# Lessons from a Baseline Study of a Garry Oak Ecosystem for Environmental Impact Assessment in the Face of Biodiversity Loss and Climate Change

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Internship for the Galiano Conservancy Association

June to October 2011

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Total word count: 18,378

Submitted and defended on April 3rd, 2013

as the final report for completion of the

Masters of Environment in Environmental Impact Assessment

from the

Department of Planning, Geography and Environment

Concordia University, Montréal, Quebec

## Acknowledgements

*I would first like to thank my husband, SH, for his unending love and encouragement during graduate school and during the creation of this final report (as well as many late night editing sessions). I would also like to thank my entire family for their sustaining support and understanding. I am most grateful to my elders, especially my parents and grandparents, who gave me food and shelter during periods of the research and writing process and always give me guidance and support. I offer a warm thank-you to my professors and peers at Concordia University for your patience and helpful contributions. I am also particularly grateful to all of the people that helped this research and report come to fruition, especially Dr. Ken Millard and everyone else from the Galiano Conservancy Association. And finally, I would like to acknowledge the local Coast Salish First Nations whose traditional territories I was working on during the Retreat Island baseline report case study.*

## Abstract

This report is based on a systematic baseline assessment of Retreat Island, an almost three hectare (seven acre) area near Galiano Island, British Columbia, that is covered with plants from the coastal Douglas fir biogeoclimatic zone and its sub-communities of the environmentally and socially significant Garry oak meadows. Garry oak ecosystems are important within a variety of areas of interest within environmental assessment, including climate change, biodiversity and coping with biodiversity loss, and ecosystem modelling. Garry oak ecosystems are of particular interest because of their predicted positive responses to climate change, but only if the biological diversity of these ecosystems is maintained. This is poignant given that one of the predicted consequences of climate change is significant biodiversity loss. The issues of climate change and biodiversity loss pose distinct challenges to the process of environmental impact assessment (EIA). In order to better incorporate climate change and biodiversity loss into EIA, many researchers cite adaptive management as a key tool. This report uses adaptive management theory, ecosystem theory, and risk society theory to look at the baseline study of an island ecosystem and to also look at the concept of valued ecosystem types such as Garry oaks and the need for their incorporation into the environmental process. It then discusses the importance of these baseline reports as well as the challenges that exist when creating a baseline study. The Garry oak baseline study is then looked at for the possible lessons that we can learn from for the improvement of EIA and our adaptation to climate change.

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# 1. Internship Description

Galiano Island[1] is a small island that is part of the Gulf Islands archipelago nestled between Southern Vancouver Island and the mainland of British Columbia (see Figure 1). Galiano is just a short ferry ride from Vancouver and is described as an “Emerald Isle” by the locals and tourists alike. On this Emerald Isle, there exists a small organization, which strives to protect, conserve, and improve the quality of the human and natural environment of Galiano Island and beyond (Galiano Conservancy Association, 2011). The Galiano Conservancy Association (GCA) is a non-profit environmental group dedicated to land and marine conservation, stewardship, and restoration. Additionally, they work towards environmental education and public environmental awareness for the Galiano Island community and its tourists. It was established in 1989 as a democratic grassroots organization based upon the goal of promoting positive environmental and social goals (Galiano Conservancy Association, 2011). The CCA works towards these goals through efforts that include fundraising, purchasing and protecting environmentally sensitive areas; public outreach, a native plant nursery, ecosystem restoration work, ecosystem monitoring, conservation mapping, baseline environmental assessments and coordinating outdoor education programs.

Successful projects coordinated by the Conservancy include the establishment and restoration of the Great Beaver Swamp and Pebble Beach land reserve, establishment of a protective land covenant on Retreat Island, and the establishment of the “Forest to the Sea” watershed project. Most recently, the GCA has successfully acquired a large parcel of land for restoration and the establishment of their restorative learning centre for

[1] Galiano has a small population of just over 1000 permanent residents. It is within the jurisdiction of the Islands Trust and the Capital Regional District. (Statistics Canada, 2012)

at-risk youth. The Galiano Conservancy Association has already successfully offered a wide range of environmental and restoration programmes to a wide community of over 10,000 people, primarily youths, but also a large number of adults[2].

Typically, the GCA employs five full-time staff who collaborate in attaining the GCA's education and conservation goals. A twelve member volunteer board of directors coordinates these employees. The GCA also employs several interns per year, and coordinates a great number of volunteer efforts annually. The staff members have backgrounds in fields such as environmental studies and biology, as well as environmental education, species at risk (SAR), mapping, baseline assessments, and restorative learning. Everyone who is employed at the GCA also specializes in fundraising and grant writing in order to advance the association's projects and growth, a continuous challenge to the continuation of their valuable work in the community. The organization is based in a single story office located in the "downtown" core of Galiano, near the BC Ferries terminal at Sturdies Bay. It is a welcoming environment, with an extensive public library, a lounge area and kitchen for group meetings, as well as several offices and work areas. It is an office where collaboration is encouraged and I was fortunate enough to have the opportunity to work with and learn from each of the employees and interns while I was employed by the GCA.

While working at the Galiano Conservancy Association I was involved in several aspects of their wide-ranging operations. These included ecosystem restoration fieldwork, the operations of their native-plant greenhouse, educational outreach programmes with children and adults, development of their Restorative Learning Centre (RLC), research, and report writing. I was also involved in the preparation of an in-depth baseline report on the 2.8-hectare land covenant on Retreat Island. Ecosystem restoration fieldwork

[2] Many of these youth were considered to be from "at risk" groups. Adults have attended from the public at large as well as groups from the local eating disorder treatment centre and the Victoria Refugee Centre, for example.

usually took place in isolated Garry oak meadows, so the morning commute frequently included kayaking and rock climbing. We concentrated on monitoring and the removal of non-native invasive species, specifically Scotch Broom (*Cytisus scoparius*), that are outcompeting rare and often endangered native plant species. This work filled the early part of my internship, and it required identification of native and non-native species in Douglas fir and Garry oak ecosystems and the careful removal of species that are detrimental to that ecosystem's well-being. While in the field, we often sustainably collected seeds of native species for germination at the native plant nursery. The propagation of these native plants at the GCA's 0.6-hectare nursery and greenhouse facilities are an integral part of their ecosystem restoration projects, as locally collected seeds are raised for several years before they are transplanted back into native ecosystems.

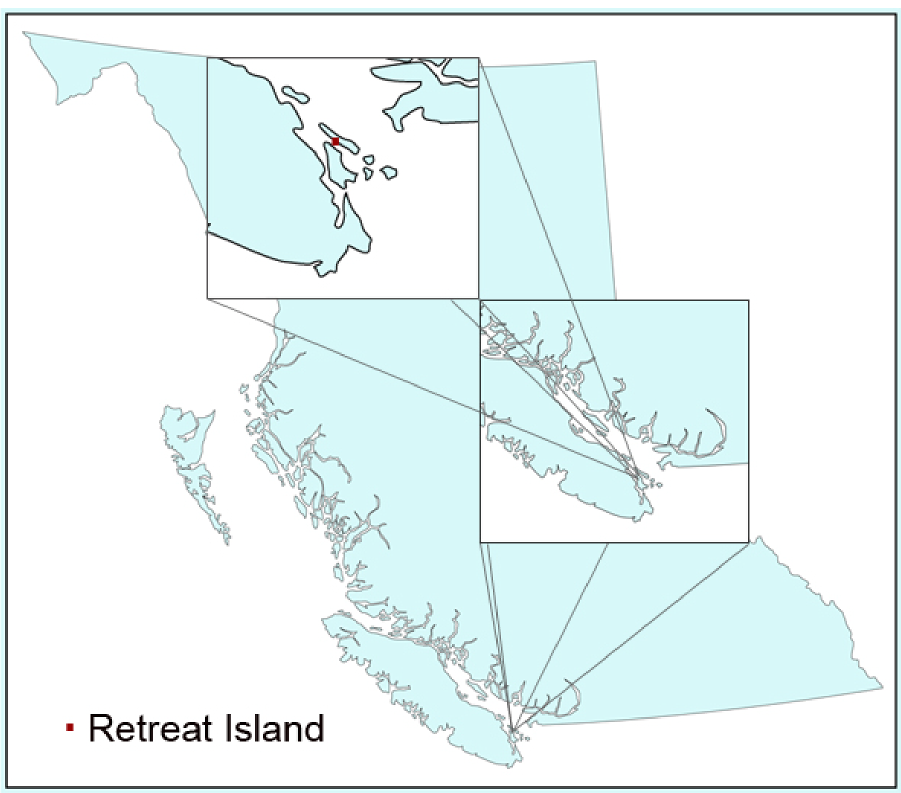


**Figure 1: Map of Retreat Island relative to British Columbia**

In addition to working on ecosystem restoration, I was also involved in leading several day programs with schoolchildren and adult groups on local ecology. Ecosystem types that were explored with participants included intertidal, wetlands and bogs, Garry oak meadows and bluffs, and Douglas fir forests. These public outreach sessions are among the programs that will be incorporated into the Sustainability and Restorative Learning Centre. Restorative education, as an emerging practice, combines and builds upon the traditions of environmental education, outdoor education, cultural acceptance, and cognitive behavioural therapy. A large part of my internship was dedicated to creating a best-practice report for the continued development of the RLC. This included comparisons of other sustainability learning centres in North America and summarizing their key services and organizational features. The 50-page report summarized these findings and made recommendations of best practices for the continued development of the Galiano RLC.


Figure 2: Map of the Southern Gulf Islands (Google Earth image)

The final project that I was involved in while working at the GCA was a detailed baseline ecosystem report for Retreat Island, which is adjacent to Galiano (see Figure 2). This environmental baseline was created to serve as a solid foundation for future monitoring studies of Retreat Island's nearly three hectares. This in-depth ecological study took place on an island property in which I was living, and have lived on, seasonally, for the last twenty years. The report included all herbaceous plants, shrub, and tree species present on the island, as well as the fauna, save for the majority of the insects, which were beyond the scope of the project. Retreat Island contains ecologically rare and sensitive Garry oak (and associated) ecosystems (see Figure 3). These unique ecosystems provided the foundation for our case study and serve as the inspiration for the research in this report.

This report has been filed within the Retreat Island covenant paperwork, which is held by the Galiano Island Conservancy, the BC Land Conservancy, and the Garry Oak Meadows Preservation Society (GOMPS). It is currently being slightly modified in order to submit it to the British Columbia Ministry of Environment. The wide array of background research required for the baseline report coupled with years of personal interest in Gary oak ecosystems led me to even more questions around their social and environmental significance, especially in the face of global climate change.

**Figure 3: A Garry oak (*Quercus garryana*) meadow on Retreat Island in August, 2011**

# 2. Introduction

Despite a few staunch deniers, the debate over climate change is largely over. Even public opinion, as evidenced by the large amount of media attention to the subject, has come to accept it as a reality. One of the consequences of climate change is significant biodiversity loss. This cannot be understated for climate change alone is anticipated to put approximately one quarter of the Earth’s species at risk for extinction by the year 2050 (Chivian & Bernstein, 2010). Beyond the aesthetic loss of seeing polar bears or butterflies going extinct, biodiversity loss can have a drastic impact on human life by decreasing our capacity for future food production, medicinal discoveries, and general use of ecosystem services (Biodiversity BC, 2008; Chivian & Bernstein, 2010).

In Canada, one of the most biodiverse ecosystems can be found in Garry oak Meadows. These Garry oak ecosystems are not only incredibly diverse but also severely threatened. The Garry oak ecosystems' flora alone represents the greatest concentrations of species at risk in all of Canada (MacDougall *et al.*, 2013). Yet, if measures, such as restoration and/or monitoring and mitigation of threats, are enacted to protect this important ecosystem from extinction, Garry oaks ecosystems are actually predicted to expand their ranges because of climate change. This creates a particular challenge in the future management of this unique ecosystem. The objective of this report is to look carefully at an environmental baseline study of a Garry oak ecosystem and derive lessons from it and these ecosystems in general, with regard to climate change and biodiversity loss, baseline assessments, monitoring, adaptive management, and general improvement of the environmental assessment practice.

This report has several overlapping areas of research, including baseline studies, climate change, biodiversity's value, coping with biodiversity loss, and ecosystem modelling. We also explore the current state of federal and provincial level environmental assessment (EA) policies and the Garry oak ecosystem, which was the key ecosystem present in the environmental baseline case study region. To guide the research several research questions were created. How has EA changed since the new Canadian Environmental Assessment Act ("the Act") was put into place in 2012? How are baseline studies, biodiversity and climate change incorporated into the EIA process? How are climate changes ecosystem effects modelled? What impacts will climate change have on biodiversity, in general as well as in Garry oak ecosystems? What lessons can we learn from Garry oak ecosystems for the improvement of EIA and adaptation to climate change? This research found that Garry oaks ecosystems are of great value because they are predicted to have a positive response to climate change, with increasing ranges. The capacity of these ecosystems to respond to environmental change relies on high levels of biodiversity, and points to several lessons for environmental assessment.

## 2.1. Relevance

This report is based upon a case study of Garry oak ecosystems, an ecosystem that has great relevance both environmentally and socially, particularly as we move forward into a future heavily influenced by climate change. The report highlights both the adaptability of Gary oak community's species in the face of climate change and the high level of biodiversity that they represent in British Columbia. It is hoped that this case study can demonstrate how the continued incorporation of environmental baseline studies and scientific research on biodiversity and climate change can enhance EIA efforts, particularly within a framework of adaptive management where adaptation, rather than preventative mitigation of climate change is the favored approach. This study also attempts to show the value of modeling of ecosystem types (in this case Garry oaks) and their expected responses to climate change into environmental impact assessments and how it can help us better adapt to this risk. To this purpose, this report offers adaptive tools for coping with advancing climate change when planning, assessing, and monitoring development projects.

## 2.2. Organization of this Report

After the description of the internship on which this entire report is based, this report will then discuss the background research. We will begin with federal and provincial (British Columbia) EIA requirements and a discussion on their policies. Following this, we will look at environmental baseline reports, the issue of climate change and climate change policies, as well as the issue of biodiversity loss and biodiversity policies. Subsequently we will look at this report's underlying theoretical framework of integrated ecosystem theory, risk society theory, as well as adaptive management theory. Then the case study, a baseline report on Retreat Island, BC, will be looked at, as well as the environmental and social significance of the Garry oaks ecosystem. We will then discuss the threats to Garry oak ecosystems before moving into a broad discussion of the lessons that can be learned for EIA from the case study and the background research presented.

# 3. Background

## 3.1. Federal EIA

In Canada, the environment is not explicitly named in the Canadian Constitution, thus causing a situation in which neither the federal nor the provincial governments have sole jurisdiction over the environment in its entirety. Instead, the onus for caring for the assorted components of the environment falls to different "heads of power", such as fisheries, species at risk, natural resources, and criminal law (Blakes Environmental Group, 2012). Within the Canadian Environmental Assessment Agency (CEAA) environment is defined as Earth's components, including the land, water and air (including all layers of the atmosphere) as well as all biotic and inorganic matter and organisms that exist within Earth's various interconnected natural systems (Canadian Environmental Assessment Agency, 2012a, line 174). Environmental assessment (EA) is a method for incorporating socio-economic, cultural, and health considerations in planning and decision-making that has been put into place in nations around the world (Canadian Environmental Assessment Agency, 1996). It has been in practice in Canada for the last four decades, with federal, provincial, and municipal governments, as well as First Nation's groups having developed legislation. Within Canada the first federal environmental assessment act was passed in 1992 as recognition of the importance of incorporating environmental issues into decision making and project planning processes (Canadian Environmental Assessment Agency, 1996). The 1992 Canadian Environmental Assessment Act[3] created the CEAA, a self-monitoring regime that ensures that environmental assessments are undertaken when necessary (Government of Canada, 1992; Blakes Environmental Group, 2012).

The current state of affairs of the Act has been dramatically altered over the last year, and is undergoing a period of streamlining (Canadian Environmental Assessment Agency, 2012b) that has simplified the responsibility of federal agencies and placed a larger amount of the responsibility for environmental assessment to provincial authorities. In April 2012 the *Jobs, Growth, and Long-term Prosperity Act* was tabled as part of the national budget (Government of Canada, 2012a). Passed in June, 2012, part three of this act served as the foundation for the current Harper Government's plans to modernize the regulatory system for project reviews in order to develop Canada's natural resources responsibly and for the betterment of all Canadians (Canadian Environmental Assessment Agency, 2012b). This led to the repeal of the previous Canadian Environmental Assessment Act and a new *Canadian Environmental Assessment Act, 2012*. The government has enacted major changes in the name of facilitating development of national environmental resources, greater responsibility at the provincial level, and a reduction in the number of triggers that require an assessment to be done (Government of Canada, 2012b). Even with this devolution of environmental

[3] The CEAA 2012 does not usually apply north of 60 degrees latitude, where there are other EA regimes, like the *Yukon Environmental and Socio-Economic Assessment Act*, that have resulted from land claim agreements. (Canadian Environmental Assessment Agency, 2012c)

authority, there is still an inclusive and systematic process created to recognize and analyze the environmental effects of proposed projects that actually go under assessment (Bell *et al.*, 2003). Despite the many changes made to the legislation in the last 30 years, it remains, as Beanlands and Duinker (1983: 7) termed it, a "fairly complicated sociopolitical phenomenon involving extensive administrative support systems".

At the federal level there are multiple triggers for an environmental impact assessment. These include when the proponent of a project is the Federal government; when federal funds are being used; the project impacts federal lands; or there is a need for federal approval of some sort (Blakes Environmental Group, 2012). The EIA process is meant to involve Canada's aboriginal people and its public in a transparent and inclusive manner (Bell *et al.*, 2003). It is also meant to allow for practical incorporation of environmental considerations into the decision-making process and help in the attainment of sustainable development (Bell *et al.*, 2003). This iterative process is a complex one that, although incorporating continuous refinement with the attainment of new information, is often criticized for its vagueness (Blakes Environmental Group, 2012; Bell *et al.*, 2013). The new Act attempts to address these challenges and its intent is to protect the components of the environment from significant damage in a careful and precautionary fashion (Government of Canada, 2012b). It states that its purpose is to encourage cooperation between different levels of government, as well as with the Aboriginal people of the country while also including meaningful dialogue with the public in general (Canadian Environmental Assessment Agency, 2012b). The new Act includes stricter deadlines for the completion of assessments and promotes sustainable development and cumulative impact assessment. An important underlying tenet of EA in Canada is the precautionary principle, which states that in the face of a situation where there is a risk of a project causing harm and there is a lack of scientific consensus, the burden of proof that it will not cause damage falls to those proposing the development. In cases where there are many opinions within the scientific community, there is a responsibility to protect the public and the environment from possible harm (Canadian Environmental Assessment Agency, 2012a).

Federally, there were four types of assessments that existed under the Act before the advent of the new, 2012, Environmental Assessment Act. These were screening, comprehensive study, panel review, or mediation (Blakes Environmental Group, 2012). The new, streamlined Act's system of administering EAs has been modified, and there are now typically designated projects, environmental assessment by a responsible authority, such as the National Energy Board (NEB) or by the Agency itself or, an assessment by a review panel, which is a panel of experts appointed by the Minister of Environment (Government of Canada, 2012b). It has always been the case, and still remains so, that the vast majority of environmental assessments are screenings, wherein the project description is submitted, and there is a period for public comment (20 days) (Government of Canada, 2012b). Once it is deemed that a full environmental assessment is required, each of the EAs generally includes the steps of scoping, analyzing, creating mitigation measures, determining the significance of effects and the following up with a monitoring program (Canadian Environmental Assessment Agency, 1996). The reports are submitted by the proponents to the Agency and then the project is either approved or denied (Canadian Environmental Assessment Agency, 2012b). These are the specific steps that exist within a federal EA, which are similar to those required at other levels of government. Given that there is now a much greater level of harmonization between Federal and provincial EAs the next section will look in depth at the EIA process in the province of British Columbia, where the case study and relevant Garry oak ecosystems exist.

## 3.2. British Columbia EIA

The British Columbia (BC) system of environmental assessment is similar to the Federal system, and is known among practitioners as one of the most robust provincial acts in the country (Blakes Environmental Group, 2012). The process of EA is usually under concurrent jurisdiction, with the federal and provincial government both having regulatory responsibilities (Blakes Environmental Group, 2012). The provincial agency responsible for conducting environmental assessments and setting recommendations for approval (with or without conditions) is the Environmental Assessment Office (EAO), which was established by the BC Environmental Assessment Act (BCEAA) in 1995, and underwent major revisions in 2002 (British Columbia Environmental Assessment Office, 2010). The BCEAA is in accordance with the Federal Act in that it accepts the review of other regions as equivalent and is supportive of the delegation of more responsibility to the province as well as working towards harmonization, as it is set out in the *Canada – British Columbia Agreement on Environmental Assessment Cooperation* (British Columbia Environmental Assessment Office, 2010).

The system in place in BC incorporates participation by government agencies, First Nations, local government, stakeholders, and the public (British Columbia Environmental Assessment Office, 2010). It is a comprehensive process, applicable to all major projects in BC (Blakes Environmental Group, 2012). The list of projects is set out under the Reviewable Projects Regulations, and includes: industrial, mines, energy, water management, waste disposal, food processing, waste disposal, transportation, and tourist destination resorts (Environmental Law Centre, 2010). These projects must undergo an environmental assessment that, if approved by EAO, will then receive an environmental assessment certificate (Blakes Environmental Group, 2012)

### 3.2.1. Environmental Baseline Studies

Environmental baseline reports are a key part of the EA process, as they are needed to establish the original environmental conditions, recognize the possible risks and impacts of proposed projects, and identify the relevant standards that should be incorporated (Bamberger, 2010). The term "baseline" refers to the description of existing environmental conditions against which changes can be compared during future monitoring and surveying (Beanlands & Duinker, 1983). The similar term "baseline study" is often used as a catchall phrase that includes all manner of pre-project studies (Beanlands & Duinker, 1983). These studies are a key part of the scoping phase of the EIA process. The objective of scoping is to efficiently collect relevant background information and reduce the amount of required data collection through identifying the key environmental components and variables to concentrate on (Noble, 2000).

The collection of baseline data is recognized in guidelines and impact statements as the starting point for any field study (Beanlands & Duinker, 1983). The function of a baseline is to serve as a point against which follow-up research can be compared. The careful and systematic collection of data needs to be initiated well before the implementation of the project (Canadian Environmental Assessment Agency, 2011). It is important that the approach taken to creating baselines attempts to establish a statistical basis for use in the prediction of impacts and the development of a monitoring program (Beanlands & Duinker, 1983) and, as well, attempts to incorporate predictive methods such as computer modeling. It is also very important that the accompanying monitoring program be established before the project approval phase because, in its strictest sense, monitoring addresses the question of whether the baseline condition is changing (Garry oak Ecosystem Recovery Team, 2011). The process of answering this question will help improve the continuity of the study and supports the rationale for creating baselines at all (Beanlands & Duinker, 1983; Canadian Environmental Assessment Agency, 2011).

There is a wide array of types of baseline studies that are done in the process of EA. These baselines can include water and river-way quality, air quality, fish, wildlife, socioeconomic, or mercury, climate, topography, soil, vegetative composition, and/or successional trends (Barrick & Nova Gold, 2007; Garry oak Ecosystem Recovery Team, 2011). In order to create baselines, it is important to also include any other available historical data, ranging from historical accounts and photos to scientific methods such as woody debris and dendrochronological (tree ring) records and pollen profiles of soils (Garry oak Ecosystem Recovery Team, 2011). The preparation of environmental baselines requires an understanding of biodiversity and the ways in which it is measured and understood. For example, when focussing on species at risk in a region, the data that are necessary to collect includes the size distribution, abundance, and condition (health and reproductive success) of the local species at risk (Garry oak Ecosystem Recovery Team, 2011). Sampling methods must be appropriate to the location and boundaries that are under investigation, as well as the time frame that the researchers are working with.

The limitations imposed by boundaries on time and space are especially problematic for baseline studies (Beanlands & Duinker, 1983). It is unrealistic to obtain a truly comprehensive collection of baseline data; studies are often restricted to descriptive one-time surveys of the various environmental components (Beanlands & Duinker, 1983; Noble, 2000). Given this, it becomes essential to identify each system's key or indicator variables when establishing baseline data (Noble, 2000). In order to better address the possible risks of project development, baselines must incorporate adequate descriptions of the variability that exists for the most valuable components of the ecosystems. The establishment of baselines in themselves are not predictive, but they do allow for a greater understanding of the changes that may occur, especially the predicted effects on the valued ecosystem components (Beanlands & Duinker, 1983).

### 3.2.2. Valued Ecosystem Components

Within federal and provincial EIA, the concept of a valued ecosystem component (VEC) is often used as a tool when establishing priorities for conservation within an EA. VECs are defined by the CEAA as the environmental elements of an ecosystem that have "scientific, social, cultural, economic, historical, archaeological or aesthetic importance" (Canadian Environmental Assessment Agency, 2012a: 3). They are established during the baseline assessment phase of the EA and can be determined based on cultural or scientific significance, as considered by the First Nations, proponents, public, scientists and multiple levels of governmental agencies that are involved (British Columbia Environmental Assessment Office, 2010). Once determined, it is of great value to understand the impact of a particular project on the VECs as well as the cumulative impacts of the project in combination with other local developments (Canadian Environmental Assessment Agency, 2012a). VECs act as a lens to better understand the wider impacts of the physical, chemical, and biological changes that come with the development of a proposed project (Beanlands & Duinker, 1983).

According to both provincial and federal legislature, it is also essential to look to the cumulative impacts to which a project may contribute, and VECs offer a tool to analyze these. In order to include the cumulative impacts, which are the effects of a possible project when looked at in conjunction with all other developments that already exist or are approved for an area of a project, EA practitioners consider land use plans (like land, resource, or water management plans), baseline studies, other developments and proposed future development plans (British Columbia Environmental Assessment Office, 2010). After a project has been developed and during the monitoring process it is also of great importance to continue to monitor particular VECs in order to see if there are negative impacts on these indicative components (Byer *et al.*, 2011).

## 3.3. Climate Change

Barely a day goes by without the issue of climate change being in the news, and this topic is one of the greatest challenges to our collective future. Climate change has been recognized internationally, and by federal, provincial and territorial governments in Canada, as an important issue that must be addressed rapidly (British Columbia Environmental Assessment Office, 2010). According to the intergovernmental panel on Climate Change's (the IPCC) fourth assessment report, the year 2007 marked a disturbing turning point at which it became clear that the collective global effort to reduce greenhouse gasses (GHGs) was not enough to stop the occurrence of human induced global climate change (Intergovernmental Panel on Climate Change (IPCC), 2007). International scientists have shown that global average temperatures have increased 0.2 degrees Celsius per decade since the 1970s, and global average precipitation has increased 2% in the last 100 years (Byer, 2009).

A wide consensus has emerged that climate change, caused by natural sources as well as novel anthropogenic sources like pollution, habitat fragmentation, land-use changes, invasive species, and changing fire regimes, is now causing the planet to undergo changes whose rapidity is without historic precedent (Millar *et al.,* 2007). The changes that come from the atmospheric release of GHGs such as carbon dioxide and methane will have impacts on society in a multitude of ways, though the exact impacts are still highly debated (Byer & Colombo, 2010). In 1992 Canada became a signatory to the

United Nations Framework Convention on Climate Change (UNFCCC) a non-binding treaty with the goal of stabilizing greenhouse gas levels in the atmosphere at a level that is below the point that will cause hazardous anthropogenic interference with the climate system (UNFCCC, 2012). The most well known international accord is the Kyoto Protocol, which, when signed in 1997, legally bound the signatory countries to binding targets for reduction of GHG emissions. Canada was one of the countries that committed to this agreement with the UNFCCC until the current Conservative government withdrew from it, and there are currently no binding targets in place for this nation, despite the mounting evidence that climate change is ongoing and that it will have a wide array of impacts on the world around us.

Recent research shows that there is a wide array of possible impacts from climate change, all of which will be influenced by changes to global weather patterns and shifts in climatic systems (Harris *et al.*, 2006). Climate change in the next 100 years is expected to have considerable impacts on forest ecosystems, sea-surface temperatures, variability of weather patterns, mean temperatures, patterns of precipitation, and sea level (Bulkeley, 2001; Harris *et al.*, 2006; IPCC, 2007; Byer & Colombo, 2010). These impacts are expected to be disproportionately felt in northern latitudes, where large shifts in temperatures are already being observed, as well as on small, low-lying oceanic islands that are prone to inundation (Spittlehouse & Stewart, 2003; IPCC, 2007). The climate has continuously changed over millions of years, but what makes the current and predicted changes significant is their speed and magnitude (Cannings & Cannings, 2004). The impacts of climate change in Canada and, more specifically, BC, are predicted to cause range shifts for our forest ecosystems northward, as well as changes in species composition for these systems. In particular, it is suggested that there will be in some areas a trend towards dominance by species that are more drought tolerant (Hamann & Wang, 2006).

Problematically, the rate of projected climatic change is increasing, and some researchers are forecasting sudden changes (possibly at the time frame of less than five years), that will likely be unpredictable as to their timing and intensity. It is becoming apparent that the shifting climate is already having impacts on some species and ecosystems in Canada and internationally (Harris *et al.*, 2006). These changes will not only pose an enormous environmental challenge, but a serious challenge to economic and social development, with billions of people vulnerable to the impacts of climate change (Agrawala *et al.*, 2010). The changes include "super-storms", droughts, floods, extreme winds, longer storm seasons, greater amounts of melted water in the hydrological cycle, drying trends, increasing sea surface temperature and other expected and unexpected impacts (Halpin, 1997; Bulkeley, 2001; Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, 2003; IPCC, 2007; Hellmann *et al.*, 2008; Wilson & Hebda, 2008; Agrawala *et al.*, 2010). These events cause infrastructure damage, loss of housing, loss of crops, loss of biodiversity, challenges to transportation networks, delays, loss of goods and services, and societal insecurity, as well as the loss of lives, to name just a few (Suffling & Scott, 2002; IPCC, 2007). Given the wide array of changes to systems that will influence our daily lives, it is vital that we concentrate research on the spatial distributions of our surrounding ecosystems and communities. This is generally done by examining plant fossil records and climate records from the last 10,000 years and modeling the possible implications of different levels of climatic change (Hamann & Wang, 2006).

Climate change presents dual, interconnected, uncertainties that are often looked at through computer models of future climates or ecosystem responses and distribution.

Firstly, there are uncertainties about the future state of the climate, and secondly there are uncertainties based on the process of modelling for the future climates (Byer & Colombo, 2010). It is important to cultivate a greater understanding of the impacts of climate change at relevant scales for local plans, and the use of bioclimatic models to predict the potential changes to spatial distribution of species and ecosystem types are therefore becoming more prevalent (Pellatt *et al.*, 2012).

Climate models are based on historic climate information and possible future climate variables, and they have varying levels of reliability and varying scales of application. They are useful for quantifying possible changes in habitat types, species' ranges, biodiversity, risk of extinction, and management planning (Hamann & Wang, 2006; Pellatt *et al.*, 2012). They are usually based on possible future climate scenarios in terms of varying statistical parameters of climate-relevant variables like mean maximum temperatures and precipitation levels. The outputs of these models vary according to the model's scope and sophistication (Byer & Colombo, 2010).

No matter what model is applied for climate forecasting there is a characteristic constraint in that historic climate data are not always available, and climate models have to be refigured for more specific projections at the local scale (Agrawala *et al.*, 2010). The historic abundance of a species at the landscape scale has often been used as a goal in conservation efforts, and, though this may not always be a viable direct objective, this information is of great value when climate and ecosystem models are being developed (Harris *et al.*, 2006). In British Columbia there have been several reports dealing with the local impacts of climate change and incorporating climate and ecosystem models and projections (see (Hebda, 1997; Spittlehouse & Stewart, 2003; Hamann & Wang, 2006; Harris *et al.*, 2006)). Since British Columbia has a wide variability of biogeoclimatic zones, modeling has presented a challenge, but climate scientists generally agree that there will be over-all drying trends with drought, fire, and extreme weather events increasing throughout the province (see Figure 4) (Hamann & Wang, 2006). There remains a great need for the incorporation of this research into the practice of ecosystem management to facilitate adaptation to climate change. It is hoped that future models will be capable of considering edaphic factors, disturbance regimes, competition, and other complex ecosystem processes (Pellatt *et al.*, 2012).

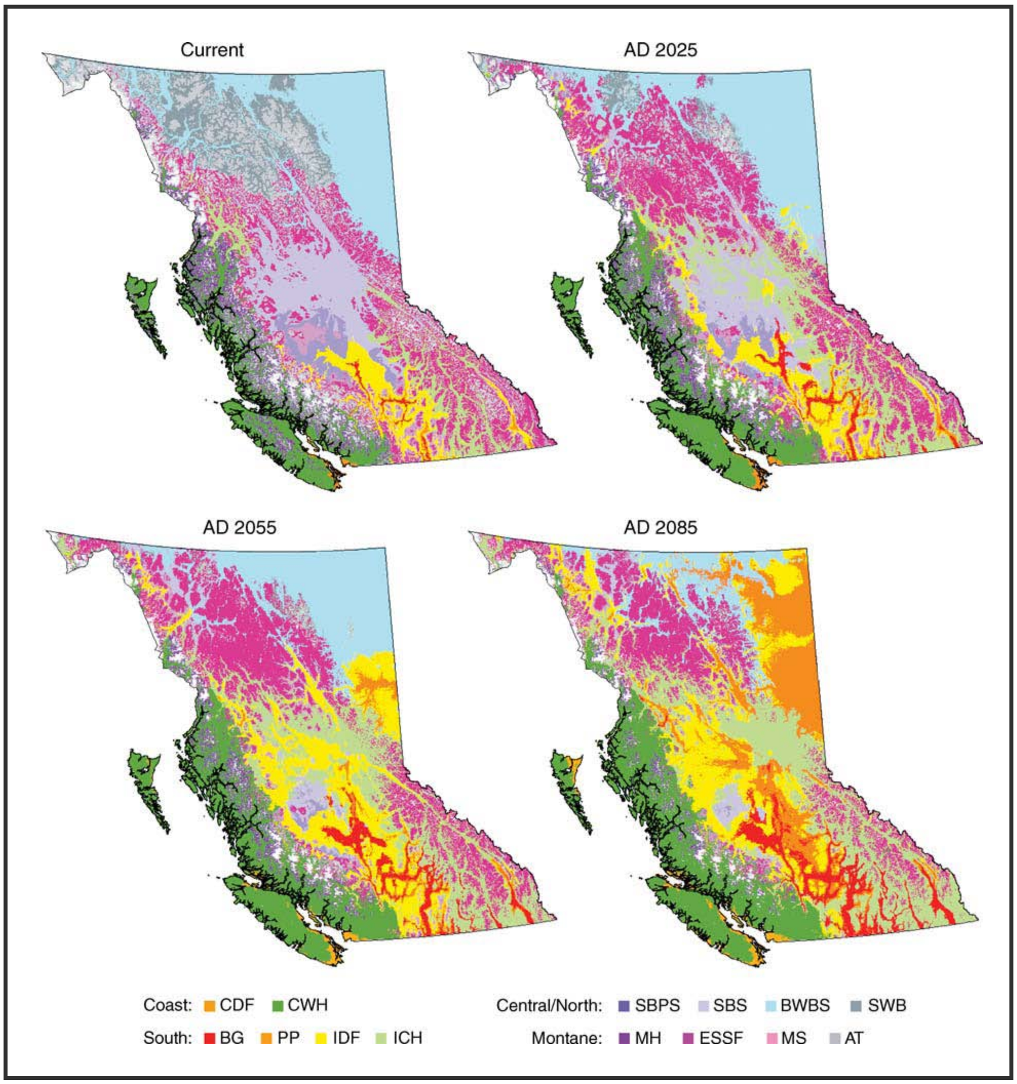


**Figure 4: Future climate change scenarios for BC (Hamann & Wang, 2006)**

### 3.3.1. Climate Change Policy

In many places around the globe, one of the emerging ways of coping with the risks of climate change is the incorporation of methodologies and tools within EIA to screen for climate change risks. There have been extensive efforts by researchers, development co-operation agencies, and national governments to establish these methods and tools, but these have chiefly been recommendations or stand-alone initiatives (Agrawala *et al.*, 2010). Several entry points for incorporating climate change impact and adaptation into EIA have been documented, from the initial phases of an EA, through the scoping, assessment, and execution phases (Agrawala *et al.*, 2010). Leading this process are the multilateral development banks, but several national and regional authorities are also beginning to include climate change in their EA processes (Agrawala *et al.*, 2010).

Within Canada the CEAA has recognized the need for the EA process to include climate change considerations, with regard to the way a project can be affected by, or affect, climate change (Byer, 2009). Yet, given a search of the text of the Canadian Environmental Assessment Act (2012) the actual term “climate change” does not appear (Government of Canada, 2012b). This means that climate change is not actually addressed by law, but it is instead addressed through federal directives. In 2003, the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment published their guidelines for *Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners.* (FPTC (CCEA) guidelines) (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, 2003).

The FPTC guidelines are seen as an important step toward highlighting the importance of including climate change in project level EAs (Byer *et al.*, 2011). They focus primarily on two different areas, firstly, greenhouse gasses (GHGs) and their reduction, and secondly, the determination of the future impacts of climate change on a proposed project (Bell *et al.*, 2003). These considerations of GHGs and impacts offer generalized advice, but they are not specific about the techniques that practitioners should use during the planning and decision-making phases (Byer *et al.*, 2011). The FPTC states that it's important to have good information sources for practitioners to use when conducting an EA, but there is still a large amount of uncertainty for scientists to address (Byer *et al.*, 2011; Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, 2003). In the face of the uncertainties that exist and the complexity of the issues associated with climate change, it is common, at the federal level, for project planners to simply assume that climate will remain stable during the project's lifetime. Project proponents often defer the issue to the future by favouring more research, monitoring, and adaptation (Byer *et al.*, 2011). The inherent uncertainty that climate change presents poses a serious challenge for EIA, and environmental policy in general, and BC planners have been attempting to adjust to this by creating many acts, strategies, and directives regarding climate change mitigation and adaptation over the last decade

The British Columbia government is increasingly concerned about preparing for unavoidable climate change, and, in their most recent budget, the BC government stated that this continues to be a key priority (British Columbia Ministry of Environment and Environmental Assessment Office, 2011). The government began this process in 2008, when a number of new laws, specifically aimed at reducing the emissions of GHGs in B.C., were introduced. The Greenhouse Gas Reduction Targets Act sets as a province-wide target, a 33% reduction in the 2007 level of GHG emissions by 2020 and an 80% reduction by 2050 (Blakes Environmental Group, 2012). The Climate Action Secretariat of BC concentrates on mitigation of climate change through carbon taxing and sequestration, and is working across government and with industry, communities, other governments and stakeholders to work toward mitigating and adapting to climate change (British Columbia Ministry of Environment and Environmental Assessment Office, 2011). The BC EAO supports the new *Provincial Climate Change Adaptation Strategy*, an objective set that requires government organizations to consider climate change and its effects in all variety of activities, such as "planning, projects, policies, legislations, regulations and approvals" (British Columbia Ministry of Environment and Environmental Assessment Office, 2011: 33). These requirements apply to provincial EIAs and require the assessment of adaptation activities, cumulative effects, and environmental impacts while carefully looking at project alternatives and mitigation measures that will help us move towards greater adaptation strategies (British Columbia Ministry of Environment and Environmental Assessment Office, 2011). This strategy is not law, but it does serve as a base for continued adaptive management in the face of climate change, and gives British Columbia's planners and EA practitioners more tools to work with than the federal government does.

## 3.4. Biodiversity

Biodiversity is globally and locally significant in its own right as well as for our social and economic well being, as it is the underlying interconnected network upon which a wide array of ecosystem services relies. These ecosystem services include pollination and water filtration, as well as essential resources, such as forest products, pharmacological and medicinal compounds, and our atmosphere. Biodiversity is the essential part of environmental baseline studies such as the Retreat Island case study. Biodiversity also fosters stability and resilience within ecosystems, be they managed or not, by allowing for functional complimentarity to exist, with different species successfully surviving under varying conditions and thus buffering the effects of environmental change (MacDougall *et al.*, 2013). Redundancy of species that occupy similar functional roles within ecosystems is critical for the ecosystems stability under perturbation.

To proceed with a discussion of the importance and value of biodiversity it is essential to have a clear definition of *what* biodiversity is. The word biodiversity literally comes from the combined terms of biological and diversity. For the purposes of this report we will rely on the CEAA's definition of biodiversity as the multiple levels of species[4] variety, the genetic composition of species and communities, ecosystems and ecological structures, and ecosystem functions and processes at all levels (see Figure 5) (Biodiversity Convention Office, 1995). Protecting endangered ecosystems has the capacity to conserve biodiversity within its nested levels, from the diversity of biomes and ecosystems, to communities, species, populations, and even including the microscopic level of genetic diversity as well (Heller & Zavaleta, 2009). Within these nested scales of biodiversity, it can be challenging to measure the levels of diversity that are present in a certain area. There are several different measures of diversity that come into play when collecting baseline data, with the most commonly quantified facets being: richness ("numbers"); evenness; and difference (Purvis & Hector, 2000).

[4] For the purposes of this report, the term species will be defined as a group of organisms that are capable of reproducing and creating reproductive offspring. There are many challenges within this definition, particularly when looking at floral, fungal, and other non-faunal taxonomic groups, but these are far beyond the scope of this report.

Within each of the multiple measures of biodiversity, there is usually a research emphasis on the species level, with species richness, generally ascertained through detailed inventories, as the most commonly utilized quantification. It is important to remember that the process of counting variations can also be applied to ecosystem or community types within a region, as well as to the phenotypic variability (which partially reflects the genetic diversity of each individual species) (Purvis & Hector, 2000). Measuring species evenness requires a large amount of data, and is usually expressed as an index that reflects the symmetry of the distribution of each species present; this is important because if an area contains 1000 individuals, but 999 are from one species, then the area is not biodiverse (Purvis & Hector, 2000). The measurement of difference in biodiversity is usually applied to populations of a particular species and represents the level of variability within the phenotypes or genotypes that are present.

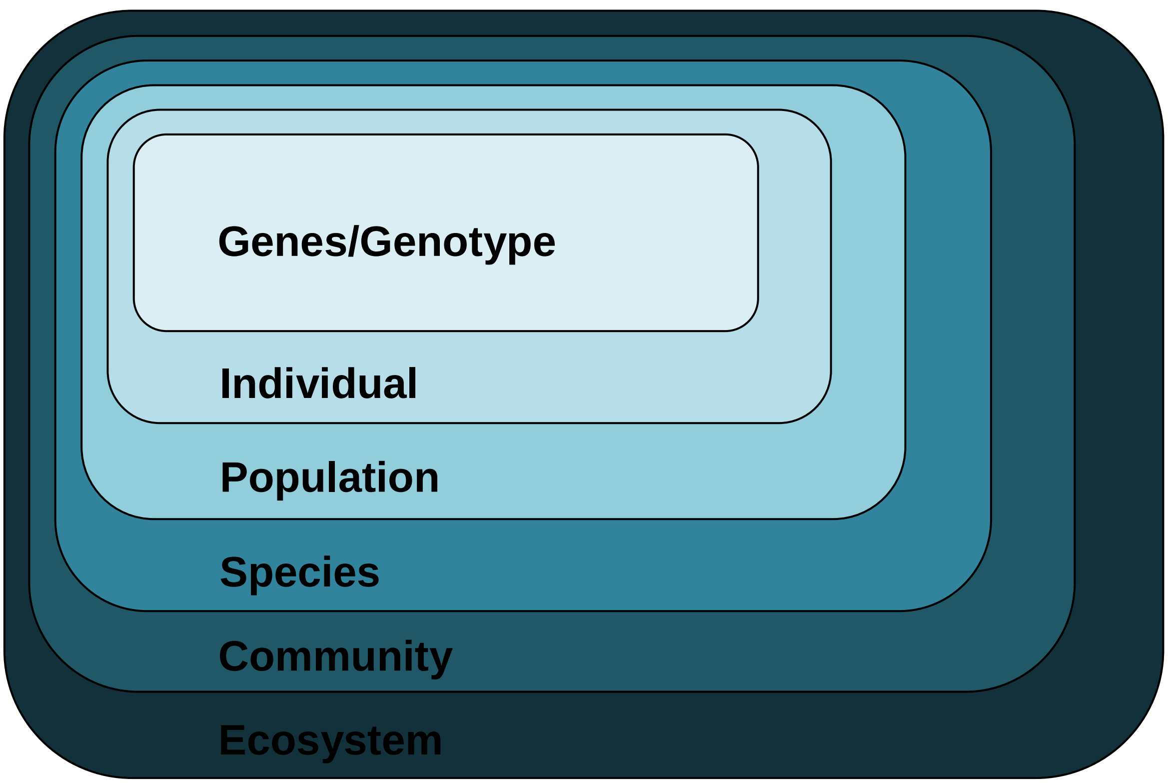


Figure 5: Nested levels of biodiversity

These three ways of measuring biodiversity are the most commonly utilized in biological investigation, and for the purposes of the baseline report on Retreat Island the species richness was calculated in the simplest fashion possible: by amassing as complete of a species inventory as possible within the existing time and knowledge constraints. In general, even this depth of research is usually not possible for most environmental investigations, and randomized methods of data gathering are used in order to gain an idea of the level of biodiversity present within a genetic, species, or ecological population (Heller & Zavaleta, 2009). British Columbia's biodiversity is globally significant because of its variety and integrity, but it is vulnerable to rapid deterioration in light of rapid climate change (Biodiversity BC, 2008).

### 3.4.1. Biodiversity Policies

All of these multiple levels of biodiversity are vulnerable to impacts such as habitat loss; invasive species, and increased resource consumption and pollution (Canadian Environmental Assessment Agency, 1996; Biodiversity BC, 2008). In 1992, the international community recognized the quickening rate at which biodiversity is decreasing, and the negative impacts of this, at the United Nations Convention on Biological Diversity ("the Convention") in Rio de Janeiro, Brazil. Canada was the first signatory on the Biodiversity Convention, which is an international, legally binding treaty, meaning that there is an international obligation to continually assess our efforts to sustainably use and protect biodiversity. It has been ratified at both the Federal and Provincial levels (Canadian Environmental Assessment Agency, 1996). In order to uphold the Canadian commitment, a group of federal, provincial, and territorial ministers of Parks, Wildlife, Environment and Forestry departments worked together to create the Canadian Biodiversity Strategy (CBS) (Biodiversity Convention Office, 1995). The CBS's primary goals are to 1) conserve national and global biodiversity; 2) promote the sustainable development of biological resources; 3) improve resource management capabilities; 4) and create legislation that helps with the conservation of biodiversity (Biodiversity Convention Office, 1995). Working in conjunction with the CBS is the Species at Risk Act (SARA), which recognizes species considered at risk, and categorizes them as threatened, endangered, extirpated, or of special concern and prohibits several specific activities that harm these species, such as damaging or destroying their critical habitats (Blakes Environmental Group, 2012).

Environmental assessment is noted in article 14 of the Convention as a key part of the decision-making process for protecting biodiversity (Canadian Environmental Assessment Agency, 1996). Currently biodiversity is a consideration within Canadian EA practices, though it is not part of the law, but rather incorporated through a set of recommendations. Biodiversity is considered in Canadian EA through cumulative environmental assessment, sustainable development consideration, and best practice techniques (Canadian Environmental Assessment Agency, 1996) The CEAA's goal is to determine the possible impacts of project development on ecosystems, species, and genetic resources and propose suitable methods for avoiding or decreasing these effects to levels deemed acceptable (Canadian Environmental Assessment Agency, 1996). It is an area of enquiry within EIA that requires specialization in a wide array of ecosystems, and requires that the practitioner establishes whether any of the species, communities, or ecosystems is endemic, sustainably managed, or hold social or scientific significance (Canadian Environmental Assessment Agency, 1996). In addressing these questions, EA is expected to assess the potential effects of development on ecosystem, species, and genetic resources (Canadian Environmental Assessment Agency, 1996). Given the importance of biodiversity and the precautionary principle, the CEAA recognizes that it is imperative to avoid irreversible losses to ecosystem, species or genetic diversity (Canadian Environmental Assessment Agency, 1996). It is also important to look at the impact that a project may have in combination with other developments in an area through cumulative assessment.

EA can be used to help understand the cumulative environmental effects that are a result of human activities on ecosystems, species and genetic diversity (Canadian Environmental Assessment Agency, 1996). One of CEAA's goals is to identify and eliminate or reduce cumulative impacts on ecosystems, species and genetic diversity (Canadian Environmental Assessment Agency, 1996). Methods for this end can include early-warning indicators, and creating national and international agreements that incorporate cumulative impacts on biodiversity. It is advantageous to incorporate biodiversity into both project and cumulative assessments as it a key method for building adaptive capacity (Heller & Zavaleta, 2009). Given that the more diverse a population is, the more capable it is of adapting to change, it is of great importance to be aware of the bioclimatic variability within and across landscapes and to design managed systems to include high levels of species, structural, and landscape diversity (Heller & Zavaleta, 2009). It is also of great importance to maintain distinct areas of endemism, ecotones or refugia, if they are in a project area (Heller & Zavaleta, 2009) as well as continue to work towards gaining a greater understanding of the historical trends of species and habitat losses that exist in Canada (Canadian Environmental Assessment Agency, 1996).

## 3.5. Biodiversity and Climate Change

In this report, we have looked at the impacts of climate change and the importance of biodiversity, but it is also important to look at the effect of climate change on biodiversity. The increasing levels of atmospheric carbon dioxide ($CO_2$) and other GHGs over the next century are expected to pose a considerable challenge for biodiversity conservation. In fact, it is expected to become the greatest force behind global biodiversity loss in the short term future (Heller & Zavaleta, 2009). Biodiversity is one of the key aspects of the integrity of ecosystems, and it is important to monitor it carefully in the face of climate change (Canadian Environmental Assessment Agency, 1996). Local ecological communities tend to disaggregate and shift pole-ward, being replaced by species more adapted for warmer situations; meanwhile, species are expected to continue to suffer from habitat loss (Heller & Zavaleta, 2009).

# 4. Theoretical Framework

The research, development, and writing process for this report has been influenced by several theoretical standpoints, including integrated ecosystem theory, risk society theory, and adaptive management theory. Beyond these three frameworks there is also an underlying faith in the scientific method and a personal grounding in the inherent value of all forms life that make up the biodiversity around us and that we do not, in fact, manage ecosystems, but rather that we manage our behaviours and attitudes towards them. This section will begin by describing integrated ecosystem theory, then the basics of risk society theory, and then move to the topic of adaptive management, which has many interrelated elements, such as mitigation and adaptation, and adaptive methods including resistance, resilience, and response.

## 4.1. Integrated Ecosystem Theory

Integrated ecosystem theory, as presented by Jørgensen in *An integrated ecosystem theory* (2007), is a framework that integrates the viewpoints of many systems ecologists and outlines the "general tendencies of ecosystem properties and processes that can be applied to understand ecosystems and their responses to human impacts" ( 2007: 20).

Integrated ecosystem theory provides a guide for the wider application of the ecological sciences in ecosystem and resource management that looks at systems rather than differing variables. This theory attempts to move away from reductionist traditions, instead incorporating the complex systems of Earth holistically (Jørgensen, 2007). Jorgensen defines an ecosystem as a dynamic complex that includes floral, faunal and microorganismal communities and their abiotic environment as well as their functional interactions, in which humans play a fundamental role (Jørgensen, 2007). Adding to this is the fundamental assumption that different combinations of environmental conditions will support different species sets (an assumption that has been upheld in many different regions and habitats) (Vellend *et al.*, 2008). These systems are interconnected, complicated, adaptive, and continuously evolving (Biodiversity BC, 2008).

Working in the same vein of understanding ecosystem level dynamics, thirty years ago in a groundbreaking report, G. E. Beanlands and D. N. Duinker (1983) proposed the adoption of an ecological approach for the practice of EIA. They recognized the importance of incorporating science into the EIA framework and of conceptualizing EIA within an ecological perspective, so that the varied impacts that a project may have, be they on physical, chemical, biotic or energy systems, can all be examined. It is also important to look at it in the opposite manner, by questioning the impacts that these systems may have on the project itself (Beanlands & Duinker, 1983). The point at which ecological theory is included in EA is usually during the baseline data collection process. Given that a baseline gives a picture of the environmental conditions prior to development, it is important for the practitioner to be aware of the fact that the environment is not static, but rather that there may be positive or negative local trends or cyclic patterns of change (Noble, 2000). Another approach that has been promoted for the incorporation of ecological theory is that of creating an ecological characterization of the study area prior even to the baseline data collection (Beanlands & Duinker, 1983). Either prior to, or during, the baseline data collection, it is essential that the pre-project environmental assessment incorporates local ecological resources that are important for society, as well as the key habitat components, the key biological processes, and the ecosystem's physical driving forces such as climatic conditions and transport mechanisms (Beanlands & Duinker, 1983). This is of great value because it considers the range of basic ecological linkages between the project and the ecosystem, and this will narrow the possible avenues of research (Beanlands & Duinker, 1983).

## 4.2. Risk Society Theory

Risk society theory emerged from sociologist Ulrich Beck's publication of *Risk Society: Towards a New Modernity* (1992). According to this theory, the modernization of society has changed both the nature of risks and the way in which we cope with them. Beck (1992) argues that societies are now moving towards coping with these risks by incorporating future-oriented environmental planning, such as the precautionary principle and adaptive management, as well as modern technology (Beck, 1992; Weston, 2004). In the face of an uncertain future it is necessary to manage with a portfolio of approaches, for both the short and long term, which works to enhance the resilience of ecosystems and therefore promotes the optimum level of adaptations to different possible futures (Millar *et al.*, 2007; Brown & Damery, 2009).

Within EA the issue of natural variability is one that poses great challenges for practitioners, and it is important to keep this risk in mind during steps such as baseline data collection. Beanlands and Duinker (1983) explain that the problem of natural variation impacts nearly all aspects of EA, and can be traced back to the variability that is inherent to most biological and physical phenomena. Annual variations and multi-year cycles often superimpose random variations as well, and this is then compounded by the fact that situations arise when there are shifting baselines, or, in other words, the natural baseline of an area may be in flux, and this is an added difficulty for practitioners incorporating future-oriented environmental planning (Beanlands & Duinker, 1983). The dynamic nature of an ecosystems natural state and the added challenge of climate change and biodiversity loss create a situation that can be difficult to manage, and it is upon the EA practitioner to attempt to include as many different methods of understanding the risks of natural variation as possible. Natural variability will affect the variables that need to be measured and the selection of experimental approaches, and will determine, in large measure, the accuracy of the impact predictions. (Beanlands & Duinker, 1983).

From the risk society perspective it is necessary to incorporate a variety of methods for coping with the risks of natural variation and of the project itself, both those known and unknown. To understand the potential results of a proposed project, EA practitioners must move beyond a general, one-time, descriptive approach to creating baselines (Noble, 2000). To this end, an experimental approach needs to assess baseline conditions but also consider potential changes in system interactions. This is because ecosystems are often in flux, and the state of a complex system at a given time seldom gives a clear idea of the ecosystems' responses to changed environmental conditions due to human interference (Noble, 2000). Experimentation is a vital part of impact assessment and adaptive management. This need for a wide array of information to allow for future adaptation in the face of risk is tempered by the fact that it is unrealistic to undertake an all-inclusive (holistic-comprehensive) baseline study of all of the species and interactions within the study region (Noble, 2000). Given that impact assessment is "inherently about the future and is aimed at dealing with future risks in a proactive way"

(Larsen, 2011: 2), the theory of risk society is directly applicable to the process of creating baseline studies, and to incorporating biodiversity loss, and/or climate change (both human-induced environmental risks) into EIA. In order to cope with these types of risks and others, many planners choose to use methods of adaptive management (Suter *et al.*, 1987).

## 4.3. Adaptive Management

Adaptive management is a conceptual framework that allows practitioners to work under the assumption that future environments will be different from present and that those changes present a challenging uncertainty (Millar *et al.*, 2007). In its broadest sense, adaptive management is based in the fundamental premises of flexibility; learning from experiences; and iteratively integrating lessons into plans (Millar *et al.*, 2007; Byer *et al.*, 2011). Adaptive management is a pragmatic approach to environmental management that promotes decision-making incorporating ongoing research and learning and ongoing modification as methods to cope with uncertainty (Walters & Hollings, 1990; Spittlehouse & Stewart 2003). Within adaptive management, baseline data, such as that collected in the case study, is essential for future development and its establishment needs to be initiated in advance of impact assessments (CEAA, 2010). Adaptive management is defined in the CEAA's *Operational Policy Statement* as "a planned and systematic process for continuously improving environmental management practices by learning about their outcomes", and its incorporation into follow-up programs was introduced in the 2003 Canadian Environmental Assessment Act (Kwasniak, 2010).

In order to manage adaptively in the face of risk and natural variation it is necessary to establish an explicit idea or model of the ecosystem or region that is under question (Walters, 1986). The explicit vision provides the baseline from which variations and surprises are compared and it has been posited that “without surprise, learning does not expand the boundaries of understanding” (Lee, 1999: lines 150-152). The baseline is the point from which EA practitioners can predict possible futures for a system, both with, or without, the impacts of the proposed project (Noble, 2000). It is important that EA practitioners, with the goal of mitigating the impacts of a project, remember that baselines can and will vary, so that management goals and objectives are also adapting to changing conditions (Noble, 2000).

Adaptive management is an integrated holistic approach (as opposed to integrated comprehensive, which attempts to exhaustively describe all aspects of the study region), it requires a more focused, and practical method of identifying the key environmental components to monitor during the scoping and baseline phases of an EA. One of the most important contributions of adaptive management is the process of identifying the key environmental indicators, be they species, ecosystem types, or systems that are of the greatest concern when natural and anthropogenic changes occur (Noble, 2000). The process of ensuring future flexibility of options can cost more at the outset to ensure that there will be options of action available in the future, but this cost allows for the level of uncertainty to be reduced (Byer *et al.*, 2011). In the face of uncertain or absent knowledge, this initial “buy-in” allows for further actions to be initiated after enough experience has been gathered (Lee 1999). Adaptive management is particularly important when dealing with climate change, as there are still varying forecasts for the impacts that can be expected (Byer *et al.*, 2011). It is important to note that adaptive management has been criticized by those who believe it is a method of deferring action to a later date thus it is important to incorporate the best possible science as well as realistic deadlines.

### 4.3.1. Adaptation and Mitigation

Within the challenge of coping with an unsure future, in the cases of climate change, or biodiversity loss, or the development of a proposed project, adaptive management is used to cope with uncertainties. The underlying goal of adaptive planning is “resilience in the face of surprise” (Noble, 2000: 100). There are two commonly proposed methods, that of adaptation to uncertainties, and that of that of mitigation of uncertainties. Mitigation generally works to slow or stop the causes of damage or uncertainty, while adaptation, on the other hand, is the adjustment of systems to a changing future in ways that may reduce harm and take advantage of possibly beneficial scenarios (IPCC, 2007). Resource managers face the challenge of incorporating both mitigation and adaptation into their plans, and this is a challenge for EA practitioners as well.

Typically, over the last decades the most common method of responding to possible changes, in particular climate change has been through mitigation methods, and there has been a lack of support from government or private backers for switching to adaptive methods of response (Heller & Zavaleta, 2009). Mitigation of emissions and the creation of carbon credits are methods that have been commonly been used in order to slow the rate of climate change. Other mitigation methods in the face of climate change have included substitute fuel sources and increasing carbon assimilation capacities through planting trees (Byer *et al.*, 2011). In the face of biodiversity loss, mitigation methods have concentrated on eliminating the potential impacts that projects may have on the environment and sensitive ecosystems in particular (Canadian Environmental Assessment Agency, 1996). Mitigation also has the objective of eliminating or reducing possible negative impacts of development projects on the environment (Canadian Environmental Assessment Agency, 1996).

Adaptation is broadly understood as the adjustment in natural or social systems, such as structures, processes, and practices (IPCC, 2007), and while scientists have been discussing this for decades, development of adaptive measures in laws, and plans, policies, and programmes has not progressed quickly (Heller & Zavaleta, 2009). Adaptation is most currently discussed in correlation with climate change, and it is based in the understanding that some of the impacts of climate change are ongoing or imminent (Byer *et al.*, 2011). Resilience and resistance are two common adaptive strategies used when responding to environmental changes. Resilience is the capacity for a system to absorb rapid environmental change, while resistance is the capacity to buffer itself from change (Heller & Zavaleta, 2009). Managing for resilience is usually seen as the more pragmatic approach, as it is focused on flexibility and can be seen as a part of an adaptive management framework (Heller & Zavaleta, 2009). The UNFCCC has made a collection of tools and methods available to help in the decision-making process and adaptation to climate change. These include many methods, like Benefit-cost analysis (BCA), cost effectiveness analysis, adaptation decision matrix (ADM), tools for environmental assessment and management (TEAM), etc. Benefit-cost analysis, for example, evaluates alternatives in terms of financial wellbeing (i.e., best monetary-equivalent return for a given financial investment) *(*Byer et al., 2011). Uncertainty about the future can be integrated into BCA by increasing the future discount rate to reduce the present value of future unknown benefits and costs, although this is thought to be inadequate for evaluating adaptation alternatives for climate change *(*Byer et al., 2011).

Resilience options are usually based on ensuring that an ecosystem can continue to thrive after a disturbance (like increasing genetic diversity), while resistance options attempt to stop the impacts in order to protect highly valued resources (Millar *et al.*, 2007). Resistance has been a more common response to climate change and other environmental changes, but it is recognized that a shift towards resilience as a goal for ecosystem management is more realistic when changes are already occurring (Heller & Zavaleta, 2009). Although these three methods are all seen as adaptive measures, the core values of resilience and adaptation look towards adjusting to changes, while resistance and mitigation are methods that hope to stop or slow the driving forces behind uncertainty and change. Response options vary from these two other options by providing support for the transition of ecosystems from current to future conditions (such as interventions like sandbagging) (Millar *et al.*, 2007). It is important to differentiate between adaptive management, adaptation and adaptive capacity (Byer *et al.*, 2011). Adaptive capacity is the *ability* of a country, industry, community, or individual to apply adaptation measures to an environmental risk, a process that is influenced by many factors, like "institutional structures, access to education, technological capabilities and financial resources" as well as the effectiveness of decision making frameworks (Byer *et al.*, 2011: 17).

According to the Canadian Environmental Assessment Agency's definition of adaptive management, communities with a narrow range of ecological tolerance (such as Garry oak associations) can serve as a gauge of greater ecological conditions (CEAA, 2010), such as climate change. Within the incorporation of climate change into environmental impact assessment, many researchers cite adaptive management as a key tool in helping integrate the impacts of climate change on a project, and one key part of this relationship are models of the possible impacts of climate change on forest coverage types, such as those described in the following case study.

# 5. Case study

This section is going to look at the case study that I have chosen from my internship at the Galiano Conservancy Association in 2011, a baseline for Retreat Island that was requested as an update and intensification of a perfunctory (and somewhat incorrect) baseline report that was written 20 years ago for the Ministry of Environment. The description of the baseline report is followed by a description of BC's biogeoclimatic zones, Garry oak ecosystems environmental and social importance, and the expected impacts of climate change on this distinct ecosystem type.

## 5.1. Retreat Island

The case study that inspired this research was a large component of my internship at the Galiano Conservancy Association[5] between June and November 2011. This extended baseline ecosystem analysis was of the ecosystems on Retreat Island, a 2.8-hectare[6] island off the west coast of Galiano Island in the Gulf Islands of Southwest British Columbia. Retreat Island lies nestled in one of the very few coves along the western shore of Galiano, which is dominated by sandstone and tafoni bluffs. During my preliminary research, I undertook the tasks of the removal of the highly invasive Scotch broom (*Cytisus scoparius*) and then moved on to creating a comprehensive baseline study of the island as requested by the Galiano Conservancy Association. This report was created in order to enhance understanding of the biodiversity and ecosystem types present on the island, and to replace the often inaccurate and incomplete baseline study that was done in 1992. This island locale has been described as "a naturalists delight" with a beautiful meadows filled with spring wildflowers such as wild orchids, lilies, and many other small wonders (Benger, 1988).

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[5] http://www.galianoconservancy.ca/
[6] 2.8 hectares

There are hundreds of floral and faunal species present in this island, which is generally classified as a Coastal Douglas Fir Moist Maritime (CDFmm) biogeoclimatic subzone that includes several endangered Garry oak (*Quercus garryana*) association and community types[7] (BC Ministry of Forests, 1994; Fuchs, 2001). My 50-page baseline study included the differentiation of nine different ecosystem areas (polygons) on the island and a detailed floral and faunal species inventory. These were delineated according to W. R. Erickson's *Garry oak (Quercus garryana) Plant Communities and Ecosystems in Southwestern British Columbia* (1998). I relied on a wide array of field guides (particularly (Pojar & MacKinnon, 1994) and (Sibley, 2000)), my own years of natural history and ecological experience in southwestern BC, as well as collaboration with local specialists in ornithology, ecology, entomology, and ethnobotany to ensure that the species inventory was as thorough and accurate as possible. The level of local knowledge that I was lucky enough to have for the region of study is likely beyond that of a typical practitioner, but it would be desirable for those creating ecosystem baselines to have an intimate knowledge of the regional ecology. Here there are several endangered ecosystems and communities, as well as several bird species classified as species at risk (BC Ministry of Environment, 2011). Mature old growth Douglas fir forests such as the one that exists on Retreat Island are quite rare in this region, as there was a large amount of logging at the arrival of Europeans, so trees that are as tall and large as those present on the island are unusual. The CDF ecological classification has been ranked as imperiled (a high risk of extinction) both at the provincial and global levels (Biodiversity BC, 2008). These ecosystems have been significantly reduced in their coverage in British Columbia since European settlement began, and are presently further threatened by many factors, including non-native invasive species (Fuchs, 2001).

[7] For the purposes of this report Garry oak ecosystems includes associated ecosystems as well, such as vernal pools and rocky outcroppings (Erickson, 1998).

The concept of Biogeoclimatic classification zones in British Columbia was briefly mentioned in the section on biodiversity. These zones are geographic areas that have similar energy flows, vegetation, and soils types due to their similar macroclimate (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, 2003). This system was created by Dr. V. Krajina in the 1960's for the provincial Ministry of Forests to delineate vegetation types based upon their geology, geography, and climate (Biodiversity BC, 2008). British Columbia there are 16 different biogeographic zones, 12 these are forests 3 Alpine 1 dominated by grass (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, 2003). The inclusion of these ecological characterizations at the beginning of the baseline process is an example of the incorporation of ecological theory as per Beanlands and Duinker (1983).

During my research, the British Columbian Ministry of Forests' recommendations for identification and interpretation of forests (*Land Management Handbook 28*) and for describing terrestrial ecosystems (*Land Management Handbook 25*) were followed in order to create an in-depth characterization of the ecosystem types (BC Ministry of Forests, 1994; BC Ministry of Forests and Ministry of Environment, 2010). These handbooks divides the broad biogeoclimatic zones into narrower ecosystem descriptions, each referred to as the "site series". In combination with these two handbooks, I used many methods, including floral and faunal inventories, mapping, plant community classification, and interviews with experts[8] in order to obtain the data for this study, which is reflective of risk society theory by incorporating a variety of methods of attaining information for the baseline in advance of adaptive management. Besides the

[8] Including a geologist (Dr. Jim Haggart), an ecologist (Dr. Keith Wade), a lichenologist (Dr. Trevor Goward), an ornithologist (Dr. Mike Hoebel), and several conservation specialists (including Dr. Ken Millard and Keith Erickson).

wide variety of plants[9], there are also numerous faunal species (primarily birds[10]) that rely on this ecosystem. In a six-month span I observed a wide array of community types, as well as almost 50 bird species, nearly 100 floral species, and 11 different terrestrial species. Several provincially red listed endangered ecosystem types (according to the BC Conservation Data Centre (Fuchs, 2001)) exist on Retreat Island. Of particular interest, were the rarer species that occurred on the island, such as the purple martin (*Progne subis)* and the Great Blue Heron (*Ardea herodias fannini*).

The field data for this research was derived from a wide variety of techniques, such as field photos, randomly thrown plots, listed species inventories, and percent coverage, and amassed spatial data that I later used to create several land-use and ecosystem type maps. During my field research I surveyed the entire island and created a variety of localized maps with 2-meter contour intervals that are available at up to a 1:800 scale. These maps were created using ESRI's Arc GIS 9.1 and contained a wide array of point, line and area data, such as eagle nest locations (and other nesting bird sites), trail locations, and ecosystem community type polygons. These maps have boundaries that seem definite, but it must be remembered that of the numerous community types that exist within Gary oak ecosystems, many of them have very minor soil types, and the "borders" really represent blurred ecotones between them (see Figure 6) (Erickson, 1998).

9 Including vascular plants, non-vascular plants, and lichens.
10 Including the rare band-tailed pigeons (*Patagioenas fasciata*), Pacific great blue herons (*Ardea herodias fannini*), purple martins (*Progne subis*) as well as a nesting pair of bald eagles (*Haliaeetus leucocephalus*).

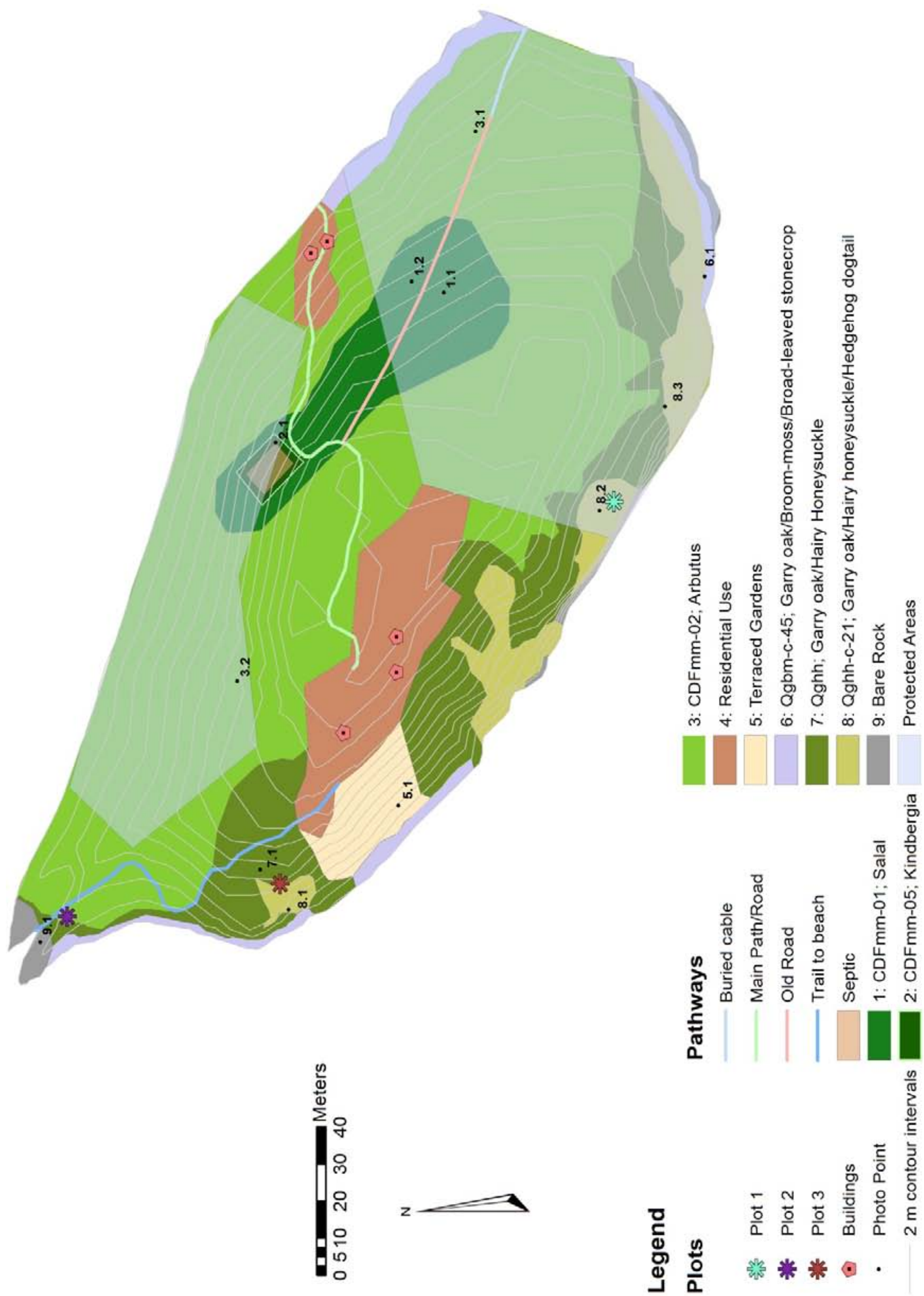


**Figure 6: Example of an ecosystem type map for the Retreat Island baseline study**

levels is the fact that there have been active ecosystem restoration efforts made on the island for the last twenty years by volunteers and employees of the Galiano Conservancy Association (including myself for several years). Beginning with removing the non-native Scotch broom species in the early 1990s the biodiversity of the island has been noticeably increased since restoration efforts began. Beyond removal of non-native species, restoration approaches have included transplanting native tree and shrub species on the island as well as the scattering of herbaceous bulbs, and the seeds of grasses and forbs collected from native stock in very close geographic proximity (Garry oak Ecosystem Recovery Team, 2011).

## 5.2. Garry Oak Ecosystems

Garry oak (*Quercus garryana*), also called Oregon white oak, is a broad leaved deciduous hardwood tree, noted for its distinct appearance and its namesake ecosystem type, which contains savannahs that hold a wide array of unique species and communities in complex mosaics with "maritime meadows, coastal bluffs, vernal (ephemeral) pools, grasslands, rocky outcrops, and transitional forests" (Fuchs, 2001: 5; Lea, 2006; Pellatt *et al.*, 2012). Garry oaks exist along the Pacific coast of North America, from Vancouver Island to southern California, spanning more than 15 degrees of latitude from just below 50° to 34°, and it is the only species of oak native to BC and Washington (see Figure 7) (Pellatt *et al.*, 2012). In Canada, Garry Oak meadows are particularly rare, scattered across eastern and southern Vancouver Island and the smaller adjacent islands including the Gulf Islands from sea level to at least 200 metres (Pojar & MacKinnon, 1994). Garry oaks are not native on the province's mainland except in two disjunct populations near Hope in the foothills of the Coast Mountains (United States Department of Forestry, 2006; Biodiversity BC, 2008). Their deep taproots means that they are highly drought tolerant (Fuchs, 2001), and it is this adaptation that ensures

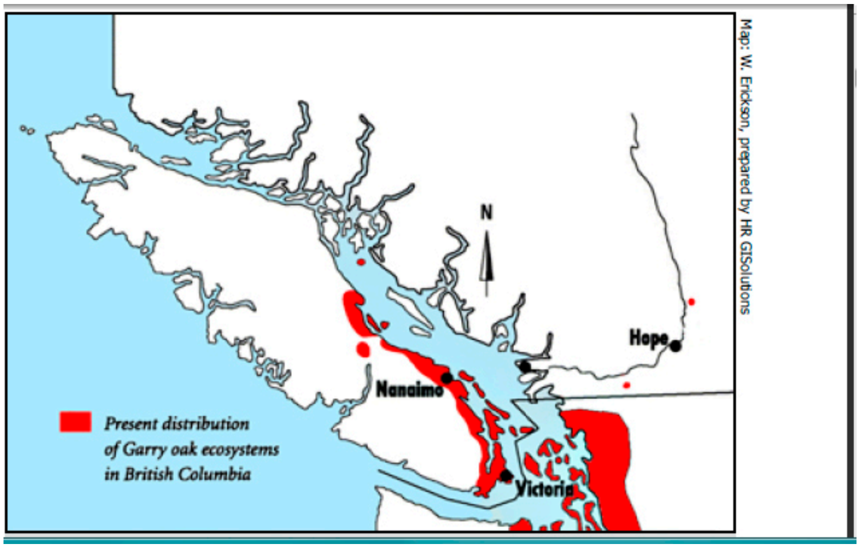


**Figure 7: Current Garry oak distribution (Erickson, 1998)**

that they are able to survive at this, their northernmost location, in the lowest, warmest, and driest parts of the broader region, within a unique Mediterranean sub-type climate that exists in the rain-shadow of the Olympic Peninsula (Erickson, 1998; Vellend *et al.*, 2008; Pellatt *et al.*, 2012). The region is classified as Warm-summer Mediterranean climate (Csb) according to the Köppen-Geiger climate classification system, a climate type that is typified by warm but dry summers and rainy and chilly winters and at least four months with average temperatures over 10 degrees Celsius (Rubel & Kottek, 2010). Garry Oak ecosystems are found within the Coastal Douglas-fir (*Pseudotsuga heterophylla*) (CDF) biogeoclimatic zone and they thrive in full sun, usually existing on dry rocky outcroppings, slopes with southern exposure, hilltops, and coastal bluffs, or ephemerally in deep moist sites as an early stage of succession after a disturbance (most commonly fire) (Meidinger & Pojar, 1991; Pellatt *et al.*, 2012). Two site series sometimes include a Garry oak component and these will frequently will be outcompeted by local conifers on moist sites unless there are disturbance regimes that maintain them (Fuchs, 2001).

**Figure 8: Fawn lilies (*Erythronium oregonum*) in great abundance in a Garry oak meadow, Retreat Island, March 2009**

Garry Oak ecosystems are very ecologically diverse, and though they occupy only a tiny portion of British Columbia's landmass, they contain a disproportionate 100 (+/- 5%) species officially listed by the Canadian federal government as at risk (Garry Oak Ecosystems Recovery Team, 2003) (Species at Risk Act, 2009). As well, the entire Garry oak ecosystem type is identified as at-risk under the Canadian Species at Risk Act SARA) (Pellatt *et al.*, 2012). There are eight different communities that the BC Conservation Data Centre currently monitors. All of these are considered to be critically imperilled, imperilled, or imperilled/vulnerable (Fuchs, 2001). Sixty-one plant taxa are defined as being at risk in Garry oak and associated ecosystems, counting 11 identified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as being at risk on a national scale, while twelve of these are at risk on a global scale (Fuchs, 2001). The total biological diversity that exists within Garry oak meadows includes at least 694 plant species, 104 species of birds, 7 amphibians, 7 reptiles, 33 mammals, and about 800 insects and mite species (Garry Oak Ecosystems Recovery Team, 2003; Fuchs, 2001). This threatened assemblage of flora and fauna includes camas (*Camassia quamash*), fawn lily (*Erythronium oregonum*), white-top maple (*Acer curtus*), chocolate lily (*Fritillaria lanceolata*), Lewis's woodpecker (*Melanerpes lewis*), Western bluebird (*Sialia mexicana*), and the Western meadowlark (*Sturnella neglecta*) (see Figure 8) (Erickson, 1998). Garry oaks are typically propagated by Stellar's Jays, as well as through vegetative reproduction (Fuchs *et al.*, 1999).

Upon the arrival of Europeans in Southern BC 150 years ago Garry oak plant communities had open, oak dominated canopies, with understories populated by early spring flowering plants, grasses and mosses (Lea, 2006). These majority of these oak savannahs have been damaged by human activities and changes in disturbance regimes, such as those described in section 5.3, leaving much of the previously rich and biodiverse areas dominated by a cover of invasive species such as Scotch broom (*Cytisus scoparius*), ivy (*Ilex aquilinium*), agronomic grasses and other weed species (Lea, 2006). At the advent of Western observations of Garry oak ecosystems in the 1800s they were found in a wide range of conditions, but there has been a bias in the types of sites that were either destroyed or left mostly intact, and this has resulted in current distributions that are not at all representative of their historical extent (Vellend *et al.*, 2008). The main reason for this initially was that the sparsely treed oak savannahs on deeper soils were the easiest to convert to agricultural lands; further, their historic extent depended on periodic disturbances from fire, both natural wildfires and anthropogenically prescribed burning (Pellatt *et al.*, 2012; Fuchs, 2001). Other cultural management practices, such as the harvesting of camas and the removal of similar, yet poisonous, death camas, are also thought to have maintained Garry oak ecosystems within the dynamic mosaic of the CDF biogeoclimatic zone (Pellatt *et al.*, 2012; Fuchs, 2001). This wide array of biological values as well as cultural values (see the following section) vested in Garry oak and associated ecosystems assigns them a great amount of environmental and social significance (Fuchs, 2001).

## 5.3. Garry Oak Ecosystem's Social Significance

The role of indigenous cultural practices in shaping the landscape of southeastern Vancouver Island has a long and important history (Turner, 1999; MacDougall *et al.*, 2004), and there is a great need to explicitly address its social importance when planning for the future of these ecosystems (Vellend *et al.*, 2008). Garry Oak landscapes contain a wide variety of plants that are significant to the ethnobotany of the Indigenous Peoples of Southwestern British Columbia. They grow within the traditional territories of the Coast Salish First Peoples. (Fuchs, 2001). These groups include (but are not limited to) the *Saanich, Songhees (Lekwungen), Esquimalt, Cowichan, Tsartlip, Penelakut, Pauquachin, Tseycum, Tsawout* and *Malahat* (Elder Florence James, Penelakut First Nation, personal communication, October 5$^{th}$, 2011; Simonsen, *et al.* 1997; Tudge 2006). A growing body of ethnobotanical research shows that there are hundreds of plants from Garry oak savannahs that have important uses as nutritional sustenance, medicinals, materials, and sacred spaces in the lives of the Coastal First Nations (Turner, 1999; Simonsen *et al.*, 2002; Turner *et al.*, 2005).

Traditional Ecological Knowledge (TEK) is accumulated through generations of people spending time observing, interacting, and living from the land. It includes all aspects of the environment - biophysical, economic, social, cultural and spiritual - and includes humans as a part of it, rather than agents acting upon it (Assembly of First Nations, 2011). Academics have emphasized that since the arrival of Europeans the degradation of Garry Oak ecosystems and loss of biodiversity is reflective of the elimination of traditional practices from those areas and changing land management regimes (Hebda, 1997; Simonsen *et al.*, 2002; Fuchs, 2001; British Columbia Environmental Assessment Office, 2010; MacDougall *et al.*, 2013).

The Coast Salish Peoples' local knowledge is an integral part of their ethnoecology, a field of study that is gaining attention among restorationists of cultural landscapes (Beckwith, 2005) and that gives important information for the environmental baseline. Ethnoecology is the study of cultural land use and the ecological systems that sustained human societies. It involves examining how Indigenous or local peoples affected the ecological structure and function of their ecosystems (Beckwith, 2005). A traditional Saanich saying reconfirms the importance of their relationship with the environment:

> *"The plants, the water, and the people as equal members of a complex system, an integrated entity connected through cultural traditions". The landscape, therefore, is essential to the continuity of traditional Aboriginal culture and, like traditional cultures, is threatened by the pace of development"* (Simonsen *et al.*, 2002, section 2.1)

Garry Oak meadows are a place of ceremonial importance for many Indigenous people of Southern Vancouver Island, in their entirety, as a place for cleansing and regeneration (Simonsen *et al.*, 2002). These spaces are key in the spiritual and ceremonial rituals of many Indigenous peoples of this region, and within them grow many plants that are also identified through TEK as ceremonially significant. Camas (*Camassia quamash and C. leichtlinii*) (see Figure 9), as previously noted, was the key carbohydrate food source on the British Columbia coast, and the intensive seasonal harvest of the bulb roots is considered by many to be analogous with agricultural cultivation (Turner *et al.* 2005; Suttles, 2005). It was thought to be a much more important food source than acorns for the local lFirst Nation's due to the vast size of the harvests, which are estimated to have been tens of thousands of tonnes per year (N. J. Turner, March 7th, 2013, personal communication). Wayne Suttles Straight's Salish informants provided background on the growing and cultivation of camas in Garry Oak meadows on southern Vancouver Island, a practice that included burning, and selective harvesting practices on heritable family-owned plots (2005). Although the term "owned" is used, the term usually is thought to refer to what elders truly call "living on, using and looking after" the land (Turner *et al.*, 2005: 153). This process is different from ownership because it reflects First Nations' reciprocal and deeply rooted history within these landscapes.

**Figure 9: Camas (*Camassia quamash*) in bloom**

The history of oak-prairie ecosystems across North America is deeply interconnected with frequent, low intensity fires (Vellend *et al.*, 2008). There is a large amount of oral history and physical evidence showing that prior to European settlement BC's Coastal First Nations' undertook seasonal burning to anthropogenically maintain cleared and productive Garry Oak meadowlands and to inhibit the continuation of successional processes towards a climax Douglas-fir (*Pseudotsuga heterophylla*) forest type (Simonsen *et al.*, 1997; Turner, 1999; Beckwith, 2005). This was done in order to maintain an open vegetation structure best suited to the long-term growth of their main vegetable food source, the camas bulb (Tudge, 2006).

The use of burning, as well as other First Nation's ecosystem management techniques, have shaped the "natural" patterns of vegetation cover on Southern Vancouver Island and the Gulf Islands. In the most extreme example, it is hypothesized that the Garry oak meadows near Comox, their most northerly location, are entirely anthropogenic in origin, as this is their northernmost distribution, and they occur, unusually, within the moist coastal western hemlock biogeoclimatic zone (Turner, 1999). They used fire to manage and shape the landscape of open woodlands that were "stately", "bountiful", "verdant", and "delightful meadows" according to the first European settlers that colonized Southern Vancouver Island over 150 years ago (Turner, 1999, p. 195; Lea, 2006). Ironically, the beautiful vistas and vegetation that drew settlers to this area were then quickly compromised by development and changes in principal land use management regimes. Fire suppression, as well as agricultural practices and grazing, following European settlement has caused dramatic changes to the composition, structure, and function of the ecosystems (MacDougall *et al.*, 2013; Fuchs, 2001).

These variations, and the shifting baseline that has occurred due to the reduction of anthropogenic burning, highlight the need for adaptive management that is reflective of the changing responses of Garry oak ecosystems in response to a changing environment. A particular part of the Retreat Island baseline study that will help for future monitoring of the region was the establishment of permanent one metre square plots that were randomly selected in three different Garry oak community types. The plots were marked with rebar at the outer corners, and the exact plant compositions and the percentage of coverage of each of these was recorded for comparison with future measurements and to allow for adaptive management.

## 5.4. Threats to Garry oak ecosystems

Garry oak ecosystems ranges have been severely reduced and fragmented from their previous extent at the time of European settlement of southwestern Vancouver in the 1850s and 1860s (Fuchs, 2001). They currently occupy less than ten percent of their original extent, and both protected and unprotected areas are under threat from a range of sources, including fire suppression, grazing animals, development, and non-native invasive species (Fuchs, 2001; Erickson, 1998; Garry Oak Ecosystems Recovery Team, 2003). Even though European settlers were enamored with the Garry oak landscapes that were perpetuated through anthropogenic burning, they quickly began suppressing fire once they took power over the land (Erickson, 1998; Turner *et al.*, 2005). Domesticated grazing and browsing animals like cows and goats were also a European introduction, and were responsible for considerable damage to the sensitive species that live in Garry Oak ecosystems through pruning, consumption, and compaction.

Adding to the damage that has been done to these fragile ecosystems by grazing animals, the rapid agricultural, urban, and, more recently, suburban, development of Vancouver Island and the Gulf Islands has destroyed many Garry Oaks and associated species. Compounding these threats are the impacts that highly competitive non-native invasive species such as ivy (*Hedera helix*), scotch broom (*Cytisus scoparius*), gorse (*Ulex europaeus*), holly (*Ilex aquilifolium*) and grasses have on the native plant species of Garry Oak meadows that persist. These different pressures on Garry oak ecosystems from chronic human disturbances have concurrently changed the stability and diversity of these systems (MacDougall *et al.*, 2013). This has caused a reduction of ecosystem functionality, such as resistance to invasive species as well as reduced buffering effect of species diversity (and niche redundancy) when responding to changing environmental conditions (MacDougall *et al.*, 2013)

## 5.5. Garry Oak Ecosystems and Climate Change

Garry oak ecosystems' projected responses to changing environmental conditions created by climate change are positive, but only if the biological diversity of these ecosystems is maintained and, possibly, augmented. Garry oak ecosystems that contain a very high level of biodiversity are projected to *expand* their ranges in response to the impacts of climate change like locally increased temperatures, decreased precipitation, and increased wildfires (Hebda, 1997; MacDougall *et al.*, 2004; Erickson & Meidinger, 2007). Currently, however, these ecosystems are at a very high risk of extinction from the causes described in the previous section. Climate change models predict that Douglas fir forests will have a reduced range, while their Garry oak components are expected to replace them in many regions within the next 40-50 years (Fuchs, 2001; Hamann & Wang, 2006). Models forecast that Douglas fir forest will respond in two quite different possible ways: (1) drying conditions will favor these forests being replaced by ecosystems that are characteristic of the Victoria region, with rolling hills and larger meadow zones, or (2) the possibility of a warmer and wetter ecosystem are predicted to cause conversion of local forests to deep soil Gary oak wood lawn and forests (Hamann & Wang, 2006). The climate data have been compiled based on an ecosystem-based climate envelope model of future climate scenarios and comprehensive knowledge of the varying responses of Garry oaks and their associated species to climate change (Hamann & Wang, 2006). This response of expanding their range is in contrast to the majority of the ecosystem types that exist in this same area, indicating that their management and preservation may be an important step for coping with the uncertainty of predicted climate change.

The impacts of climate change on Garry oak meadows in particular, and forest ecosystems in general, are a developing area of study that incorporates the expected impacts on the included species as well as the expected areas of distribution. In order to do this, researchers often rely on data relating to historic and prehistoric distributions of different forest types in conjunction with studies of changing climate patterns over time and climate change scenario forecasts (Bjorkman & Vellend, 2010). In the case of Garry oak meadows, which are at the northernmost point of their distribution in southwestern British Columbia, they are known to have had a much larger range in the region during previous warmer climatic periods (Lea, 2006), a range that has diminished due to many forces, initially climatic cooling and then pressures from sources such as human land-use and invasive species (Hebda, 1997; Erickson W. , 1998; Emmings & Erickson K., 2004).

One of the particular challenges that face Garry oak ecosystems has been the process of fire suppression over the last century and a half. After approximately 150 years of fire suppression, most remaining Garry oak regions are dominated by high-biomass, low-diversity mixtures of exotic pasture grasses, and other non-native species (MacDougall *et al.*, 2013). The concept that there will be a reduction of the resilience of these ecosystems due to reduced biodiversity was supported by experiments conducted by MacDougall *et al.* who examined the impacts of the reintroduction of burning, an impact of climate change that is expected to become more common according to climate scientists (Hannah, Midgley, Hughs, & Bomhard, 2005; Hamann & Wang, 2006). After the fires were reintroduced in Garry oak meadows, the responses to the abrupt disturbances varied according to the levels of remnant diversity in the area (MacDougall *et al.*, 2013). In areas with higher levels of remnant concentrations of native species there was a proliferation of rare and functionally redundant species, but in areas that had severely reduced levels of biodiversity, the response to fire was a conversion from open meadows to later stages of succession with greater coverage by woody plants like Douglas fir (*Pseudotsuga heterophylla*) and ocean spray (*Holodiscus discolor*) (MacDougall *et al.*, 2013). These Garry oak systems are similar to many other terrestrial systems; wherein persistent human activity has led to this recognizable patterns of reduced heterogeneity increasing compositional homogenization that indicates possible vulnerability to sudden environmental changes caused by climate change (MacDougall *et al.*, 2013). Given that biodiversity is crucial for the stability of ecosystems, it is imperative for the long-term sustainability of Garry oak ecosystems to increase their levels of native plant biodiversity while this remains a possibility (MacDougall *et al.*, 2013).

## 6. Discussion/Analysis

As the previous sections have shown, the issues of biodiversity and climate change are very possibly humanity's greatest environmental challenges for the 21st century. After all, ecosystems provide goods and services that maintain all life (including human) on this planet and there is no amount of money that can fully restore a badly damaged ecosystem (Chivian & Bernstein, 2010). We are currently at a crossroads where the decisions we make now regarding climate change and biodiversity management have the opportunity to either reduce our level of harm and conserve biodiversity or ignore it entirely and irretrievably lose it. The baseline study of a Garry oak ecosystem offers us a unique lens with which to inspect the interrelated environmental issues of climate change and biodiversity loss and that can provide several lessons for incorporating these issues into EA. These lessons cover several areas that are important to EA practitioners, working in both the public and private spheres, as well as environmental managers in general. These areas of enquiry include climate change and biodiversity, as well as adaptive management, TEK, environmental uncertainty and modeling.

## 6.1. Reflecting upon the Case Study

The Retreat Island baseline study case study was a project unlike any other that I have ever undertaken, and there were many challenges that had to be overcome during the process and many lessons that were learned. The process of collecting a baseline for the environmental assessment has been established as a necessary process, but despite this, the levels of investigation in EAs vary greatly, and the level of incorporation of ecological processes and valued components may vary as well. The reality is that the baseline assessment is a necessity for the understanding of the types of change that may occur in the future, especially in the face of risks from both development as well as environmental variation like climate change and biodiversity loss. The process of establishing the components of the ecosystem that are of value is an important process within the adaptive management of a region, but it could likely be bettered by including valued ecosystem types, such as Garry oak systems, since they are expected to have an unusual (positive) response to climate change if they can maintain their biodiversity in the meantime. The baseline assessment that I undertook on Retreat Island is not particularly representative of the typical level of attention to detail that EA practitioners give a regional baseline analysis at the outset of an environmental assessment, but it would be of great advantage for practitioners of these baseline reports to have a particularly strong knowledge of ecology and its varying dynamics as well as access to expert opinions, such as I did when working for the Galiano Conservancy Association. The greater our understanding of the interconnected ecosystems that surround us, through methods like the modeling of forest dynamics in the face of climate change the more informed are our adaptive measures as we cope with the risks of environmental stochasticity and shifting baselines. Baseline studies must include the information that is necessary, but not that which is excessive. It is likely that although the baseline that I created (according to the standards expected by the BC Ministry of Environment and the GCA), is beyond the scope that necessary to incorporate into EA. Instead, perhaps, it is of value to incorporate an understanding of the high level of biodiversity and its high level of social and environmental significance, by including not only the valued ecosystem components of a region into the EA statement, but also ensuring that valued ecosystem types also garner the attention that they require during the planning and development of a project and during the monitoring phases.

This set of plant communities carries great environmental importance as well as a disproportionate amount of social significance. Within their particular locality they are a good example of an ecosystem that magnifies two of the most pressing environmental challenges at the present time, climate change and biodiversity loss. Given that they are a rare instance in Canada where an ecosystem is expected to increase its range under the changing climate conditions, this is an interesting case study from which we can derive lessons in the practice of environmental assessment. The choices that are made for Garry oak ecosystems management and preservation at this point could help with the process of coping with the challenge of uncertainty within predicted climate change (MacDougall *et al.*, 2013)**.**

Ultimately, what becomes apparent is a need for valuing and protecting the state of Garry oak ecosystems so they can withstand future environmental changes due to the impacts of climate change. It is imperative that we look to the types of ecosystems, rather than just ecosystem components, that we need to preserve in order to maintain a minimum level of genetic diversity to allow for their successful expansion under the projected impacts of climate change. This is particularly true at this moment, as we are at a political junction, where the environmental policies and international agreements that we have established over the last three decades in Canada are under great threat. Our withdrawal from the Kyoto protocol, for example, is an important event that forces environmental management into a situation that requires adaptation to climate change rather than attempting to avert or avoid the ramifications of increased global carbon dioxide and other greenhouse gasses.

## 6.2. Baselines, Biodiversity, and Climate Change

The streamlining of the environmental assessment in Canada brings the incorporation of biodiversity management and climate change impacts into the process of EIA under increasing threat. Up until recently, "the goal of incorporating climate change impacts and adaptation within environmental assessments […] has remained more aspirational than operational" (Agrawala *et al.*, 2010: 3). Maintenance of biodiversity is also under threat in the newly published streamlined 2012 Canadian Environmental Assessment Act, and this shortcoming threatens these tightly interconnected environmental issues. An ecological pattern is beginning to be understood that occurs in Garry oak ecosystems and is thought to be possible in many other similarly compromised ecosystems. This pattern is that of possible positive responses to climate change, if and when they have high enough levels of biological diversity, but emerging research points to the great importance of having high enough levels of native plant diversity to allow for this succession pattern to occur. If levels of diversity fall too drastically then it is likely that these ecosystems may be on a path towards extinction. The concern is that the ecosystem type that is predicted to have a positive response to the challenge of climate change is also dwindling in area occupied and diversity. This indicates that the management and preservation of their biodiversity are key steps towards coping with the uncertainty that will come with climate change (Pellatt *et al.*, 2012; MacDougall *et al.*, 2013).

In order to be able to best cope with the challenges that exist for current Garry oak ecosystems it is of the greatest importance that practitioners are aware of their distinct responses to climate change. It is also important in planning to be able to recognize the projected trajectory for their range increases, which will see gains in their terrain to the north of their current ranges. In order to cope with this spatial shift, planners need to locate reserves and perhaps focus their restoration activities in areas in the northern boundaries of species' ranges (Agrawala *et al.*, 2010). Given the threats that exist for Garry oak ecosystems there are several activities to consider that will help increase the survival capacity of Garry oak meadows that can be incorporated into their restoration. These include removing invasive species; restoring suitable areas; developing the capacity to assist species at risk in their northward migration; and preventing rich Garry oak ecosystems from becoming threatened (Lea, 2006; Heller and Zavaleta 2009). These actions are examples of adaptation options that will allow forests to accommodate change rather than resist it.

The important thing to consider is that Garry oak ecosystems are relevant at a relatively small scale, as their range/distribution is not that large, having been greatly reduced by human activities. It is; however, greatly important in its locale, as it is the local ecosystem type that has the greatest chance of range expansion with the impacts of climate change. The species that are contained within this ecosystem can also be used for ecosystem restoration projects, thus their maintenance for the long term, particularly when included in a large development project's region, could have multiple benefits. Adapting to climate change in the face of the uncertain timing of impacts means we must have a suite of readily available options. A high priority will be coping with and adapting to forest disturbance while maintaining the genetic diversity and resilience of forest ecosystems. (Spittlehouse & Stewart, 2003). It also becomes vital to not only to make planning decisions that emphasize entire systems, rather than singular components (Harris *et al.*, 2006).

Efforts like those taken by the Galiano Conservancy Association, where non-native plants are removed, and seed stocks with local provenance for native threatened plants are raised and then planted into Garry oak meadows as part of their restoration processes are the kind of options that EA practitioners should be made aware. Treatments that mimic, assist, or enable ongoing natural adaptive processes such as migration, and changing disturbance regimes should be encouraged within biological restoration (Millar *et al.*, 2007). The strategic goal is to encourage gradual adaptation and transition to inevitable change, and thus avoid rapid threshold or catastrophic conversion that may occur otherwise (Millar *et al.*, 2007; MacDougall *et al.*, 2013). Thinking further into the future of possible ecosystem restoration it could be possible to create a ‘‘transformative restoration’’ in which the plant species used to repopulate restoration sites are determined by future climate conditions rather than historical presence (Heller and Zavaleta 2009).

The continuous adaptive management of this ecological resource will possibly require changes in the way that ecosystem managers and EA practitioners understand climate change impacts and ecosystem responses to those changes (MacDougall *et al.*, 2013).

To best preserve and promote biodiversity, it is important for EA personnel to have access to as much information available. Given that levels of species biodiversity can be onerous to establish, it is important to take it into account at the ecosystem level. In particular, it is important to emphasize areas of high biological diversity, critical habitat, relics, or fragile systems.

## 6.3. Recommendations for EIA and the Future

Given that one of the Federal government's directives is to establish whether the impacts of a project will affect any ecosystems, communities, or species identified as valuable (Canadian Environmental Assessment Agency, 1996), it is critical to help EA practitioners become more aware of the importance of small, diverse ecosystems such as Gary oak ecosystems (British Columbia Environmental Assessment Office, 2010). There is ample scope for employing EIA procedures as a vehicle for enhancing the resilience of projects to the impacts of climate change (Agrawala *et al.*, 2010). Incorporation of knowledge about ecosystems such as Gary Oak ecosystems into the EIA process can be done within the planning and baseline stages as well as within the monitoring phase. It is becoming even more necessary for our long-term management and monitoring programs to incorporate adaptation strategies that take climate change into account.

Baseline reports originally were created in order to record the species types and their levels of abundance as they exist now, in order to ascertain whether there are any that are of distinct value, such as being at risk or of particular ethnobotanical importance while also collecting quantitative measurements on abiotic processes (e.g. river turbidity). Baseline studies have also often been used to serve as a template for the way the system should remain, in other words, they represent how that ecosystem should remain and a project should not cause the system to seriously vary from the baseline state. This concept of the baseline needs reframing, as it is not entirely possible to attempt to maintain an ecosystem in a state that will become unviable with the impacts of rapid climate change. The equilibrium state that we think a baseline system represents is not a state that we can necessarily aspire to maintain as there are shifting baselines and successional progressions that can change the future state of regions due to the impacts of climate flux. Given this, it is of even greater importance that EIA incorporates climate-vegetation models in order to have a clearer understanding of the systems that have the greatest long-term viability and that need the greatest amount of biodiversity conservation and restoration. This allows for managing for future flexibility and maintaining options, while incorporation of GIS and climate models will help in the process of making decisions about where to situate new projects and restoration programs (Agrawala *et al.*, 2010). Though models of ecosystem migration are in their infancy, they are currently our only tool for forecasting the possible impacts that climate change may have on ecosystems. To adapt to these likely changes, it is necessary for practitioners to have a clearer idea of what is coming, and it is through models and lists of critical ecosystems, that they can incorporate these environmental threats. Knowledge of species groups that are like Garry oak ecosystems would be of great use for land use management and ecosystem planning and restoration as well as EA because they require adaptive management in order to be able to respond in a positive fashion to the expected environmental pressures of climate change. Regardless of the region or the stage of an environmental assessment process, it would be of great value for EIA in general to have lists of the ecosystem/species types in every region that have been shown to have the greatest chance of range expansion under climate change pressures.

Canada is currently “streamlining” its approach to environmental impact in general, as well as stepping away from earlier international GHG reduction targets like the Kyoto Accord. Adaptive management in the face of climate change will need to move away from mitigation efforts and towards adaptation efforts. The expected changes to the environment around us are possibly drastic, and given this, as well as the requirement of the precautionary principle, it is important that our actions reduce possible harm.

The first step of an environmental assessment is the process of scoping, which includes background research and planning based upon relevant research. This is the part of the EIA process when the practitioner can take note of any regions within the project development plan that contain high levels of endangered biodiversity, as well as those that will respond positively to climate change (British Columbia Environmental Assessment Office, 2010). Within EA there is an emphasis on incorporating climate change by looking at the impacts that it will have on a project as well as the impacts of the project on climate change. The importance of Garry oak ecosystems can be incorporated within planning and preparation stages of a project EA, as well as decision-making processes as to locations and lands that will or will not be developed. It is also important to move towards identifying valued ecosystems types, rather than just components, and understanding better methods of ecosystem restoration using native local species stock to increase native plant biodiversity and improving restoration efforts.

In the later stages of environmental assessment are the monitoring phases, which permit practitioners to pay closer attention to the impacts that climate change is having on the ecosystems that are under study. The process of monitoring native species can give us insight into the impacts of the project as well as climate change and can help environmental managers create appropriate responses at local scales. These management strategies that are based on local and timely observations can mimic emerging natural adaptive responses (Millar *et al.*, 2007).

This is an important addition to EIA as it incorporates the precautionary principle. During the monitoring phase it is necessary to include the locations and significance of ecosystems at risk and do as much as possible to protect and preserve these regions. Environmental assessment also has the potential to link projects on the ground with the broader management of climate change issues in Canada and give us a hands-on experience that we can attempt to incorporate into adaptive management (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, 2003). Particular attention must be paid to valued ecosystems during the monitoring process, with room for varying management approaches in order to adapt to unforeseen changes (Hannah *et al.*, 2005).

It may also be useful if practitioners looked at the proposal not only for effects (on biodiversity) at the local level but also for effects at the larger, regional ecosystem level (Beckwith, 2005). Within EA there is a general need to be aware of the way in which ecosystems like Garry oak will be impacted when doing cumulative impact assessments as well as when project based assessments are required. Cumulative assessments permit better management at a regional level as it can promote species protection plans, natural resource management, and research and development agendas across wider geographic areas. The process of recognizing and incorporating traditional ecological knowledge will help the EA process in the process of involving more diverse actors than in current practice. There is a great need for developing beyond an environmental assessment process that looks solely at single projects one at a time, and through singular VECs and moves towards incorporation of valued ecosystem types and regional planning. A long-term, regional perspective and improved coordination among scientists, land managers, politicians, and conservation organizations are some of the most often cited recommendations to protect biodiversity in the face of climate change (Heller & Zavaleta, 2009). Thus, the incorporation of Garry oak and other Valued ecosystems is a realistic way to help the practice of EA move towards these goals. The creation and use of lists of plant communities and ecosystems that are expected to have positive responses to climate change is one innovative way in which the EIA practitioner can identify the most practicable option for mitigation of biodiversity loss. For the private sector the process of incorporating Garry oak ecosystems into EA and into corporate sustainability plans alike is that it shows a heightened level of corporate social responsibility and environmental awareness as well as making economic sense by improving local and regional long-term climate change resilience.

## 6.4. Valued Ecosystems/Valued Ecosystem Components

One particular aspect of EIA that could be slightly augmented to incorporate the lessons that come from Garry oak ecosystems is the concept of valued ecosystem components, or VECs. Perhaps it is time for us to redefine and expand the concept of VEC's to allow it to include not only singular species or attributes of an ecosystem, but to also allow for the greater valuation of particular biotic and abiotic communities or ecosystems that have identified value for their recognized resiliency to climate change. It is important in this situation to look to the level of ecosystems, as Garry oak ecosystems include a disproportionate amount of biodiversity at that level, as well as the species level and, in turn, the genetic level. Given that there are so very many socially and ecologically significant species in this ecosystem and its distinct communities it is very likely that its inclusion as a particular area of concern in EA will have the effect of including several valued ecosystem components at the same time. By doing this, it becomes possible for us to look beyond simple static species lists to include the wider consideration of ecosystem functions and processes in response to a changing climate (British Columbia Environmental Assessment Office, 2010).

In a way, this then becomes another call for "streamlining", as we focus not on everything but on those areas of special when planning for a project. If a project has the capacity to negatively affect a particular ecosystem type, it is important to ensure that the species sets that are expected to expand their range under climate change pressures are preserved or enhanced. This requires the prioritization of these endangered ecosystem types as a whole, rather than the typical single species approaches that are frequently used (NovaGold Canada Inc., 2006; C.V.R.D. Environment Commission 2010).

## 7. Conclusion

As a society, we are currently at a crossroads. One path leads towards a future in which we have made decisions based on possible adaptive management options that have, to the best of our knowledge, incorporated the precautionary principle. This path could allow for adaptive measures such as ensuring quality and accuracy of baseline assessments, maintaining high levels of biodiversity, such as Garry oak meadows, that will enhance our resilience, rather than resistance, to climate change. The alternative path is likely easier, as it requires little action. On this second path it is very likely that there will be a loss of vast amounts of biodiversity, Garry oak meadows included, from which we derive, in many ways, our environmental and social stability. This case study of Retreat Island in particular, and Garry oak meadows in general, has highlighted that there are many challenges for the overlapping issues of climate change and biodiversity loss, and that a complicated relationship exists between these two variables. The incorporation of high quality baseline analysis and of valued ecosystem types into the environmental assessment process will allow for greater flexibility and enhanced adaptive management as we face an uncertain future due to the risks of climate change.

**Figure 10: Harvest Brodiaea (*Brodiaea elegans*)**

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# Appendices

## List of Abbreviations

ADM: Adaptation decision matrix

BC: British Columbia

BCA: Benefit-cost analysis

BCEAA: British Columbia Environmental Assessment Act

CBS: Canadian Biodiversity Strategy

CDC: Conservation Data Centre

CEA: Cost effectiveness analysis

CEAA: Canadian Environmental Assessment Agency

Coastal Douglas Fir Moist Maritime (CDFmm)

COSEWIC: Committee on the Status of Endangered Wildlife in Canada

EA: environmental assessment

EAO: Environmental Assessment Office

EIA: Environmental impact assessment

FPTC (CCEA): Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment

FPTC: Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment

GC: Government of Canada

GCA: Galiano Conservancy Association

GHG: greenhouse gas(ses)

GOMPS: Garry Oak Meadows Preservation Society

IPCC: Intergovernmental Panel on Climate Change

IPCC: Intergovernmental panel on climate change

NEB: National Energy Board

RLC: Restorative Learning Centre

SARA: Species at Risk Act

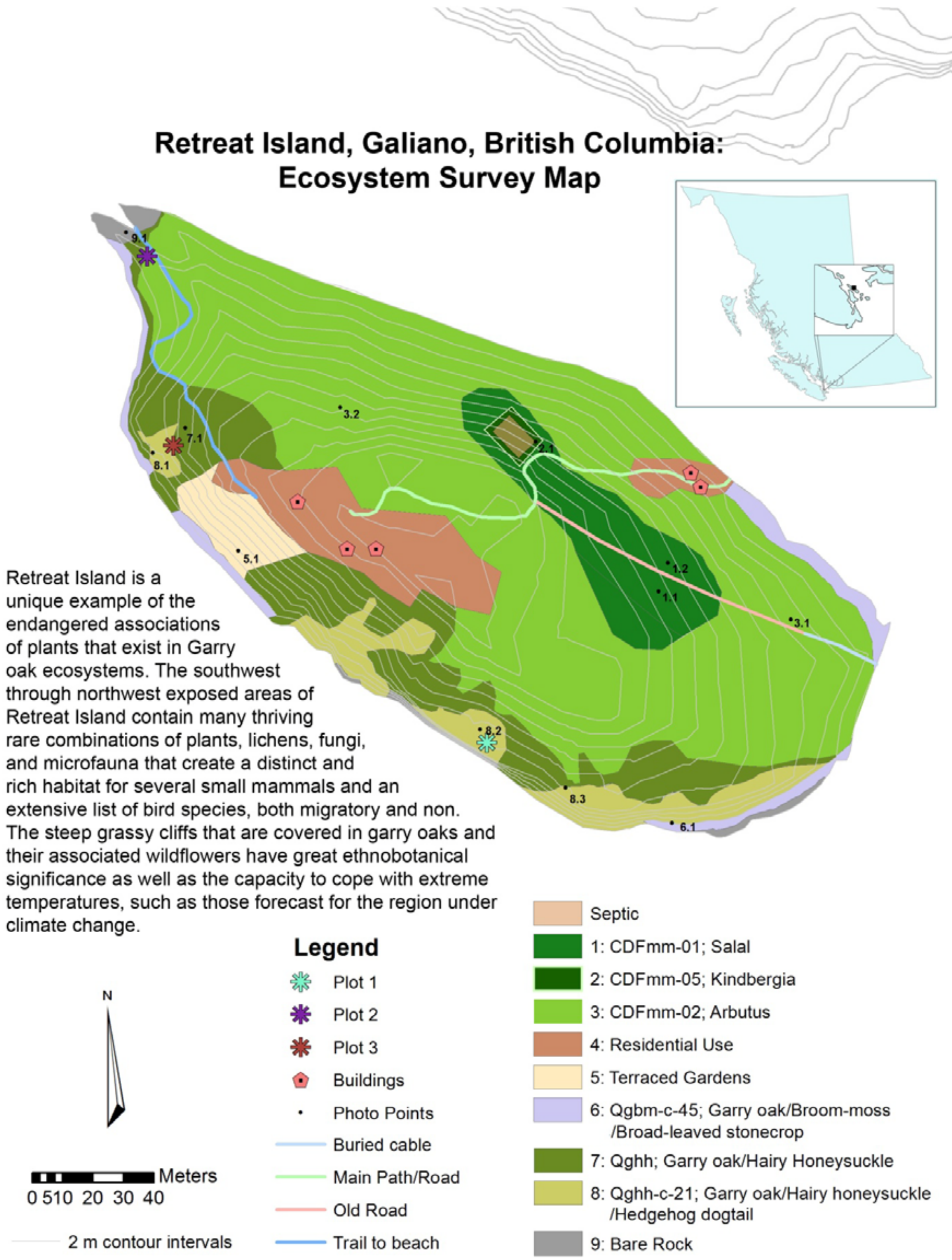


**Figure 11: Information poster for Retreat Island, BC**

**Table 1: The Birds of Retreat Island**

| **Birds of Retreat Island** | | | |
|---|---|---|---|
| **Group** | **Common Name** | **Latin Name** | **Family** |
| **Crows/Ravens** | Crow | *Corvus caurinus* | Corvidae |
| | Raven | *Corvus corax* | |
| **Finches** | House finch | *Carpodacus mexicanus* | Fringillidae |
| | Purple finch | *Carpodacus purpureus* | |
| | Pine Siskin | *Spinus pinus* | |
| | American Goldfinch | *Spinus tristis* | |
| **Gulls** | mew gull | *Larus canus* | Laridae |
| | glaucous winged gull | *Larus glaucescens* | |
| **Hummingbirds** | Anna's Hummingbird | *Calypte anna* | Trochilidae |
| | Rufous hummingbird | *Selasphorus rufus* | |
| **Sparrows** | Dark-eyed junco | *Junco hyemalis* | Passeridae |
| | Song Sparrow | *Melospiza melodia* | |
| | Spotted Towhee | *Pipilo maculatus* | |
| | Chipping Sparrow | *Spizella passerina* | |
| | white crowned sparrow | *Zonotrichia leucophrys* | |
| **Swallows** | Barn swallow | *Hirundo rustica* | Hirundinidae |
| | Purple Martin | *Progne subis* | |
| | Violet Green Swallow | *Tachycineta thalassina* | |
| **Thrushes** | Swainson's thrush | *Catharus ustulatus* | Turdidae |
| | Robin | *Turdus migratorius* | |
| **Wrens** | House Wren | *Troglodytes aedon* | Troglodytidae |
| | Winter Wren | *Troglodytes troglodytes* | |

| | | | |
|---|---|---|---|
| **Warblers** | yellow rumped warbler | *Dendroica coronata* | Parulidae |
| | Townsend's warbler | *Dendroica townsendi* | |
| | orange crowned warbler | *Oreothlypis celata* | |
| | Wilson's warbler | *Wilsonia pusilla* | |
| **Woodpeckers** | Northern redshafted flicker | *Colaptes auratus cafer* | Picidae |
| | Pileated woodpecker | *Dryocopus pileatus* | |
| | Hairy woodpecker | *Picoides villosus* | |
| | Downy woodpecker | *Picoides pubescens* | |
| **Predators** | Great blue heron | *Ardea herodias fannini* | Ardeidae |
| | Bald eagle | *Haliaeetus leucocephalus* | Accipitridae |
| | Osprey | *Pandion haliaetus* | Pandionidae |
| **Other** | Cedar waxwing | *Bombycillya cedrorum* | Bombycillidae |
| | Canada Goose | *Branta canadensis* | Anatidae |
| | Pigeon Guillemot | *Cepphus columba* | Alcidae |
| | Pacific-slope Flycatcher | *Empidonax difficilis* | Tyrannidae |
| | Belted Kingfisher | *Megaceryle alcyon* | Coraciiformes |
| | Chestnut-backed chickadee | *Parus rufescens* | Paridae |
| | Western Tanager | *Piranga ludoviciana* | Cardinalidae |
| | Red breasted nuthatch | *Sitta canadensis* | Sittidae |
| | Cassin's vireo | *Vireo cassinii* | Vireonidae |

**Table 2: The Animals of Retreat Island**

| **Animals of Retreat Island** | |
|---|---|
| Bats (2 species, one approximately 25 cm in wingspan; one smaller, at 15-20 cm in wingspan) | |
| Douglas Squirrel | *Tamiasciurus douglasii* |
| Mink | *Neovison vison* |
| Raccoon | *Procyon lotor* |
| River otter | *Lontra canadensis* |
| Townsend's vole | *Microtus townsendii* |
| Vagrant Shrew | *Sorex vagrans* |
| White-footed Deer Mouse | *Peromyscus leucopus* |
| Alligator Lizard | *Elgaria coerulea* |
| Garter Snake | *Thamnophis sp.* |

**Table 3: The Plants of Retreat Island**

| | | |
|---|---|---|
| **Asteraceae** | Yarrow | *Achillea millefolium* |
| | Cornflower | *Centaurea cyanus* |
| | Hairy cat's ear | *Hypocaeris radicata* |
| | Gumweed | *Grindelia?* |
| | Wall lettuce | *Mycelis muralis* |
| | Dandilion | *taraxicum officinale* |
| **Ericacae** | Salal | *Gaultheria shallon* |
| | Kinnikinnick | *Arctostaphylos uva-ursi* |
| | Red huckleberry | *Vaccinium parvifolium* |

| | | |
|---|---|---|
| | Evergreen huckleberry | *Vaccinnium ovatum* |
| **Fabaceae** | Broom | *Cytisus scoparius* |
| | Purple Peavine | *Lathyrus nevadensis* |
| | Common Vetch | *Vicia sativa* |
| **Liliaceae** | Harvest Brodiaea | *Brodiaea coronaria ssp. coronaria* |
| | Fawn lily | *Erythronium oregonum* |
| | Chocolate lily | *Fritillaria affinis var. affinis* |
| **Orchidaceae** | western (spotted) coralroot | *Corallorhiza maculata* |
| | Rattlesnake Plantain | *Goodyera oblongifolia* |
| | Tall Rein Orchid | *Piperia elegans* |
| | | *Piperia...* |
| **Poaceae** | Sweet vernalgras | *Anthoxanthum odoratum* |
| | Cheatgrass | *Bromus tectorum* |
| | Hedgehog dogtail | *Cynosurus echinatus* |
| | Hedgehog dogtail | *Cynosurus echinatus* |
| | Orchard Grass | *Dactylis glomerata* |
| | Blue wild rye | *Elymus glaucus* |
| | Western fescue | *Festuca occidentalis* |
| | Kentucky bluegrass | *Poa pratensis* |
| **Rosaceae** | Wild strawberry | *Fragaria virginiana var. glauca* |
| | Oceanspray | *Holodiscus discolour* |
| | Nootka Rose | *Rosa nutkana* |
| | Himalayan blackberry | *Rubus discolor* |
| | Thimbleberry | *Rubus parviflorus* |
| | Trailing blackberry | *Rubus ursinus* |

| | | |
|---|---|---|
| | Trailing blackberry | *Rubus ursinus* |
| OTHER | Indian paintbrush | *Castilleja miniata* |
| | Yerba Buena | *Clinopodium douglasii* |
| | Blue eyed Mary | *Collinsia grandiflora* |
| | Fireweed | *Epilobium angustifolium* |
| | Cleavers | *Galium aparine* |
| | Sweet-scented bedstraw | *Galium triflorum* |
| | Herb robert | *Geranium robertianum* |
| | Small flowered alumroot | *Heuchera micrantha* |
| | Orange Honeysuckle | *Lonicera cilosia* |
| | Hairy honeysuckle | *Lonicera hispidula* |
| | Rose Campion | *Lychnis coronaria* |
| | Tall Oregon grape | *Mahonia aquifolium* |
| | Dull oregon grape | *Mahonia nervosa* |
| | Chickweed Monkey Flower | *Mimulus alsinoides* |
| | Largeleaf sandwort | *Moehringia macrophylla* |
| | Indian-pipe | *Monotropa uniflora* |
| | Miner's lettuce | *Montia perfoliata* |
| | Falsebox | *Paxistima mirsinites* |
| | Pacific Sanicle | *Sanicula crassicaulis* |
| | Ribwort Plantain | *Plantago lanceolata* |
| | Sea blush | *Plectritis congesta ssp. congesta* |
| | creeping buttercup | *Ranunculus repens* |
| | Flowering red currant | *Ribes sanguineum* |

| | | |
|---|---|---|
| | red elderberry | *Sambucus racemosa* |
| | Broadleaf stonecrop | *Sedum spathulifolium* |
| | Snowberry | *Symphoricarpus albus* |
| | Broad leaved starflower | *Trientalis latifolia* |
| **Ferns/Mosses** | Red bryum moss | *Bryum miniatum* |
| | Juniper Haircap Moss | *Polytrichum juniperinum* |
| | Grey Rock-moss | *Racomitrium canescens* |
| | Oregon beaked moss | *Kindbergia oregana* |
| | Licorice fern | *Polypodium glycyrrhiza* |
| | Step moss | *Hylocomium splendens* |
| | Menzie's tree fern | *Leucolepis acanthoneuron* |
| | sword fern | *Polystichum munitum* |
| **Trees** | Big leaf maple | *Acer macrophyllum* |
| | Red alder | *Alnus rubra* |
| | Arbutus | *Arbutus menzieseii* |
| | Crab Apple | *Malus fusca* |
| | Bitter Cherry | *Prunus emarginata* |
| | Garry Oak | *Quercus garryana* |
| | Scouler's willow | *Salix scouleriana* |
| | Sitka Mountain Ash | *Sorbus sitchensis* |
| | Douglas fir | *Pseudotsuga menzieseii* |
| | Western Yew | *Taxus brevifolia* |
| | Cedar | *Thuja plicata* |

**Figure 12: A Garry oak in the BC Governor General's gardens (with author).**