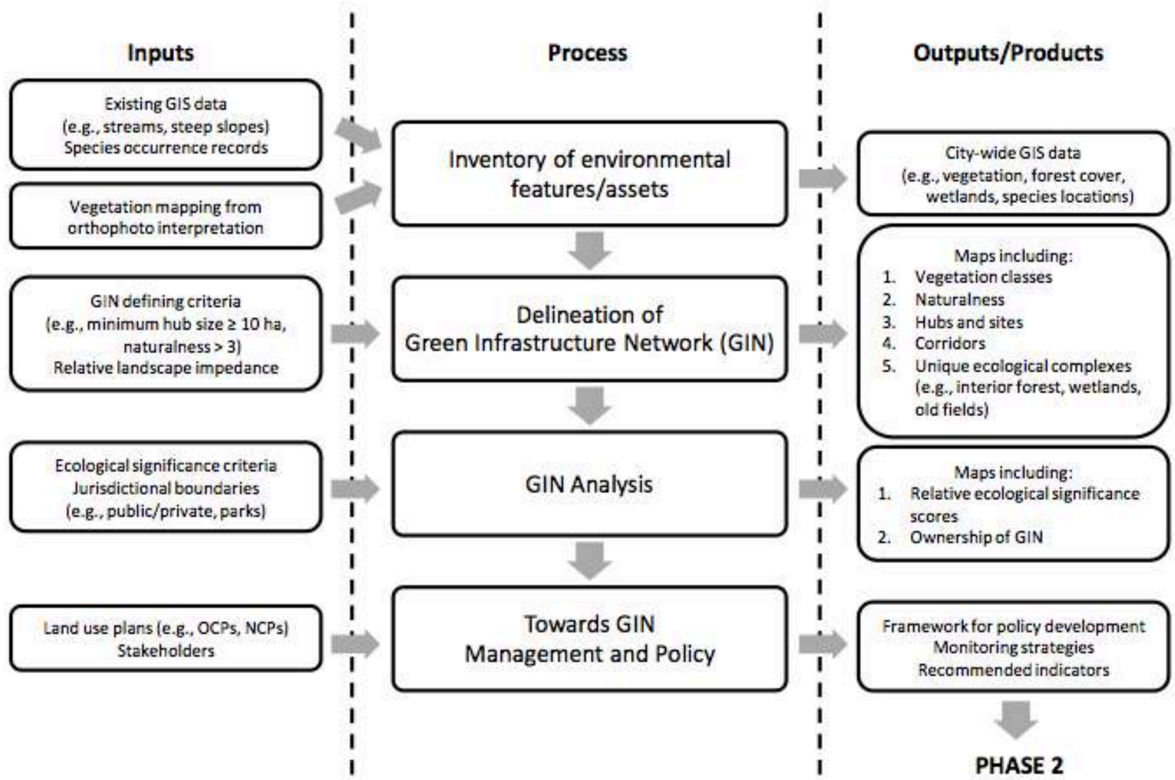


Figure 3. Flowchart of methods used to create the Surrey Green Infrastructure Network and Ecosystem Management Study (HB Lanarc & Raincoast, 2011).

### 3.14 California

California developed connectivity maps and 'cookbook-style' guides for statewide, regional and local scale initiatives. The guides and projects, including a strategic plan entitled *California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California* (Spencer et al., 2010) are available at http://www.dfg.ca.gov/habcon/connectivity/. There is also a guide specifically for managing road impacts.

California's connectivity project drew widespread support and participation from federal, state, local, tribal and non-governmental organizations. The project included a multidisciplinary team consisting of 200 people from 62 organizations, a technical team of 44 people from 23 organizations, and a steering committee of 10 from 4 organizations.

In California, the hubs were called Natural Landscape Blocks, fondly referred to as 'blobs'. The Essential Connectivity Areas, or 'sticks', were determined by least corridor analysis. An inverse of ecological integrity was used as the resistance surface. Local-scale analyses incorporated focal species (Spencer et al., 2010).

**3.15 Washington**

The Washington Wildlife Habitat Connectivity Working Group (WHCWG) led a variety of connectivity projects in Washington State (see [http://waconnected.org](http://waconnected.org)). Like California's project, collaboration was an  integral part of connectivity planning in Washington. The *Washington Connected Landscapes Project: Statewide Analysis* (WHCWG, 2010) involved a core team; a statewide analysis modelling team; statewide analysis focal species leads; document editors, writers, and cartographers; a communications and implementation subgroup; a focal species subgroup; a modelling subgroup; a landscape integrity subgroup; a peer review planning subgroup; a mapping and GIS data subgroup; and a climate change subgroup.

The statewide analysis involved a two-pronged approach. The first focused on focal species and the second on landscape integrity (Figure 4). As used by the WHCWG (2010), the term 'landscape integrity' is analogous to landscape condition, a factor of landscape naturalness and the extent of the human footprint.

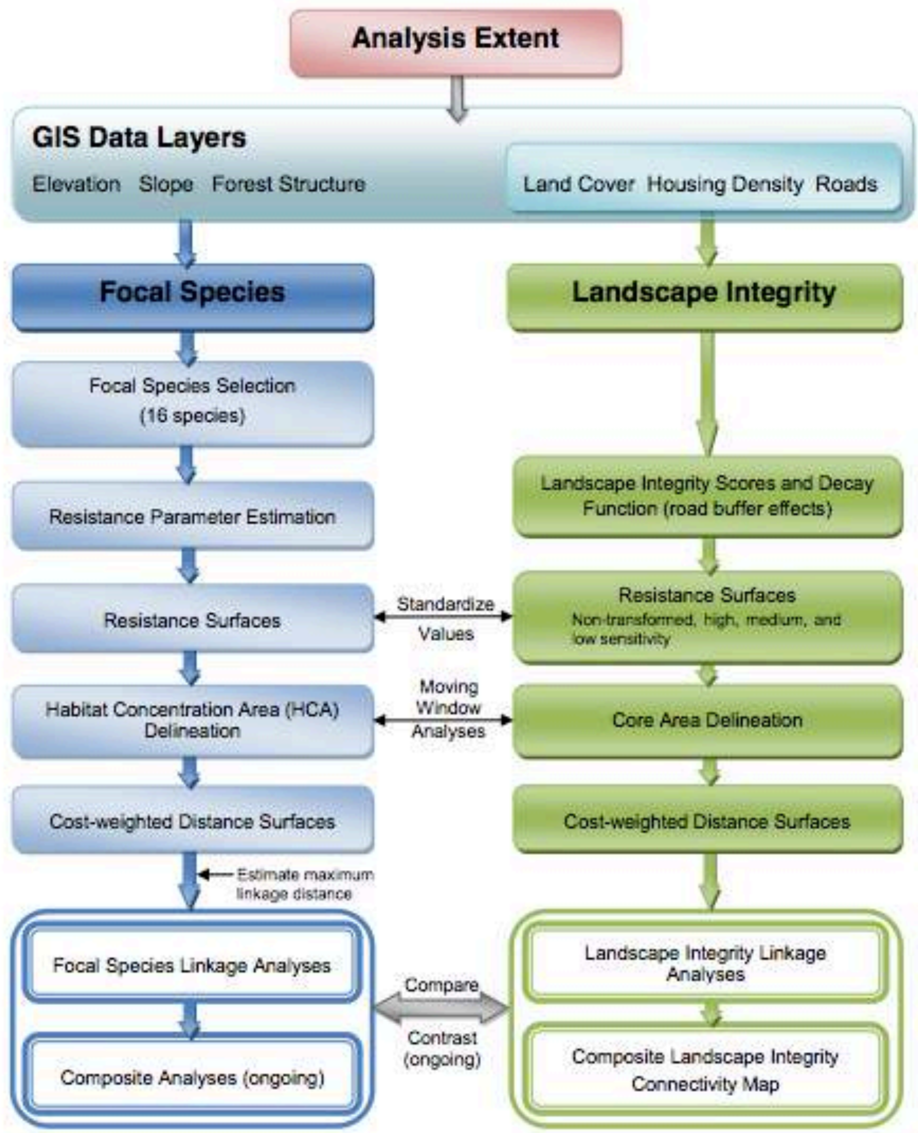


Figure 4. Flowchart of the Washington statewide connectivity analysis (WHCWG, 2010).

### 3.2 Choosing a Foundational Model

GOERT and its partners in the VIU Geography Department (Advanced GIS diploma program) adopted the Washington landscape integrity model as a starting point for its prototype. There were several reasons to begin with this model, the first being that it was relatively simple to learn. It included one habitat layer and six resistance layers: land cover, housing density, roads, slope, elevation and forest structure. It was flexible, as a single layer could be independently enhanced with new or better data, and replaced in the model. The modelling tool, called Linkage Mapper, was readily accessible, downloadable from the Internet.

Perhaps most importantly, the Washington model had been applied to other areas of BC, and used spatial data produced in BC. Further, we had an accessible BC connection, a representative from the BC Ministry of Environment who co-chaired the Washington Connectivity Transboundary Working Group - the group conducting a connectivity analysis in the Okanagan-Kettle region (mentioned in 3.11 Okanagan, above). Additionally, the climate change adaptation aspects of the model were becoming progressively more sophisticated. A key objective of the Okanagan-Kettle analysis was to identify linkages likely to be resilient to climate change.

### 3.3 Developing a Model for a Pilot Area

Jurisdictions within the range of BC Garry Oak ecosystems were asked to contribute spatial data towards development of a connectivity prototype. We chose a  10 x 16 km pilot area in the Cowichan Valley and Saltspring Island included the following jurisdictions: Islands Trust and the Capital Regional District, Cowichan Tribes, Cowichan Valley Regional District (CVRD), District of North Cowichan, and City of Duncan. This pilot area was chosen because it encompassed territorial, regional and local jurisdictions; it included the potential for linkages across marine and lacustrine (lake) ecosystems; it contained the pilot area for GOERT's Bring Back the Bluebirds translocation project; and most importantly, it was one of the few remaining areas with a significant expanse of Garry Oak ecosystems - including rare deep soil sites at the Somenos Garry Oak Preserve and the Cowichan Garry Oak Preserve.

From December 2012 through early April 2013, Leandra Paria - an international student in the Advanced GIS Program at VIU, developed a prototype with assistance from GOERT and academic support from Professor Brad Maguire. Our prototype would differ from the other models by connecting ecosystems that were designated as imperiled or sensitive. Our aim was to amalgamate existing datasets from all known sources for the ecosystems and for the resistance layers, and then to link the ecosystems across the resistance layers using the modeling tool. Below, we describe the most important aspects of prototype development. It does not include the many steps in ArcGIS that were required; these are discussed in more detail by Paria (2013).

#### 3.31 Habitat Concentration Areas

A 'core areas' or Habitat Concentration Areas layer was created using five inputs: 1) a single source of Garry Oak ecosystem site data, retrieved from the BC Conservation Data Centre and documented in Lea (2006); 2) Sensitive Ecosystems Inventory (SEI) data (Axyx, 2005; McPhee et al., 2000; Ward et al., 1998); 3) wetland and riparian data from provincial datasets; 4) Cowichan Tribes reserve lands (boundaries only), as Garry Oak ecosystems were known to have been inventoried on these lands (T. Fleming, pers. comm.); and 5) a single source of protected areas data, i.e., BC provincial parkland. The Habitat Concentration Areas layer indicated where Garry

Oak ecosystems were known to be located, as well as areas where Garry Oak and other sensitive ecosystems may be located.

All of the SEI types that overlapped the Garry Oak sites were included in the Habitat Concentration Areas layer. These included Coastal Bluffs (CB), Terrestrial Herbaceous (HT), Woodland (WD), Wetlands (WN), Riparian (RI), Older Forest (OF), and Second Growth Forest (SG). The SEI wetlands and riparian data were edited using more recent (2011) information from provincial datasets. All of the overlapping polygons were aggregated to create one polygonal layer which represented the core areas or Habitat Concentration Areas.

**Limitations, Sensitive Ecosystems Inventory** (from GOERT Model Bylaws, 2014)

The Sensitive Ecosystems Inventory (SEI) is a valuable coarse filter resource, and like all coarse filter resources has significant limitations. The SEI was mapped at a scale of 1:20,000. The original maps were based primarily on air photography taken between 1984 and 1993, at scales ranging from 1:8,000 to 1:20,000. The minimum target mapping size for non-forested ecosystems was 0.5 ha. About 30% of sites were visited to verify the air photo interpretations and to evaluate condition (McPhee et al., 2000; Ward et al., 1998). The spatial information was later updated and examined to determine the extent of disturbance, by overlaying the original polygons on 1:10,000 digital orthophotos taken in 2002; most of this imagery was black and white. Some forms of disturbance were difficult or impossible to identify, such as invasion by exotic species (Axys Environmental Consulting, 2005). Vernal pools, which are ephemeral wetlands, may have been missed altogether on photos taken in the summer.

### 3.32 Resistance

Following the creation of the Habitat Conservation Areas layer, a cost surface was created to represent how external factors such as terrain and roads would affect connectivity. This surface was generated using the sum of five of six resistance layers (i.e., land cover, housing density, roads, elevation and slope). The layers were derived from available BC datasets, using NatureServe-adapted methodology by Comer and Hak (2012) and modifications that had been employed in the Washington statewide analysis.

Importantly, landscape integrity values reflect generic ecological conditions, as opposed to the movement behaviour of specific plants or animals. Rather than attempting to translate landscape integrity into resistance, the WHCWG developed four resistance models representing different levels of sensitivity to human modification (i.e., linear, low, medium and high), based on differing hypotheses about the relationship between landscape integrity and resistance (see Figure 5). The landscape integrity values were transformed so that areas with greatest human modification were 100, 1000, and 10,000 times more resistant to movement than the least altered areas. These represented the smallest, median and largest maximum resistance values used for the suite of focal species models in Washington (WHCWG, 2010).

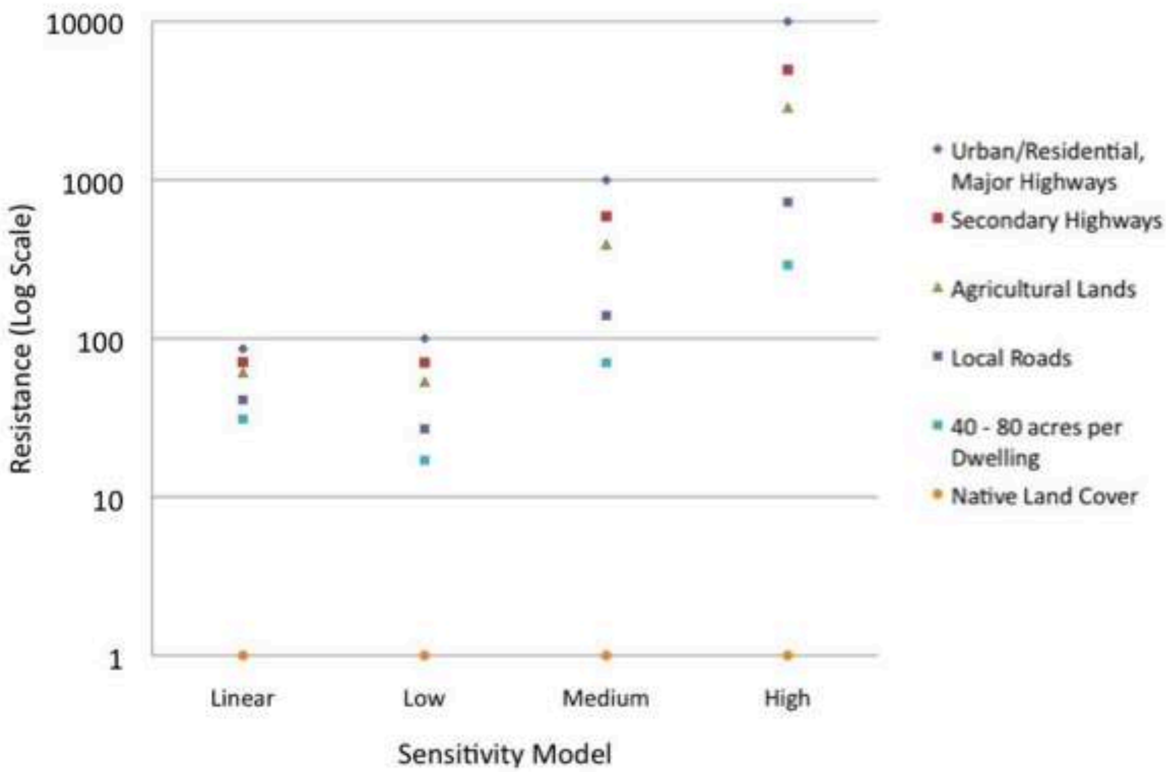


Figure 5. Example resistance values for different features, for each of four sensitivity models used in the Washington landscape integrity connectivity analysis (WHCWG, 2010).

For our prototype, the resistance values and category breaks for roads, land cover and housing density were taken directly from the Washington statewide analysis. The parameter values for the elevation and slope layers were estimated by overlaying the Garry Oak sites from Lea (2006) onto the elevation and slope map layers.

The parameter values were substituted into two resistance formulas used in the Washington statewide analysis.

Linear Resistance Formula:

RLI = [10*(10-LI)] – 9, where RLI = the linear resistance value, and LI = the parameter value.  The linear resistance value was a normalized version of the low resistance value.

Resistance Formula for Low, Medium and High Models:

Rsens = (10-LI) Psens, where Rsens = the resistance value, Psens = Constant, and LI = the parameter value. This resistance formula was used to determine the low, medium and high resistance values. The Psens value differed for each resistance level. The maximum achievable resistance (Rsens) for the low, medium and high resistances were 100, 1000 and 10000 respectively. The constant and the parameter value were substituted into the formula, to determine the resistances for the elevation and slope layers.

There were many different road classes (e.g., highways, arterial, recreation, service, etc.). These were organized into three categories or 'Road Types': major highways, secondary highways and local roads. Buffers were created around each 'Road Type' in order to spatially represent the resistance associated to the 'Road Type'. A 12.5 m buffer was used for the major highways, a 500 m buffer was used for the secondary highways, and a 1000 m buffer was used for the local roads.

For the land cover layer, three coarse-scale input datasets were used: Biogeoclimatic Ecosystem Classification (BEC), Vegetation Resource Index (VRI) and Baseline Thematic Mapping (BTM). Within the pilot study area, VRI only existed for a minute portion, in comparison to the BEC and BTM. The BEC and BTM datasets were captured at a 1:250,000 scale, whereas the VRI was captured at a 1:20,000 scale.

The BEC and VRI layers were used to separate the dry and wet forest land cover types. All of the areas within the VRI layer that did not contain any information about forest types were updated with information from the BEC layer. The BTM layer was then used to add all of the non-forest land use types (e.g., urban, agricultural etc.). The combination of the BEC and VRI layers were used to update the BTM layer.

Polygonal 2006 census boundaries and the dwelling unit counts for each census zone from Statistics Canada were used to create the housing density layer. The dwelling unit counts and the areas of the census zones were extracted from the census table.

Existing Digital Elevation Models (DEMs) and raw data were used to create a complete DEM for the pilot area. Two existing DEMs covered most of the pilot study area (i.e., dem092b013e and dem092b014w). Terrain Resource Information Management (TRIM) breaklines, spot heights and DEM points from TRIM map sheets 92B.072 and 92B.073 were used. Only the hydrographic breaklines from the breakline data were incorporated, which provide a reference to riparian features without altering the elevations. The hydrographic breaklines, spot heights and DEM points from both map sheets were used to create a 25 m DEM, where the hydrographic breaklines were a 'Stream' feature type, and the spot heights and DEM points were a 'PointElevation' feature type. The individual DEMs were then merged into one.

The merged DEM, TRIM breaklines, spot heights and DEM points were used to create a slope layer with three classes: 0 to 20, 20 to 40 and 40 to 60 degrees.

Elevation and slope classes were determined by overlaying the Garry Oak sites layer with the elevation and slopes layers; most Garry Oak sites were located between 0 and 500 m in elevation and on 0 to 40 degree slopes. Within the slope classes, the majority of Garry Oak ecosystems were found between 0 and 20 degrees, so were assigned a lower resistance value than the other classes. Slopes between 20.1 and 40 received a slightly higher resistance value, as there was still a significant amount of Garry Oak ecosystems on these slopes. Slopes exceeding 40 degrees received a high resistance value. Elevation classes and resistance values were determined in a similar fashion.

The resistance values for four degrees of resistance (linear, low, medium and high) are shown in Table 1. It is noteworthy that <10/acre housing densities means “less than 10 acres of land per dwelling unit”. These area represents the densest areas within the pilot area, and they have the highest resistance values. Similarly, >80/acre means “greater than 80 acres of land per dwelling unit”. There are fewer houses in these areas with respect to the amount of land, and they have the lowest resistance values (L. Paria, pers. comm., September 23, 2013).

For greater accuracy, an in-depth review of resistance values is recommended. Ideally, these values would be specific to Garry Oak and other sensitive ecosystems in the pilot area, and based on scientific evidence.

Table 1. Resistance values used in the connectivity prototype

| Layers | Resistances | | | |
|---|---|---|---|---|
| Elevation (m) | **Linear** | **Low** | **Medium** | **High** |
| 0 | 86 | 100 | 1000 | 10000 |
| 150 | 1 | 1 | 1 | 1 |
| 250 | 21 | 10 | 30 | 90 |
| 500 | 41 | 27 | 140 | 724 |
| 750 | 86 | 100 | 1000 | 10000 |
| 1000 | 86 | 100 | 1000 | 10000 |
| 1500 | 86 | 100 | 100 | 10000 |
| Slope (degrees) | | | | |
| 0-20 | 1 | 1 | 1 | 1 |
| 20.1-40 | 21 | 10 | 30 | 90 |
| 40.1-90 | 86 | 100 | 1000 | 10000 |
| Housing density | (dwellings units per acre) | | | |
| >80 | 0 | 0 | 0 | 0 |
| >40 to 80 | 31 | 17 | 70 | 291 |
| >20 to 40 | 41 | 27 | 140 | 724 |
| >10 to 20 | 41 | 27 | 140 | 724 |
| <10 | 86 | 100 | 1000 | 10000 |
| Land Cover | | | | |
| Agriculture | 61 | 54 | 392 | 2867 |
| Barren Surfaces, Dry and Wet Forests, Fresh Water, Recently or Selectively Logged, Wetlands | 1 | 1 | 1 | 1 |
| Salt Water | 41 | 27 | 140 | 724 |
| Urban | 86 | 100 | 1000 | 10000 |

Each layer (e.g., roads (Figure 6), land use) was converted to a resistance raster, and corrected for the land/sea boundary, where the sea was set to 'No Data'. For this initial model, connectivity across waterbodies was not considered. To create a model with linkages between Vancouver Island and Saltspring Island, one need only remove the 'No Data' specification for the saltwater body (L. Paria, pers. comm., September 23, 2013).

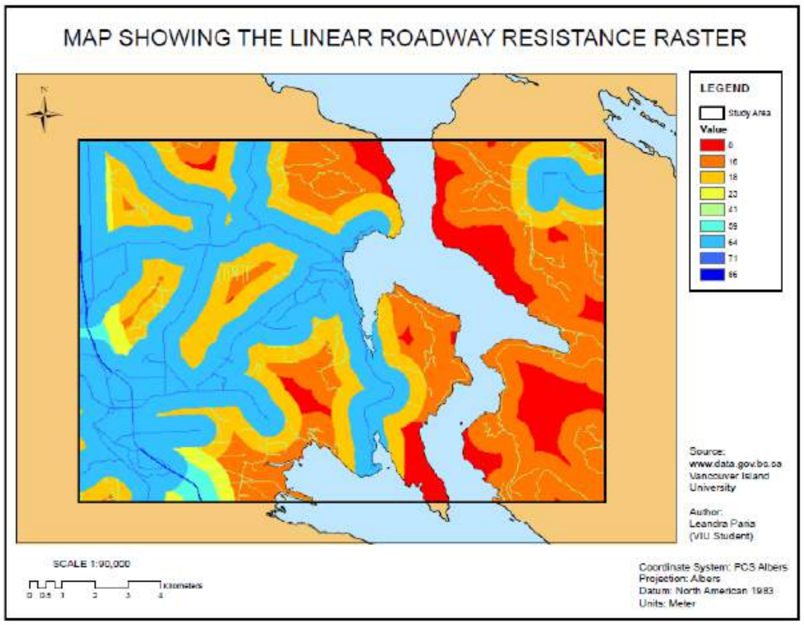


Figure 6. Linear sensitivity resistance layer for roads

The creation of the final four cost surfaces were a simple combination of all of the resistance surfaces. For example, to create the linear cost or resistance surface, all of the linear resistance surfaces created for each of the input layers were summed to produce the final linear resistance surface. This process was repeated for the low, medium and high resistance surfaces.

**3.33 Linkages**

The Linkage Mapper 1.01 tool, developed by WHCWG, was used to perform an analysis on the layers, constructing a connectivity network of core habitat areas and linkages. The tool modeled corridors between the polygons, or core areas, in the Habitat Concentration Areas layer. Linkage Mapper took approximately 4 hours to run for each of the cost surfaces (i.e., linear, low, medium, and high). Least cost path corridors were generated for each pair of core areas. A summary of how this tool works is available in Paria (2013). A more detailed explanation can be found at http://code.google.com/p/linkage-mapper/.

**3.34 Sensitivities and Limitations**

In the initial prototype, there were a total of 302 core, or habitat concentration areas within the pilot study area, using only Lea's 2006 Garry Oak Sites, SEI polygons, First Nation reserve lands and BC parks and conservation areas in the layer.

In producing the four models of differing sensitivity, the linear and low resistance connectivity models exhibited similar corridors connecting core areas. Compared to the medium and high sensitivity models, there was a greater number of corridors produced, and the width of these corridors was significantly wider. However, some corridors overlapped with known urban areas, suggesting the linear and low resistance values did not accurately represent real world conditions.

The medium sensitivity connectivity model and resulting map better represented the distribution and extent of the region's urban and natural areas. The corridors were narrower through the urban areas, and wider in natural habitats. This model provided numerous yet relatively narrow alternative routes between core habitat areas (Figure 7).

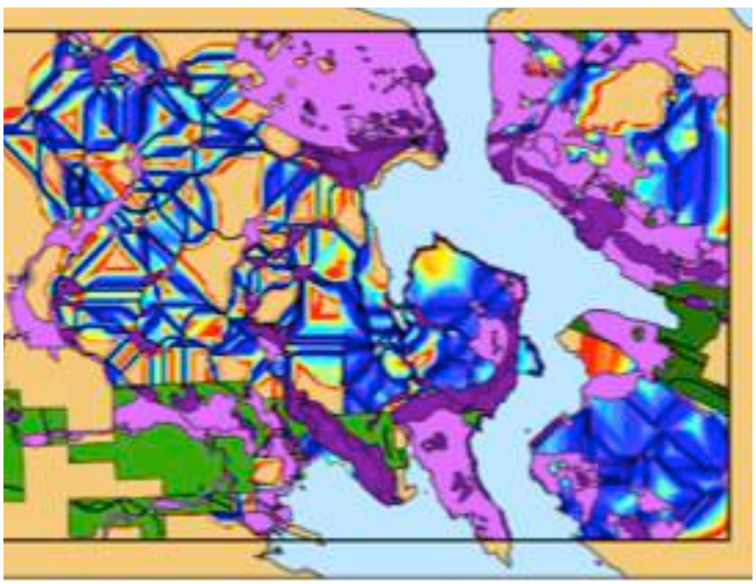

Figure 7. Medium sensitivity connectivity map. Garry Oak sites = dark purple, SEI = dark purple, First Nation reserve lands = light green, BC parks and conservation areas = dark green, low resistance corridors = dark blue, ranging through light blue, yellow and orange to higher resistance corridors = red

The high sensitivity connectivity map was characterized by narrow corridors through much of the Cowichan Valley, probably too narrow to facilitate the movement of species sensitive to human disturbance. On Saltspring Island, however, multiple, wide corridors were available. In the area bordering Sansum Narrows, the island is largely undeveloped with little access (Figure 8).

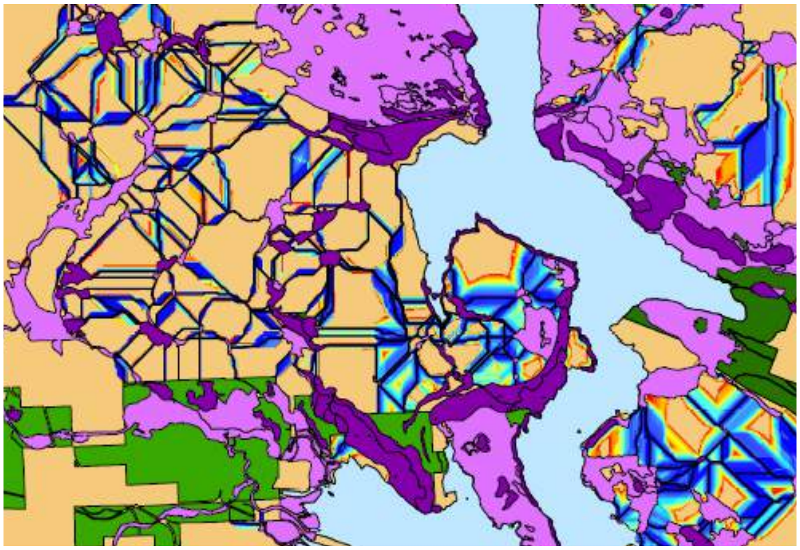

Figure 8. High sensitivity connectivity map. See medium sensitivity map above for an explanation of colours.

The four models provided a good starting point to visualize where potential corridors may exist, and how different sensitivities reflect the extent of actual natural and built areas on the landscape.

However, datasets that covered the entire pilot area were few, due to different datasets across local governments. In some cases, datasets could be stitched together to provide complete coverage. Proxy data was used to address certain gaps. For other gaps, this was not possible. For example, there were data gaps in the housing density layer because the census polygons did not match the statistical data in the census table. These data gaps carried through the entire analysis.

**3.35 Enhancing the Model**

We identified several ways to improve the prototype. Population density might be better represented by determining the population per unit area. The outdated SEI could be re-digitized with more recent orthophotography; such a project is currently underway in the Comox Valley. The datasets used for the land cover resistance layer were poor and should be improved, perhaps with the use of Landsat imagery. Finally, Light Detection and Ranging (LiDAR) data could be used to develop a forest structure layer, which would benefit the entire resistance surface.

From late April through mid-August, GOERT partnered with the undergraduate Geography Department of VIU. International student André Bertoncini added background imagery to our maps to better interpret the core areas and linkages. Initially, 2010 LiDAR-derived orthophotos were used, provided by the CVRD. Later, due to data gaps and discontinuities, Bertoncini replaced this background with Landsat imagery. The resolution was not on par with the orthophotos, but the layer was complete. Later, we discovered that the CVRD imagery had not been sufficiently processed.

In future, this layer should be improved. The District of North Cowichan may be able to provide a version that was processed for greater accuracy (e.g., augmented with 2002 orthophotos, with Google Earth and Google maps as references).

Data to enhance the Habitat Concentration Areas layer were secured from various sources and added to the model. Notably, there were no issues around data sharing; in fact, the only issues encountered throughout the project were with provincial TRIM maps. Amalgamated data layers included critical habitat bounding areas from Parks Canada; Garry Oak priority sites updated by Kathy Dunster in 2011, contributed by GOERT and provided by Caslys Consulting courtesy of Environment Canada; and Sensitive Ecosystem Mapping/Terrestrial Ecosystem Mapping (SEM/TEM) derived from the provincial Coastal Douglas-fir Zone (CDF) TEM from the Islands Trust. Given time constraints, there were some data that were not added to the model; these included CDF TEM for the Cowichan Valley, and Conservation Data Centre element occurrences for Garry Oak ecosystems.

First Nations' ecosystems data were confidential at this time, so were not included. The First Nations reserve lands and protected areas were removed from the Habitat Concentrations Area layer, in favour of a pure ecosystems layer. Jurisdictional, ownership, zoning and protected status should be considered in the next phase of the project, and treated as independent layers.

Enhancements were made to the resistance layers as well, the most significant of which was housing density data provided by the District of North Cowichan. A VIU Advanced GIS student, while working on a project to develop GIS-based OCP indicators for North Cowichan, had mapped housing density with point data, more precisely than Statistics Canada. With fewer time constraints, we could have developed a forest structure layer using LiDAR.

The Linkage Mapper tool was run with the enhanced datasets for the high sensitivity cost surface only. Figure 9 shows a revised, high sensitivity map with Landsat imagery, some additions to the Habitat Concentration Areas layer, and enhancements to the housing density resistance data in the District of North Cowichan. Although a medium sensitivity model is preferred, the narrow corridors allow a better view of the landscape beneath.

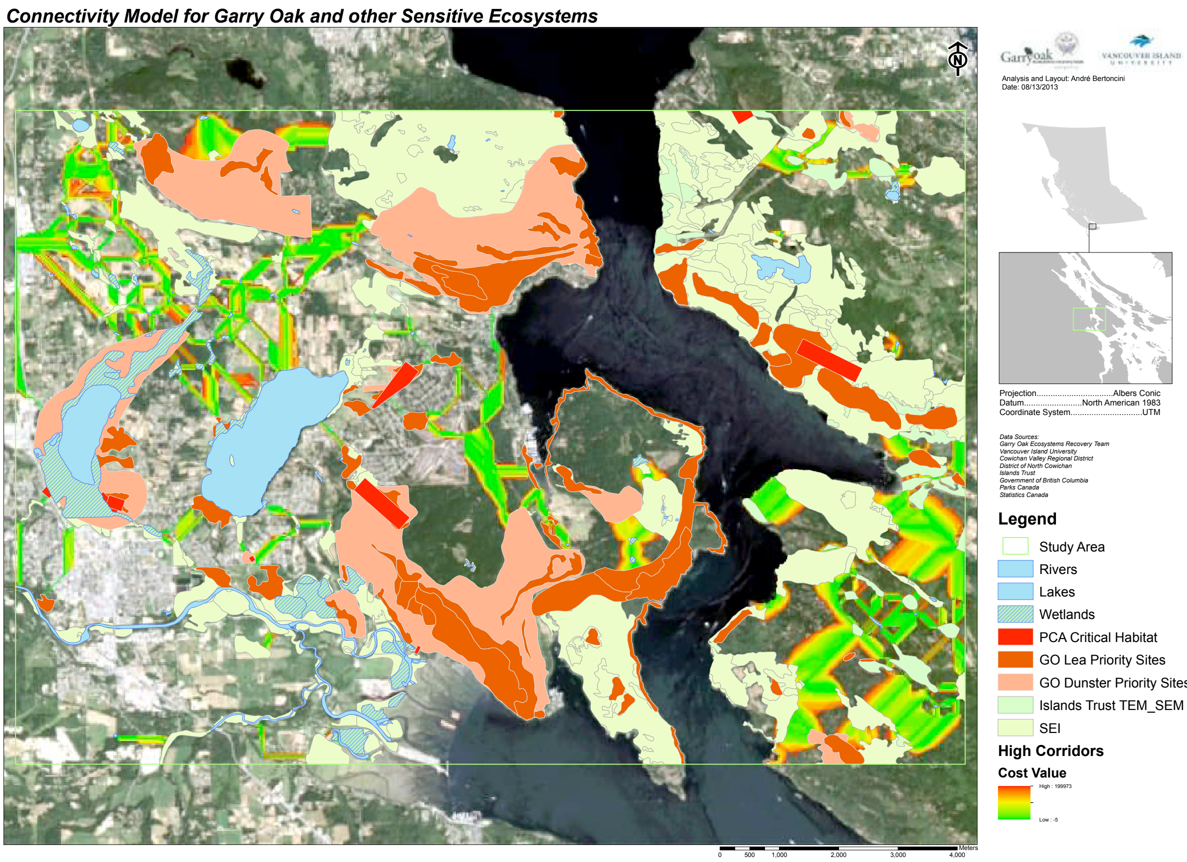


Figure 9. An enhanced high sensitivity connectivity model. Please note, the map should read GO Priority Sites (Lea) and GO Priority Sites (Dunster).

# 4.0 Focal Species

Our intent was to identify and use a suite of focal species to test and enhance the prototype, in order to maximize its effectiveness in addressing the needs of nearly 700 plant species, more than 100 species of birds, 7 amphibians, 7 reptiles, 33 mammals, and an estimated 800 invertebrates known to use Garry Oak and associated ecosystems. These species include 113 species that are provincially listed as at-risk and 55 that are nationally listed (Fuchs, 2001; GOERT, 2011).

Focal species can fall into several different categories. Keystone species, umbrella species, flagship/charismatic species, Indicator species, and cornerstone species may be used. *Keystone species* refer to those species whose impact on an ecosystem is disproportionately greater than their presence would suggest, and whose removal from that ecosystem would have a serious effect on its functionality (Miller et al., 1998). To avoid assessing a species to determine whether it is indeed disproportionately greater than some other species, we use the term, 'ecologically significant' to refer to a species whose presence has a considerable effect on a Garry Oak or associated ecosystem.

*Umbrella species* are used to represent the requirements of a larger group of animals. These species generally possess the most restrictive life history parameters or habitat needs of their group and are generally well-studied, making them useful stand-ins for species for which there is less information available.  Species with large area requirements are often preferentially chosen as umbrella species, as providing for their habitat requirements will ensure that the needs of those species with smaller ranges are also met.

*Indicator specie*s are the canaries in the coal mine. Generally, they are closely linked with a specific biological process or habitat, and are sensitive to ecological changes. They are used in biomonitoring studies to gauge the overall health of an ecosystem or specific habitat.

*Flagship species* are highly visible or charismatic species such as the panda or monarch butterfly, used in public relations campaigns to raise awareness or draw support for specific conservation initiatives (Miller et al., 1998).

*Cornerstone species* are rare species at low trophic levels that have keystone characteristics; despite their low numbers, they have a significant influence on the abundance and diversity of other species and the ecosystem as a whole (Bracken & Low, 2012). In their study of an intertidal ecosystem, Bracken and Low found that the removal of a species at the base of the food web, representing less than 10% of ecosystem biomass, precipitated declines in many other species - including mobile animals such as crabs. Like keystone species, cornerstone species are considered 'ecologically significant'.

In many cases, a species may possess characteristics that cause it to fall under more than one of the above categories. In this study, it was important to ensure that focal species were umbrella species, well suited to stand in for other species with similar or less restrictive ecological requirements. Meeting that criterion, emphasis was placed on ecologically significant species. The ability of species to draw public support due to a charismatic nature was taken into consideration but was not a main criterion for inclusion as focal species. As this project did not aim to measure ecosystem functioning, the ability of species to act as a bioindicator was not considered. However, some focal species may indeed be useful indicators, and vice versa; this merits closer examination at a later time.

'Indirect representation' is possible for some focal species. Where a relationship exists between species, it might be appropriate to use one or the other of them in the model rather than both, with the expectation that ensuring connectivity between Garry Oak and associated ecosystems for the chosen species will ensure connectivity for the related species not included for modeling. For example, it may be easier to model connectivity for Garry Oak trees, the food source for the Propertius Duskywing butterfly (*Erynnis propertius*), and use it as a stand-in for both species. This reduces monitoring costs while ensuring that adequate representation for both species is not lost.

**4.1 Generic Focal Species**

An alternative to the traditional use of real life focal species in habitat connectivity modelling, *generic focal species*, with artificially constructed habitat requirements, have been successfully used in an increasing number of studies. In this approach, life history parameters are described for a hypothetical or conceptual species based on the requirements of real species, which are then used in connectivity modelling. The use of generic focal species deals with some of the disadvantages associated with the use of real-life species, especially regarding the difficulties in rationalizing the use of one species over another with similar needs, and the issues inherent in discarding certain species without background data adequate for modelling purposes (Watts et al., 2010). They also have a more general applicability as they allow species with similar requirements to be represented as a group (Bailey, 2007). By using generic focal species, researchers can choose which characteristics to include in a fabricated profile which would contain habitat and life history requirements similar to those of real species under study (Watts et al., 2010).

There are a number of different approaches to generating generic focal species. The Biological and Environmental Evaluation Tools for Landscape Ecology (BEETLE) model, developed by the Edinburg Forestry Commission, used generic focal species to represent different habitats and ecological processes (for example, 'pinewood specialist' and 'woodland generalist') in the place of real species (Moseley, Ray, & Watts, 2007). Watts et. al. (2010) used a panel of experts to provide opinions on generic species parameters for their model, developing a suite of generic focal species specific to woodland habitats. For example, the first generic focal species they developed was given 'high patch area requirements (10 ha) and poor to moderate dispersal ability (1 km)' while the second was able to 'utilize smaller patches (2 ha) and disperse further (5 km)', parameters representative of real-life, moderately fragmentation-sensitive woodland species. Similar methods have been used in other studies, allowing the researchers to account for the needs of species for whom those parameters were not available.

However, since unique species are not used, there is no potential for the use of flagship species to draw public support. Also, validation of the model is not possible regardless of how simple the model might be (Bailey, 2007). Model validation would require the real life parameters of a focal species to be measured and compared to results predicted by the connectivity model, which is not possible if real life species had not been used for the basis of that model. One solution that has been suggested to address the validation deficiency is to group real species within each generic focal species type and use data on them to check model predictions (Eycott, Watts, Moseley, & Ray, 2007).

**4.2 Selecting a Suite of Focal Species**

Biological consultant Danielle Morrison was hired to help outline the role of focal species in connectivity planning, and provide a list of prospective focal species with accompanying rationales. First, literature reviews were conducted to gather information about focal species. We then drew upon a detailed methodology from the Washington Connected Landscapes Project (WHCWG, 2010), chosen because it was based on Natureserve - the foundation for BC's Conservation Data Centre, and described a clear scientific process behind the selection of focal species. This process used a series of filters designed to reduce individual bias in the selection process.It was similar in its requirements to those of several other habitat connectivity projects (Beier, Majka, & Jenness, 2007; Noss, 1999; Spencer et al., 2010; WHCWG, 2010).

**4.21 Vertebrate and Invertebrate Species**

An initial list was made of species currently at-risk in Garry Oak and associated ecosystems with a provincial status of S1 through S3. The habitat requirements for these species were anticipated to account for the needs of all species within the ecosystems (WHCWG, 2010). Species which were extinct or extirpated from Garry Oak and associated ecosystems were excluded. Species which lightly used these ecosystems were flagged for removal, in order to restrict the sample to those species for whom the ecosystems were essential habitat. Species which were of significance to Garry Oak and associated ecosystems in the provision of a resource or a process - including species not currently at-risk (S4-S5 status), were introduced to the list or unflagged if they were indicated as light users. Any species marked for removal and which was not considered a significant species for Garry Oak and associated ecosystems was then removed.

**Conservation Status Ranks**

S Subnational rank assigned and maintained by the BC Conservation Data Centre

1 Critically imperiled

2 Imperiled

3 Special concern, vulnerable to extirpation or extinction

4 Apparently secure, with some cause for concern

5 Demonstrably widespread, abundant and secure

Remaining species were evaluated for suitability as focal species using criteria which had been used in other studies to indicate a sensitivity to fragmentation and a usefulness for modeling (Table 2) (Beier et al., 2007; Noss, 1999; Spencer et al., 2010; WHCWG, 2010). Values were given to the parameters available for each species, to gain a rough measure of their potential usefulness as a focal species (Table 3). The highest ranking species were then assessed and additional details which were not captured by these criteria were considered, such as presence of metapopulations and non-flying migratory populations. Of these species, those which appeared to best represent the requirements of Garry Oak and associated ecosystems were selected for inclusion. A diagram of the selection process is shown in Figure 12.

Table 2. Parameters used for animal (vertebrate and invertebrate) focal species selection

| Significance | Species Traits | Other Considerations |
|---|---|---|
| Specificity to Garry Oak and associated ecosystems (GOAEs). For example, are habitat specialists or broadly distributed throughout | Trophic level | Sensitivity to barriers |
| Ecologically significant. For example, are are keystone, umbrella, indicator or cornerstone species | Home range size | Can be monitored |
| Provincial status | Territory size | Adequate data to support modeling |
| | Dispersal distance | Are flagship species |
| | Migratory vs. non-migratory | |

Table 3. Values assigned to plant (P) and animal (A) species characteristics for ranking

| Characteristic | Criteria | Value |
|---|---|---|
| Provincial Status (P&A) | S1 | 2 |
| | S2-S3 | 1 |
| | S4 - S5, SX, SH* | 0 |
| Specificity to GOAEs (P&A) | GOAE Specialist | 1 |
| | Generalist | 0 |
| Ecologically Significant? | Yes | 1 |
| Part of Common GOAE Plant Associations (P) | Yes | 1 |
| Information to Support Modeling (A) | Home Range Size | 1 |
| | Territory Size | 1 |
| | Dispersal Distance | 1 |
| Commonly Associated Vegetation Type(s)/Topographic Element(s) (P) | Each Type or Element | 1 |
| Sensitive to Habitat Barriers? (P&A) | Yes | 1 |
| Movement Choices Match Scale of Modeling (P&A) | Yes | 1 |
| Monitoring Feasible? (P&A) | Yes | 1 |

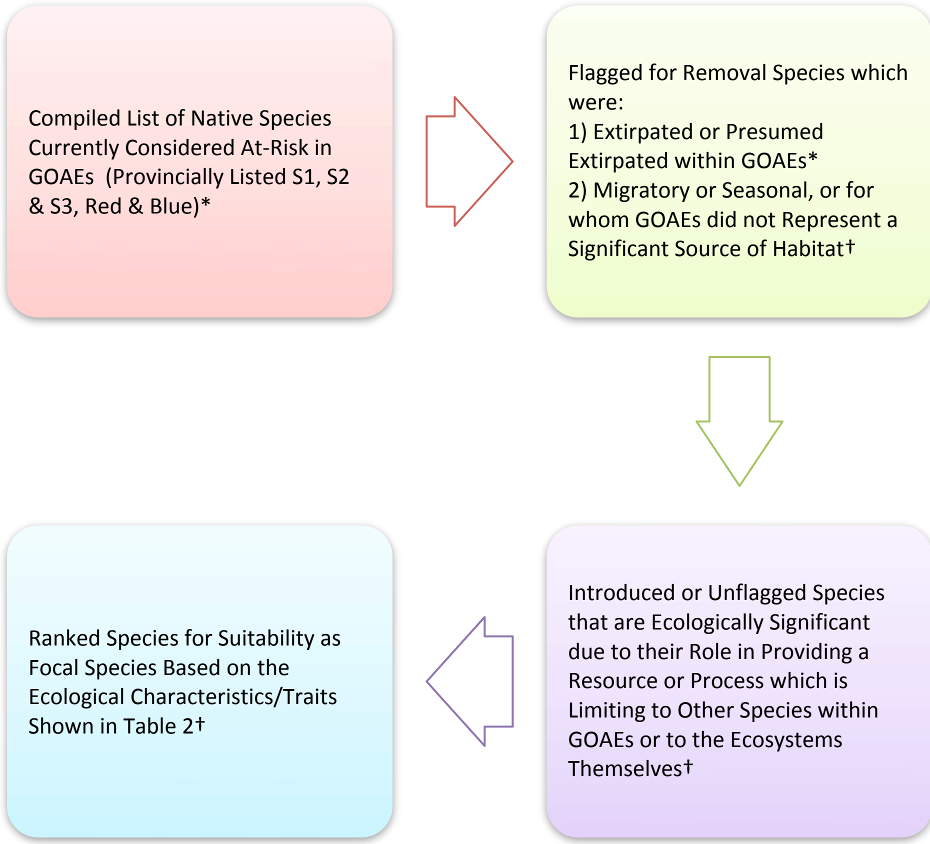


Figure 10. Selection process used to determine potential vertebrate and invertebrate animal focal species

*Information obtained from NatureServe and the Conservation Framework, accessed via the BC Ecosystem Explorer, as well as from GOERT resources

†Information obtained from above sources as well as in consultation with experts in the field

### 4.22 Plant Species

A list of at-risk plant species was produced, using a method similar to that used during filtering of vertebrate and invertebrate species. However, it was realized that a slightly different approach would be necessary, as the connectivity projects used as templates focused primarily on animal species (Hinam & St. Clair, 2008; Penrod, Spencer, Rubin, & Paulman, 2010; Spencer et al., 2010; WHCWG, 2010).

Since this connectivity project was intended to protect a set of related ecosystems rather than specific at-risk species, it was important that the plants chosen as focal species be representative of the plant communities that make up these ecosystems. The initial list included a number of rarer species which were not cornerstone species, experienced nearly no dispersal, and may have been benefitting from their isolation. Therefore, plant focal species were chosen which formed significant components of Garry Oak and associated ecosystems.

Our revised list included the species that form the common plant associations described by Erickson and Meidinger (2007) and included in Restoration Ecosystem Units defined by GOERT (GOERT, 2011). We added species through literature reviews and in consultation with experts in the field, to provide a more well-rounded and informed selection from which to make a subset of prospective species.

The majority of the species' traits used to describe fragmentation sensitivity of animal species were not applicable in the selection of plant species. To augment the list of traits to be considered, presence or absence in the various ecosystem types was added as a criterion (Table 4), derived primarily from the GOERT Restoration Guide (GOERT, 2011) and Erickson and Meidinger's (2007) *Garry Oak Plant Communities in British Columbia: A Guide to Identification* (Table 5). Other classification systems, such as the Conservation Data Centre's classification of ecological communities, Erickson's 1998 classification (which included disturbed plant communities), Mackenzie's 2012 publication *Biogeoclimatic Ecosystem Classification of Non-Forested Ecosystems in British Columbia*, or U.S. classifications such as Chappel (2006), and Roccio and Crawford (2008) were not considered for this exercise. Taken into consideration were method of dispersal for each plant species, and whether or not each plant formed a part of one (or more) of the common plant associations of Garry Oak and associated ecosystems. Similar to the process used for animal species, plant species were ranked on the basis of values assigned to each parameter, individual traits were assessed, and those species which appeared to best suit the needs of the project were included. A diagram of the selection process is shown in Figure 13.

Table 4. Parameters used for plant focal species selection

| Significance | Species Traits | Other Considerations |
|---|---|---|
| Part of common plant associations within GOAEs | Commonly associated vegetation type(s)/topographic element(s) | Sensitivity to barriers |
| Ecologically significant | Distribution method | Can be monitored |
| Provincial status | Dispersal Distance | Adequate data to support modeling |

Table 5. Communities within Garry Oak and associated ecosystems used during the focal species selection process

| **Broad Restoration Ecosystem Units (GOERT 2011)** | **Plant Associations (Erickson and Meidinger 2007) Other Considerations** |
|---|---|
| Deep Soil Garry Oak Communities | Qgcc (Garry Oak - Common Camas - Blue Wildrye)<br>Qggc (Garry Oak - Great Camas - Blue Wildrye)<br>Qgos (Garry Oak - Oceanspray - Common Snowberry) |
| Shallow Soil Garry Oak Communities | Qgrm (Garry Oak - Grey Rock-moss - Wallace's Selaginella<br>Qgbm (Garry Oak - Broom-moss)<br>Qghh (Garry Oak - Hairy Honeysuckle)<br>Qgrf (Garry Oak - Roemer's Fescue) |
| Maritime Meadow Communities | Non-defined |
| Vernal Pool Communities | Non-defined |
| Coastal Bluff Communities | Non-defined |
| Douglas-fir Communities | Not used |

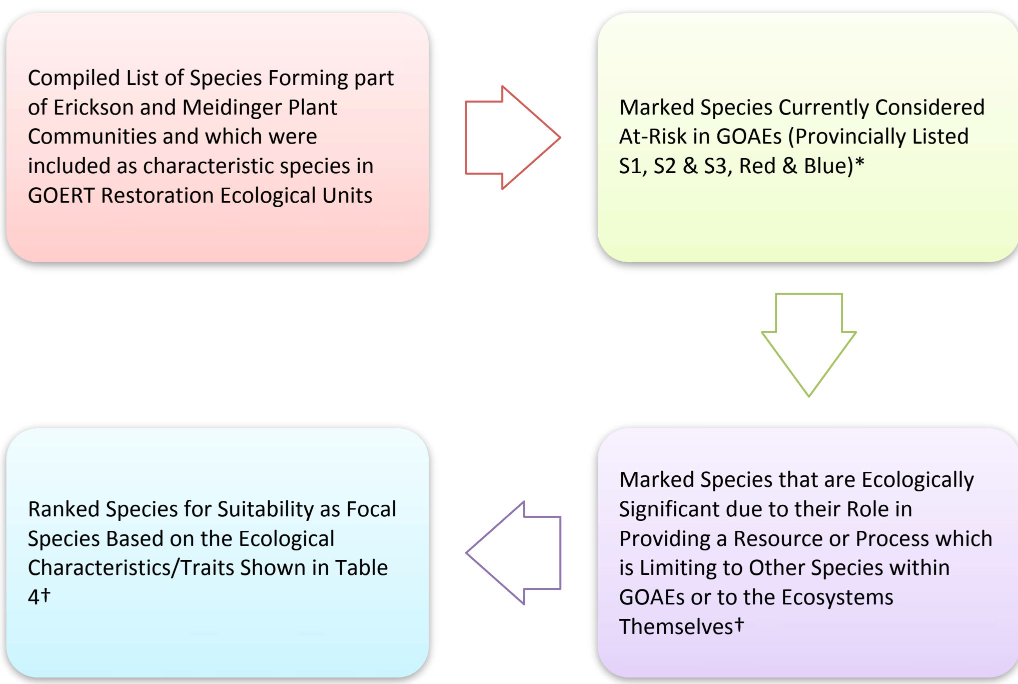


Figure 11. Selection process used to determine potential plant focal species

*Information obtained from Nature Serve and the Conservation Framework, accessed via the BC Ecosystem Explorer, as well as from GOERT resources

†Information obtained from above sources as well as in consultation with experts in the field

**4.3 Potential Focal Species**

Through this process, a total of 16 potential focal 'species', including seven vertebrate species, two invertebrate species, three invertebrate pollinator guilds, and four plant species were selected (from ~1,600 species). Chosen were two mammals, Townsend's Vole (*Microtus townsendii*) and Townsend's Big-Eared Bat (*Corynorhinus townsendii*); three birds, including Western Bluebird (*Sialia mexicana*), Coastal Vesper Sparrow (*Pooecetes gramineus affinis*) and Steller's Jay (*Cyanocitta stelleri*); two reptiles, Sharp-tailed Snake (*Contia tenuis*) and Northwestern Alligator Lizard (*Elgaria coerulea*); the Anise Swallowtail (*Papilio zelicaon*) and Propertius Duskywing (*Erynnis propertius)* butterflies; ground nesting, cavity nesting and brood parasite pollinator guilds; and within the plant kingdom, one tree, a shrub, and two herbs, namely Garry Oak, Oceanspray (*Holodiscus discolor*), Common Camas (*Camas quamash*) and Spring Gold (*Lomatium utriculatum*). In the Appendix, the status, life histories, and suitability for use as focal species are reviewed for each 'species'.

Notably, some species are not exclusively found within Garry Oak and associated ecosystems, but also use other types of ecosystems in the Coastal Douglas-fir moist maritime (CDFmm) biogeoclimatic subzone. However, they tend to use Garry Oak and associated ecosystems preferentially and/or provide an important service which contributes to the functioning of these ecosystems, as well as contributing to overall biodiversity. It has been suggested that management for these species be considered in the context of the entire CDFmm (Feldman, 2002). While this report focuses on the animal and plant species within Garry Oak and associated ecosystems specifically, future efforts may find it useful to consider CDFmm ecosystems as a whole.

# 5.0 Mapping Garry Oak with Hyperspectral Imaging and LiDAR

Although ecologists have mapped many of BC's Garry Oak ecosystems, remote sensing technologies may help find unmapped remnants, and document changes in the extent and health of known ecosystems or their elements (e.g., Garry Oak trees). Hyperspectral remote sensing is one such technology. It measures colour, capturing a nearly continuous reflected shortwave energy spectrum from the visible to shortwave infrared (Niemann, 2008). Spectral signatures can be used to determine species composition, environmental stress, and natural disturbance (Jones, Coops & Sharma, 2011; Niemann, 2008). They have been used for early identification of trees infected with Mountain Pine Beetle (*Dendroctonus ponderosae*), for example (Sharma, 2007).

LiDAR, sometimes called 'laser radar' is a remote sensing technology that utilizes high frequency, pulsed laser light to measure the location and three-dimensional geometry of objects on the ground. LiDAR can measure elevations; the height, volume and area of individual trees; and the vertical distribution of vegetation, among other things (Niemann, 2008). Ko, Sohn and Remmel (2013) were able to classify tree genera with an accuracy of 88.3% using LiDAR. The CVRD and UVic created a LiDAR-derived contour map of soil moisture at a 2 m resolution. Such advancements have significant implications for planning in and around Garry Oak ecosystems, which are highly vulnerable to subtle changes in hydrology and geology.

In Gulf Islands National Park Reserve, University of BC and Parks Canada used LiDAR data and hyperspectral imagery to predict Garry Oak ecosystem distribution with an overall accuracy of 86.4% (Jones, Coops, & Sharma, 2011). The technologies were found to deliver more detailed, more accurate, and cheaper data than a conventional air photo interpretation campaign (Jones, Coops, & Sharma, 2010; 2011). Vauhkonen et al. (2013) used a hyperspectral LiDAR instrument to classify spruce and pine trees in Scandinavia with accuracies of 78 to 97%.

### 5.1 Sourcing and Processing Hyperspectral and LiDAR Data

Bertoncini and VIU's Geography professors were keen to begin working with these technologies, and especially to determine whether Garry Oaks in the pilot area could be identified using hyperspectral data. University of Victoria's LiDAR and Hyperspectral Lab, working in collaboration with the CVRD, had processed a narrow strip (1-2 km) of 1 m resolution hyperspectral data along the Cowichan Valley coastline for a sea level analysis. (The Lab had additional data for the CVRD and parts of the Capital Regional District.) UBC and Parks Canada were willing to share their data for parts of Gulf Islands National Park Reserve with GOERT, beginning in late August (pers. comm., Nicholas Coop and Tara Sharma).

The UVic/CVRD hyperspectral images were taken by an Airborne Imaging Spectrometer for Applications (AISA) sensor in a airborne platform on August 12, 2011, by Terra Remote Sensing.

This sensor allowed the acquisition of 212 bands in single image (Bertoncini et al., 2013). LiDAR data had been simultaneously collected, however time constraints prevented us from using it.

The hyperspectral images had been geometrically corrected in ENVI software. (See http://www.exelisvis.com/portals/0/pdfs/envi/Hyperspectral_Intro.pdf for an ENVI introduction to hyperspectral data.) Thirteen images were associated with flight line 0812-2207_RAD, encompassing a thin, coastal strip of our pilot area. To classify the images with the same reliability a mosaic was created; this 'mosaiking' would ensure all images would be spectrally in the same range (Bertoncini et al., 2013).

As hyperspectral sensors acquire large volumes of information, atmospheric interferences are easily transferred to the images. To correct for these, visible errors, or 'bad bands' were first extracted from the images by creating an animation, a movie that shows all of the image's bands. The Quick Atmospheric Correction (QUAC) method was then used to further correct the images; this determines correction parameters directly from an image's pixel spectra by examining the average reflectance and standard deviation of a collection of diverse material spectra (Bernstein et al., 2005; Bertoncini et al., 2013).

### 5.2 Geo-referencing and Verifying Garry Oak in the Field

On July 24, 2013, the area for which we had hyperspectral data was visited and GPS coordinates were acquired for isolated Garry Oak trees. Forty trees were geo-referenced, and 35 chosen to extract the target spectrum from the hyperspectral images. In the ENVI software, polygon features known as regions of interest (ROIs) were created representing the extent of the Garry Oak canopy (Bertoncini et al., 2013). The hyperspectral mosaic was then classified using the Spectral Angle Mapper (SAM), which compares the similarity between two spectra (Bertoncini et al., 2013; Instituto Nacional de Pesquisas Espaciais, n.d.). Based on the resulting spectral signature, a map was generated to show where the Garry Oak trees were located.

The mosaic was then divided into seven areas, and at least 10 trees were selected in each area for field verification. Tree selection was largely based on accessibility, as much of the area was privately owned. On August 7, 2013, the areas were visited on foot and by sea kayak, with the same hand-held GPS units used in July. These Garmin eTrex Vista® H units had an accuracy of 3.3 m when using Wide Area Augmentation System (WAAS). Fifty-eight trees were field-checked. Other sites were avoided due to a combination of time constraints and inaccessibility.

Figure 10 shows the potential locations of Garry Oak trees (in red) on Maple Mountain. The field checks in this area were 60% accurate; in other words, 6 out of 10 of the trees mapped as Garry Oak were indeed Garry Oak, and 4 out of 10 were other species, and in some cases, a combination of other species (i.e., Douglas-fir (*Pseudotsuga menziesii*) above Arbutus (*Arbutus* *menziesii*), Douglas-fir overtopping Bigleaf Maple (*Acer macrophyllum*), or Red Alder (*Alnus rubra*)).

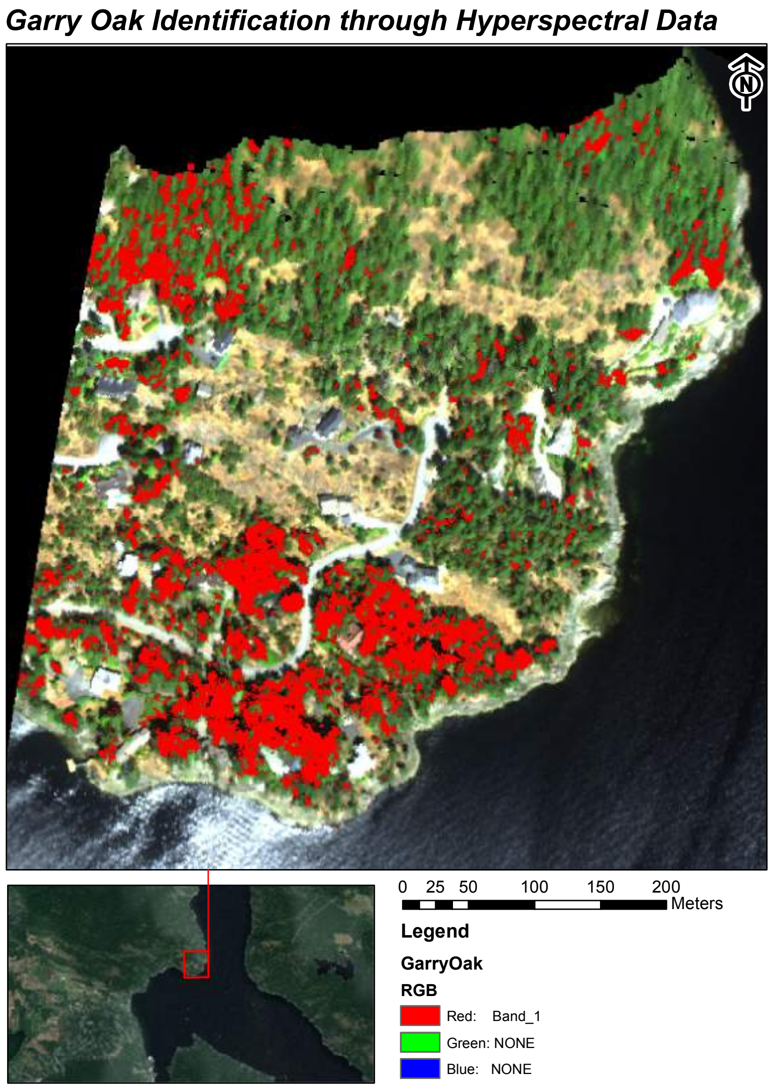


Figure 12. Potential distribution of Garry Oak trees (in red) on Maple Mountain.

Farther south, accuracy declined. Overall, only 23 of 58 (40%) identified by the application of hyperspectral data as Garry Oak turned out to be correct. Figure 11 shows the accuracy of field verification in six of the seven areas accessed; one area was privately owned and it had been too late in the day to request permission for access. Other commission errors (i.e., the mapped Garry Oak trees that on the ground were not Garry Oak) included Arbutus overtopping Douglas-fir, maple over Arbutus, maple, Western Red Cedar (*Thuja plicata*), cedar over Arbutus, Douglas-fir and cedar, Arbutus, English Holly (*Ilex aquifolium*) and two other, unidentified exotic species. The majority of commission errors (at least 37%) involved a coniferous tree (Bertoncini et al., 2013). If LiDAR were used to help classify the hyperspectral imagery, coniferous commission errors could be readily eliminated.

In general, acceptable error for hyperspectral imaging should not exceed 25%. The high level of error could have arisen from GPS precision - the two handheld units frequently disagreed with one another, or spectrum biases. To avoid the latter, hand-held field spectrometers or lab spectrometers would be used to generate spectral signatures and classify the hyperspectral images. UBC and Parks Canada used hand-held spectrometers for hyperspectral classification of Garry Oak and other species in Gulf Islands National Park Reserve (Jones, Coops, & Sharma 2011). The spectral signatures and data could be examined in concert with our Cowichan Valley imagery to generate better results (Bertoncini et al., 2013).

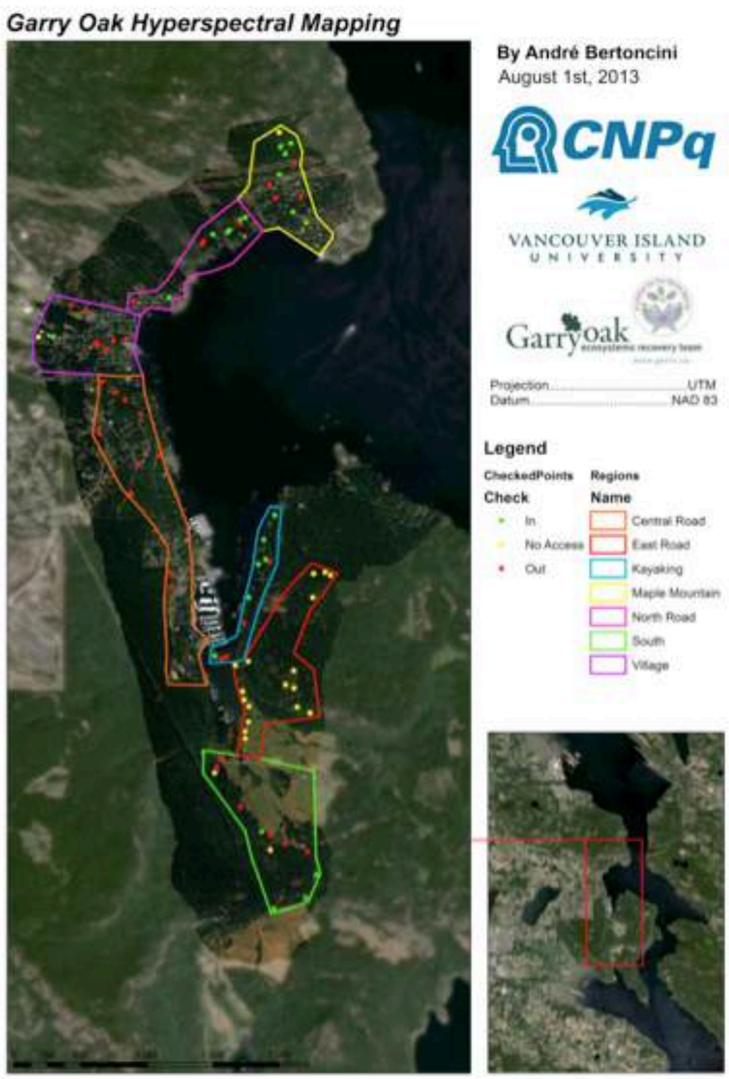


Figure 13. Field verification areas and points. Points in green are confirmed Garry Oak trees. Red points are other species. Yellow points were inaccessible.

# 6.0 Assessing and Building Capacity

## 6.1 Surveys

Essential to achieving ecological connectivity among Garry Oak and other rare and sensitive ecosystems are the support and involvement of those engaged in land use planning, land management, and technical pursuits such as mapping. To gather information relevant to the logistics of connectivity planning, and as a first step to initiating a discussion about connectivity conservation, we surveyed local governments, First Nation groups and others.

### 6.11 Field-testing Surveys

Our local government surveys were tested at two GOERT workshops held December 6 and 7, 2012, with seven local governments. These initial survey respondents found that only 5 to 10 minutes were needed to complete a survey. A trial run was conducted with a planner from Songhees First Nation and a land manager from Lyackson First Nation. The local government surveys were deemed unsuitable for use by First Nations. Melissa Dorey, a member of the Eastern Woodland Métis Nation (Nova Scotia) and VIU student with expertise in Garry Oak ethnobotany, helped modify and distribute the surveys to Island First Nations.

The final surveys were completed and first administered in early to mid December. Planning and mapping surveys were sent by email to specific individuals identified through GOERT contact databases or through local government websites. A third, more in-depth survey focused on data sets developed in-house by a First Nation or local government. This survey was never used but is likely to be valuable in the next phases of the project.

### 6.12 Surveying First Nations

All methods used for the First Nations surveys reflect the importance of respecting protocols embedded in First Nations cultures. To establish a starting point, all First Nation groups on Vancouver Island with potential or known Garry Oak and Associated ecosystems within their traditional territory were identified. Contact information was gathered online. On December 21, 2012, and January 7, 2013, an introductory email was sent to 34 individual First Nation Bands, accompanied by a project overview and links to two surveys.

Due to the lack of response using this generalized approach, methods for obtaining support and involvement of First Nation Bands evolved to more narrowly focus on establishing personal connections. As each First Nations Band is unique with respect to protocols and traditional practices, gaining support and involvement became a three step process where:

1) First Nation Band offices were contacted by phone to identify the name(s) of land managers/ planners and mapping staff and, if possible, obtain personal contact information;

2) Land managers/planners and mapping staff were then contacted by phone to introduce the project team members and an overview of the project, and to explain the project's benefits specifically pertaining to First Nation groups; and

3) With permission of First Nation Band staff, an electronic version of the project overview, links to surveys, and an overview of potential benefits were shared via email.

This approach illuminated additional, cultural project benefits that were not conceived of prior to the engagement of First Nations - including promotion of community health and strengthening of traditional knowledge, which ultimately support cultural identity. A discussion of such benefits while introducing the project generated an immediate level of interest.

By the project's end, considerable effort had been made to obtain contact information for, and communicate with thirty-four individual First Nation Bands on Vancouver Island in order to gain support and involvement in Connectivity Conservation. There was some progress in terms of relationship-building with the majority of First Nation Bands, resulting in a final contact list of 21 interested Bands. Some were removed from the initial list after it was confirmed that their territories were devoid of Garry Oak and associated ecosystems. Others were removed when it was established that they lacked the capacity to participate in the early stages of the project, lacking land managers or mapping staff. There may be an opportunity to use future phases of the Conservation Connectivity project to build capacity within First Nations, and engage with them again in the future. Several Bands in the Capital area were missed and will need to be contacted in the next phase of the project.

Importantly, First Nation support and participation in the Connectivity Conservation surveys cannot be measured by the number of completed surveys. It was clear that the limiting factor in seeking project support and involvement was not lack of interest, but rather, the amount of time and effort required to establish personal connections with multiple land managers and follow First Nation protocol as it relates to relationship-building and conducting business. Establishing positive relations and adhering to protocols involves delicate processes which cannot be rushed.

We understood, and this was confirmed, that email would likely be relatively ineffective and a concerted effort to build relationships would be needed. There was a high level of uncertainty as to whether project overview and links to surveys were reaching land managers and mapping staff. Our efforts were more successful once we focused on establishing personal connections with land managers by corresponding first by phone and then following-up with additional project information via email.

Overall, interest in the project appeared to be strong with all 11 land managers agreeing to take the next step, despite low numbers of surveys being completed to date. Following traditional protocols of First Nation Bands is necessary and typically involves a multi-step process. The land manager must present the project and potential involvement of their First Nation Band to Band Council. Once the Chief and Council have approved the project, it is understood that the land manager may go ahead with supporting the project, including participation in surveys. It is important to note that some Bands only have Council meetings once each month. Also, First Nation Band staff have been overwhelmed with referrals regarding proposed projects, causing important issues to be pushed aside due to a lack of capacity.

### 6.13 Local Government Planning Survey Results

Fifteen local governments within the range of Garry Oak ecosystems on Vancouver Island and the Gulf Islands completed the planning survey. In two cases, more than one individual from a local government completed a survey; because they were from different departments, they provided a window into the diversity of views on connectivity within governments.

The survey shows that natural connectivity is being considered, at least in a general way, in some higher level planning documents (Table 6).

Table 6. Survey Responses: Is natural connectivity (e.g., linking parks, creating wildlife corridors, preventing fragmentation of ecosystems) part of your local government's...?

| Response | Chart | Percentage | Count |
|---|---|---|---|
| Strategic plan | | 18% | 3 |
| Regional Growth Strategy | | 29% | 5 |
| Official Community Plan | | 82% | 14 |
| Regional Biodiversity/Conservation Strategy | | 24% | 4 |
| Parks and Trails Plan | | 41% | 7 |
| Recreation Master Plan | | 0% | 0 |
| Neighbourhood Plans | | 0% | 0 |
| Sustainability Plan | | 18% | 3 |
| Other, please specify... | | 24% | 4 |
| | **Total Responses** | | **17** |

"Other" responses:

| # | Response |
|---|---|
| 1. | Islands Trust Policy Statement |
| 2. | Urban Forest Strategy |

| | |
|---|---|
| 3. | OCP only identifies connectivity as a desirable goal: points to developing a biodiversity network plan as a follow-up project. |
| 4. | at a very general level only, this is part of the Regional Growth Strategy, the CVRD Sustainability Strategy and the rural Comox Valley Parks and Greenways Strategic Plan |

Among local governments surveyed, there were only two connectivity plans completed or in development: 1) the CRD Parks Master Plan (formerly the *Green and Blue Spaces Strategy),* which informs the CRD's Regional Growth Strategy and CRD Strategic Plan; and 2) Islands Trust Future Direction.

The CRD's *Regional Parks Strategic Plan 2012-2021*, available at http://www.crd.bc.ca/parks/documents/regionalparksstrategicplan.pdf, subscribed to the idea that "nature needs half", commits to connecting people to each other and to nature, strives to conserve biodiversity and ecological connectivity, and envisions establishing "in perpetuity, an interconnected system of natural lands" (p. 6).

The plan endeavoured to connect CRD and other communities with a regional trails system; to connect existing parks and protected areas by natural area corridors; and to connect regional parks to other national, provincial and major municipal parks and trails. It proposed specific linkages, such as a connection to the Cowichan Valley through Sooke Hills Wilderness Regional Park.

According to an Islands Trust survey respondent, the guiding document for all planning departments was the Islands Trust Policy Statement, http://www.islandstrust.bc.ca/tc/pdf/orgpolstatement.pdf which stated: "Local trust committees and island municipalities shall, in their official community plans and regulatory bylaws, address the planning, establishment, and maintenance of a *network of protected areas* that preserve the representative ecosystems of their planning area and maintain their ecological integrity."

Most local governments that responded to the survey had considered natural connectivity in the design of Development Permit Areas (DPAs) (Table 7).

Table 7. Survey Responses: Has your local government considered natural connectivity in...?

| Response | Chart | Percentage | Count |
|---|---|---|---|
| Zoning | | 33% | 4 |
| Creation of development permit areas | | 83% | 10 |
| Creation of development approval information areas | | 17% | 2 |
| Other development screening tools | | 8% | 1 |

| | | |
|---|---|---|
| Rainwater management, or runoff control or drainage requirements | 25% | 3 |
| invasive species management | 33% | 4 |
| Planning subdivisions | 42% | 5 |
| Planning for climate change | 25% | 3 |
| Other, please specify... | 33% | 4 |
| **Total Responses** | | **12** |

"Other" responses:

| # | Response |
|---|---|
| 1. | neighbourhood action plans (OCP documents) |
| 2. | not that I'm aware of, we are awaiting mapping |
| 3. | City of Campbell River Marine Foreshore Habitat Assessment and Restoration Plan |
| 4. | most of these do not apply to the regional level |

Most jurisdictions had some foundational tools for connectivity planning, such as habitat atlases or Environmentally Sensitive/Significant Areas (ESA) mapping (Table 8).

Table 8. Survey responses: If your local government has developed map products or tools for connectivity planning, please list and provide a brief description of each.

| # | Response |
|---|---|
| 1. | Islands Trust has our own in house Sensitive Ecosystem Mapping, but does not yet have mapping for connectivity planning. |
| 2. | We will be conducting a 'watershed blueprint' beginning this year on one inter-jurisdictional watershed |
| 3. | Environmentally Significant Areas Atlas and GIS layers. |
| 4. | We are working on connectivity mapping for our next regional conservation plan. |
| 5. | The District has no known intact Garry Oak ecosystems. My guess is that there are less than 6 patches in the District. I could be wrong... [Note: There are Garry Oak ecosystems in this jurisdiction.] |
| 6. | While connectivity isn't specifically mentioned, the City's OCP Environmental Develop Permit Area maps are a tool that help support planning for ESA connections. |
| 7. | Environmentally Sensitive Areas Atlas Environmental Development Permit Areas Atlas Streamside Development Permit areas Atlas |
| 8. | None developed at present |
| 9. | We rely on our GIS system to identify these areas. This system is currently for internal use only. |
| 10. | CRD Atlas |
| 11. | Conservation framework map in the Regional Growth Strategy, Recreation Inventory and Biodiversity Corridors map, Appendix 2 of the Rural Comox Valley Parks and Greenways Strategic Plan |

The survey response in Table 9, in combination with discussions held with local governments, suggested that prioritization of natural areas for protection is often opportunistic, or based on public demand, rather than a science-based process. This is consistent with Clermont (2006), who found that many reserves were protected for recreational interests, and Hanna et al. (2008) who discovered that protection was largely conflict-driven. A premise of this connectivity initiative is, that to conserve connectivity, one or more types of science-based processes will likely need to be implemented that identify and prioritize core areas or hubs as well as linkages for protection.

Table 9. Survey responses: How does your local government select and prioritize acquisition/securement of parks and other types of natural reserves?

| # | Response |
|---|---|
| 1. | Parkland dedication through Section 941 of the LGA during the subdivision process. |
| 2. | In accordance with Section 941 of the Local Gov't Act. Regional parks are acquired slowly with public funds or by private donors. |
| 3. | at time of subdivision application review and rezoning application review |
| 4. | Islands Trust cannot acquire parks; however, we can require parkland through subdivision, rezonings...that must be held by another agency/public body with the authority to do so. Islands Trust Fund Regional Conservation Plan and/or consultation with Islands Trust Fund is factored into decisions regarding development applications with conservation opportunities/elements. |
| 5. | We need to update our acquisition strategy. The last two nature parks were dedicated, which was very fortunate. |
| 6. | We have a list of priority properties, and a set of criteria for unplanned opportunities |
| 7. | Regional Parks and Trails Plan has identified priority areas/sites for acquisition |
| 8. | Most acquisitions have been opportunistic - by donation or put forward by a local conservation organization or park agency. However, we do have an applications process for these areas and they are required to meet the goals and objectives of a regional conservation plan. We are working towards being more strategic. |
| 9. | No formal process other than via riparian areas acquisitions or Right of ways/covenants. |
| 10. | Environmentally sensitive areas (ESAs) as defined in the OCP are generally returned to crown/City as development occurs. A typical example is a riparian setback determined through an RAR assessment by a QEP. ESAs cannot be donated in lieu of the 5% parkland requirement. |
| 11. | We have a list of preferred sites based on acquisitions or through development |
| 12. | Sidney is close to completely built out so there are not many subdivisions or developments large enough to require parkland acquisition by the Town. Sidney is a coastal community and the Development Permit areas we have identified in our OCP reflect that: they are mainly for protection of marine life and wildlife (Roberts Bay); protection and conservation of salt marsh and estuary habitat (Mermaid Creek); protection of significant stand of Douglas Fir and Arbutus as fragile vegetation and wildlife habitat (Beaufort Road); and protection and enhancement of the creek as habitat for salmon, trout and other aquatic life and wildlife (Reay Creek). |

| | |
|---|---|
| 13. | There are various policies in the OCP that speak to park acquisition and protecting natural areas. In general the District does not support taking natural areas as park land dedication for subdivision as park land should ideally be functional space. Although in some specific situations staff may recommend this depending on the size and/or feature. |
| 14. | The municipality does not have an overall vision - we only respond to opportunities when they come up. |
| 15. | Under Protected Greenspace Policy Area - protect ecosystems, provide habitat for plants and animals, and support the natural cleansing of water and air. Regional Parks also contribute to the economy and tourism; walking, hiking and visiting parks are the top three activities enjoyed by visitors to the Capital Region. |
| 16. | We have identified priority areas for acquisition in the Comox Valley parks and greenways strategic plan, 2011-2030. The plan includes some areas that largely meet recreation goals and some that would protect rare ecosystems, e.g. coastal sand ecosystem and Garry Oak ecosystems. The parks and greenways strategic plan also includes a set of acquisition criteria to help assess recreation, social, cultural and conservation values of areas of interest as potential park or greenway. |

Additional comments included statements of need for Connectivity Conservation, or suggested that connectivity planning faced a number of challenges, such as funding, political will, reliance on the SEI, and existing processes associated with ecosystem protection.

“This survey highlights that although environmental actions, policies etc. are wide ranging throughout the City literature we have not clearly identified "connectivity conservation". This is an outstanding need that we can incorporate into our proposed climate adaptation plan.”

“There are a couple of large gaps in our OCP; natural connectivity is one of them. Tackling the work within a comprehensive Parks & Open Space Master Plan process has been an un-funded municipal project for 4 or 5 years. It is a challenge to get support for this work among other priorities of Council.”

“Our OCPs speak very broadly about ecosystem protection, and leave it up to the professional biologist to identify the ecosystem that may be impacted, and to suggest measures for protection through development -so we don't have a consistent policy/standard that we use in every development review to specifically consider e.g. wildlife corridors and connections.”

### 6.14 Local Government Mapping Survey Results

There were fifteen responses to the mapping survey, representing 13 local governments. Mapping services resided in multiple departments, most frequently planning, engineering, and Information Technology. They were also found in Infrastructure Services, Information Services/ Systems, Development Services, and Finance (IT Division). All (13) respondents said their local government had mapping software. Ninety-three percent (13) used ArcGIS and 57% (8) also use or exclusively use AutoCAD software. Most had software versions dated 2010 or later. Eighty-six percent (12) did not rely on external companies for mapping. Fourteen percent (2) relied on external companies for mapping products. One respondent noted a reliance on senior governments for mapping services.

For digital imagery, respondents used colour and/or black and white orthophotos, with dates ranging from 2007 through 2013, and resolutions ranging from 10 cm - 1 m. Forty-six percent of respondents (6) used LiDAR, dated 2007 or later, with a point spacing of 10 points per square metre, vertical accuracies of 15 cm, or spatial resolutions ranging from 1.5 to 2 metres (Table 10 ).

Table 10. Survey Responses: Terrain data sets used by local governments

| Response | Chart | Percentage | Count |
|---|---|---|---|
| Small-scale (e.g., NTS 1:50,000) | | 0% | 0 |
| Terrain Resource Inventory Management (TRIM) 1:20,000 | | 54% | 7 |
| Light Detection and Ranging (LIDAR) | | 46% | 6 |
| Other high resolution terrain | | 15% | 2 |
| Other external data set | | 8% | 1 |
| Internal data set (e.g., survey-based) | | 46% | 6 |
| | **Total Responses** | | **13** |

Use of hydrological datasets is shown in Table 11. Internal datasets included historical streams; updates to other datasets; watershed and drainage mapping; a sensitive habitat atlas; and drainage basins, watercourses, waterbodies, ditches and aquifers.

Table 11. Survey Responses: Hydrological data sets used by local governments

| Response | Chart | Percentage | Count |
|---|---|---|---|
| Terrain Resource Inventory Management (TRIM) 1:20,000 | | 67% | 8 |
| Watershed Atlas | | 25% | 3 |
| Other external data set | | 17% | 2 |
| Internal data set | | 50% | 6 |
| | **Total Responses** | | **12** |

Local governments used a variety of external land use/land cover datasets, including datasets from the Habitat Acquisition Trust (HAT) and Caslys Consulting; Google Maps; mapping by Lynda Fyfe and Nick Page showing the distribution of Garry Oak trees; and 2002, 1:20,000 Forest Cover Inventory, a parcel-based land use inventory (Table 12). Zoning and cadastral datasets were offered as internal land use/land cover datasets.

Table 12. Survey Responses: Land use/land cover data sets used by local governments

| Response | Chart | Percentage | Count |
|---|---|---|---|
| Small-scale (e.g., Baseline Thematic Mapping 1:250,000) | | 9% | 1 |
| Other external data set | | 45% | 5 |
| Internal data set | | 55% | 6 |
| | **Total Responses** | | **11** |

Ninety-two percent of respondents (12) used the SEI. Thirty-eight percent (5) used CDC element occurrence mapping, which locates imperiled ecosystems (Table 13). The Islands Trust has extensive TEM (i.e., 2007 Gulf Islands National Park Reserve; 2008 CDF; 2008 Saltspring Island; 2010 Howe Sound; 2011 Executive Islands). One respondent mentioned the CAPAMP (see https://www.for.gov.bc.ca/hfd/library/documents/bib94911/bib94911.htm). Another local government had internal data for fish bearing streams, invasive species, and marine features.

Table 13. Survey Responses: Ecosystem data sets used by local governments

| Response | Chart | Percentage | Count |
|---|---|---|---|
| Vegetation Resource Inventory (VRI) | | 8% | 1 |
| Terrestrial Ecosystem Mapping (TEM) | | 23% | 3 |
| Sensitive Ecosystem Inventory (SEI) | | 92% | 12 |
| Biogeoclimatic Ecosystem Classification (BEC) | | 38% | 5 |
| BC Conservation Data Centre occurrence mapping | | 38% | 5 |
| soils mapping, please specify | | 15% | 2 |
| Other External | | 15% | 2 |
| Other Internal | | 23% | 3 |
| | **Total Responses** | | **13** |

Only seven responded to the question about protected area datasets (Table 14). Most of these used internal datasets. One respondent commented that the Land Trust Alliance of British Columbia (LTABC) database was incomplete. Respondents also noted Wildlife Tree Areas, eagle and heron nest trees, Federal Bird Sanctuaries, Environmental Development Permit Areas (EDPAs), Streamside DPAs, Marine Area DPAs, and municipal and regional parks.

Table 14. Survey Responses: Protected Area data sets used by local governments

| Response | Chart | Percentage | Count |
|---|---|---|---|
| Protected Lands Catalogue (from LTABC) | | 14% | 1 |
| Provincial protected areas (parks, ecological reserves, wildlife management areas, etc.) | | 57% | 4 |
| Federal protected areas - National Framework Canada Lands Administrative Boundaries | | 43% | 3 |
| North American Conservation Areas Database | | 0% | 0 |
| Other External | | 14% | 1 |
| Other Internal | | 71% | 5 |
| | **Total Responses** | | **7** |

Aside from BC Crown Tenures (Table 15), respondents relied on the BC Land Titles office, BC Assessment, Integrated Cadastral Information Society (ICIS) parcel fabric, Agricultural Land Reserve land status, maps for Private Managed Forest Lands, and tabular datasets (not in map form).

Table 15. Survey Responses: Tenure data sets used by local governments

| Response | Chart | Percentage | Count |
|---|---|---|---|
| BC Crown Tenures | | 75% | 6 |
| Other External | | 50% | 4 |
| Other Internal | | 38% | 3 |
| | **Total Responses** | | **8** |

Only five responded to a question about disturbance datasets (Table 16). One respondent found that the MFLNRO Invasive Alien Plant Species mapping was too localized, but regularly used TEM with its disturbance and structural stage codes.

Table 16. Survey Responses: Disturbance data sets used by local governments

| Response | Chart | Percentage | Count |
|---|---|---|---|
| Terrain Resource Inventory Management (TRIM) | | 20% | 1 |
| Forest activity (e.g., tenure roads or cutblocks) | | 20% | 1 |
| MFLNRO Invasive Alien Plant Program | | 20% | 1 |
| Community Mapping Network Invasive Species Atlas | | 40% | 2 |
| Habitat Acquisition Trust Tree Cover and Impervious Surface Mapping | | 40% | 2 |
| Other External | | 40% | 2 |
| Other Internal | | 20% | 1 |
| | **Total Responses** | | **5** |

One respondent had created a shoreline layer sourcing DEM of LiDAR ground points, noting also that one can model for sea level rise/encroachment using ArcGIS. Two respondents mentioned climate mapping and modeling tools that may be used in the future: one was a commissioned report from Pacific Climate Impacts Consortium (PCIC) on regional climate impacts assessment for Georgia Basin, and the other projected sea level rise mapping at a provincial scale.

Additional comments are provided below.

| # | Response |
|---|---|
| 1. | Our water features mapping is not spatially accurate or current. Still using MoE 1980's paper maps. |
| 2. | Ladysmith is a small town with minimal resources. Generally ground truthing is affordable and efficient for staff. If a larger rezoning application is received the applicant is asked to provide an environmental analysis and contour information. Mapping resources and skills are very limited at this time. |
| 3. | We are a fairly new GIS Department and obtain much of our conservation data from Project Watershed here in Courtenay. I would be happy to assist and support whatever initiatives you may have. The best we can offer is our LIDAR data (spring 2012), as well as our 10 cm orthophoto. |
| 4. | Getting full, comparable regional data coverage is an issue for us as we have a small area with a number of different jurisdictions. |
| 6. | no funding to maintain eagle nest trees. RAR data is butchering our hydrology dataset (b/c parcel based edits). SEI is outdated and not being maintained. |

### 6.15 First Nations Planning Survey Results

Four responded to the First Nations planning survey. Natural connectivity was considered in Comprehensive Community Planning (CCP) for half of respondents (2). One respondent stated that, “it will be outlined in our proposed CCP and strategic plan”. Another respondent said it was part of the Nation's Land Code and ESA (in process). With a Land Code, First Nations are able to govern their own lands and resources (see presentation by K. Cossey in GOERT, 2012). Another First Nation was collecting information for the development of various community planning exercises. No connectivity plans had been completed.

Half (2) of respondents had considered natural connectivity in developing Development Approval Information Areas (DAIAs) (Table 17). Another was in the process of integrating connectivity into the various other tools.

Table 17. Survey Responses: Has your Tribal Council/First Nation considered natural connectivity in...?

| Response | Chart | Percentage | Count |
|---|---|---|---|
| zoning? | | 25% | 1 |
| creation of development permit areas? | | 25% | 1 |
| creation of development approval information areas? | | 50% | 2 |
| other development screening tools? | | 25% | 1 |
| rainwater management, or runoff control or drainage requirements? | | 25% | 1 |
| invasive species management? | | 25% | 1 |
| planning subdivisions? | | 25% | 1 |
| planning for climate change? | | 25% | 1 |
| resource extraction programs or projects? | | 25% | 1 |
| Other, please specify... | | 50% | 2 |
| | **Total Responses** | | **4** |

Towards connectivity planning, one First Nation was archiving spatial traditional knowledge. An Aboriginal Fund for Species at Risk (AFSAR) project included planning for rare and cultural species habitat management and restoration.

In general, First Nations have a much different perspective on protection than do other governments or stakeholders (Table 18).

Table 18. Survey Responses: How does your Tribal Council/First Nation group select and prioritize securement of additional lands or protection of natural areas?

| # | Response |
|---|---|
| 1. | Not sure what this means. We do have a checklist that we use when a land referral is received from a third party or government body. |

| | |
|---|---|
| 2. | Need identifies priorization, Indian Affairs sets out the criteria for need; basically for housing and economic development; housing primarily. I'm not sure the Lyackson buy into 'parks or protected areas' - this is a band aid approach to managing human behaviour. Our culture dictates we manage our behaviour 'uy shqwalawun' good thoughts, good manners, good behaviour in all that we do, including "our place in the natural world" we unlike the non-native society cannot be separated from the natural world. we are a part of it, it is a part of us. |
| 3. | - referral process - land use planning - marine ecosystem planning |
| 4. | Housing is the most critical issue for acquisition of additional lands. Capacity is limited in ensuring those lands are developed and managed for natural area protection. We hope that the CCP, Land Code and ESA initiatives will help with this important aspect of Cowichan culture: ie, cultural connection to the natural environment. |

### 6.16 First Nation Mapping Survey Results

There was only one response to the First Nations mapping survey. This respondent anticipated acquiring ArcGIS by year-end, had some internal capacity for smaller projects, and relied on the Treaty Group to provide mapping services for larger projects. From earlier discussions with First Nations, it was clear that few have in-house mapping support and software.

### 6.2 Meetings and Dialogues

In their literature review of biodiversity conservation and climate change adaptation, Heller and Zavaleta (2009) were alarmed to find that most recommendations neglected the social aspects, such as cooperation with landowners and the role of human behaviour in determining conservation outcomes. During the course of this project, every opportunity was taken to meet and speak with government staff and representatives, members of First Nations and First Nations staff, as well as other interest groups and individual stakeholders. Meetings, and presentations followed by dialogue sessions were used to gather views and suggestions regarding further development of the prototype, and connectivity planning and implementation.

In February 2012, we hosted a series of Connectivity Conservation dialogue sessions to bring together representatives from senior and local governments, First Nations and corporate landholders to discuss habitat protection for species at risk. Participants commented that it was the first time that planners, land and wildlife managers, and on-the-ground workers had come together to talk about the challenges and opportunities associated with species at risk protection and restoration. They requested continued opportunities for information exchange and better tools to plan and manage at-risk ecosystems. The results of these dialogue session are documented in a separate report (GOERT, 2012).

Connectivity Conservation presentations were later provided to staff from the District of Highlands, Islands Trust, District of Saanich, City of Colwood, City of Victoria, and the Capital Regional District in the Town of View Royal on December 6, 2012. Oak Bay and District of Saanich staff, Friends of Uplands Park and a keen Oak Bay resident attended a presentation in

Oak Bay on December 7. On January 8, 2013, a presentation was provided to Islands Trust North planners and an Islands Trust Fund representative on Gabriola Island. A presentation to a large and diverse group of local government representatives, including engineers, planners and Council members, was held in Colwood on May 29, at the request of BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) organizers. These, and smaller meetings held with District of Saanich and CVRD mapping staff, BC Ministry of Environment and MFLNRO staff, District of North Cowichan planners, the Director of Lands and Real Estate Operations and land manager at Songhees First Nation, Project Watershed, and others, helped to shape the project and its outcomes.

We hosted two dialogue sessions in the pilot area itself. The first was held with Cowichan Tribes on July 24, 2013, and the second with local and senior governments and non-profit groups on September 11, 2013. Cowichan Tribes Chief, Council and certain staff members were invited to the second dialogue but were unable to attend. A presentation was given to the representatives of GOERT's expert advisory committees on September 20, 2013. Additionally, GOERT discussed the status of the project with attendees at a Real Estate Foundation networking event in Parksville in June 2013.

A list of the agencies and organizations reached through this project is provided in Table 32. A few individuals attended one or several events, helping the project develop as the year progressed.

Table 19. Agencies and organizations reached from October 15, 2012 through September 20, 2013

| Agency/Organization | # of Representatives |
|---|---|
| BC Ministry of Environment (meeting with BC Parks, meetings with Conservation Date Centre, GOERT Team meeting) | 4 |
| BC Ministry of Forests, Lands and Natural Resource Operations (3 meetings, Colwood event, Cowichan SSI dialogue, GOERT Team meeting) | 9 |
| Capital Regional District (View Royal and Colwood events) | 8 |
| City of Colwood (View Royal and Colwood events) | 7 |
| City of Duncan (Cowichan SSI dialogue) | 1 |
| City of Langford | 1 |
| City of Victoria (View Royal and Colwood events, GOERT Team meeting) | 3 |
| Cowichan Tribes (meeting and dialogue) | 6 |

| Agency/Organization | # of Representatives |
|---|---|
| Cowichan Valley Regional District (2 meetings and Cowichan SSI dialogue) | 3 |
| District of Central Saanich | 1 |
| District of Highlands (View Royal and Colwood events) | 2 |
| District of Metchosin | 1 |
| District of North Cowichan (meeting, Colwood event and Cowichan SSI dialogue) | 4 |
| District of North Saanich | 2 |
| District of Oak Bay (Oak Bay event) | 6 |
| District of Saanich (meeting, View Royal, Oak Bay and Colwood events, GOERT Team meeting) | 7 |
| District of Sooke | 3 |
| Environment Canada (Colwood event) | 1 |
| Friends of Uplands Park (Oak Bay event) | 2 |
| Islands Trust (meetings, View Royal, Gabriola Island and Cowichan SSI dialogue) | 12 |
| Nature Conservancy of Canada | 1 |
| Parks Canada | 1 |
| Project Watershed | 1 |
| Songhees First Nation (meeting) | 2 |
| Town of Sidney (Colwood event) | 2 |
| Town of View Royal (View Royal and Colwood events) | 2 |
| Township of Esquimalt | 1 |
| Other (View Royal, Oak Bay events, Cowichan SSI dialogue) | 3 |
| TOTAL | 96 |

*Each dialogue session included a presentation to explain the complexities of Connectivity Conservation.*

**6.21 Goal-setting**

Information gathered from these meetings shaped the project as it developed. Prior to the dialogue sessions in the Cowichan Valley/Saltspring Island pilot area, eight goals were identified for the next phase of the Connectivity Conservation Project (Table 20). The dialogues helped to define some of the challenges and opportunities associated with these goals. For future connectivity planning, goals 1 through 4 are guiding principles. Goals 5 to 7 are technical in nature, to create a model that builds upon this work. Goal 8 reminds us to link the technical and practical aspects of connectivity planning. Here, landscape connectivity planning is not just a technical exercise whereby tools are developed to support policy development protecting corridors, enhancing stepping stones, or maintaining a permeable landscape. It is also an assignment to examine how policies, legislation, and incentives can be developed that use and demand ongoing mapping and modeling efforts.

Table 20. Goals, Challenges (C) and opportunities (O), from meetings and pilot area dialogue sessions.

| Goal | Comments from Pilot Area Dialogues |
|---|---|
| 1. Create a mindset where the landscape is seen as permeable, a network of patches of ecosystems that work together. | • O: Connectivity data and connectivity corridors can be used for many other purposes, such as Integrated Flood Management modeling, conservation of salmonids, and mapping access to medicinal resources for First Nations.<br>• O: As a society, we are slowly taking a broader landscape view, rather than a parcel by parcel view.<br>• O: There is so much overlap - corridors are going to be through some of the areas we have been trying to protect, because they are the most natural areas remaining.<br>• C: Planners are in a Catch 22 with forest lands. We're not supposed to provide guidance regarding forestry activities because we're not foresters, yet we need to protect the functions on forest lands that affect other areas.<br>• C: There are 2000 houses in elk habitat. There are elk corridors, but [the landowners] all have dogs, ATVs, mountain bikes that use the corridors. We need to start to look at social relationships.<br>• C: What needs protection? We need to look at the matrix, at land use bylaws, at excluding some areas from connectivity planning. |
| 2. Champion climate change adaptation through biodiversity conservation and ecosystem connectivity. | • O: It's about changing the way people look at their backyards. By protecting nature on their own property they are protecting their own well-being in the future. They are lucky to have that in their yard [for climate change adaptation] (also applicable to Goal 1).<br>• O: We have got to get all the local governments and the Province to agree on a few principles, [supporting the idea] that connectivity is key.<br>• O: We have to explain it doesn't always mean a no go zone, there are ways to develop....<br>• O: Councilors need to understand that the municipality owns land that has ecosystems that are globally significant. The third highest ranked element occurrence in the world. "The land that I am responsible for is really important." They need to put it into context. This has brought some people around.<br>• C: As a Councilor, this is huge but one tiny piece of what I need to be thinking about. It's complicated and difficult for me to debate effectively. I don't have the expertise. With the CDF, I have better knowledge. I have been to some workshops and they have changed my thinking. Some of my colleagues don't spend time doing research beyond what goes on at the table.<br>• C: From planners I often hear, "That's not really for me, I rely on the biologist we hire, that's too complicated, I don't want to know about it".<br>• C: All of these people have stuff going on with their lives - their mom has cancer... Things get dropped. Staff are overwhelmed, working late, sending email at 10 p.m. |

| Goal | Comments from Pilot Area Dialogues |
|---|---|
| 3. Develop planning and management systems that reach across administrative boundaries, including property lines. | • O: This project could be used to build GIS and other forms of capacity within First Nations.<br>• O: The urban fire interface - they are telling people to remove all vegetation on your property because of fuel ladders. Maple Mountain is an example of an incredibly dry ecosystem, an incredibly vulnerable ecosystem to a fire, but these ecosystems were developed to be relatively resistant to fire. People should know that you can enhance your ecosystem and protect your house from fire. It's not an either/or.<br>• C/O: Some say, why bother? The Crown lands are all going to treaty lands anyway. We [the Province] wrote the legislation where requirements on the forest land base are less. Sometimes we can't get information on provincial Crown land where others have tenure. [Tenure holders] are reluctant to come to the table. They don't like that we roped in CWHxm1. We have to work with the people that are willing to work with us.<br>• C: Connectivity has never been a very big focus, even where there have been watershed and other landscape level plans. Connectivity was intended but never happened. The Province admittedly has not been a leader.<br>• C: There are so many jurisdictions at a landscape level. How to do this landscape level analysis when looking at all these little players? I would have trouble working outside of my jurisdiction.<br>• C: My section in my region is strapped for resources and staff... (provincial) (Capacity was an ongoing theme.) |
| 4. Find a place for connectivity in the economic development - environmental protection equation. | • C: With a land code, First Nations reserve lands are more open for business than ever.<br>• C: For me it's a no brainer, these areas need to be protected, but not everybody else thinks that way. "We could make millions of dollars if we develop that forest."<br>• C: Partisanship is a really big barrier to getting to decisions. Their political ideology says, "This looks like fact," or "you're wrong". |
| 5. Amalgamate data for ecosystems and resistance layers. | • O: Cowichan Tribes has completed botanical inventories that could be operationalized within the context of this project.<br>• O: Even as a new model is being developed using the new technologies, it is important to continue amalgamating existing data layers, showing some level of connectivity, bringing in the zoning and protected areas. Get GIS departments working on it, playing with it, understanding that it's their own.<br>• O: In a discussion about the point at which to add protected area and cadastral layers: A site may have high values, but no opportunity. We need to do a reality check. We face this all of the time - ongoing resource extraction at the same time we're saying we have to conserve the ecosystem.... Maybe we need to do that first analysis and then look at opportunity.... Opportunity versus "let's look at the issues and pressure points and find the best possible solution"... Maybe do it all at once.... A landscape has to have an intact, functioning ecosystem. You need to know that at the end of your corridor something is going to be there later on. |

| Goal | Comments from Pilot Area Dialogues |
|---|---|
| 6. Realize the potential of LiDAR and hyperspectral data. | • O: It would make sense to tap into federal funds - to refine the spectral signature of the trees, which would lead to more accurate identification of ecosystems, and steps to protection.<br>• O: The SEI is often disregarded by developers and other landowners. “That’s a big blob. My property doesn’t have that on it.” Planners may not have time to get out and look at it, or look at an orthophotos and decide there is not much there. What we need is... these are the areas, these are potential corridors. This is where we need to go in an urban framework.<br>• O: Response to the comment that BC Parks is reticent of doing anything outside of its land base: CVRD has LiDAR and hyperspectral coverage of BC Parks.<br>• O: TEM, as an older tool, has rigour and a standardized process, but we have to take advantage of something that is much more fluid.<br>• O: LiDAR [is used] provincially for hydrology work and measuring mass wasting of landslide events.<br>• O: Response to the question, “Can you pick out sub-canopy flyways with LiDAR?”: Yes, with LiDAR you can do 3D structural mapping, from canopy to bare earth and everything in between. The dataset and tools are useful beyond Garry Oak. Old Growth analysis is related. |
| 7. Create a model that meets policy needs and is in a policy relevant format. | • O: I am always looking for that right moment to say, “Here’s this great mapping, go put it in your OCP”.<br>• O/C: The data must be in a usable format, easy to incorporate, at a scale that you can work with - not a pdf, not another website. It must be a derivative product for use in our own GIS. I often hear, “I don’t understand [the tool], no one has told me to use it”.<br>• O: What are the incentives in doing anything about it?...We should try to move towards a tax-based fund of some kind.<br>• O: If you protect your riparian area, we will give you tax relief... It’s a small area... There is the expense of an RAR report. This is in discussion... Even a $100 bonus [makes a difference.] Private land incentives are key.<br>• C: That the Garry Oak tree is not protected, while the ecosystem, which relies upon the trees, is imperiled, constitutes a significant legislative gap.<br>• C: What is needed is inventory, available at the click of a mouse.<br>• C: A planner at a public meeting will be asked, “What does connectivity mean? Does it mean I can’t build my house, I can’t have fences?” [Council will ask,] “Why do you need this, why aren’t existing tools doing it for us?”<br>• C: Planners are generalists. Developers want things through as quickly as possible. We need a schedule and a map in the OCP. If I say “Don’t develop in this property,” I will get pushback. I need enough to back it up. All too often, people say “This will take too much time.” There is too much on our plates. We need it to be simple.<br>• C: All too often, it’s “We’ll give you that if you give us this.”<br>• C: [With regulations]... DPAs, there is a confrontational mindset. Politicians who suggest them will get voted out. We need to educate the electorate. |

### 6.22 Indigenous Knowledge and Eco-cultural Restoration

First Nation perspectives on biodiversity and ecological connectivity were interwoven with their views of Traditional Ecological Knowledge (TEK) and eco-cultural restoration. Traditional Ecological Knowledge (TEK) is place-based knowledge from having engaged in natural resource use over a long period of time (Charnley, 2007). 'Eco-cultural restoration' involves restoring both the ecosystem and cultural knowledge and practices that have shaped that ecosystem historically (Pukonen, 2008). Renewing the relationship between ecological and cultural health is the foundation of eco-cultural restoration. For example, a successful eco-cultural restoration project was spearheaded by the Songhees First Nation and a team of ethnobotanists on Discovery Island, near Victoria, BC in July of 2000, resulting in the first harvest of Blue/Common Camas *(Camassia quamash)* bulbs in more than a century (Higgs, 2005). In addition to harvesting camas seeds and replanting on nearby sites, weeding programs were initiated and prescribed fire was reinitiated.

In our Connectivity Conservation meetings, restoration was often focused on access to traditional foods and medicines. A land manager for the Tseshaht First Nation described camas as a cultural keystone species - a staple food important for regulating insulin and preventing diabetes. Several others described the re-introduction of traditional foods into First Nation diets as fundamental to cultural identity and community health and well-being. They referenced multiple health issues currently affecting First Nation members, and how western diets and medicines were hindering the overall health of First Nation peoples.

Increasingly, ecological and Indigenous cultural linkages are explored and discussed in scientific literature. For example, Charnley (2007), in *Integrating traditional and local knowledge into forest biodiversity conservation in the Pacific Northwest,* reminds us that 'pristine' or 'wilderness' experienced by early settlers were actually shaped for thousands of years by a combination of biological and cultural forces. Maffi (2005) showed how the world's biological and cultural diversity hotspots overlapped (cited in Charnley, 2007). Still, the authority of western science and the increasingly technological structure of restoration may hinder the use of eco-cultural restoration in connectivity conservation (Higgs, 2005).

There are other challenges, foremost being the decline of TEK over the past 50-60 years (Turner & Turner, 2008). Turner and Turner (2008) believed that the cumulative effects of colonialism had contributed to losses of cultural knowledge relating to the sustainable production, harvest, processing and use of plant foods and medicines. Our meetings and dialogues revealed that prominent elders were themselves learning TEK and how to practice eco-cultural restoration, primarily to enable the transfer of skills and knowledge to their communities' youth. Most Nations had lost access to large parts of their traditional territories and the food systems with which they had maintained their food security and cultural identity. In general, First Nations participating in the Connectivity Conservation project were supportive of connectivity conservation initiatives if they served to 1) help transfer traditional knowledge and practices to youth in their communities, and 2) identify points of access to cultural foodstuffs in their traditional territories, without giving away the location of these sites to others.

# 7.0 Next Steps

Connectivity Conservation developed a protoype to model connectivity for a pilot area, identified a suite of potential focal species to test future models, explored how LiDAR and hyperspectral imagery could be used to identify remnant Garry Oak, and identified how to build capacity for connectivity planning among local governments and First Nations. On the premise that GOERT will be unable to carry this project into its next phase, this section outlines steps needed to enhance our model, summarizes some key findings from surveys, meetings and dialogues, and explores how the project might be guided into the future. Please see 6.21 Goal-setting, for additional recommendations.

### 7.1 Modeling for Connectivity

The prototype we developed could be enhanced in several ways.

1. Improve the Habitat Concentration Areas layer with additional ecosystem data, since moving beyond the SEI is, in and of itself, a valuable step towards greater precision in land use planning and land management;
2. Improve each resistance layer with data from each jurisdiction, add a forest structure layer derived from LiDAR, and investigate changing the slope layer to an aspect layer;
3. Create resistance values that are specific to BC, or other, larger scales suitable for regional or local planning and management;
4. Include focal species in the model, for example, by developing a binary habitat surface for each focal species, where each grid cell is a raster designated as habitat or non-habitat based on habitat suitability models (WHCWG, 2010);
5. Consider species interactions (cf., Collinge, 2009; Woodward et al., 2010);
6. Add climate data, for example, conducting a climate gradient corridor analysis (cf. Nuñez 2011 and the WHCWG Climate Change Analysis at http://waconnected.org/climate-change-analyses/); and
7. Use a combination of LiDAR and hyperspectral data. This will require efforts to develop a spectral signature for Garry Oak, and additional work to to develop spectral signatures for associated ecosystems. Because Linkage Mapper uses a vector-based Habitat Concentration Areas layer, new modeling software or a revision to Linkage Mapper must be created to accommodate a raster-based Habitat Concentration Areas layer.

### 7.2 Connectivity Planning and Implementation

All aspects of Connectivity Conservation - modeling, the use of remote sensing technologies to improve the precision of modeling, and dialogue across jurisdictional boundaries, generated interest and enthusiasm among project participants.

Many local governments within the range of Garry Oak and associated ecosystems had taken steps to address ecological connectivity, by including the concept in higher level plans such as OCPs, Regional Growth Strategies, and Parks and Trails Plans. In general, connectivity planning appeared to coincide with the development of these higher level plans, and was perceived primarily as a broad landscape-scale issue. Moving forward, it will be necessary to ensure that connectivity mapping is scaleable, taking into account both the regional landscape and small, local parcels. Currently, connectivity planning typically relies on visual assessments of maps or digital map layers. A science-based method, particularly map layers created using LiDAR and hyperspectral data, is expected to make connectivity planning and decision-making more objective and defensible.

The local governments in the pilot area, and at least one local government within other regions were interested in the project and very willing to share their datasets. There is an appetite for additional pilot areas.

Almost all local governments but very few First Nations had the capacity to run their own connectivity models in ArcGIS, should a working baseline model become available to them. The flexibility and confidentiality of internal modeling capability, while being standardized with neighbouring jurisdictions, was appealing to all.

For First Nations, connectivity initiatives may help plan housing developments on reserve lands, as housing is a critical need and without careful planning, some Garry Oak ecosystems could be lost. They also see its potential to provide access to and conserve increasingly rare cultural resources within the landscapes outside of their reserve lands, over which they currently have little control. Projects to restore connectivity to ecological and cultural resources and landscapes was also viewed as a way of engaging youth and strengthening cultural identity.

Among First Nations, connectivity is inherent in their understanding of traditional landscapes. Most do not subscribe to the concept of protection as parkland, having lost access to important fishing areas and hunting grounds as areas became designated as parks. Rather, a common assertion is that everything is indeed connected, people are part of the natural landscape, and we collectively need to be competent guardians of that landscape.

By incorporating the idea of a permeable landscape, and the need to support connectivity within our own backyards, the project had a positive, cooperative flavour. However, local governments involved in the dialogue sessions recommended public education as a prerequisite to connectivity planning, anticipating push-back from landowners when linkages are identified and conservation measures are introduced. The notion of climate change adaptation through biodiversity conservation and ecological connectivity was virtually unknown and will need to be explained and promoted to enable widespread support.

**7.3 The Future of Connectivity Conservation**

If this project could be summed in a word, it would be *enthusiasm*. Nearly everyone that came into contact with Connectivity Conservation was struck by its possibilities, particularly its potential to engage private landowners in conservation, and to advance the use of LiDAR and hyperspectral technologies in ecosystem mapping. With GOERT unable to move forward with the project in 2013, several organizations and individuals expressed interest in advancing or contributing to a future project.

In autumn 2013, one third of a class of fourth year Geography students at the University of Victoria was dedicated to creating spectral signatures for Garry Oak and other deciduous species in the Cowichan Valley/Saltspring Island pilot area. The VIU Advanced GIS program was eager to continue to develop the model and fine-tune the remote sensing analysis. Several local government survey respondents and meeting attendees expressed interest in contributing data to, and participating in additional pilot projects.

Cowichan Tribes staff members expressed interest in expanding the pilot project to encompass all ecosystems within their traditional territory. CVRD staff were interested in participating in a formal natural and social science research partnership with adjacent jurisdictions and institutions, with an emphasis on advancing LiDAR and hyperspectral-based ecosystem mapping and modeling. This arrangement was described as a collaboration among researchers, with agreements around data sharing and intellectual property, regional peer review processes, and a series of case studies based on the interests of each jurisdiction. With such an arrangement in place, they anticipated participants would be more willing to contribute funding, and results would be more likely to be used - respected for its regional scope and scientific integrity. Collaborations would facilitate economies of scale in securing additional LiDAR and hyperspectral data.

The Coastal Douglas-fir Conservation Partnership, and Species and Ecosystems at Risk Regional Local Government Working Group were two other organizations described as well-positioned to drive connectivity planning for Garry Oak and other rare and sensitive ecosystems.

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# 9.0 Appendix. Focal Species

This section describes the rationale for choosing species or other taxonomic groups (or not) as potential focal species to test one or more connectivity models. It pares down a list of some 1,600 species known to live in Garry Oak and associated ecosystems to a manageable sixteen. Additional work may be required to further narrow this list. A summary table for each potential focal species is provided (Tables 21-33).

### 9.1 Vertebrates - Large Mammals

Large mammals, principally Black Bears (*Ursus americanus*), Cougars (*Felis concolor*), Grey Wolves (*Canis lupus*), Roosevelt Elk (*Cervus canadensis roosevelti*), and Black-tailed Deer (*Odocoileus hemionus columbianus*) were inappropriate focal species for the purposes of this project.  None of these species were considered to use Garry Oak and associated ecosystems selectively enough to be considered candidate focal species. While the sensitivity to fragmentation and large territorial requirements of large carnivores such as cougar and wolves have made such charismatic species useful as focal species for other habitat connectivity models (Beier et al., 2007), these models have generally been more species-focused and/or covering a larger landscape. Large carnivores generally avoid urbanized areas, where many of the fragmented patches of Garry Oak and associated ecosystems are located, and the above species on Vancouver Island move freely and more often within other ecosystem types (T. Chatwin, pers. comm.).

While there is evidence that Roosevelt Elk once used the entire range of Garry Oak and associated ecosystems to their southern extent on Vancouver Island, and may have played a role in the maintenance of Garry Oak savannahs through their grazing of saplings, their population is now largely restricted to other areas of the island. Black-tailed Deer, while frequent users of Garry Oak and associated ecosystems, are readily found across the island, in many different ecosystems and within the urban landscape. Additionally, there is some evidence that they may have a negative impact on these ecosystems through their introduction of non-native and/or invasive plant species, and their browsing of native and rare vegetation (Gonzales & Arcese, 2008). For these reasons, large mammals were deemed unsuitable and were considered no further.

### 9.2 Vertebrates - Small-Medium Mammals

A number of small- to medium-sized mammals use Garry Oak and associated ecosystems throughout the year. None of these are restricted to these ecosystems, but many are commonly found within them and contribute to their functioning.

The **Townsend's Big-Eared Bat** plays an important role within Garry Oak and associated ecosystems as a nocturnal aerial insectivore. This species typically avoids large open spaces but will feed at forest edges and among larger shrubs (Gruver & Keinath, 2006). While their ability to fly reduces their sensitivity to habitat barriers, these bats are not strong forward fliers (Gruver & Keinath, 2006), and have relatively small home range sizes (Dobkin, Gettinger, & Gerdes, 1995; Fellers & Pierson, 2002). As a result, they are probably heavily influenced by landscape patterns, and require suitable foraging and drinking habitat near their roosts and/or vegetated corridors linking the different sites (Gruver & Keinath, 2006). Gruver and Keinath (2006, p. 31) believed that "connectivity may be especially important as commuting distance from roosts to foraging or drinking habitat increases." Maintenance of current patch connectivity may be necessary in order to ensure the continued presence of these bats within Garry Oak and associated ecosystems and the protection of their current habitat.

Table 21. Townsend's Big-Eared Bat

| | |
|---|---|
| **Species** | Townsend's Big-Eared Bat (*Corynorhinus townsendii*) |
| **Provincial Status** | S3 Blue-listed (BC CDC, 2012) |
| **BC Distribution** | Ministry of Environment Regions: Vancouver Island, Lower Mainland, Thompson, Kootenay, Cariboo, Okanagan (BC CDC, 2012) |
| **Habitat Preference** | Agricultural; Forest; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Shrubland; Subterranean (BC CDC, 2012)<br><br>In Oregon, bats foraged in more open habitats of shrub steppe and forest-shrub ecotones (Dobkin et al., 1995)<br>In California, bats foraged mainly in riparian habitat. On occasion they would forage in more open habitats but only in association with trees and large shrubs. They avoided open grassland (Fellers & Pierson, 2002). A separate population in coastal California was noted foraging in an oak and ironwood forest (Brown, Berry, & Brown, 1994) |
| **Home Range Size/**Distance from Roost to Foraging Area | In Oregon, 24 km from hibernacula to foraging areas. Distance from interim roosts to foraging areas before entry into maternity colonies was typically 2-8 km (Dobkin et al., 1995)<br>In California, foraging individuals traveled less than 10.5 kilometers from primary day roost (post-breeding). Center of activity for females: 3.2 +/- 0.5 km from roost. Center of activity for males: 1.3 +/- 0.2 km from roost (Fellers & Pierson, 2002) |
| **Territory Size** | Not territorial (Barrett & Timossi, 1995) |
| **Dispersal Distance** | |
| **Migration** | No long distance migration - move seasonally to hibernacula, distance varies with geographical location 3.1 to 64 km (Kunz & Martin, 1982) |
| **Sensitive to Barriers** | no |

| | |
|---|---|
| **Species** | Townsend's Big-Eared Bat (*Corynorhinus townsendii*) |
| **Pros to Use as Focal Species** | As a more sedentary species of bat, foraging and drinking habitat located near roosts and/or connected by vegetated patches or corridors may be necessary to support colonies (Gruver & Keinath, 2006); Low reproduction potential (BC CDC, 2012) |
| **Cons to Use as Focal Species** | Not uniquely or strongly associated with Garry Oak and associated ecosystems; May avoid open grasslands (Fellers & Pierson, 2002); All known maternity colonies in BC are associated with human built structures (BC CDC, 2012). |
| **Notes** | Low reproduction potential (one young per year per female), but high post-weaning survivorship (BC CDC, 2012) |

**The Townsend's Vole** is a rather common resident of Vancouver Island and favours open grassland, moist meadows and riparian habitats (BC CDC, 2012). It is a significant source of prey for many species of raptor using Garry Oak and associated ecosystems, including some at-risk owl species (Delta Farmland and Wildlife Trust, 2011), and are most common to herbaceous, meadow habitats, such as those found within Garry Oak and associated ecosystems (Ward et al., 1998). This species forms an important aspect of the predator-prey relationships within Garry Oak and associated ecosystems and could be considered a stand-in for modeling connectivity of other small prey species across these ecosystems.

Table 22. Townsend's Vole

| | |
|---|---|
| **Species** | Townsend's Vole (*Microtus townsendii*) |
| **Provincial Status** | S5 Yellow-listed (BC CDC, 2012) |
| **BC Distribution** | Vancouver Island, Triangle Island, east in BC to Chilliwack (BC CDC, 2013) |
| **Habitat Preference** | Salt and fresh marshes, moist meadows (sometimes dry grass), wetlands along streams; alpine and subalpine meadows (BC CDC, 2012) |
| **Home Range Size** | Spring 1988 198 +/- 16 m2 (M) 141 +/- 12 m2 (F)<br>Spring 1989 237 +/- 47 m2 (M) 152 +/- 27 m2 (F)<br>Summer 1988 219 +/- 26 m2 (M) 94 +/- 8 m2 (F) (Lambin & Krebs, 1991)<br>16.6 m (M) 12.0 m (F) (Lambin, 1994) |
| **Territory Size** | |
| **Dispersal Distance** | 19.4 +/- 1.8 m (M) 12.4 +/- 0.7 m (F) (Lambin, 1994)<br>median: 0.008 km (M) 0.003 km (F)<br>max: 0.068 km (M) 0.054 km (F)<br>(Sutherland, Harestad, Price, & Lertzman, 2000) |
| **Migration** | Non-migratory |

| | |
|---|---|
| **Species** | Townsend's Vole (*Microtus townsendii*) |
| **Sensitive to Barriers** | yes |
| **Pros to Use as Focal Species** | Associated with open meadow areas of Garry Oak and associated ecosystems; Susceptible to cat predation (impacts of urbanization); Consumes acorns and will gnaw on Garry Oak roots and saplings when food is scarce (Clements et al. 2011); An important prey species of many predators, including a number of raptors which use Garry Oak and associated ecosystems (Delta Farmland and Wildlife Trust, 2011) |
| **Cons to Use as Focal Species** | Also associated with agricultural areas where they can be considered a pest species; High reproduction potential (Delta Farmland and Wildlife Trust, 2011) |
| **Notes** | More abundant in herbaceous habitats than the Deer Mouse (Ward et al., 1998) |

### 9.3 Vertebrates - Birds

Birds are excluded from many fragmentation studies due to their ability to fly, overcoming many habitat barriers. However, there are certain avian species that figure prominently in Garry Oak and associated ecosystems and which have reacted negatively to their fragmentation. The Coastal Vesper Sparrow, Western Bluebird, Western Meadowlark and the Streaked Horned Lark have historically preferentially used and bred within Garry Oak and associated ecosystems. With the fragmentation and decline in their habitat, all of these species but the Coastal Vesper Sparrow have been recorded as extirpated from the region (BC CDC, 2012). In 2012, the Garry Oak Ecosystems Recovery Team began its *Bring Back the Bluebirds* campaign, translocating Western Bluebirds from Washington State to the Cowichan Valley. With four juveniles returning to the Cowichan Valley and another dispersing from the U.S. San Juan Islands in spring of 2013, the species can no longer be considered extirpated from BC.

Both the small population of Coastal Vesper Sparrow and the newly reintroduced Western Bluebirds breed exclusively in Garry Oak and associated ecosystems. Other birds which also breed within these ecosystems tend to also readily nest in nearby CDFmm forests, to the extent that it has been suggested that all species in the CDF biogeoclimatic zone should be managed together (Feldman, 2002).

The **Coastal Vesper Sparrow** is currently restricted to a single breeding location on Vancouver Island as a result of the fragmentation of Garry Oak and associated ecosystems, despite efforts to establish new breeding colonies, and has an estimated breeding population of five to ten pairs (Beauchesne, 2002). As fragmentation has already adversely impacted this species, and there is consistent monitoring of this last population and a drive to establish new breeding populations in other areas, the Coastal Vesper Sparrow could be useful as a focal species for this project. There is no available dispersal data for the Coastal Vesper Sparrow, but home range and territory information have both been recorded. Should the data available for the Vesper Sparrow not prove to be adequate for modeling purposes, it may be useful to consider the savannah sparrow as a practical alternative due to similarities in breeding and habitat requirements (T. Chatwin, pers. comm.).

Table 23. Coastal Vesper Sparrow

| | |
|---|---|
| **Species** | Coastal Vesper Sparrow (*Pooecetes gramineus affinis*) |
| **Provincial Status** | S1B Red-listed (BC CDC 2012) |
| **BC Distribution** | Ministry of Environment Regions: Vancouver Island, Lower Mainland (BC CDC, 2012) |
| **Habitat Preference** | Grassland/Shrub Steppe; Rock/Sparsely Vegetated Rock; Shrubland (BC CDC, 2012) |
| **Home Range Size** | <40 ha (BC CDC, 2012)<br>13.33 ha (Panjabi & Beyer, 2010) |
| **Territory Size** | 0.14 ha (Camp & Best, 1994) (Derived by Fuchs, 2001)<br>3.05 +/- 0.78 ha (1984), 3.57 +/- 1.31 ha (1985) (Perritt & Best,1989) |
| **Dispersal Distance** | |
| **Migration** | Partial migrants, move south to overwinter with other populations (likely in Southern California) (BC CDC, 2012) |
| **Sensitive to Barriers** | no |
| **Pros to Use as Focal Species** | Reliant upon Garry Oak and associated ecosystems for breeding habitat, fragment size and proximity to human activity have influenced habitat choices in other populations (Beauchesne, 2002); Currently endangered; On-going monitoring effort for future use in modeling. |
| **Cons to Use as Focal Species** | Only found breeding in one location; Very low numbers; Known to use highly modified habitats |
| **Notes** | Appears to be very particular about nesting habitat, and to avoid areas of permanent pasture |

Since their decline, due mainly to urban development, several **Western Bluebirds** were reintroduced to Garry Oak meadows in the Cowichan Valley in 2012, where a pair nested and successfully fledged young (GOERT, 2013b). A species that has already been severely impacted by the effect of urbanization and fragmentation on GOAE habitats, there is currently an ongoing recovery project focused on these bluebirds and it is anticipated that there should be good monitoring data into the near future which would lend itself well to modeling in a connectivity project. However, the recovery project is just beginning, and it is uncertain whether this species will be able to successfully re-establish itself within its historic ranges.

Table 24. Western Bluebird

| | |
|---|---|
| **Species** | Western Bluebird (Georgia Depression Population) (*Sialia mexicana*) |
| **Provincial Status** | SHB Red-listed (BC CDC, 2012) |
| **BC Distribution** | Ministry of Environment Regions: Vancouver Island, Lower Mainland (BC CDC, 2012) |
| **Habitat Preference** | Agricultural; Forest; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Shrubland (BC CDC, 2012) |
| **Home Range Size** | |
| **Territory Size** | 0.56 - 0.79 ha (Szaro, 1976 in Vesely & Rosenberg, 2010)<br>1.26 ha (Kraaijeveld & Dickinson, 2001)<br>11.11 ha (Tietje & Vreeland, 1997) (derived by Fuchs, 2001)<br>20 ha (Verner, Purcell, & Turner 1997) (derived by Fuchs, 2001) |
| **Dispersal Distance** | 7.8 ± 6.48 km (F) 2.3 ± 3.52 km (M) (Keyser, Keyser, & Promislow, 2004) |
| **Migration** | Migratory |
| **Sensitive to Barriers** | no |
| **Pros to Use as Focal Species** | Closely associated with Garry Oak savannahs, which they use for breeding; Current recovery efforts and ongoing monitoring for future data. |
| **Cons to Use as Focal Species** | Very few individuals; Unsure whether population can be maintained (though there may be a benefit to ensuring future re-introductions are considered in planning for connectivity) |
| **Notes** | GOERT initiated a 5 year translocation and Western Bluebird nest box program in 2012. Four adult pairs and 9 nestlings were translocated in spring of 2012. One pair nested at their aviary site and raised a second clutch. In the first spring after translocation, four juveniles (3 translocated as nestlings and 1 Vancouver Island-hatched) returned to nest. One juvenile dispersed from the U.S. San Juan Islands and nested in the Cowichan Valley. Also in 2013, 9 breeding pairs were translocated, 3 with a total of 10 dependent . Twenty-two juveniles fledged from 7 nests. One additional nest was found after fledging, indicating there may have been another breeding territory (GOERT, internal reports; K. Martell, pers. comm.). The data have not yet been analyzed for territory sizes or habitat preferences, and there is insufficient data to calculate dispersal distances. |

**Steller's Jays** are important figures in Garry Oak ecosystems, though they do not form a part of the breeding bird population and their range tends to be further north (BC CDC, 2012). They are sporadic seasonal users of Garry Oak ecosystems (Fuchs, 1998), but perform a major function as the primary dispersers of Garry Oak acorns (Fuchs, Krannitz, & Harest, 2000). Due to the significant ecological role of this species in maintaining Garry Oak ecosystems, it is likely that the requirements of Garry Oak trees and Steller's Jay should be considered together when studying or modeling their roles in these ecosystems.

Table 25. Steller's Jay

| | |
|---|---|
| **Species** | Steller's Jay (*Cyanocitta stelleri*) |
| **Provincial Status** | S5 Yellow-listed (BC CDC, 2012) |
| **BC Distribution** | Ministry of Environment Regions: Skeena (Year-round resident and confirmed breeder); Frequent irruptive dispersals elsewhere (BC CDC, 2012) |
| **Habitat Preference** | Coniferous and mixed coniferous-deciduous forest. Humid coniferous forest (in northwestern North America), and arid pine-oak. Also occurs in open woodland, campsites, orchards, and gardens (BC CDC, 2012) |
| **Home Range Size** | 57.7 ± 9.5 ha (Vigallon & Marzluffl, 2005)<br>max annual: 231.2 ± 13.5 m (Gabriel & Black, 2010) |
| **Territory Size** | Fairly gregarious; Territory defense weak except immediately around nest (Hope, 1980) |
| **Dispersal Distance** | < 4 km (Burg, Gaston, Winker, & Friesen, 2005), though irruptive larger dispersals of >50km (up to several hundred km) frequently occur (Brewer, Diamond, Woodsworth, Collins, & Dunn, 2006) |
| **Migration** | Migratory |
| **Sensitive to Barriers** | no |
| **Pros to Use as Focal Species** | Main agent of Garry Oak acorn dispersal; sensitive to urbanization (Fuchs et al. 2000); Likely necessary to consider Steller's Jays needs when looking at Garry Oak dispersal issues. |
| **Cons to Use as Focal Species** | Sporadic seasonal user of Garry Oak and associated ecosystems (Fuchs et al., 2000). |
| **Notes** | none |

### 9.4 Vertebrates - Reptiles and Amphibians

There are 14 reptiles and amphibians recorded as using Garry Oak and associated ecosystems. Of these, most are commonly found in other types of ecosystems. However, two species might be used as adequate focal species. **The Sharp-tailed Snake** is a small, red-listed snakes species which can be associated with the south-facing talus slopes of Garry Oak and associated ecosystems. These areas are thought to be important to the species as they likely use them as egg-laying sites (BC CDC, 2012). While the species is quite rare and is not easily found, the presence of a recovery team studying this snake and its habits make future monitoring efforts likely. Data resulting from this monitoring could then be used in connectivity modeling.

Table 26. Sharp-Tailed Snake

| | |
|---|---|
| **Species** | Sharp-tailed Snake (*Contia tenuis*) |
| **Provincial Status** | S1S2 Red-listed (BC CDC, 2012) |
| **BC Distribution** | Ministry of Environment Regions: Vancouver Island, Lower Mainland (BC CDC, 2012) |
| **Habitat Preference** | Forest; Rock/Sparsely Vegetated Rock; Subterranean; Urban. Protected south facing slopes thought to be used as egg-laying sites, can be associated with talus. Found from Garry Oak meadows to relatively open CDF stands. Pastures, meadows, oak woodlands, broken chaparral, edges of coniferous or hardwood forests (BC CDC, 2012) |
| **Home Range Size** | Max distance between two farthest individual recaptures: about 25 m<br>Max distance traveled by female with between two relocation points by two individuals with subcutaneous implants: 39 m (F) 93 m (M) (Engelstoft & Ovaska, 2000) |
| **Territory Size** | |
| **Dispersal Distance** | |
| **Migration** | No Evidence for Seasonal Migration (Engelstoft & Ovaska, 2000) |
| **Sensitive to Barriers** | yes |
| **Pros to Use as Focal Species** | Associated with talus slopes within Garry Oak and associated ecosystems, which they likely use for egg-laying sites; Small size and limited movement makes them poor dispersers (Engelstoft & Ovaska, 2000).<br>As ectotherms (i.e., organisms dependent on external sources of heat), the reproductive biology, development, population dynamics, spatial distribution and species interactions of reptiles have been shown to be directly affected by changes in temperature (Walther et al., 2002). |
| **Cons to Use as Focal Species** | Very rare; particular to a single aspect of Garry Oak and associated ecosystems (talus slopes), not distributed throughout (Engelstoft & Ovaska, 2000) |
| **Notes** | none |

The **Northwestern Alligator Lizard** is commonly found within Garry Oak and associated ecosystems, especially along talus slopes, rocky outcrops and grassy meadows. There is currently no dispersal information available for this species but they exhibit very small home ranges sizes, appearing to stay near their hibernacula year-round (Rutherford & Gregory, 2003). There is currently good distribution data available for this species (T. Chatwin, pers. comm.).

Table 27. Northwestern Alligator Lizard

| | |
|---|---|
| **Species** | Northwestern Alligator Lizard (*Elgaria coerulea*) |
| **Provincial Status** | S4 Yellow-listed (BC CDC 2012) |
| **BC Distribution** | Ministry of Environment Regions: Vancouver Island, Lower Mainland, Thompson, Kootenay, Cariboo, Okanagan (BC CDC, 2012) |
| **Habitat Preference** | Forest; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Shrubland (BC CDC, 2012). In some areas, associated with rock outcrops and talus (Lais, 1976) |
| **Home Range Size** | Mean = 16.1 m, SE = 5.56. Most recaptures within 10m radius of original capture site (Rutherford & Gregory, 2003) |
| **Territory Size** | No evidence of territorial defense of resources (Rutherford & Gregory, 2003) |
| **Dispersal Distance** | |
| **Migration** | Not migratory - Rutherford and Gregory (2003) found no significant distance traveled between summer and hibernation sites. |
| **Sensitive to Barriers** | yes |
| **Pros to Use as Focal Species** | Commonly found within Garry Oak and associated ecosystems, representative of whole range; Susceptible to urbanization (predation by cats); Good distribution data (T. Chatwin, pers. comm.)<br>As ectotherms (i.e., organisms dependent on external sources of heat), the reproductive biology, development, population dynamics, spatial distribution and species interactions of reptiles have been shown to be directly affected by changes in temperature (Walther et al., 2002). |
| **Cons to Use as Focal Species** | Very high site fidelity, occupying small areas, little apparent dispersal |
| **Notes** | none |

### 9.5 Invertebrates

There are difficulties in using invertebrates as focal species for fragmentation projects (and indeed many such projects rely solely on vertebrate species), due to the lack of information available for most species and difficulties associated with long term monitoring of invertebrate populations at the species level. Members of the Order Lepidoptera, with their relatively large adult size and distinctive colouration, are more easily identifiable than most other orders, are among the better-studied of the invertebrate species, and make charismatic flagships for public support.

Currently, 12 of the butterfly species using Garry Oak and associated ecosystems in BC are considered at risk. Of these, the Island Blue (*Plebejus saepiolus insulanus*) is thought to be extinct, the Island Marble (*Euchloe ausonides insulanus*) is presumed extirpated from BC, and Perdiccas Checkerspot (*Euphydryas chalcedona perdiccas*) has been extirpated from Garry Oak ecosystems. Taylor's Checkerspot (*Euphydryas editha*) was thought to be extirpated, is still very rare. There is a very small and vulnerable population on Denman Island living in vernally-moist clear-cut areas occupied by its necessary adult nectar sources (Fuchs, 2001; Karsten, 2013). Since its rediscovery on Settlement Lands owned by the Denman Island Conservancy in 2005, Taylor's Checkerspot have been found on additional sites and a propagation program has been established on the island (Karsten, 2013).

Butterflies appear to track climate warming, matching elevational and northern shifts in temperature (Parmesan, 1996; Parmesan et al., 1999; Walther et al., 2002). Walther et al. (2002) reported a northward range shift of 39 species of butterflies in North America and Europe, up to 200 km over 27 years. Taylor's Checkerspot Butterfly shifted 124 m upward and 92 km northward since the beginning of the 20th century (Parmesan, 1996; Parmesan et al., 1999).

The **Propertius Duskywing** is blue-listed in BC and closely linked with Garry Oak ecosystems. The larval stage feeds exclusively on Garry Oak and, as such, is always found in association with Garry Oak trees (BC CDC, 2012). There is little data available on the spatial requirements of this species, but information from another species within the same genus, the Dingy Skipper (*Erynnis tages)*, may be used as a substitute (Gutiérrez, Thomas, & León-cortés, 1999). The strong correlation between presence of the Propertius Duskywing and Garry Oak trees, its weaker flight and dispersal ability in comparison to other butterfly species, and its at-risk status make this species a good candidate for focal species.

Table 28. Propertius Duskywing

| | |
|---|---|
| **Species** | Propertius Duskywing (*Erynnis propertius*) |
| **Provincial Status** | S2S3 Blue-listed (BC CDC, 2012) |
| **BC Distribution** | Ministry of Environment Regions: Vancouver Island, Lower Mainland, Thompson (BC CDC, 2012) |

| | |
|---|---|
| **Species** | Propertius Duskywing (*Erynnis propertius*) |
| **Habitat Preference** | Forest; Grassland/Shrub Steppe; Rock/Sparsely Vegetated Rock. Requires the presence of its larval food plant, Garry Oak, to complete its lifecycle (Guppy & Shepard, 2001) . Usually present within Garry oak and associated ecosystem habitats, although usually not present where there has been extensive landscaping below a Garry Oak tree (BC CDC, 2012) |
| **Home Range Size** | |
| **Territory Size** | |
| **Dispersal Distance** | *Erynnis tages*: average 81 +/- 87 m (M), 104 +/- 158 m (F) between successive capture attempts (Gutiérrez et al., 1999) |
| **Migration** | Locally, across metapopulations (based on life history traits of *Erynnis tages*)? Little information. |
| **Sensitive to Barriers** | yes |
| **Pros to Use as Focal Species** | Larval food plant is Garry Oak; Always found in association with oak in BC. Butterflies appear to be tracking climate warming (Parmesan, 1996; Parmesan et al., 1999). |
| **Cons to Use as Focal Species** | Species data is sparse for this species, although another species within the same genera, *Erynnis tages*, could potentially be used as a substitute. |
| **Notes** | Possibly reliant on metapopulations, as appears to be the case with Erynnis tages (Gutiérrez et al., 1999) |

The **Anise Swallowtail** is a large generalist which frequently uses Garry Oak and associated ecosystem habitats. Though it is not specific to these ecosystems, its preferred nectar and larval food sources (i.e., species of Camas and Spring Gold) are significant components of several plant communities linked with Garry Oak and associated ecosystems. However, there is little data available on the spatial requirements of this species or species similar to it within the same genus. Spring Gold or Camas could represent the needs of this species without having to estimate dispersal parameters.

Table 29. Anise Swallowtail

| | |
|---|---|
| **Species** | Anise Swallowtail (*Papilio selicaon*) |
| **Provincial Status** | S5 Yellow-listed (BC CDC, 2012) |
| **BC Distribution** | Ministry of Environment Regions: Vancouver Island, Lower Mainland, Thompson, Kootenay, Cariboo, Skeena, Omineca, Okanagan, Peace (BC CDC, 2012) |

| | |
|---|---|
| **Species** | Anise Swallowtail (*Papilio selicaon*) |
| **Habitat Preference** | Avoids dense forest, but found nearly everywhere else. Open or lightly wooded habitats with necessary food sources used for breeding (BC CDC, 2012) |
| **Home Range Size** | |
| **Territory Size** | |
| **Dispersal Distance** | |
| **Migration** | |
| **Sensitive to Barriers** | Less than other butterflies |
| **Pros to Use as Focal Species** | Larval food plant: *Lomatium utriculatum*, *Camas spp*. as adult nectar source, species which are commonly found within Garry Oak and associated ecosystems (Fuchs 2001). Butterflies appear to be tracking climate warming (Parmesan, 1996; Parmesan et al., 1999). |
| **Cons to Use as Focal Species** | Uses diverse set of food plants, good flight ability. Not as restricted by barriers, broad habitat. Generalist, may not be very sensitive to habitat edges (Hellmann, Pelini, Prior, & Dzurisin, 2008) |
| **Notes** | Associated species: Spring Gold (*Lomatium utriculatum*) and Camas (*Camas spp.*). In the absence of spatial data for this species, perhaps using one of this species' food/nectar sources would be an adequate alternative to the species itself if an estimation of relevant spatial information is not possible. |

### 9.51 Insect Pollinators

Insect pollinators are ecologically significant species in a majority of terrestrial ecosystems. Bees for example have been shown to be sensitive bio-indicators for oak savannah restoration (Taylor, 2007).

Habitat fragmentation has been cited as one of the leading causes of the global decline in pollinators, and wild pollinators in particular (Kearns, Inouye, & Waser 1998; Steffan-Dewenter and Tscharntke, 1999; Taylor, 2007). Such declines are believed to have cascading effects on ecosystems (Steffan-Dewenter & Tscharntke, 1999; Taylor, 2007).

Yet it is difficult to easily and efficiently distinguish between members of different pollinator species in the field. It is unlikely that there is sufficient data on any single species to inform connectivity modeling. It is suggested here that insect pollinators be separated into nesting guilds, as has been done in other studies (e.g., Neame, Griswold, & Elle, 2013; Taylor, 2007), Each guild would be associated with a set of spatial parameters encompassing the needs of all members of that group. This would ensure not only that future monitoring would be more feasible, but removes the challenges of choosing single species for use as focal species. This approach would be similar to the use of generic focal species in other studies, and one of those methodologies might be used to estimate dispersal parameters which could be applied to all species within each group. It is noteworthy that Taylor (2007) found that changes in bee communities were more detectable at the guild level than through broad biodiversity indices. Additionally, recent studies portraying wild pollinators as significantly better than domestic honeybees at pollinating various crops may encourage the agricultural sector to play a role in monitoring (Chung, 2013).

In their study of habitat fragmentation of oak-savannah ecosystems on Vancouver Island's Saanich Peninsula, Neame, Griswold and Elle (2013) separated pollinators into guilds reflecting nesting habitat: ground-nesting, cavity-nesting, brood parasite, flower flies, and managed pollinators (i.e., honeybees). The guilds responded differently to habitat loss and fragmentation, ground-nesting and cavity-nesting bees being strongly negatively affected. As flower flies are of a different Order (i.e., *Hymenoptera*), it may advisable to exclude this outlier in order to consider the requirements of similar pollinator guilds. In Taylor (2007), bees were split into more groups, including solitary ground-nesters, social ground nesters, cavity-nesters, bumblebees and cleptoparasites. Solitary wild bees are known to be more susceptible to landscape destruction and fragmentation than more social bees (Steffan-Dewenter et al., 2002). Three guilds were chosen as potential focal "species", namely **ground-nesting, cavity-nesting and brood parasite guilds**, however these merit further study and consideration.

**9.6 Plants**

The plant focal species included here are commonly found within Garry Oak and associated ecosystems. However, it may be useful to include a selection of the rarer species to include that perspective in the model, derived from a panel of experts familiar with the distribution and traits of the many at-risk species in Garry Oak and associated ecosystems. Many species are restricted to only a few sites, or sometimes a single site. Some may benefit from the isolation that the patchiness of the present Garry Oak ecosystem landscape provides. No focal species have been included representing vernal pool ecosystems - this is a gap that should be addressed. Alternatively, the use of a generic species might be appropriate, as many of these species do not have sufficient data (e.g., dispersal information) for modeling purposes.

An obvious choice for a focal species to represent Garry Oak ecosystems is the **Garry Oak** (*Quercus garryana*) itself. It forms part of the deep soil Garry Oak communities and shallow soil Garry Oak communities, but can also be found in lesser amounts in associated ecosystems (GOERT, 2011). It is part of all seven of the Erickson Plant Associations (Erickson & Meidinger, 2007). Though the BC population is currently considered secure (BC CDC, 2012), this tree is the backbone of imperiled Garry Oak ecosystems and is required to maintain these ecosystems. The primary mode of dispersal for these trees is through acorn transport by birds, specifically

Steller's Jays, which have been shown to transport acorns up to a kilometre away from a parent tree (Fuchs et al., 2000).

Table 30. Garry Oak

| | |
|---|---|
| **Species** | Garry Oak (*Quercus garryana*) |
| **Provincial Status** | S5 Yellow-listed (BC CDC, 2012) |
| **BC Distribution** | Ministry of Environment Regions: Vancouver Island, Lower Mainland |
| **Habitat Preference** | Restoration Units: Shallow to Deep soil Woodland, Maritime Meadow, Coastal Bluff, and Vernal Pool communities (GOERT, 2011). Plant communities: Qgrm, Qgbm, Qghh, Qgrf, Qgcc, Qggc, Qgos (Erickson & Meidinger, 2007). Ecological communities: Garry Oak - Bigleaf Maple - Cherries at Yale on the Lower Mainland, Garry Oak - Arbutus, Garry Oak/California Brome, Garry Oak - oceanspray (BC CDC, 2012) |
| **Home Range Size** | not applicable |
| **Territory Size** | not applicable |
| **Dispersal** | Acorns dispersed by Steller's Jays (acorns drop Sept-Oct). Also vegetative reproduction (Fuchs, 1998). Fuchs (1998) observed Steller's Jays moving acorns up to 600m from their tree of origin. One group of Steller's Jays in the same study appeared to be moving acorns to a hoarding location at least 1 km away (the author was only able to track them 1 km towards that location and was not able to actually reach it). |
| **Migration** | |
| **Sensitive to Barriers** | |
| **Pros to Use as Focal Species** | Species central to maintaining Garry Oak ecosystems |
| **Cons to Use as Focal Species** | None identified in literature |
| **Notes** | none |

**Common Camas** (*Camas quamash*) is an herbaceous species which makes up a significant portion of the understory in a number of GOAEs, mainly deep soil Garry Oak Communities, shallow soil Garry Oak communities, and maritime meadow communities (D. Clements et al., 2011), and is extremely attractive to insects due to the large flowers it produces each spring. In a study by Parachnowitsch and Elle (2005), camas flowers were shown to be preferentially visited by pollinators a significant majority of the time during the course of the study. Other flowers which occur in the GOAEs likely benefit from the presence of insects attracted to camas flowers found in GOAEs, as without the camas flowers many insects might not otherwise be drawn to visit these areas. Additionally, camas is a historically significant species for many First Nations peoples, whose traditional tending and harvesting of camas bulbs within GOAEs is well-known. It can be found in plant communities associated with six of the seven Erickson Plant Associations within Garry Oak Ecosystems: the Garry Oak - Broom-moss, Garry Oak - Hair Honeysuckle, Garry Oak - Roemer's Fescue, Garry Oak - Common Camas - Blue Wildrye, Garry Oak - Great Camas - Blue Wildrye, and Garry Oak - Oceanspray - Common Snowberry associations (Erickson & Meidinger, 2007)

Table 31. Common Camas

| | |
|---|---|
| **Species** | Common Camas (*Camas quamash* ssp. maxima) |
| **Provincial Status** | S4 Yellow-listed (BC CDC, 2012). |
| **BC Distribution** | Grassy slopes and meadows, low to middle elevations; southeast Vancouver Island, also in a bog on the Brooks Peninsula (Pojar and Mackinnon 1994) |
| **Habitat Preference** | Garry Oak meadows; Rock outcrops; Coastal mountain forests; Inland wet meadows (Kinkenberg, 2013). Scattered to plentiful in open-canopy Garry oak stands on water-shedding sites; occurrence decreases with increasing elevation and precipitation. Also inhabits meadow-like communities where early spring moisture is followed by mid-summer drought; occasionally found around vernal pools, springs, and intermittent streams (Klinka, Krajina, Ceska, & Scagel, 1989). Found in Qgbm, Qghh, Qgrf, Qgcc, Qggc, Qgos (Erickson & Meidinger, 2007). Found in Deep soil Garry Oak communities, Shallow soil Garry Oak communities, and Maritime Meadow communities (GOERT, 2011) |
| **Home Range Size** | not applicable |
| **Territory Size** | not applicable |
| **Dispersal** | Wind or gravity, May through summer (Beckwith, 2004) |
| **Migration** | |
| **Sensitive to Barriers** | |
| **Pros to Use as Focal Species** | Nectar source for Blackmore's Blue (*Icaricia icarioides blackmorei*) and Anise Swallowtail. Wildflower most visited by insects in Parachnowitsch and Elle (2005) study. Browsed by ungulates (Beckwith, 2004) |
| **Cons to Use as Focal Species** | Is locally frequent on SE Vancouver Island and not restricted to Garry Oak and associated ecosystems (found in other low elevation habitats, especially those which are ephemerally moist) (BC CDC, 2012) |
| **Notes** | Forms common plant associations with Garry Oak, Easter Lily (*Erythronium oregonum*), Henderson's Shooting Star (*Dodecatheon hendersonii*), and Western Buttercup (*Ranunculus occidentalis*) (Erickson & Meidinger, 2007) |

**Oceanspray** (*Holodiscus discolor*) is a significant component of many Garry Oak and associated ecosystems, including deep soil Garry Oak communities, shallow soil Garry Oak communities, and coastal bluff communities (GOERT, 2011). It forms a common plant association with Garry Oak and Common Snowberry (*Symphoricarpus albus*) (Erickson & Meidinger, 2007). It is present in plant communities based around six of Erickson's seven common Garry Oak plant Associations: the Garry Oak - Broom-moss, Garry Oak - Hair Honeysuckle, Garry Oak - Roemer's Fescue, Garry Oak - Common Camas - Blue Wildrye, Garry Oak - Great Camas - Blue Wildrye, and Garry Oak - Oceanspray - Common Snowberry associations (Erickson & Meidinger, 2007). Its flowers attract large numbers of pollinating insects and provide significant forage for native bees (Vaughan & Black, 2006). Its seeds represent an important food source for granivorous bird species, such as Chipping Sparrows and Dark-Eyed Juncos, and its foliage provides moderately important browse for Coastal Black-tailed Deer (GOERT, 2013c).

Table 32. Oceanspray

| | |
|---|---|
| **Species** | Oceanspray (*Holodiscus discolor*) |
| **Provincial Status** | S5 Yellow-listed (BC CDC, 2012) |
| **BC Distribution** | Dry - mesic bluffs, Rocky slopes, Clearings, Thickets, Forest edges, Open forests (Klinkenberg ,2013) |
| **Habitat Preference** | In Deep Soil Garry Oak Communities, Shallow Soil Garry Oak Communities, Coastal Bluff Communities (GOERT, 2011). In Qgbm, Qghh, Qgrf, Qgcc, Qggc, Qgos (Erickson & Meidinger 2007) |
| **Home Range Size** | not applicable |
| **Territory Size** | not applicable |
| **Dispersal** | Wind-dispersed August - September (Wender, Harrington, & Tappeiner, 2004) |
| **Migration** | |
| **Sensitive to Barriers** | |
| **Pros to Use as Focal Species** | Part of Garry Oak - Oceanspray vegetation community, in which it commonly occurs with plants such as Oregon Grape (*Mahonia spp*.) and Oregon Beaked Moss (*Kindbergia oregana*); Important food source for granivorous bird species, moderately important browse for Coastal Black-tailed Deer (GOERT Native Plant Propagation Guidelines). Flowers attract large numbers of pollinating insects and provide significant forage for native bees (Vaughan & Black, 2006) |
| **Cons to Use as Focal Species** | Common within southern BC, in a variety of habitats (Kinkenberg, 2013) |

| | |
|---|---|
| **Species** | Oceanspray (*Holodiscus discolor*) |
| **Notes** | Forms a common plant association with Garry Oak and Common Snowberry (Erickson & Meidinger, 2007) |

**Spring Gold** (*Lomatium utriculatum*) is the primary nectar source for Taylor's Checkerspot and would likely be an important factor in any future recovery efforts for the butterfly in Garry Oak and associated ecosystems. It is also a major source of nectar for the Anise Swallowtail, and attracts other butterfly and pollinator species. It is commonly found within shallow soil Garry Oak communities and maritime meadow communities (GOERT, 2011; GOERT Native Plant Propagation Guidelines). Spring Gold can be found within Garry Oak - Broom Moss, Garry Oak - Roemer's Fescue, and Garry Oak - Common Camas - Blue Wildrye plant associations (Erickson & Meidinger, 2007).

Table 33. Spring Gold

| | |
|---|---|
| **Species** | Spring Gold (*Lomatium utriculatum*) |
| **Provincial Status** | S5 Yellow-listed (BC CDC, 2012) |
| **BC Distribution** | Locally common on SE Vancouver Island and the Gulf Islands; S to CA (Illustrated Flora of BC in Klinkenberg (2013)) |
| **Habitat Preference** | Dry bluffs, Rocky slopes, Grassy sites (low elevation) (Kinkenberg, 2013). In Deep Soil Garry Oak Communities, Maritime Meadow Communities (GOERT, 2011). In Qgbm, Qgrf, Qgcc (Erickson & Meidinger, 2007) |
| **Home Range Size** | Not applicable |
| **Territory Size** | Not applicable |
| **Dispersal** | Wind or gravity (Marsico, 2008), late summer (GOERT Native Plant Propagation Guidelines) |
| **Migration** | |
| **Sensitive to Barriers** | |
| **Pros to Use as Focal Species** | Primary nectar source for Taylor's Checkerspot, other butterfly and pollinator species also attracted by flowers, commonly found within Garry Oak and associated ecosystems |
| **Cons to Use as Focal Species** | Taylor's Checkerspot currently restricted to Denman Island; Other flowering species also attract butterflies and pollinators |
| **Notes** | none |

**2018 Revision**

In 2013, this was an internal GOERT document. In 2018, it was restructured and revised for distribution beyond GOERT.  No additional data or references have been examined since 2013.