# GROUNDING FOR AN ECOLOGICAL FIELD STATION

by Simon Nessman

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Concentration Mentor

Simon Nessman

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## INTRODUCTION

This document is an academic justification for the conception of an ecological field station in Clayoquot Sound, British Columbia, Canada. The Cedar Coast Field Station is part of a proposed solution to a deep underlying issue in our society: the dissociation of human beings from the rest of the natural world, which provides us with life sustaining resources. The basic premise of the Cedar Coast Field Station is that developing a personal connection to life-sustaining resources—such as plants, animals, water, food and energy— is a fundamental step towards preserving the integrity of those resources. In this paper the integrity of these life-sustaining resources will be referred to as 'ecological health.' While a broad scope of ecological health issues will be explored, solutions to these issues will be grounded in a specific place: Clayoquot Sound. As renowned ecologist Scott Sampson explains, "any successes in achieving sustainability at higher levels (state, nation, biosphere) will be realized only through the iterative accumulation of sustainable societies in local places, roughly equivalent to watersheds or bioregions" (Kahn & Hasbach, 2012, pg. 45). With the proliferation of the internet, social media, and globalization, there is increasing opportunity for cumulative local action on the scale of watersheds and bioregions—or towns and cities—to influence global affairs. The far-reaching potential of local action provides justification for the large scale issues raised in this paper, and the locally focused solutions proposed.

'Part I— What Is Ecological Health and Why Should We Care?' introduces the concept of ecological health and highlights the necessity of preserving ecological health. 'Part II— How Can We Preserve Ecological Health' discusses three ways in which we can work to preserve ecological health: ecological research, management, and education. 'Part III— Embracing Human Dependence on Ecological Health' explores the ways in which grounding research, management, and education in place and lived experience can lead to more ecologically grounded practices and perspectives. 'Part IV— Cedar Coast Field Station: A Space for Ecological Research and Education' proposes an ecological field station in Clayoquot Sound as a way to preserve ecological health through local, place-based research and education.

# PART I— WHAT IS ECOLOGICAL HEALTH AND WHY SHOULD WE CARE?

Recent technological advances—including the mechanization of food production, transportation, and communication—have enabled citizens of the western developed world in particular, to become less immediately dependent on natural resources (Odum et al., 2004). Despite the dissociation of humans from the rest of the natural world, we are still entirely dependent on natural resources for our survival. 1944 Aldo Leopold described the conservation of these life sustaining resources as "a state of health in the land," which he defined as, "a state of vigorous self-renewal in each of [these resources], and in all collectively" (Meine & Knight, 1999, pg. 147). Ahead of his time, Leopold recognized that the 'land' was "a community to which we belong," rather than "a commodity belonging to us" (Meine & Knight, 1999, pg. 147). In the same sense that Leopold was focused on "a state of health of the land," this paper will focus on ecological health.

While Leopold inspired many to reconsider their relationship with the natural world, humanity as a whole has continued on a destructive trajectory towards ecological degradation (Gislason & Rothman, p. xxi). Despite a commitment among world leaders in 2002 to significantly reduce biodiversity loss by 2010, a study of 31 biodiversity indicators – including species population trends, extinction risk, habitat extent, habitat condition and community composition – found no significant declines in biodiversity loss rates (Butchart et al., 2010). Meanwhile, human induced impacts on biodiversity – including resource consumption, introduction of invasive alien species, nitrogen pollution, overexploitation, and climate change – have shown marked increases since 2002 (Butchart et al., 2010). Declines in cultural diversity also continue around the world, as 22% of the surviving 6900 human languages are spoken by less than 1000 people and face extinction due to speaker decline (Butchart et al., 2010). In addition to negative impacts on social health, the loss of these languages may prove detrimental to biological health due to the loss of traditional ecological knowledge (TEK) held within these languages. Poverty also continues to degrade ecological health, with over 100 million people living in environmentally compromised ecoregions where they are immediately dependent on ecosystem goods and services (Butchart et al., 2010). Despite individual successes at the local scale, each of the above indicators suggest that the current strategies being implemented to restore and maintain ecological health amidst complex socio-biological forces are vastly inadequate.

As we continue on this trajectory, human activity, environmental degradation, and disease and illness are becoming ever more closely related in time and space (Gislason & Rothman, p. xx, 2013). The close relationship between human actions and environmental health suggests that addressing environmental degradation will require an emphasis on human health, as people who do not have their basic needs met are less likely to refrain from environmentally destructive behavior (Adams et al., 2004). Furthermore, there is a growing interdisciplinary acceptance that human impact on ecological health has reached a scale that threatens the well-being of humanity as a whole (Gislason & Rothman, 2013, p. 69). In order to address this critical issue, we need to develop an interdisciplinary ecological perspective, which draws on “biological, cultural, economic, political, psychological and social factors” (Gislason &Rothman, 2013, p. 71). In other words, we need to break down the disciplinary and conceptual boundaries that separate humans from nature.

Rachel Carson was among the first to consider biological, cultural, economic, political, psychological and social factors from an ecological perspective in her 1962 publication, 'Silent Spring'. In this groundbreaking work Carson explained the interconnection of the land, air, animals, water, and people in a way that was widely accessible to the public. Silent spring broke ground in its inclusion of strong scientific evidence from multiple disciplines, as well as local knowledge from conservation, gardening, and birding clubs from across the U.S. and Europe who were opposed to insecticide spraying (Gislason & Rothman, 2013, p. 130). This interdisciplinary and locally informed work contributed to a more holistic contextual framework that continues to inform the study of ecological health to this day.

Building on the work of Leopold, Carson, and others, the 1970's saw the emergence a new bio-centric perspective (Gislason & Rothman, pg. 134). Environmental lobbyists, academic philosophers, back-to-the-landers, and conservation biologists all converged in the pursuit of one unified goal: to bring humanity back from the brink of disaster by addressing "the health of the earth and its non-human inhabitants" through a "politics of the wild" (Gislason & Rothman, 2013, pg. 134). This new bio-centric perspective found application in bioregionalism, which disregards geopolitical boundaries in order to study and reconstruct a regional ecological community based on natural boundaries (bioregions) (Gislason & Rothman, 2013, P.135). Bioregionalism addresses ecological health in three ways (Gislason & Rothman, 2013 p. 136). Firstly, it identifies an optimal ecological state based on historical baselines. This approach is problematic as it disregards the many biotic and abiotic fluctuations that are inherent in a healthy functioning ecosystem. Secondly, it monitors the health of the relationship between human beings and the rest of the ecosystems in which they exist. This is a subjective measure as it depends on the individual's conception of an 'ideal' human-nature relationship. Lastly, the bioregionalism movement approached land restoration through an anthropocentric perspective in which the ecological community is seen as the patient and the restoration worker is seen as the doctor trying to fix the patient. While bioregionalism worked to promote a more sympathetic view of nature, this anthropocentric approach to conservation of ecological communities has contributed to a problematic divide between humans and nature.

The anthropocentric perspective adopted by bioregionalism in the 70's was largely inspired by the James Lovelock's Gaia Hypothesis. First published in 1968, the Gaia Hypothesis likened the planet earth to one unified living organism, and created parallels between the earth organism (Gaia) and the human organism (Kirchner, 2002). Lovelock identified the various ways in which human impacts were disrupting "Gaia's homeostasis," including industrial agriculture, deforestation, acid rain, ozone depletion, and global warming (2002, pg. 142). Lovelock likened global warming to "Gaia's fever," and diagnosed it as a symptom of the disrupted forest ecosystems – which would normally perform climatic regulation (Gislason &Rothman, 2013, pg. 142). In 1974 Lovelock and Margulis published a paper titled, "*Atmospheric homeostasis by and for the biosphere: The Gaia hypothesis,"* in which they argue that biological life maintains the earth's atmosphere in a homeostatic state that is optimized for its own continued success. In 2002, J.W. Kirchner refuted this aspect of the Gaia hypothesis by explaining that biologically mediated feedbacks are not homeostatic. While some basic principles of the Gaia hypothesis do hold up to modern scientific scrutiny – namely that human beings are inextricably connected to the rest of the natural world – the theory as a whole has been widely criticized in the scientific literature (Kirchner, 2002; Gislason &

Rothman, 2013.

Building on the work of Leopold, Carson, and Lovelock, the 1990's saw the emergence of a new field dubbed 'Eco-Health' (Gislason & Rothman, 2013, pg. 143). Eco-Health incorporates the fields of conservation medicine, medical geology, and health and sustainability into an integrative and ecosystem based approach to health (Gislason & Rothman, 2013, pg. 143). Rather than anthropomorphizing the planet, this field simply recognizes environmental health as a key contributor to human health and vice versa, thus acknowledging the interconnection between social and ecological health factors.

Applying a human metric like 'health' to an ecosystem could also be seen as anthropocentric, or it could be seen as a useful tool to asses and manage human impacts on the ecosystems in which we exist. The reason we monitor human health is to identify changes we can make to improve human health. In a similar vein, ecological health can be monitored in order to identify ecologically harmful human actions that should be avoided, and ecologically beneficial human actions that should be promoted. This is not a matter of anthropomorphizing the earth. Rather, it is creating a framework in which we can monitor and inform human impacts on ecological health.

## Human Impacts on Ecological Health

Human beings are inextricably connected to the ecosystems in which we exist. Consequently, our actions have direct and indirect impacts on the health of the ecosystems in which we exist. While consequences of our individual actions may be unperceivable on the global scale, it is the collective action of humanity as a whole that has had, and continues to have, a dramatic impact on global scale ecological health (Gilsason & Rothman, p. 69). Below are some examples of the ways in which human actions influence ecological health around the world.

### Colonialism and loss of culture

If we consider human beings as subjects within an ecological framework, anything that impacts human health will ultimately influence ecological health. It follows that harming a human population can be viewed as ecological degradation of the area they inhabit. A local example of this lies in the recent history of European colonialism in Canada. Prior to European contact, the First Nations lived in what would now be considered an ecosystem based economy (Berkes, 2012, pg. 30). The forces of colonialism— including the spread of disease, residential schools and potlatch bans— lead to the degradation of this ecosystem based economy, and with it the oral history, traditions and local ecological knowledge on which it was based (Regan, 2010, Pg. 36; Berkes, 2012, pg. 271). This is one of many examples around the world in which colonialism has led to the degradation of local cultures, and the local ecological knowledge they hold.

### Capitalism and Consumerism

Most of the western developed world currently operates in a capitalist free-market economy that is based on the premise of infinite growth without decay (Gordon and Rosenthall, 2003). In contrast to the capitalist free-market economy, the rest of the natural world functions on the premise of finite natural resources, in which growth is dependent on decay. For example, the decomposition of trees is required to replenish soil nutrients so that forests many continue to grow sustainably.

One of the major drivers of our unsustainable free-market economy is consumerism. Consumerism is largely caused by the pursuit of fulfilment, autonomy and freedom through consumption (Chatzidakis et al., 2012). Access to this 'freedom' is determined by the consumer's ability to succeed within the free-market economy. Driving the consumers desire for this 'freedom' is the advertising industry, which floods media outlets with advertisements for the newest 'must have' choice on the market.

### Climate Change and Pollution

There are strong correlations between pollution, climate change, and ecological health (Myers et al., 2015). Human emitted pollution (including $CO_2$ emissions) has expedited climate change, which poses a serious threat to global scale ecological health (McMichael et al., 2006). Despite widespread agreement on human induced climate change within the scientific community, many Americans today—including the president of the U.S.— underestimate the consensus on climate change (Myers et al., 2015). Other examples of major pollution concerns include the impact of neonicotinoid pesticides on pollinator species (Erickson, 2014), risk of oil spills in the oceans from tanker traffic and deep sea rigs (Mei & Yin, 2009), and freshwater contamination caused by fracking (Burton et al., 2014).

### Poverty

Poverty is another major obstacle to solving ecological health issues. By situating human beings within an ecological context, we can see two ways in which poverty leads to ecological degradation. Firstly, high levels of poverty in an area can negatively impact human populations through lack of shelter, clean water, and food. Secondly, high levels of poverty in an area are likely to make the people of that area less able to act in environmentally responsible ways. Because of this there is a strong correlation between local poverty levels and loss of local biodiversity (Adams et al., 2004).

### Habitat and biodiversity loss

Loss of habitat and biodiversity are among the most immediate and serious consequences of ecological degradation. In 1938, Aldo Leopold provided a strong justification for preserving biodiversity: "If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts?" (Meine & Knight, 1999, p. 141). While today's ecologists have further revealed the interconnectivity of ecosystems and the importance of individual species—especially keystone species—Leopold's reasoning for preserving biodiversity remains among the strongest arguments we have. Contained in the biodiversity of our planet is a wealth of genetic information, the functions of which we have only just begun to understand.

## Local Ecological Health: Clayoquot Sound as a Case Study.

### History

The ecological health of Clayoquot Sound has been intimately connected to human life since time immemorial. Western science is moving towards the inclusion of biological, social and human aspects of ecological health, but for the local Nuu-chah-nulth First Nations the interconnectedness of these metrics is engrained into the very fabric of their culture (Atleo, R.E. 2007). Early inhabitants of the Sound were directly dependent on a variety of local ecosystem goods and services, including the Pacific salmon (*Onchorhynchus* spp.) and the versatile Western Red cedar (*Thuja plicata)*- also known as "the tree of life" (Horsfield and Kennedy, 2014, pg. 13).

While the dependence of Clayoquot residents on ecosystem goods and services has remained a constant, the pathways of this dependence have shifted over the years. The livelihoods of many Clayoquot Sound residents are now dependent on the business of an estimated 940,000 annual tourists that come to experience the area's natural beauty and ecosystem goods and services (CBT, 2016). Today, a salmon likely has a higher monetary value for a sports fisher than for a commercial fisher, and an old growth red cedar on the Meares Island Big Tree Trail likely holds a higher monetary value for local eco-tour operators than it does for a logging company. Empirical research into the monetary value of these intact resources may provide further grounds for the preservation of ecological health in Clayoquot Sound—though placing a monetary value on traditional uses of these resources may be problematic.

Colonialism is widely acknowledged as a negative influence on the ecological health of Clayoquot sound, particularly among First Nations communities. However, the early stages of colonization brought many benefits to the local people as well. Richard Atleo explains that, "The impact of the fur-trading frontier on [the Nuu-chah-nulth] culture was creative rather than destructive…as new wealth was injected into Indian culture but not in a way that was socially disruptive" (2007, pg. 76). Atleo says that, "The environment of Clayoquot Sound, as this general area has become known geographically, was relatively pristine at [the time of the fur trade]. There had been some logging but not to the extent of causing environmental degradation" (2007, pg. 76). The late Steve Lawson, who fished the waters of Clayoquot Sound for over 50 years, explained that early on the, "rivers were packed with salmon," and that this was "still less than older people's tales" (S. Lawson, Personal Communication, January 16th, 2015). Unfortunately, a lack of empirical baseline data showing historical ecological health indicators, means that incorporating anecdotal evidence – like the aforementioned examples—into a scientific framework is difficult. Any old-timer who has watched Clayoquot Sound change over the decades has a sense of the ecological impacts of human activity in this area, but there is little scientific evidence to support their claims.

In the summer of 1993 protests over the logging of old growth forests grew into the largest act of civil disobedience in Canadian History, and put Clayoquot Sound on the world stage as a hotspot for environmental conservation (Walter, P. 2007). Continued local and global pressures to preserve the cultural and biological diversity of Clayoquot Sound eventually led to its designation as a UNESCO biosphere reserve in 2000 (Henn, R. D. 2009). The UNESCO designation was touted by many as the savior of Clayoquot Sound, despite its limited regulatory power (Henn, 2009). Others disregarded the biosphere reserve as an arbitrary designation that has led to an ungrounded sense of security among environmentalists (Henn, 2009). Since the biosphere reserve designation, continued logging of old growth forests, open pit mining proposals, and rapid growth of the finfish aquaculture industry have spurred heated debates and protests over the ecological health of Clayoquot Sound (Henn, R. D. 2009).

Adding to the political complexity of Clayoquot Sound, local First Nations are actively pursuing more control over the natural resources in their territories with little regard for the existing management and governance structures (Murray, and King, 2012). The Tla-o-qui-aht First Nation has established a large tribal park in which they have declared greater control over natural resources- also known as their Hahoulthee (Murray and King, 2012). Contained within the park boundaries are crown land, provincial park, and private land, raising many questions over who holds ultimate authority in these lands with conflicting declarations of ownership and stewardship. More recently, the Ahousaht First Nation published a land management plan that protects 80% of the forests in their territory from commercial logging, and claims a much higher level of control over natural resources than they have held in recent decades (MHSS, 2017). The power struggle over control of natural resources in the sound is deeply rooted in the history of conflict between colonial settlers and indigenous peoples (Horsfield and Kennedy, 2014, pg. 48).

Perhaps the most destructive outcome of colonialism in the sound was the multi-generational separation of First Nations children from their families (Horsfield and Kennedy, 2014, pg. 256). Richard Atleo explains that "In the Nuu-chah-nulth worldview it is unnatural, and equivalent to death and destruction, for any person to be isolated from family or community" (Atleo, 2007, pg. 27). Many Canadians today consider Indian residential schools to be an unfortunate and distant remnant of Canadian history with little influence in modern life, despite the last residential school operating until 1996 (Trocmé et al., 2004). Paulette Regan sheds light on this misunderstanding by explaining that, "When the focus is on colonizers as individual perpetrators, the number of victims is smaller; when colonizers are understood as collective beneficiaries of a system that created and perpetuates inequities and breaches the human rights of oppressed groups, the number of victims increases exponentially." If we accept the role of non-indigenous Canadians as beneficiaries – and therefore perpetuators – of colonialism, any analysis of ecological health, must acknowledge the continuing influence of this historical relationship.

## Human Health

### First Nations

Public Health data on individual communities within Clayoquot Sound is limited. In 2016 the Clayoquot Biosphere Trust (CBT) published a report, titled "Vital Signs". The report provides a snapshot of many ecological health determinants, including health and wellness, economy, transportation, food security, learning, and environment (CBT, 2016). The report contains little differentiation between communities in the sound, with few exceptions. The report contains Nuu-cha-nulth literacy rates, which show a decrease in fluent speakers from 3.1% in 2012 to 1.7% in 2016. Aboriginal high school graduation rates (approximately 55%) are shown as substantially lower than non-Aboriginal graduation rates (75%) based on Alberni Clayoquot school district data. The "proportion of residents that identify as aboriginal" is listed at 17%. This figure is also based on Alberni Clayoquot data, which likely underrepresents the First Nations population within the Clayoquot Biosphere Reserve region by a large margin. The lack of demographic specific health data in small communities of Clayoquot Sound may be necessary in order to maintain an adequate level of confidentiality.

On a national scale there have been many concerted efforts to analyze determinants of health among First Nations communities, including the 2012 Aboriginal Peoples Survey (Statistics Canada). While it is problematic to take national averages and apply them to local communities, this survey does provide a useful overview of the disparities that exist between First Nations and non-First Nations communities around the country. In contrast to many government reports, this one was conducted in a collaborative effort with first nations leaders in an effort to "redefin[e] how success is measured in aboriginal learning." Off-reserve aboriginals measured substantially higher in chronic conditions, daily smokers, heavy drinking, and food insecurity (Statistics Canada, 2012). Food insecurity showed the greatest disparity, with 22% of off-reserve First Nations members receiving inadequate nutritional intake, compared to only 7% of non-First Nations members (Statistics Canada, 2012). That the data reflects only off-reserve First Nations members makes it increasingly difficult to extrapolate for Clayoquot Sound, as a large portion of the First Nations population there live on reserves. The largest First Nation in Clayoquot Sound, Ahousaht, has a total population of 1973 people, with approximately 719 living on-reserve at Maaqtisiis (Government of Canada, 2016).

### Tofino Residents

Tofino is the largest community in Clayoquot Sound, with a year round population of 1,876 (2011) and a large tourism economy that welcomed 940,000 visitors in 2015 (Statistics Canada, 2011; CBT, 2016). In sharp contrast to Maaqtisiis, Tofino is predominantly Caucasian, with Aboriginals making up 5.7% of the total population, and "visible minorities" making up 3.3% of the population (City Data, 2011). Many Tofino residents are young (average age 34) environmentally conscious people living at "the end of the road" (Clayoquot Biosphere Trust, 2016). It's true that Tofino marks the westernmost point of the Trans-Canada Highway, but the town's emphasis on "end of the road culture" reflects a blind spot in which the rest of Clayoquot Sound residents live.

Largely due to the popularity of Tofino as a tourist destination, the town has a high living wage $19.27 per hour, compared to the B.C. average of $10.85 per hour (CBT, 2016). 79% of the biosphere region's residents report feeling "satisfied with life" compared to the B.C. average of 69% (CBT, 2016). The Alberni/Clayoquot infant mortality rate dropped from 9.5/1000 in 2011 to 4.3/1000 in 2015, likely due to the requirement that Clayoquot mothers must leave the region to give birth nearer to a fully equipped hospital (CBT, 2016). In general Tofino gives the initial impression of a young, vibrant, healthy community. However, there is limited data that addresses specific demographics of the population who face more challenging circumstances.

While residents of Clayoquot Sound have traditionally depended largely on resource extraction industries such as logging and fishing, recent years have seen a rapid transition towards an eco-tourism based economy (Thicke, C. 2011). Non-First Nations residents of Tofino receive a disproportionally high level of income from the eco-tourism industry in Clayoquot Sound, as only one of 20 formal-sector ecotourism businesses in the sound are owned by First Nations members (Levine et al., 2016). Further contributing to the income disparity within eco-tourism, the majority of eco-tourism businesses are operated by transient or seasonal non-First Nations employees (Levine et al., 2016).

### Transient Population

The transient population in Tofino can be broken into two main groups: those that come to Tofino as tourists, and those that cater to the tourists while they are here. With nearly one million visitors annually and a year round population of under 2000 residents, the town is heavily dependent on the transient workforce that live in Tofino during the summer months. There is little data showing the demographics and population health of this transient workforce- an issue that requires future research. Dramatically increased rates of sexually transmitted infections (STI's) in other B.C. boomtowns with a similar influx in young transient workers suggests that there is reason to be concerned about the public health of this population (Goldenberg et al., 2008). Furthermore, high rates of STI's are among the many stigmas that have been attributed to the transient workforce in Tofino. Again, there is a lack of empirical evidence to support these generalizations, which highlights the need for research on the subject in order to avoid further stigmatization based on anecdotal and potentially false information.

### Biological Health

Despite the complex and in some cases difficult human health outlook for Clayoquot Sound, the rest of the biological community has been left relatively intact. The aforementioned eco-tourism economy is largely based on the 'pristine wilderness' of Clayoquot Sound (relative to the rest of Vancouver Island and British Columbia). The term pristine wilderness is problematic in that it implies a lack of human presence, which essentially disregards the long history of First Nations habitation in Clayoquot Sound (Braun, B. 2002). However, the term also symbolizes the extent to which the biological communities in the area have been left intact.

Clayoquot Sound is home to many biological reserves including the Pacific Rim National Park, the Vargas Island Provincial Park, the Cleland Island ecological reserve, Tla-qui-aht Tribal Parks, and a number of biological reserves established in the 2017 Ahousaht Hahoulthee land use vision (MHSS, 2017). While each of these reserves afford different types and levels of protection to biological communities, they are the culmination of a hard fought – and largely successful – effort on all sides to preserve the biological integrity of Clayoquot Sound. We are only beginning to understand the implications of preserving this biological integrity; from the expansion of highly productive Eelgrass (Z. *marina)* meadows to the increased rates of visitation from Transient Orcas (*Ornicus orca)* and the return of Sea otters (Enhydra *lutris sp.)* there are many reasons to be optimistic about the biological health of Clayoquot Sound moving forward (Palm, R., 2014). However, the 'pristine wilderness' of this area has in fact been influenced by human actions since time immemorial, and the recent past is no exception (Tsawalk, R., 2007, pg. 62).

In Horsefield and Kennedy's history of Tofino and Clayoqout, Ahousaht member Sam Paul speaks of the biological degradation brought by colonialism, "This was a fishing village, but the salmon are going because the white man has not cared for the spawning beds and the cod have been over-fished by the trawlers" (2014, pg. 454). Indeed, destructive clear-cut logging practices and an intense gillnet fishery in the 1960's contributed to the collapse of highly productive local fisheries in Clayoquot Sound (Pitt-Brooke, D., 2004, pg. 222). A century earlier a minor gold rush in the Bedwell River marked one of Clayoquot Sound's few mining operations with presumably negative influence on the adjacent salmon bearing streams. The recent refusal of an open pit copper mine on Catface Mountain means the area is safe from the impacts of further mining operations for now. However, continued clear-cut logging practices in the Tofino Creek watershed, a highly controversial fin-fish aquaculture industry, and an every growing eco-tourism industry each pose unique threats to the biological integrity of Clayoquot Sound (Martin, J., personal communication, February 9th, 2017; McDougall, G., 2016).

Pre-contact Vancouver Island had 2.3 million hectares of coastal temperate rainforest, 75 percent of which had been clear cut logged by 2009 (Mychajlowycz, M. (2009). These old growth forests were spread over 91 primary watersheds, only 6 of which remained intact as of 2004 (Pitt-Brooke, D., 2004, pg. 199). While Clayoquot Sound contains the largest area of remaining old growth forest on Vancouver Island, approximately 63,000 hectares (26%) of its total forested area had been logged by 2009- including clear-cuts in Stewardson Inlet, Atleo River watershed, Bedingfield Bay, Whitepine Cove, Cypre Bay, Catface Mountain, and Tofino Creek (Pitt-Brooke, D., 2004, pg. 199; Martin, J., personal communication, February 9th, 2017). Following the Clayoquot logging protests of 1984 and 1993, the Forest Practices Code of British Columbia was implemented in 1995 to "promote the conservation of biological diversity through management of the forests, based on ecological units, watersheds, or groups of watersheds" (Laird et al., 2001).

Despite government recommendations that no more-old growth forests be logged in Clayoquot Sound, clear-cut logging of old growth stands continues to threaten the ecological integrity of forests in a variety of ways- including increased landslide activity (Henn, R.D., 2009; Jakob, M., 2000). A study of 1004 landslides in Clayoquot Sound found that the frequency of landslides was 9 times higher in areas that had been logged than in areas covered with intact old growth forest. These clear-cut correlated landslides have many implications for local ecological health- including enhanced "flow, turbidity, concentrations of dissolved ions, and temperature" in salmon bearing streams (Laird et al., 2001). Changing stream conditions are just one of many threats to local salmon stocks, which provide a valuable source of marine-derived nutrients to the flora and fauna of Clayoquot Sounds terrestrial ecosystems (Henn, R. D., 2009; Heaslip, 2008; Nyland et al., 1995).

Once a staple of life in Clayoquot Sound, commercially viable salmon stocks have virtually disappeared- with unregulated sport fishing protocols and aquaculture being identified as major threats to remaining stocks (Henn, R.D., 2009). Attempts to address the dwindling salmon stocks in B.C. have relied largely on technocratic solutions – including hatchery production, construction of spawning channels, and salmon farming – rather than addressing the root causes of the problem (Rajala, R. A., 2008). Salmon farms in particular, likely contribute to further degradation – rather than restoration – of wild salmon stocks. Escaped Atlantic salmon from fin-fish aquaculture operations prey on wild juvenile salmon, and produce competitive genetic hybrids (Heaslip, 2008). Furthermore, salmon farms placed in key migratory routes infect wild salmon with parasitic sea lice (Lepeophtheirus *salmonis*), and diseases like infectious salmon anemia (ISA Virus) (Nyland et al., 1995). Salmon aquaculture impacts other parts of the ecosystem as well, including harassment and killing of wild predators by farm operators, and discharge of pollutants such as; "fish feces, unconsumed feed pellets, antibiotics in medicated fish feed, dead fish carcasses and hazardous wastes such as petroleum products, paints and cleaning products" (Heaslip, 2008).

With an ecotourism-based economy that includes a large sports fishing fleet, the communities of Clayoquot Sound have reason to be concerned about the threat of fin-fish aquaculture to remaining fish stocks; "On February 11, 2013 the Vancouver Sun reported that "British Columbia's recreational fishery is worth as much to the provincial economy as commercial fishing, aquaculture and fish processing combined"" (Horsefield & Kennedy, 2014, pg. 181). Other issues that pose a threat to the eco-tourism based economy of Clayoquot Sound include water shortages, inadequate sewage treatment, lack of public transit, housing shortages and climate change (Dodds, R., 2012; McDougall, G., 2016). Climate change may be of particular concern moving forward, as the United Nations World Tourism Organization (UNWTO) has identified "the tourism sector as one of the most highly climate sensitive industries" (McDougall, G., 2016).

Climate change projections for Clayoquot Sound include annual warming of between 1.4°C and 3.9°C, increase in large storm events, increased precipitation during fall and spring, and decreased precipitation during the summer- with a drought frequency increasing between 15% and 46% (McDougall, G. (2016). All of these local environmental changes have so far benefited the local eco-tourism industry, with visitors enjoying warmer, sunnier summer weather, and more dramatic storms during "storm watching" season. Increased participation in high carbon emissions ecotourism activities such as whale watching and scenic flights further expedite anthropogenic climate change- creating a positive feedback cycle (McDougall, G., 2016).

A common misconception about the "pristine wilderness" of Clayoquot Sound is the idea that the area is free of pollution. Perfluorinated compounds (PFC's) – which were recently added to the Stockholm Convention of Persistant Organic Pollutants in 2009 – were recently found throughout Clayoquot Sound in concentrations comparable to much more populated and industrial active areas of Puget Sound (Dinglasan-Panlilio et al., 2014). The sources of these PFC's in Clayoquot Sound are thought to be a combination of atmospheric contributions and regional sources, such as untreated wastewater discharge. Presence of local pollutants like these add to a long list of potential causes of unexplained local species population declines- including the rapid disappearance of kelp (*Nereocystis luetkeana*) forests and sea stars (*Pisaster ochraceus)* (Palm, R., 2014).

While some species populations are in decline in Clayoquot Sound, others are thriving; 2014 saw Orca (*Ornicus orca*) visitation increase to 80 days—compared to 60 days in 2009 (Palm, R., 2014). Sea otters have also repopulated Clayoquot Sound in massive numbers with rafts of up to 100 individuals being sighted on a regular basis around Bartlett Island (Palm, R., 2014). Eelgrass (*Zostera marina)* meadows in the Tofino mudflats expanded from 1,626,716 $m^2$ in 2000 to 1,980,063 $m^2$ in 2014 (Palm, R. 2014). These eelgrass meadows provide critical habitat to many marine species, such as herring, rockfish, crabs and clams (Osborn & Olive, 2013; Horsefield &Kennedy, 2014, pg. 541). Seagrass meadows are also significant carbon sinks; they sequester as much carbon globally as all terrestrial forests (Osborn & Olive, 2013). Furthermore, "eelgrass is sensitive to both physical disturbance and water quality, so it makes an excellent environmental indicator, both for water quality as well as a proxy for ecosystem integrity" (Osborn & Olive, 2013).

The extent to which Clayoquot Sound has been spared destructive human influence is largely a subjective measure, limited by a short history of biological baseline data for the area. Professor George Spencer of the University of British Columbia was likely the first person to collect substantial scientific biological baseline data when he spent the summer of 1920 cataloguing the biodiversity of Clayoquot Sound (Horsefield and Kennedy, pg. 413). Still, the baseline data since that time is sparse and inconsistent, leaving ample room for the phenomenon of shifting baselines – in which people's perceptions of what a healthy ecosystem looks like change over time along with the changes in their surroundings.

In recent years Clayoquot Sound has become of focal point for the biological sciences. The relatively easy access, and low human impact in comparison to other industrial Centre's around B.C. make it a prime location for collecting baseline data with which to compare environmental degradation in other areas (Elliot et al., 2008). Clayoquot Sound also has a large First Nations population with a relatively strong connection to their culture, making it an ideal location for the intersection between biological and social sciences (Levine et al., 2016).

A study by Levine et al. from the University of British Columbia exemplifies Clayoquot Sound's strong potential for interdisciplinary research; the team used an interdisciplinary lens to explore the different cultural perspectives associated with the recent repopulation of Sea Otters in Clayoquot Sound (2016). The Sea otters were once extirpated from the area during the fur trade, but were reintroduced in order to restore proper ecological function (Levine et al., 2016). Sea otters are a key predator of sea urchins, which have largely been blamed for the destruction of kelp forests in recent years (Levine et al., 2016). Kelp forests play an integral role in the maintenance of biodiversity in the area, which is largely the focal point of the local eco-tourism industry. Understandably, the ecotourism industry is thrilled with the return of the sea otters because of their charismatic nature, and their benefit to the local fish species (Levine et al., 2016). The local First Nations on the other hand historically used physical force to keep the sea otters out of their territory in order to protect important food sources, including sea urchins, crab, and clams. Levine et al. used the dietary preferences of First Nations and non-First Nations members to expose a disproportionately high impact of sea otter repopulation on First Nations members and women- demographics that are already disadvantaged in the current socioeconomic system (Levine et al., 2016).

While Levine et al.'s study does not take a stance on whether sea otters should continue to be protected in Clayoquot Sound, it exposes a need to incorporate both cultural and biological factors into ecological management practices. Given the previously discussed links between human health and ecological health, ecological research must address factors contributing to human health- including access to traditional food sources. This type of interdisciplinary research has great potential to improve the ecological health of Clayoquot Sound for generations to come, as it represents a paradigm shift towards a more holistic approach to ecological research, education, and management.

# Part II— How Can We Preserve Ecological Health?

## Introduction

Given our unavoidable influence on ecological health, there are many ways in which we may improve this metric through research, education, and management. These fields provide an opportunity to engage with the difficult subject of ecological health in a way that is constructive and empowering. The following descriptions of these fields are by no means an exhaustive overview. Rather, they are a starting point from which to explore the many opportunities that we have to improve the state of the natural world.

## Ecological Research

Human impacts on ecological health are creating a growing need for the practice and application of Ecology (Omerod et al., 1999, Rayers et al., 2010; Daily et al. 2000). Derived from the ancient Greek words oikos, meaning "household", and logos, meaning "study," ecology encompasses the study of all organisms in the environmental "household" of planet earth (Wilson, 2004, p.2). The biological sciences have done – and continue to do— a great deal to illuminate the many processes that make life on earth possible. However, the progress made in biology thus far has proven ill-equipped to address the ever growing list of ecologically destructive human practices. With rapid declines in the diversity, abundance, and resilience of organisms around the world, we need urgently to identify and mitigate the root causes of these ecological issues. Doing so will require a holistic ecological framework that includes all aspects of ecological health, including human activity.

This holistic iteration of ecology has evolved through a long history of humans trying to make sense of the natural world. The 18th century Naturalist Jean-Jacques Rousseau suggested that one should "observe nature and follow the path it maps out for you" (Purdy, 2015, pg. 11). In contrast to this bio-centric perspective John Evelyn and John Ray were powerful supporters of the notion that nature was something to be feared and overcome (Purdy, 2015, pg. 12). Following in the footsteps of Evelyn and Ray, John Stuart Mill declared that the human duty was "to struggle against nature; to drain swamps, channel rivers, and overcome our own natural barbarism" Purdy, 2015, pg. 13). These examples provide a glimpse into a long history of humans using nature rhetoric to support their belief systems; "Nature turns out to be flexible like that. It has been the handmaiden of revolutions and the underwriter of kings, proof of divine design and of atheistic materialism, from Athens and Rome down to the age of democracy. It has proved and disproved the injustice of slavery" (Purdy, 2015, pg. 12).

The modern term 'ecology' was first defined by German biologist Ernst Haeckel in 1869, as "the study of the natural environment including the relations of organisms to one another and to their surroundings" (Odum and Barret, 2004, p.3). Early studies in ecology focused primarily on distribution, interaction and abundance of biological organisms, and regarded human beings as a removed audience (Rayers et al., 2010). The mid 20th century saw the emergence of applied ecology, which aimed to address the growing level of anthropogenic impacts on ecological systems (Rayers et al., 2010). While the early stages of applied ecology were focused on anthropogenic impacts and influencing management, it wasn't until the late 20th century that the field of ecology began to recognize human beings as subjects within ecological systems (Rayers et al., 2010). The increasingly obvious impact of human actions on ecological systems has made it clear that the field of ecology needs to engage social science and other disciplines in order to fully address the issues facing humanity in the 21st century (Rayers et al. 2010). On the recent extension of ecology as an interdisciplinary science, ecologist E.O. Wilson says, "the future of our species depends on how well we understand [this] extension and employ it in the wise management of our natural resources" (Wilson, 2004, p.2).

Ecology's recent evolution as an interdisciplinary field has enabled it to embrace a broader scope of knowledge. However, there are still many disciplinary and ideological barriers to overcome. On the emerging field of traditional ecological knowledge (TEK), Fikret Berkes writes that "purely ecological aspects of tradition cannot be divorced from the social and spiritual" (Berkes, 2012, p. 5). This makes it difficult for ecologists to include TEK in contextually appropriate ways because social and spiritual aspects of TEK do not fit within the scientific framework. For example, the Nuu-chah-nulth saying *Heshook-ish tsawalk* – meaning "everything is one" – has recently been adopted by many individuals within academia and the environmental movement (Atleo, 2007, p. xi). This concept of "everything is one" can be taken literally as the interconnectivity of all living organisms on earth, which fits well within the existing conceptual framework of ecology. While the literal interpretation of *Heshook-ish tsawalk* is not false, it fails to acknowledge that "*Heshook-ish tsawalk* means more than the unity of the physical universe" (Atleo, 2007, p.xi).

Nuu-chah-nulth scholar E. Richard Atleo describes empirical reality as "concentrations of energy that can dissolve into the underlying quantum field," indicating the interconnectedness of all matter on a metaphysical [or supernatural] level (Atleo, 2007, xiv). It is in this sense that the Nuu-chah-nulth people traditionally believed in the concept of *Heshook-ish tsawalk* (everything is one). Contextually inappropriate uses of TEK—like the literal interpretation of *Heshook-ish tsawalk*— have created a growing number of TEK holders who are frustrated with the exploitative nature of ecological studies (Brook et al., 2008). This contextually inappropriate application of TEK is likely the result of attempts to situate TEK within the existing scientific framework (Ballard et al., 2008). Treating TEK as a process to be embraced, rather than a commodity to be obtained, may aid future attempts to include TEK in contextually appropriate ways (Brook et al., 2008).

In addition to increased recognition of TEK in the field of ecology, other sources of local ecological knowledge (LEK) have great potential to inform ecological research and its applications. Traditional ecological knowledge (TEK), Indigenous Knowledge, Rural Peoples' Knowledge, Farmer Knowledge, and Folk Knowledge, are just some of the academically recognized forms of LEK (Brook et al., 2008). While the use of LEK in ecology is on the rise, a literature review of 12 ecology journals found that between 1980 and 2004 only 0.42% of papers included LEK (Brook et al., 2008). As with TEK, other local peoples, including farmers and fishers, also obtain LEK through non-scientific methods including dreams, prayers, ceremonies, self-knowledge and learning by doing (Brook et al., 2008). Here again, western science lacks an established framework for including many of these knowledge sources, so they find limited recognition in the literature. Of the 0.42% of peer reviewed ecology articles that included LEK, only 11% "explicitly recognize or discuss a spiritual component to the local knowledge" (2008).

In order to increase inclusion of LEK in the field of ecology, more scientists need to consult with local peoples in the design, operation, interpretation and review of studies (Brook et al., 2008). Some LEK holders are initiating their own research projects in order to obtain a meaningful role in ecological research and management decisions (Ballard et al., 2008). A survey of community based forestry (CBF) organizations in the U.S. found that in all projects, "conventionally trained scientists and local people both described learning from each other" (Ballarde et al., 2008). In many of these cases the local organizations brought in conventionally trained scientists in order to provide training for organization members, and establish a higher level of scientific legitimacy (Ballarde et al., 2008). Because these research processes were driven by local peoples, they were better able to incorporate LEK in contextually appropriate ways.

The re-emerging interest in LEK may greatly benefit the field of Ecology, but it does not discredit the scientific method. There is no doubt that the scientific method has been central to developing our current understanding of the ecological systems that sustain life on earth. While LEK holders may have correctly hypothesized the functions of these ecological systems long before the emergence of science, modern science has developed the methods required to test these hypotheses in a falsifiable way. Some would argue that testing LEK with the modern scientific method is contextually inappropriate. However, this may be the only available method to effectively incorporate LEK into ecological management practices within current economic and governance structures. The scientific method is also better able to encourage objectivity, a control that is difficult to ensure with the use of LEK – especially with spiritual and metaphysical aspects. Objectivity is an important control to work towards, especially in scientific research that is being conducted in politically charged environments. Lastly, the vast existing global network of scientists trained in the scientific method enables ecologists to explore complex ecological systems on a global scale that would not be achievable with the sole use of comparably isolated sources of LEK around the world.

## Ecological Management

Similar to the word ecology, economics is also derived from the Greek root *oikos*, meaning "household," and *nomics*, meaning "management" (Odum and Barret, 2004). It follows that the management of natural resources (environmental household) has historically been closely related to the prevailing economic system. In the modern western developed world, the prevailing system is a capitalist free-market economy that operates on the premise of infinite growth (Gordon and Rosenthall, 2003). While this premise has served the free-market economy well in many regards, it has led to devastating consequences for the ecosystems of the world (Foster, 2009). In an effort to move beyond a natural resource 'management' system that is based on infinite growth, this section will introduce a more holistic approach to ecological management, or, stewardship.

E.O. Wilson said that "We live both by a market economy—necessary for our welfare on a day-to-day basis—and by a natural economy, necessary for our welfare (indeed, our very existence) in the long term" (2004). Based on Wilson's recognition of our dependence on the natural economy, it can be inferred that he recognized our dependence on ecological health. However, placing the natural world within an economic framework has pros and cons. Attempting to do so has produced the concept of ecosystem services, which has played a pivotal role in bridging the gap between ecology and land-use planning and policy (Reyers et al., 2010). The concept of ecosystem services has also contributed to a conceptual divide between humans and the rest of the natural world (Reyers et al., 2010). This divide makes the ecosystem service concept incompatible with cultures that do not recognize nature as being distinct from humans (Reyers et al., 2010). Given the importance of including diverse knowledge sources in management decisions and practices, the economically inspired ecosystem service concept is limited in its capacity to inform holistic ecosystem-based management. This highlights the need to develop a more inclusive approach to ecological management.

Traditional scientific management of 'natural resources,' which focuses on individual species and sectors, has been largely ineffective in management of broad scale ecological health (Long et al., 2015). There is a broad consensus within the scientific community that moving towards an improved management system will require a multi-faceted approach, which addresses biodiversity, complex social-ecological systems, stakeholder participation and appropriate use of incentives (Long et al., 2015). These factors, among others, are part of a widespread shift towards a more holistic ecological approach known as Ecosystem Based Management (EBM) (Long et al., 2015). Among the key considerations for EBM, is an emphasis on managing human activities that impact ecological health (Long et al., 2015).

Ecosystem Based Management has only recently emerged as a term in the scientific literature, yet it has been practiced by indigenous cultures for over 10 000 years in some cases (Long et al., 2015). Despite the wealth of experience in EBM amongst indigenous peoples, many definitions of the management approach fail to recognize the importance of local and traditional ecological knowledge in EBM. In 2015, in an effort to consolidate the many interpretations of EBM, Long et al. used a literature review to inform a particularly inclusive definition of EBM:

*"Ecosystem-based management is an interdisciplinary approach that balances ecological, social and governance principles at appropriate temporal and spatial scales in a distinct geographical area to achieve sustainable resource use. Scientific knowledge and effective monitoring are used to acknowledge the connections, integrity and biodiversity within an ecosystem along with its dynamic nature and associated uncertainties. EBM recognizes coupled social-ecological systems with stakeholders involved in an integrated and adaptive management process where decisions reflect societal choice."*

While this definition acknowledges many of the complexities inherent to EBM, it refers solely to the use of scientific knowledge, consequently failing to recognize the importance of non-scientific knowledge in EBM. This definition also fails to address the need – identified by Reyers et al. – for ecology to “engage with the purposive disciplines of philosophy, ethics and theology” (2010). A transdisciplinary approach like the one suggested by Reyers et al. is necessary in order for ecologists to develop a truly holistic and inclusive EBM system. Furthermore, attempting to create one cohesive global definition of Ecosystem Based management does not leave room for the consultation of local ecological knowledge holders in ecoregion-specific definitions of Ecosystem Based Management.

Levin et al. propose integrated ecosystem assessments (IEAs) as an effective method to inform interdisciplinary ecosystem based research and management in a locally appropriate way (2009). IEA’s “involve [] and inform [] citizens, stakeholders, scientists, resource managers, and policy makers” in a process that contributes to successful implementation of EBM (Levin et al., 2009). The first of five IEA steps is ‘scoping’, which deeply involves stakeholders to identify “critical ecosystem management drivers and specific pressures on ecosystems” (Levin et al., 2009). Following ‘scoping’, ecological health ‘indicators’ that are academically rigorous, understandable to public, cost-effective, and responsive to ecosystem changes must be identified (Levin et al., 2009). These ‘indicators’ are run through a ‘risk analysis’ to determine the likelihood that they will “reach or remain in an undesirable state (Levin et al., 2009).” Following ‘risk analysis’, a ‘management strategy evaluation’ uses computer modeling programs to simulate ecosystem behavior and forecast outcomes of management scenarios (Levin et al., 2009). Lastly, and perhaps the most poorly conducted aspect of IEA's, is the 'ecosystem assessment,' which involves continued monitoring and evaluation of ecosystem management effectiveness (Levin et al., 2009). Without long term monitoring of ecological health there is no way of knowing whether IEA's are as effective in practice as Levin et al. suggest they can be.

Long term monitoring and evaluation of research projects require long term commitment from researchers and funding sources. These factors likely contribute to the lack of long term monitoring projects currently being conducted in the field (Levin et al., 2009). One way to gather support for long term monitoring projects is through implementation of citizen science. Citizen science has traditionally been dominated by the field of ornithology, but use of citizen science in other fields of ecology is on the rise (Barberán et al., 2016). With proper training and engagement, these citizen science projects can greatly increase the geographic and temporal scales at which ecological studies can be effectively carried out (Barberán et al., 2016). Furthermore, engaging citizens in the scientific process is an effective method for distributing a sense of ownership over research projects. Widespread distribution of ownership over, and awareness of, ecological research projects has direct implications for the ecological attitudes and policies adopted by society.

## Ecological Education

If there is any hope of reconciling the ecological degradation discussed thus far, ecological education will surely play an important role. Taking a leap towards ecological reconciliation will require the average citizen to develop an ecologically grounded perspective. On this point Aldo Leopold asks a critical question, "does the educated citizen know [they are] only a cog in an ecological mechanism" (1999, pg.

262)? The answer to this question may have been unclear when it was asked in 1938, but since that time the technological advances of the western developed world have contributed to an increasingly obscured relationship between humans and nature. Barberán et al. offer insight into the importance of this obscured relationship: "Undeniably, our view of the relationship between humans and nature determines the attitudes we develop and the environmental policies we adopt" (2016). Given the critical nature of environmental policies in the 21st century, it follows that our education systems must focus on encouraging a more ecologically grounded perspective among students.

In current United States and Canadian school systems, the subject of ecological education falls under the umbrella of environmental studies, which are generally taught using a technical approach that emphasises efficient use of natural resources (Duenkel & Pratt, 2013). This narrow focus excludes many aspects of ecology, including all aspects of human ecology. Consequently, these programs reinforce an environmentally and socially unjust perspective that is dominated by values of order, hierarchy, competition, compliance, standardization, and individualism (Blenkinsop, 2012). There are many individual educators and organizations working to inspire a more holistic ecological approach to what is currently known as environmental education (Barberán et al., 2016; Juzefovič, 2015; Shaikhiev & Kadyrova, 2002; Bertling, 2013; Blenkinsop, 2012; Russ et al., 2015; Duhn, 2012, Duenkel & Pratt, 2013). Unfortunately, these are the exception rather than the norm and the education system has been slow to adopt holistic concepts of ecology that researchers have been writing about for decades (Gislason & Rothman, 2013, pg. 143). Duenkel & Pratt highlight the severity of the situation by suggesting that "education as it exists today may be the greatest obstacle to nurturing ecologically literate citizens" (2013).

Environmental education has been slow to adapt, but it has undergone a gradual evolution over the decades. The original environmental education programs stemmed from Platonic roots, and relied on the logic that knowing what was the right thing would lead to doing the right thing (Blenkinsop, 2012). A more recent, and effective, approach to environmental education draws on the notion that students with stronger relationships to the natural world are more likely to take an interest in it (Blenkinsop, 2012). Much of the work utilizing this approach was likely influenced by the work of Aldo Leopold, who said in 1949 that "We can be ethical only in relation to something we can see, feel, understand, love, or otherwise have faith in" (Meine & Knight, 1999, pg. 295). Now, in order to address the ecological issues of the $21^{st}$ century, the field of environmental education must shed its title and embrace a holistic approach to ecological education. Many of the ecological challenges facing humanity today are consequences of modernity, meaning that change will need to occur at the cultural level (Blenkinsop, 2012). In order to address cultural influences on ecological health, a holistic approach to ecological education must be adopted.

Shaikhiev and Kadyrova suggest that "ecological education is the only means of systemic "treatment"," that aims to solve social, economic, medical, biological, cultural, and ecological health problems (2002). Taking an interdisciplinary, or transdisciplinary, approach to ecological education enables educators to greatly influence "students' systemic interdisciplinary thinking" (Shaikhiev & Kadrova, 2002). As with all educational practices, this is a great responsibility and should not be taken lightly.

However, influencing students' systemic thinking is a necessary step in helping them develop more ecologically grounded perspectives.

One way to inspire a more ecologically grounded perspective is through what J. Bertling calls the 'ecological imagination' (2013). This educational approach allows students to imagine and create alternate ecological realities through artistic activities (Bertling, 2013). By leaving these ecological realities entirely up to the students' desires and imaginations, the teaching method avoids the fearful outlook that often results from addressing issues of ecological health. The artistic expression of these imagined ecological realities also enables the students to influence real change in their local ecosystems (Bertling, 2013). By sharing their artistic representations of improved ecological realities with the community, students are influencing community members' perceptions of ecological health.

Barberán et al. provide another effective ecological education approach, which involves "consideration of one's self as a microbial ecosystem" thus encouraging "an understanding of one's place in the broader "macrobial" ecosystem (2016). This method supports existing notions that ecological education should seek to engage students through exploration of the 'self' (Barberán et al., 2016). Conceptualizing the self as a microbial ecosystem provides an opportunity for in depth analysis of the self, and in depth analysis of how the one's self interacts with the surrounding ecosystem. Duenkel & Pratt describe this "opening of human awareness to our fundamental participation in the biotic community" as an "ecological sensibility" (2013).

In order to affect widespread change this "ecological sensibility" must be made accessible to all citizens, including those without immediate access to remote natural areas. Based on their work with place based ecological education in New York City, Russ et al. are convinced that we must develop a deeper understanding of cities as nature, that is just as awe inspiring as the pristine national parks that grace the pages of National Geographic (2015). If we consider the fact that the majority of human beings now live in cities, it makes sense to emphasize cities as nature in the pursuit of inspiring ecologically grounded perspectives. This process is especially important in young children, as environmental learning at a young age is a key element in developing a lifelong disposition towards caring for ecological health (Duhn, 2012). Challenging the separation between cities and nature fits within Duenkel & Pratt's conception of ecological education, which "fundamentally challenges separations between disciplines, between personal and professional, between learner and teacher, between humans and the rest of life" (2013).

# PART III— EMBRACING HUMAN DEPENDENCE ON ECOLOGICAL HEALTH

## INTRODUCTION

The topophillia hypothesis says that "humans possess an innate bias to bond with local place…and that the human brain is genetically 'wired' to incorporate knowledge through local place" (Kahn, & Hasbach, 2012, pg. 13). It follows that a holistic approach to ecological research, education and management must incorporate first-hand, place-based local ecological knowledge. First-hand experience becomes especially important when attempting to address the barriers that exist between local and scientific ecological knowledge, as there are aspects of place-based local knowledge that can only be understood through first-hand lived experience (Bertling, 2013).

This section will further explore the ways in which place-based experiential learning can contribute to more ecologically grounded perspectives. After establishing the influential power of place, the concept of ecological design is introduced as a tool to intentionally shape the influence of a place. There are many approaches to ecological design, but Van Der Ryn and Cowan aptly summarize the field's underlying function as "a way of integrating human purpose in nature's own flows, cycles, and patterns" (2007, pg. 40). Given the broad scope and incredible complexity of "nature's flows, cycles, and patterns," ecological design is necessarily an interdisciplinary field that must incorporate all available sources of ecological knowledge.

Building on the concepts of place-based learning and ecological design, this section explores the ways in which experiencing place in a remote off-grid location may further promote ecologically grounded perspectives. Vannini & Taggart suggest that the experience of living off-grid can increase a person's awareness of the ecological processes that sustain them (2013). Given the incredible human capacity for self-interest, increased awareness of life-sustaining ecological processes will logically lead to behavior that protects ecological health. For example, if we understand that we depend on the ozone layer for protection from the sun, we are likely to act in ways that protect the ozone layer.

The higher ecological footprint often associated with living off-grid or in remote areas, as compared to living in the city, brings into question the scalability of perceptual benefits associated with off-grid living (Dodman, 2009). This section investigates the ways in which people may benefit from the experience of off-grid living without having to entirely abandon their economically efficient city lifestyles. This investigation is focused on the life-sustaining resources of energy, food, and water in order to determine whether increased awareness of our dependence on these resources can lead to conservation of the ecological processes that provide them. I use the first person perspective in this section for two reasons. Firstly, by including a personal lived experience of off-grid living, the transformative effect of that experience may become more relatable to the reader. Secondly, the transformative effect of that experience has largely inspired and informed my investigation into the relationship between off-grid living and ecologically grounded perspectives.

## The Power of Place

In 1943 Aldo Leopold wrote, "there is value in any experience that reminds us of our dependency on the soil-plant-animal-[hu]man food chain, and of the fundamental organization of the biota. Civilization has so cluttered this elemental [hu]man-earth relation with gadgets and middle[people] that awareness of it is growing dim" (Meine & Knight, 1999). Long before Leopold's groundbreaking essays, indigenous peoples of North America were operating in what would now be considered an ecosystem based economy—which required an intimate understanding of, and relationship with, the rest of the natural world (Berkes, 2012). Today (2017), by any apparent metric, this human-earth relation is far more cluttered by "gadgets and middle[people]" than it was in the time of Leopold and the indigenous peoples who came before him.

The rise of technology and globalization has allowed us to forget what keeps the lights on, where our food and water comes from, and where we are in relation to our physical environment. This disconnect reaches a climax in virtual reality, where a person is allowed to temporarily remove themselves from the limitations of the human body and the ecosystem goods and services that sustain it. Granted, this is an extreme example. However, it is a symptom of the increasingly cluttered human-earth relation and a warning sign of potential outcomes that were previously inconceivable except in the pages of dystopian sci-fi novels (Orwell, 1949). Children now spend 90% less time outside than they did a generation ago (Kahn & Hasbach, 2012, pg. 23). The average citizen is now able to recognize 1000 corporate logos and fewer than 10 plant and animal species native to their home (Orr, 2002, pg. 54). This disconnect becomes particularly troubling when we consider that humans evolved as a species in constant contact with the diversity and abundance of the natural world (Kahn & Hasbach, 2012).

The evolution of humans amidst the natural world was a key contributor to E. O. Wilson's biophilia hypothesis, which describes the innate tendency of human beings to "focus on life and lifelike processes" (Kellert and Wilson, 1995, pg. 4). Wilson explains that, "to the degree that we come to understand other organisms, we will place a greater value on them, and on ourselves" (Kellert and Wilson, 1995, pg. 4). This notion is supported by the late evolutionary biologist Stephen J. Gould, who declared that, "we cannot win this battle to save species and the environments without forging an emotional bond between ourselves and nature—for we will not fight to save what we do not love." This suggests that Biophilia is a critical affinity that must be encouraged for the sake of ecological – and self–preservation.

Deeply inspired by the work of E. O. Wilson, renowned ecologist Scott Donald Sampson proposed the topophilia hypothesis as an evolution of Wilson's ideas (Kahn &

Hasbach, 2012, pg. 25). In contrast to the biophilia hypothesis, the topophilia hypothesis says that, “humans possess an innate bias to bond with local place, including both living and nonliving components” (Kahn & Hasbach, 2012, pg. 25). Sampson suggests that this bias to bond with place is a key evolutionary trait that allowed Pleistocene humans to survive in changing and unpredictable environmental conditions – adapting to their surroundings by developing an intimate knowledge of the biological and topographical features (Kahn & Hasbach, 2012, pg. 33).

The topophilia hypothesis does not devalue the affinity that human beings hold for life and lifelike processes. Rather, it suggests that biophilia must be grounded in a place for a person to benefit fully from the increased environmental adaptability that topophilia provides. Given the current climate change projections—which include sea level rise, increased frequency of severe weather events, and glacial recession— the ability to adapt to changing environmental conditions may prove to be increasingly pertinent as the 21st century progresses (Dufresne et al., 2013). The increased environmental adaptability that results from topophilia can be promoted through a variety of methods, including place-based education. The effectiveness of place-based education in promoting adaptability is likely correlated to the human brain being “genetically wired to incorporate knowledge through local place” (Kahn & Hasbach, 2012, pg. 38).

While the evolutionary adaptation of topophilia is partially genetic, social learning also appears to play an important role. For example, adult mentorship is an important factor in fostering topophilia in children (Kahn & Hasback, 2012, pg. 38). This suggests that place-based education facilitators and experts are well situated to promote topophilia mentorship among parents and role models. Place-based education – also known as pedagogy of place, place-based learning, experiential education, community-based education, sustainable education, and environmental education – has worked its way back into the mainstream education system in recent years (Meek, 2011). While some might regard place-based education as a new concept, education within most traditional cultures has historically been place-based, and it was only with the emergence of formal centralized school systems that place-based education fell to the wayside (Meek, 2011). The repercussions of the formal non place-based education system are now being realized in a variety of forms – including ecological degradation.

In the modern context Natural history and Cosmology are two effective mediums for fostering Topophilia through place-based education. The evolutionary epic of how we— and the rest of life on planet earth— came to be, combined with close observation of the natural environment, provides an engaging opportunity for students and teachers to develop a more intimate knowledge of, and connection to, place (Kahn & Hasbach, 2012, pg. 43). Thinking about time on the scale associated with Natural history and Cosmology may also help to put the short sightedness of the consumer/polluter mentality into perspective.

Engaging local ecological knowledge (LEK) holders is another effective method of place-based education. This is especially pertinent in areas where LEK and ways of knowing a place differ from the scientific method. For example, in Clayoquot Sound, "The Nuu-chah-nulth word isaak (respect) necessitates a consciousness that all creation has a common origin, and for this reason isaak is extended to all life forms" (Atleo, 2007, pg. 15). While the Nuu-chah-nulth concept of isaak is consistent with the evolutionary theory that all life originated from a single being, the Nuu-chah-nulth worldview includes a more intentional process of evolution that contrasts the predominant scientific perception of evolution as a seemingly random process (Atleo, 2007, pg. 127). Learning from the wealth of place-based traditional ecological knowledge held within Nuu-chah-nulth culture, therefore requires an understanding of the Nuu-chah-nulth worldview and the ways in which it differs from the predominant scientific worldview. As Fekret Berkes explains, “the written page will never be an adequate format for the teaching of indigenous knowledge” (2012, pg. 38).

The above examples of place-based education contribute to the broader concept of ecological education discussed in Part II. These are just two of the many ways in which connection to place can influence more ecologically grounded perspectives. The following sections will look at some of the subtler ways in which this can take place. Taking an ecological design approach to various aspects of the human built environment is another way promote ecologically grounded perspectives (Orr, pg. 148).

## Ecological Design

Ecological design has the potential to improve all aspects of the human built environment. Renowned architect, David Orr, explains that the challenges of ecological design are, “the overriding problem[s] of our time, affecting virtually all other issues on the human agenda” (Orr, 2002, pg. 14). Van Der Ryn and Cowan further describe ecological design as “a hinge that inevitably connects culture and nature through exchanges of materials, flows of energy, and choices of land use” (2013, pg. 24). Ecological design is a transdisciplinary field with widespread application. In this section we will look at some of the many ways in which ecological design can be used to improve ecological health. In the context of human design in general, ecological design represents a paradigm shift away from an anthropocentric perspective towards an ecocentric perspective in which humans are no longer the sole focus of the human built environment. As Wahl and Baxter explain, “the current norm in modern design is to focus on human interests, while neglecting the interests of other organisms” (2008, pg. 33).

The most immediate and direct application of ecological design focuses on the ecological footprint of the human built environment. This approach to ecological design is largely a matter of efficiency. Building on the premise that natural systems are inherently 100% efficient—as in energy cannot be created nor destroyed—McDonough & Braungart explain that, “to eliminate the concept of waste means to design things—products, packaging, and systems – from the very beginning on the understanding that waste does not exist” (McDonough & Braungart, 2010, pg. 104). While straightforward in intention, the concept of designing without wastes is a complex pursuit, and it requires designers to draw on 3.8 billion years of evolution to come up with strategies that effectively mimic natural processes. If successful, these strategies may become models for “farms that work like forests and prairies, buildings that accrue natural capital like trees, and waste water systems that work like natural wetlands” (Orr, D., 2002, pg. 22). These types of ecological design projects that mimic the processes of the non-human natural world are collectively known as Biomimicry (Benyus, J., 1999, pg. 7).

Advances in this type of ecological design can be found in the developing fields of green architecture, restoration ecology, ecological engineering, solar design, sustainable agriculture, industrial ecology, and ecological economics (Orr, D., 2002, pg. 185). Janine Benyus created an interdisciplinary design criterion for biomimicry projects based on the following characteristics of the non-human natural world: "Nature runs on sunlight. Nature uses only the energy it needs. Nature fits form to function. Nature recycles everything. Nature rewards cooperation. Nature banks on diversity. Nature demands local expertise. Nature curbs excesses from within. Nature taps the power of limits" (1999, pg. 7).

The idea of using nature as a model for the human built environment is by no means a new concept. Indigenous cultures around the world have developed a great diversity of ecological design strategies to adapt to specific environmental conditions (Orr, pg. 5). The development of these ecological design strategies requires "the collective intelligence of a community of people applied to particular problems in a particular place over a long period of time" (Orr, D., 2002, pg. 9). This is one of many reasons that ecological design cannot be incorporated into the rapid development that is customary of our current economic model. In the modern context, ecological design may serve as a way to reconcile people's relationships with the land they inhabit, and increase local resilience. In order to achieve this reconciliation, the ecological design process must build "connections between people, between people and the ecology of their places, and between people and their history" (Orr, D., 2002, pg. 180). If a community is successful in implementing these ecological design practices, it may become a model from which other communities may learn about land use, landscapes and human connections (Orr, D., 2002, pg. 32).

While minimizing the ecological footprint of the human built environment has direct and immediate benefits to ecological health, other aspects of the design process work in subtler ways. Wahl and Baxter describe these additional aspects of ecological design as the "meta design of our conscious awareness, value systems, world views, and aspirations" (2008). Applied through a holistic ecological lens, this meta design process has the potential to greatly improve local ecological health. For example, in Clayoquot Sound the long house constructed at the Hooksum Outdoor School in Hesquiaht Harbour, has played a central role in the personal and cultural development of many Nuu-chah-nulth and settler youth. The longhouse design is deeply rooted in traditional Nuu-chah-nulth culture, and it reinforces – in subtle ways – the cultural lessons offered within its split cedar plank walls and roof (personal communication, Steve Charleston, May 2015).

Among the greatest impacts of ecological design is the effect of the human built environment on mental well-being. Ahead of his time in many ways, renowned architect Christopher Alexander, believed that, "a person is so far formed by [their] surroundings, that [their] state of harmony depends entirely on [their] harmony with [their] surroundings" (1979, pg. 106). The supposed benefits of achieving "harmony" with one's surroundings has led many researchers to explore the relationship between proximity to nature and mental well-being (Dravigne et al., 2008; Lee & Maheswaran, 2011; Taylor et al., 2002). For example, Fuller et al. found that many measures of human well-being respond "positively to greenspace availability, including general health, degree of social interaction, mental fatigue, and opportunities for reflection" (2007). These findings are consistent with Sampson's topophilia hypothesis, and Wilson's earlier biophilia hypothesis– both of which describe an innate human affinity for the natural world. Nourishing this affinity for nature is the primary purpose of a budding branch of ecological design known as biophilic architecture, which integrates "nature or nature-like forms, elements or conditions into built environments" (Kahn & Hasback, 2012).

While many aspects of ecological design focus on ecological footprint and benefits to the end user, the means by which these ends are met is an important consideration. For example, Vannini and Taggarts' *theory of regenerative life skills* highlights "the capacity to create sustainably by improvising with the affordances of whatever materials are at hand" (Vannini and Taggart, 2014-A). This theory focuses on the use of place-specific knowledge in the design process, rather than place-altering power. This type of design, which is often exemplified by off-grid builders, is often discredited by the 'do it yourself' (DIY) expression. Vannini and Taggart deny this expression and instead claim that off-grid builders often employ the 'doing it with' (DIW) method, in which builders become social agents that are entangled with historic traditions, places, natural resources, and the availability of materials (Vannini and Taggart, 2014-A). Building in this manner has widespread potential for improving the ecological influence of human structures.

I was introduced to the 'doing it with' method of building when I moved to an off-grid boat-access property on a small Island off the west coast of British Columbia. After spending my young adult life in New York City, I had grown accustomed to having access to what I wanted when I wanted it: the antithesis of off-grid living. Instead I would have to make do with what was on hand, or wait for the weather to clear and make another trip to town. Whether it was plumbing, electrical, or carpentry, a project always began by identifying a design challenge and assessing which supplies were available to meet this challenge. My lack of experience in the trades meant that I was heavily dependent on my neighbors for their local expertise of off-grid west coast living. Many of my solutions – Teredo clam wood soffits, patch-work rain water collection systems, and not-to-code electrical connections were imperfect from an aesthetic perspective. However, many of them satisfied the ecological design criteria described earlier by Janine Benyus. In other words, they were practical solutions to real design challenges that were grounded in time and place.

Slowing the pace at which the human-built environment is designed and constructed is among the most challenging and crucial aspects of ecological design. David Orr reminds us that, "We will neither conserve biotic resources nor build a sustainable civilization that operates at our present velocity" (2002, pg. 50). The necessity of slowing development lies in the value of slow knowledge, which is essentially the outcome of extensive place based experiential learning. To the progress obsessed critic of slow knowledge David Orr argues convincingly, "Slow knowledge really isn't slow at all. It is knowledge acquired and applied as rapidly as humans can comprehend it and put it to consistently good use." As discussed in Part II, the notion of frantic development and obsession with progress – which is characteristic of our current free market economy – is based on the ecologically ungrounded premise of infinite growth. This concept of infinite growth has no place in ecological design, as, "The character of nature can't arise without the presence and consciousness of death" (Alexander, C., 1979, pg. 153).

This section on ecological design is not an altruistic call to action, solely for the sake of the environment. While all aspects of ecological design are ultimately intended to preserve ecological health, the preservation of ecological health is firmly embedded in human self-interest and survival. As David Orr explains, "The irony of our situation is that what appears from our present vantage point to be altruism will, in time, come to be seen as merely practical, farsighted self-interest" (Orr, D., 2002, pg. 219). This argument leaves room for advocates of ecological design to be optimistic, as continuation of the current ecological degradation trajectory will ultimately lead to mandatory widespread adoption of ecological design practices.

### Off-grid Energy

Here in Canada, there is a rich and diverse culture of individuals and communities that operate independently of the centralized electrical grid. Over 200,000 people live either independently, or in one of over 300 communities that are not connected to the national grid (Ranjitkar, 2006). Living off-grid has many apparent benefits and drawbacks. In this section I will draw on personal experience and academic research to analyze the overall effect that living off-grid has on people's perceptions of, and relationships with, energy. While living off grid does not necessarily equate to having a lower carbon footprint, it does lead to an increased awareness of the costs associated with energy production and consumption (Vannini and Taggart, 2013). Living off-grid also leads to increased awareness of the "cosmic and climatic rhythms of daylight and darkness," as well as wind, precipitation, and other environmental conditions. (Vannini and Taggart, 2013).

Living off-grid in Canada involves overcoming many logistical challenges. The scale of a dwelling or community's power demands has a large influence on the method of overcoming these challenges. The majority of individual off-grid homes use solar energy harnessed through photovoltaic panels to meet their energy needs (Vannini and Taggart, 2013). These systems generally store energy in a battery bank for use during nighttime and overcast days (Vannini and Taggart, 2013). Draining these batteries tends to shorten their lifespan, so energy is often conserved during times of low solar energy (Vannini and Taggart, 2013). Many of these systems also have backup gasoline or diesel generators, and inverters—which produce 120 V AC from a 12V, 24V, or 48V DC battery banks (Vannini and Taggart, 2013). In general, consumption of off-grid energy is highly responsive to changing environmental conditions that influence energy availability (Vannini and Taggart, 2013).

In contrast, energy consumption on the centralized grid occurs in a state of dissociation from the landscape that is altered for the purposes of energy production (Vannini and Taggart, 2013). Producing energy off-grid may also involve altering the landscape, but there is likely to be a higher awareness of that alteration. For example, cutting down an old growth red cedar tree on the south side of my home site created moral and social dilemmas in my life. I felt conflicted about ending the life of an organism that is approximately 300 years old, and I received criticism from community members with similar viewpoints. Despite this conflict, I decided that it was a necessary sacrifice in order to increase the solar photovoltaic collection potential on my roof, and increase direct solar energy potential for the garden. The tree also provided a valuable source of firewood to heat my home during winter months. My method was perhaps equally or more destructive than a large scale power plant that is tapped into the grid, but my awareness of the ecological consequences associated with my energy consumption is likely much higher than that of an on-grid energy consumer.

Being tapped into the grid influences energy consumers beyond just knowing where their energy comes from. The speed, light and power assemblages of modern on-grid living have contributed to what Vannini and Taggart refer to as 'time-space compression' (Vannini and Taggart, 2013). This phenomenon is the result of technologies that make most things available to us twenty-four hours a day, seven days a week (Vannini and Taggart, 2013). This increased availability through electrification has led to expansion of our daily activities long into the night, ultimately removing access to exterior darkness for much of our population (Vannini and Taggart, 2013). This decreased access to darkness makes it difficult to adapt to diurnal fluctuations in sunlight (Vannini and Taggart, 2013). The result is an increased level of dependence on chronological time (chronos) and a decreased level of dependence on opportunistic time (Kairos) for planning activities (Vannini and Taggart, 2013).

Kairos is an important component of what Vannini and Taggart refer to as 'slow living' (Vannini and Taggart, 2013). 'Slow living' is seen as a response to the dominant speed, light and power assemblages described earlier (Vannini and Taggart, 2013). Living off-grid necessitates adaptation of energy consumption in relation to diurnal and seasonal fluctuations. The extent to which this is true depends greatly on the scale and fuel source of the off-grid power generating system.

When I first inhabited my home on Vargas Island, B.C. in 2012, the electrical system consisted of a 100 Amp hour car battery hooked up to a 160-Watt solar panel, and a rusty gasoline generator that only ran with the choke fully open. The storage capacity of the battery was enough to keep a few 12 V lights on for 2-3 hours after dark. After that it was either a noisy intrusive generator, candlelight or bedtime. For a while I attempted to maintain my NYC influenced sleep schedule, running the rusty old generator full throttle late into the night. Eventually though, my sleeping patterns became synchronized with sunrise and sunset. This synchronicity is correlated to the production of melatonin, which is inhibited by light and enhanced by darkness (Selhub & Logan, 2012, pg. 90). This correlation directly influenced my sleep schedule diurnally and seasonally, as I slept much longer hours in the winter.

After a year of living with limited power generating capacity I installed a 1kW solar array, a 450 W wind turbine, a 5 kW gasoline generator, a 1000 Amp hour battery bank and a 4kW inverter. My sleeping patterns immediately fell out of synchronicity with the daylight hours, as keeping some lights on late into the night was well within the storage capacity of the battery bank. However, my energy consumption patterns remained largely in synchronicity with diurnal sunlight fluctuations. During the daytime I turned on the 120 V inverter, plugged in the fridge, ran power tools, and charged the computer. On Sunny days I did laundry because there was enough active solar energy to run the washing machine and enough passive solar energy to dry the clothes on the line. The windmill generated inconsistent power, and I rarely used the generator - certainly far less than I did with the smaller power supply system. In the end the upgraded power supply system allowed me to live a relatively modern lifestyle, that was more in tune with the natural boundaries of diurnal and seasonal solar and wind fluctuations.

Many of the behaviors exemplified by off-grid residents may be useful in mainstream society as we look to transition towards more sustainable energy practices. The benefits associated with off-grid power production could find practical application in the form of micro-grids in areas serviced by unreliable power distribution from the national grid. The B.C. Boston Bar micro grid was created as a response to regular power outages due to unreliable service from the National grid (Lidula and Rajapakse, 2011). The Boston Bar micro grid comprises of two 4.32 MVA run-of-the river hydropower generators (Lidula and Rajapakse, 2011). This is far from being a backyard independent micro-hydro project, but it does represent independent localized power for a small region. While the people in this area may not be deeply connected to the fluctuations in river flow rate, they at least have the opportunity to know where their power is coming from.

Many people in British Columbia believe that they are using 100% clean hydroelectricity. In reality, B.C. imports massive amounts of energy from financially cheap coal fired power plants in Alberta every night during times of low Alberta demand (Sopinka and Kooten, 2012). Because they are tied into the central electric grid, it is impossible for most B.C. residents to know whether the energy they consume in their homes at night is coming from coal fired power plants in Alberta. If this was the case and they were aware of it, it seems likely that at least some B.C. residents would make a conscious effort to reduce their energy consumption during nighttime hours.

Taken as a whole the energy consumption practices of people living off-grid are not necessarily any more sustainable than those living on-grid. I drive a 21′ aluminum speed boat with a 225 horsepower outboard engine to and from town to get groceries.

Many people, especially those that cannot afford expensive off-grid renewable energy systems, use gasoline generators as their primary power supply. This section is not intended to suggest that off-grid residents are somehow superior to people living on-grid. Rather, the point is that we as a society could learn from the relationship that people living off-grid have with the energy they consume. If we wish to become more efficient in our energy production and consumption, then we must abandon the practice of ignoring the cosmic and climatic fluctuations that influence energy availability. Adapting to these fluctuations may enable us to manage our energy resources in a manner that is less vulnerable to blackouts and energy insecurity. Making these adaptations will require our society to slow down from its current frantic, chronologically based pace. This is undoubtedly a tall task, but doing so may prove beneficial for reasons beyond the scope of energy production and consumption.

The more climatically and cosmically in tune energy consumption behavior described thus far has— for the most part— developed out of necessity. This begs the question; how can this energy consumption behavior be encouraged among citizens living on the grid- a demographic that accounts for the vast majority of energy consumption globally? Increasing on-grid energy users' awareness of their consumption patterns with user friendly metering devices is one potential way to promote more ecologically grounded consumption behavior. This might be particularly effective if users were able to see where their electricity was coming from at any given time. Users in B.C. may feel less inclined to waste electrical energy if they had immediate confirmation that it was being produced by coal fired power plants in Alberta. Place-based experiential learning provides another potential way to encourage on-grid users to use less energy, and to use it in accordance with seasonal and diurnal fluctuations in energy availability. Off-grid, interactive public education facilities designed to highlight energy production and storage components may provide visitors with a greater awareness of, and interest in, their energy production and consumption at home. Research is needed to determine whether experiencing an interactive off-grid facility like this would lead to more ecologically grounded energy consumption patterns among end users.

## Growing and Harvesting Food

The adapted energy consumption behaviors of people living off-grid also translates to consumption of food energy. When it comes to eating, people living off-grid tend to contrast the common emphasis of convenience (Vannini and Taggart, 2014-B). Instead emphasis is put on the importance of local, homemade, sustainably harvested and prepared foods (Vannini and Taggart, 2014-B). This practice reduces dependence on the current global industrial food distribution system (Vannini and Taggart, 2014-B). If implemented on a large scale these practices could diminish the overall spatial distribution of food, and reduce the associated energy consumption. Large-scale agricultural production with large spatial distribution is undoubtedly more financially efficient in the short term. This is evidenced by the fact that this is the dominant form of food production in our current free-market economy. While compelling, this logic relies on the assumption that financial efficiency is the ultimate goal.

Current population and consumption trajectories suggest that global food production must double by 2040, while simultaneously accommodating reduced degradation of land, water, biodiversity and climate (Groesbeck et al., 2014). This is undoubtedly a massive undertaking, but transitioning back towards more locally based food-economies may be part of the solution. Groesbeck et al. found that, "Autonomous economies have been found to, out of necessity, recognize ecological limits, and protect biological, cultural and social diversity" (2014). Scott Sampson offers a similar projection, stating that, "sustainable living will almost certainly be based locally … and most foods in sustainable societies will change on a seasonal basis" (Kahn & Hasbach, 2012, pg. 45). For anyone who has made a concerted effort to reduce their dependence on the centralized food distribution system, the importance of seasonality is unavoidable.

While the ecological influence of small-scale local food production and large-scale centralized food production vary greatly, there are benefits to both systems. On the one hand, the centralized food distribution system in North America provides abundant and cheap food in order to ensure food security for citizens. On the other hand, this same centralized system undercuts the livelihood of local farmers and makes ecologically sound agricultural practices uneconomical (David Waltner-Towes, 2004, pg. 10). Furthermore, the poor quality of the abundant cheap food supply is leading to nutrition deficiencies and diseases associated with obesity (David Waltner-Towes, 2004, pg. 10). Perhaps the biggest discrepancy in the centralized food distribution system in North America is the failure to factor ecological costs into the cost-benefit analysis. Food inputs such as fertilizers, pesticides and food miles put a substantial strain on ecological health (Hale et al., 2011).

The natural world is filled with alternative models for food production and distribution. As McDonough & Braungart explain, "humans are the only species that takes from the soil vast quantities of nutrients needed for biological processes but rarely puts them back in a usable form" (2010, pg. 98). In addition to soil degradation, large scale monocrop agriculture fails to acknowledge the crucial role that biodiversity plays in maintaining healthy productive plant communities. Without biodiversity present to ensure resilience, the large scale at which these operations take place means that they are highly vulnerable to plant and animal epidemics (Walner-Towes, D., 2004, pg. 77).

Like most ecological issues, food security has been a driving factor in human evolution since time immemorial (Groebeck et al., 2014). Unlike modern industrial agriculture systems, many indigenous cultures around the world have developed food production, harvesting, and management systems that are highly responsive to environmental conditions and species abundance (Berkes, F., 2012, pg. 166; Groesbeck et al., 2014). Disciplines that incorporate traditional ecological knowledge (TEK) such as ethnobotany and ethnoecology are gaining traction as the necessity of considering ecological health in the design of food systems becomes increasingly clear. One particularly successful adaptive food management strategy lies in the governance of ancient clam gardens by coastal communities of the pacific northwest (Groesbeck et al., 2014). Experimental and anthropological evidence suggests that Indigenous peoples of the Pacific Northwest were able to substantially increase productivity in clam gardens by simply manipulating shoreline slope with hand-made rock walls (Groesbeck et al., 2014). This type of adaptive management strategy required extensive local ecological knowledge, and provides a potential model for developing modern adaptive ecosystem management strategies in the future (Groesbeck et al., 2014).

Biomimicry is well situated to translate TEK of food production and harvesting into modern agricultural practices. Agricultural systems can function like mature natural ecosystems if gardeners plant human foods in the same pattern as natural plant communities (Benyus, J., 1997, pg. 13). Agronomists tested this logic by taking a plot of land in the jungle and gradually replacing the jungle plants with human food crops that shared similar characteristics (herbaceous perennial, tree, vine etc.) (Benyus, 1997, pg. 40). They ended up with a highly productive and resilient food forest (Benyus, 1997, pg. 40). In addition to plant community structure, ecologically designed agricultural systems should be based on local climate, soil type, and culture (Benyus, 1997, pg. 36). Designing systems at the local scale that incorporate all of these aspects will enable gardeners and farmers to create resilient food systems that are highly adaptable to changing environmental conditions.

While producing a healthy, abundant, resilient food source is the primary focus of ecologically designed gardens, research shows that gardening is also among the most beneficial recreational activities for mental and physical well-being (Selhub & Alan, 2012, pg. 151). In 1918 the positive effects of gardening led the U.S. military to develop gardening programs as a treatment regime for soldiers with shell shock (post-traumatic stress disorder) (Selhub & Alan, 2012, pg. 153). While the program eventually folded, gardening continues to serve as an effective tool for occupational therapists (Selhub & Logan, 2012, pg. 153). Preliminary research suggests that contact with soil during gardening allows beneficial bacteria to enter the body, which may explain some of the benefits that gardening has for mental and physical health (Selhub & Logan, 2012, pg. 162). Gardeners also express a greater affinity and concern for the natural world (Selhub

& Logan, 2012, pg. 154). These findings suggest that gardening may be a powerful experiential learning tool for inspiring ecologically grounded perspectives.

While there is high experiential learning potential in gardening, the intention of the gardener and the way in which they engage with the activity will influence the extent to which they learn. Dating back to the 18th century, school gardens represent one long standing attempt to deliberately embrace the experiential learning potential of gardening (Snodgrass, A., 2012). Research shows that school gardens ground children in a wide variety of natural processes, including growth and decay, predator-prey relations, pollination, carbon cycles, soil morphology, and microbial life (Blair, D., 2009). In order to improve productivity, gardeners must learn to anticipate and react to the spatial and temporal functions of the biophysical systems in the garden—an exercise that is sure to increase local ecological knowledge (Hale et al., 2011).

In conclusion, the simple act of growing and harvesting food at the local scale has great potential to improve many aspects of ecological health, including reduced environmental degradation from agriculture, improved consumer health, improved producer health, and increased local ecological knowledge.

## Water Collection and Reclamation

Water is an essential ingredient for life on earth, and therefore it has great potential to illuminate our dependence on the ecological processes that make it available to us. Humans have developed a wide range of strategies for securing safe drinking water, including direct collection from rivers and lakes, tapping in to fresh water springs, digging wells to access ground water, and collecting rainwater. Humans have also developed a wide range of technologies that threaten to contaminate clean drinking water and the lives that rely on it. Nearly 80% of human beings are at direct risk of water insecurity– a threat that is strongly correlated with poverty (Vörösmarty et al., 2010). Despite adequate supply volume in most cases, water insecurity is largely caused by unsustainable agricultural practices, pollution, floods, erosion, sewage overflows, physical disruption of rivers, and climate change (Novak et al., 2014, pg. 8). Given the severity of this threat, it is paramount that we fully understand our dependence on clean water and the measures we can take to protect it as a resource for future generations.

In the face of widespread freshwater shortages wealthy nations have devised many technocratic solutions to treat the symptoms rather than the causes of water insecurity (Vörösmarty et al., 2010). In the U.S. where large populations have inhabited arid regions that lack the ecological goods and services required to sustain them, people import natural resources from elsewhere (Novak et al., 2014, pg. 36). While end-of-pipe solution like this have worked relatively well to ensure water security for wealthy nations, the application of these technologies in developing nations has been extremely limited (Zhang et al., 2009). contributing to the socioeconomic disparity of fresh water access is the fact that many of these technocratic solutions, such as dams and desalination plants, further threaten existing fresh water resources (Ryan et al., 2009).

Many expensive technocratic solutions to water insecurity in developing nations have negative effects on biodiversity (Vörösmarty et al., 2010). Fresh water reservoirs are one example of a technocratic solution that poses little *short term* threat to human water supply, while substantially impacting "aquatic biodiversity by impeding the movement of organisms, changing flow regimes and altering habitat" (Vörösmarty et al., 2010). We do not yet have adequate knowledge of the hydrological cycles on earth to understand the full consequences of ecologically destructive actions we are currently taking. We do know that 46% of rivers and lakes in the U.S. are "too polluted to support fishing, swimming, or aquatic life" (Novak et al., 2014, pg. 3). Much of the *short term* contamination of human water supply occurs in high density areas where pollution occurs in higher concentrations. However, even in relatively pristine remote areas, trans-boundary atmospheric pollution infiltrates fresh water drinking supplies through rainwater (Vörösmarty et al., 2010). Despite the obvious drawbacks to this reality there is a silver lining: the massive scope of this dilemma means that shifting the burden elsewhere – usually to a lower socioeconomic bracket—has become prohibitively difficult.

Among the most serious threats to existing fresh water supplies is the sheer quantity of fresh water that is wasted on a daily basis. The average American directly uses 80 to 100 gallons of water each day (Novak et al., 2014, pg. 3). In contrast, my house is entirely dependent on a single 500-gallon rainwater collection cistern that provides ample water for 2 people for up to 2 weeks with no rain, which is a rarity on the west coast of Vancouver Island. This works out to approximately 18 gallons per day. While the average direct consumption of Americans is needlessly high at 80 to 100 gallons, the average American lifestyle requires over 1,400 gallons of water each day (Novak et al., pg. 3). Of this 70 percent goes to irrigated agriculture (Novak et al., 2014, pg. 3). Power plants are the second highest consumer of water in the U.S. at 136 billion gallons a day, more than three times that of residential, commercial, and all other industrial uses combined (Novak et al., 2014, pg. 3).

Water and energy are interdependent resources; vast amounts of water are used for hydroelectric power generation and thermoelectric power plant cooling, while massive amounts of electricity are used to run pumps that distribute water wherever it is needed (Novak et al., 2014, pg. 21). This interdependence highlights the ecological inefficiencies that are inherent in centralized distribution of electricity, and water. One can, of course, make the argument that centralized distribution systems are more economically efficient, but economic efficiency does not, and cannot, account for the full ecological cost of a centralized distribution system. However, there is reason to be optimistic; by collecting and using water and electricity directly at the source, the ecological inefficiencies of the aforementioned system may be resolved.

The 2009 United Nations millennium development goals list rainwater harvesting, "as a technology that can help alleviate numerous problems for drinking water in developing countries" (Novak et al., 2014, pg. 25). Research suggests that the benefits of rainwater harvesting could also alleviate numerous problems in developed countries, as "demand on water catchments can be substantially decreased when a large proportion of household's reuse greywater and/or install rainwater tanks" (Ryan et al., 2009). The benefits of rainwater collection and reclamation appear to be compounding, as a study shows that "participants who irrigated the garden with greywater were more likely to judge various other water collection and recycling proposals as being appropriate" (Ryan et al., 2009). While rainwater collection may seem like a fringe initiative to some, there are many examples in which decentralized rainwater collection tanks are plumbed into the municipal water supply (Novak et al., 2014, pg. 35). This arrangement represents a paradigm shift from passive consumption of centralized fresh water supply to active harvesting, reclamation and consumption of locally sourced fresh water. (Novak et al., 2014, pg. 35). This paradigm shift presents a design challenge in which managers must find a way to transition from a system that is based on a net loss of fresh water to a system that "allows humans to participate in the continuation of the hydrologic system" (Novak et al., 2014, pg. 3).

Rain water is "the first form of water that we know in the hydrological cycle," which means that it is a primary source of fresh water (Novak et al., 2014, pg.1). Harvesting and using this primary source of water where it falls means to understand the true value of rain (Novak et al., 2014, pg. 1). Decentralized water collection allows individuals to develop a more intimate connection to their local climate as well as the built environment (Novak et al., 2014, pg. 26). This intimate connection is beneficial for a number of reasons once established, but implementing rainwater catchment systems in the first place can be challenging in some regions due to common misconceptions about rainwater being unfit for human consumption (Novak et al., 2014, pg. 35). While rainwater is most often safe to drink, these concerns are justified in some cases, as excessive air pollution can cause rainwater to become unsafe (Zhang et al., 2009). This may seem discouraging, but it presents another opportunity for widespread improvement of ecological health. If decentralized water collection systems became the norm rather than the fringe, then we will become much more immediately dependent on air quality. This, in turn, would be create a far greater incentive to improve air quality, which has far reaching implications for ecological health.

Rainwater conservation and reclamation practices have the potential to become a cultural bridge, as water "is a basic element that supports life in every culture in this world" (Novak et al., 2014, pg. 44). When it comes to promoting these practices, "providing individuals with specific skills about how to save the liquid is a "necessary and important step" in inspiring a more ecologically grounded relationship to water (Corral-Verdugo et al., 2003). Research by Corral-Verdugo et al. found that individuals who believe they are separate from the natural world are more likely to believe that water is an unlimited resource to be used by humans without restriction (2003). Based on this correlation between environmental beliefs and water use, Corral-Verdugo et al. suggest that "promoting a change in worldviews…could be one strategy in encouraging water conservation" (2003). Alternatively, based on the correlation between environmental beliefs and water use – facilitating a more intimate connection between a person and their water source may lead to more ecologically grounded environmental beliefs. More research is needed to determine whether this is a causal relationship.

# Part IV— Cedar Coast Field Station: A Space for Ecological Research and Education

## Vision

The Cedar Coast Field Station (CCFS) is an independent, not-for-profit, organization dedicated to ecologically grounded research and education in Clayoquot

Sound. The Station will provide researchers, educators, and students with resources to learn from the ecology of Clayoquot Sound in a nature-based setting. By working with a diverse set of partnering organizations and individuals, CCFS will become an interdisciplinary learning environment that is collaborative in nature and widely accessible.

Edward O. Wilson describes our "innate tendency to focus on life and lifelike processes" as biophilia (1984). The field station aims to encourage this affinity for nature in each person that visits, regardless of their reason for visiting. While much of the research and education that takes place will be directly related to ecological studies, the station doors will be open to a broad spectrum of disciplines so that a more diverse demographic might enjoy the benefits of place-based learning in Clayoquot Sound. By weaving a thread of ecological education through each program offered, the station aims to create a cohesive, multidisciplinary learning environment that is widely accessible.

The Station's facilities will be grounded in the principles of ecological design; working within nature's flows and cycles to optimize self-sufficiency and sustainability, while creating a positive interface between humans and the rest of the natural world. Transportation systems, accommodations, classrooms, research facilities, energy harnessing systems, food production and harvesting systems, rainwater collection and reclamation systems, waste treatment facilities, and recreational facilities will all be designed in pursuit of the Station's mission: **to preserve ecological health through place-based research and education that celebrates the cultural and biological diversity of Clayoquot Sound.**

## WHAT IS AN ECOLOGICAL FIELD STATION?

The Organization of Biological Field Stations (OBFS) define field stations and marine laboratories (FSML) as "facilities or institutions that facilitate a significant amount of research (1) with a geographic focus… (2) on environmental processes… (3) by multiple research groups, over sustained periods of time" (Billick et al., 2013). The mission of the Cedar Coast Field Station (CCFS) places it within the context of FSML. In contrast to some FSML, education is a central focus of CCFS. Furthermore, CCFS places a much greater emphasis on incorporating local and traditional ecological knowledge (LTEK) in the design, operation, and interpretation of ecological research and education projects than many other FSML (BMSC, 2017; Hakai Institute, 2017). Taking a more holistic approach (including humans) to ecological research and education is the primary reason behind referring to CCFS as an ecological, rather than a biological, field station.

The OBFS report—based on a survey of 200 FSML — suggests that CCFS is not unique in its emphasis on local knowledge: "While it is often logistical considerations that attract scientists to a new facility, eventually sites develop a body of knowledge that becomes a powerful platform for supporting additional research" (Billick et al., 2013). Clayoquot Sound already has an extensive body of knowledge relating to the local ecosystems, which makes it a powerful platform for conducting ecological research and monitoring programs (Atleo, R., 2007, pg. 134). Embracing local and scientific ecological knowledge systems to inform research and education practices will be a central focus of the CCFS. Embracing diverse knowledge systems may help overcome a common FSML challenge, which is "attracting students who represent the nation's diversity" (Billick et al., 2012)

According to the OBFS, "Handling long-term monitoring…is perhaps one of the most scientifically valuable functions FSMLs can provide" (Billick et al., 2013). A Director and/or staff will be present at the CCFS 12 months/year, which will enable long-term collection of year round ecological data. CCFS will make an effort to collaborate with other nearby field stations to investigate large scale, complicated field studies that require broad spatiotemporal data collection. CCFS is also well suited to work with a diversity of scientists from various institutions because it is structured as an independent charitable not-for-profit society (Billick et al., 2013).

The Cedar Coast Field Station is just one of many organizations facilitating ecological research and education in the Pacific Northwest, as well as here in Clayoquot Sound (see Appendix C). In 1972 Bamfield Marine Sciences Centre was established by five Western Canadian Universities, "in order to provide a permanent base for marine and coastal-oriented field operations on the west coast of Canada" (BMSC, 2017). More recently, the Hakai Institute has established itself as a prominent scientific research institution, "that conducts long-term research at remote locations on the coastal margin of British Columbia, Canada" (Hakai Institute, 2017). Sitka Centre for Art and Ecology on the Oregon coast offers a more creative approach to ecological education: "By helping others discover more about their core creative selves and their connections to nature, the Sitka Center works to fulfill its mission of expanding the relationships between art, nature and humanity."

Each of these organizations, along with the many organizations working locally in Clayoquot Sound, play an integral role in preserving ecological health. By working with these and other organizations, CCFS will work to promote synergy within the fields of ecological research and education.

## LOCATION

The Cedar Coast Field Station is situated on a 45 acre, waterfront property on the southeast shoreline of Vargas Island, British Columbia. The site is located approximately 5 kilometers northwest of Tofino, and is bordered by mixed rocky and gravel beach shoreline to the east, private forested lands to the north and south, and the Vargas Island Provincial Park to the west. A sheltered gravel beach provides easy and safe entry and exit for swimming, snorkeling, diving, kayaking, and paddle boarding excursions. The site contains a mix of new and old growth forest (predominantly Western red cedar (Thuja plicata), Sitka spruce (*Picea sitchensis*), and Western hemlock (*Tsuga heterophylla*)). The dense underbrush consists primarily of Salal (*Gaultheria shallon*), Salmon berry (*Rubus spectabilis*), Evergreen huckleberry (*Vaccinium ovatum*), and Deer fern (*Blechnum spicant*). This site provides a fine balance of remoteness and accessibility. It is far enough away from Tofino to avoid much of the town's noise and light pollution, while close enough for guests to access Tofino's many goods and services via a 10-minute boat ride in most weather conditions.

## FIELD SITES

Surrounding the Cedar Coast Field Station is a number of biologically and culturally rich field sites. The field station is located directly adjacent to the 5,788 hectare Vargas Island Provincial Park, which encompasses much of the Island's west coast (B.C. Parks, 2015). Rich intertidal shoreline, old growth Sitka spruce *(Pichea sitchensis)* stands, ancient bog forests, white sand beaches, eel grass beds, mud flats, rockfish conservation areas, and kelp forests all offer important habitat to the diversity of flora and fauna that surround the Station. Vancouver Island coastal grey wolves (*Canis lupus crassodon*), Grey Whales (*Eschrichtius robustus*), Humpback whales (*Megaptera novaeangliae*), Orca whales (*Orcinus orca*), Sea Otters (*Enhydra lutris*), Pinnepeds, and Bald eagles (Haliaeetus leucocephalus) are among the wealth of fauna that frequent the field sites around the CCFS (B.C. Parks, 2015). The field sites listed below represent a fraction of those that are in close proximity to the Field Station. Access to all field sites is subject to approval from the local Ahousaht First Nation.


Figure 1. Numbers 1-10 represent field sites near CCFS—corresponding descriptions below.

**1. Vargas Sitka Spruce Stand:** The field station is surrounded by a mix of new growth (30-50 years) and a number of small old growth Western red cedar (*Thuja Plicata)* and Sitka Spruce *(Pichea sitchensis)* stands. 0.5 km south of the Station is a large intact stand of old growth forest, consisting primarily of Sitka Spruce and Western red cedar. 0.25 km north of the large old growth stand is a property that has been heavily logged, with various stages of regrowth. These sites provide a valuable opportunity for studying the forest ecosystem at all stages of growth, disturbance, and recovery.

**2. Vargas Bog Forest:** The historic telegraph trail runs 3 km from the field station to Ahous Bay. The middle section of the trail navigates a bog forest, where high PH levels in the soil result in severely stunted growth of shore pines (*Pinus contorta)*. This ecosystem supports a number of rare and endangered plant species including blue listed sand-dune sedge (*Carex pansa*), Tracy's romanzoffia (*Romanzoffia tracyi*), and California wax myrtle (*Myrica californica*). A bird's eye view of this area exposes a gradual succession of ancient sand berms that follow the curve of the Ahous bay shoreline; evidence of Vargas Island's gradually increasing elevation driven by plate tectonics (B.C. Parks, 2015).

**3. Ahous Bay:** Ahous Bay is located in the Vargas Island provincial park, which consists of 5,788 hectares of rocky shoreline, sandy beaches, forests, bogs, fresh water streams, intertidal lagoons, and bays (B.C. parks, 2015). Ahous Bay provides valuable habitat to a variety of shore bird, fish, and marine mammal species, including Eastern Pacific gray whales (*Eschrichtitis robzrstus*), which frequent the bay in the summertime to feed on a combination of benthic and epibenthic prey (Darling et al., 1998). Much of Ahous Bay is designated as a B.C. Provincial Park, while the south side of the bay contains a reserve belonging to the Ahousaht First Nation. B.C. Parks and Ahousaht First Nation are currently renegotiating management practices in the park (T. Atleo, personal communication, September 20th, 2016).

**4. Ahous Lagoon:** Approximately 4 km from the field station, an intertidal lagoon penetrates the white sand beach in Ahous bay. Two fresh water streams covered in dense forest canopy feed the salt-water lagoon. In the summer months the lagoon provides habitat to thousands of juvenile Dungeness crab (*Cancer magister*) (Darling, 1998). In early fall Coho salmon (*Oncorhynchus kitsch*) pass through the lagoon to spawn in the freshwater streams, (B.C. Parks, 2015).

**5. Cleland Island:** In 1971 Cleland Island became the first ecological reserve in British Columbia (B.C. Parks, 2015). Situated within the Vargas Island Provincial Park, Cleland Island serves as a rookery for a number of sea birds including the Rhinoceros auklet (*Cerorhinca monocerata*), Cassin's auklet (*Ptychoramphus aleuticus*), Pigeon guillemot (*Cepphus columba*) and the black oystercatcher (*Haematopus bachmani)*. Cleland Island is approximately 20 minutes away from the field station by boat.

**6. Vargas Sand Dunes:** This active dune system on the west coast of Vargas Island is accessible by a 6.5-km trail from the field station. The trail passes through a variety of ecological zones including bog forest, old growth Sitka spruce forest, white sand beach, and rocky shoreline. The sand Dunes are also accessible by boat, with a combined 20-minute boat ride and a 10-minute walk.

**7. Mud Bay:** The mud flats in and around Mud Bay are located approximately 1.75 km from the field station, and can be accessed by walking or by boat. Eelgrass beds, invertebrates, bivalves, juvenile fish, and shorebirds are among the rich diversity of organisms that inhabit this mud flat ecosystem.

**8. Elbow Bank:** The expansive eelgrass (*Zostera marina)* meadows at Elbow Bank are located approximately 5 km NE of the field station (10 minutes by boat). The eelgrass meadows provide important habitat for a rich diversity of fauna, including a variety of juvenile rockfish (*Sebastes sp.).* Directly adjacent to Elbow bank is a rockfish conservation area that provides protected habitat for adult rockfish after they leave the nursery meadows.

**9. Keltsmaht village site:** Approximately 0.75 km north of the field station is the First Nations village of Keltsmaht. The Keltsmaht once inhabited this site year round, but a combination of pre-European contact pressures resulted in their amalgamation into the Ahousaht First Nation. Currently, The Ahousaht First Nation uses this site as a summer village site (T. Atleo, personal communication, September 20th, 2016).

**10. Ahousaht village site:** Ahousaht can be loosely translated as people of Ahous, referring to a village site that the Ahousaht once inhabited on the south side of Ahous Bay. Located 4 km from the field station, this village site is now used by the Ahousaht as a summer village site (T. Atleo, personal communication, September 20th, 2016).

## LOCAL WEATHER

**Sunlight**: On average, 271.7 days per year have measurable "bright sunshine." 158 of these "bright sunshine" days occurred in the six months from April to September. Annually, 35.7% of possible daylight hours have measurable "bright sunshine," with the 6 months of April to September averaging 44.1% and the 6 months from October to

March averaging 33.27%. The shortest day of the year is December 21st, with 8 hours 12 minutes of daylight, and the longest day of the year is June 20th, with 16 hours 13 minutes of daylight (Environment Canada, 2017).

**Precipitation**: The average annual rainfall is 3098 mm, with 2276 mm falling between the months of October and March. Rainfall is spread out across the year with >0.2mm of rain on an average of 216 days a year, and >5mm of rain on an average of 130 days a year. Snowfall is minimal with an average annual snowfall of 16cm. Of the days with precipitation, heavy rain is the most severe precipitation on 7% of days, moderate rain is the most severe precipitation on 27% of days, light rain is the most severe precipitation on 48% of days, and drizzle is the most severe precipitation on 10% of days. (Environment Canada, 2017; Weatherspark, 2016).

**Temperature**: Annual daily average temperature is 9.5˚C, with a high of 13.2˚C and a low of 5.7˚C. The warmest average month is August at 15.0˚C and the coldest month on average is December at 5.0˚C (Environment Canada, 2017).

**Wind**: Wind directions vary considerably throughout the year. In the six months from April to October the predominant wind directions are South, West and Northwest. In the six months from October to March the predominant wind directions are South, Southeast and East. Maximum hourly speeds at Lennard Island (7km south of CCFS) between 1981 and 2010 ranged from 76 km/h to 87 km/h in the months November to April, and 58 km/h to 72 km/h in the months May to October. This maximum wind speeds indicate worst case scenario in regards to field station access and potential damage to facilities (Environment Canada, 2017; Weatherspark, 2016).

# FACILITIES

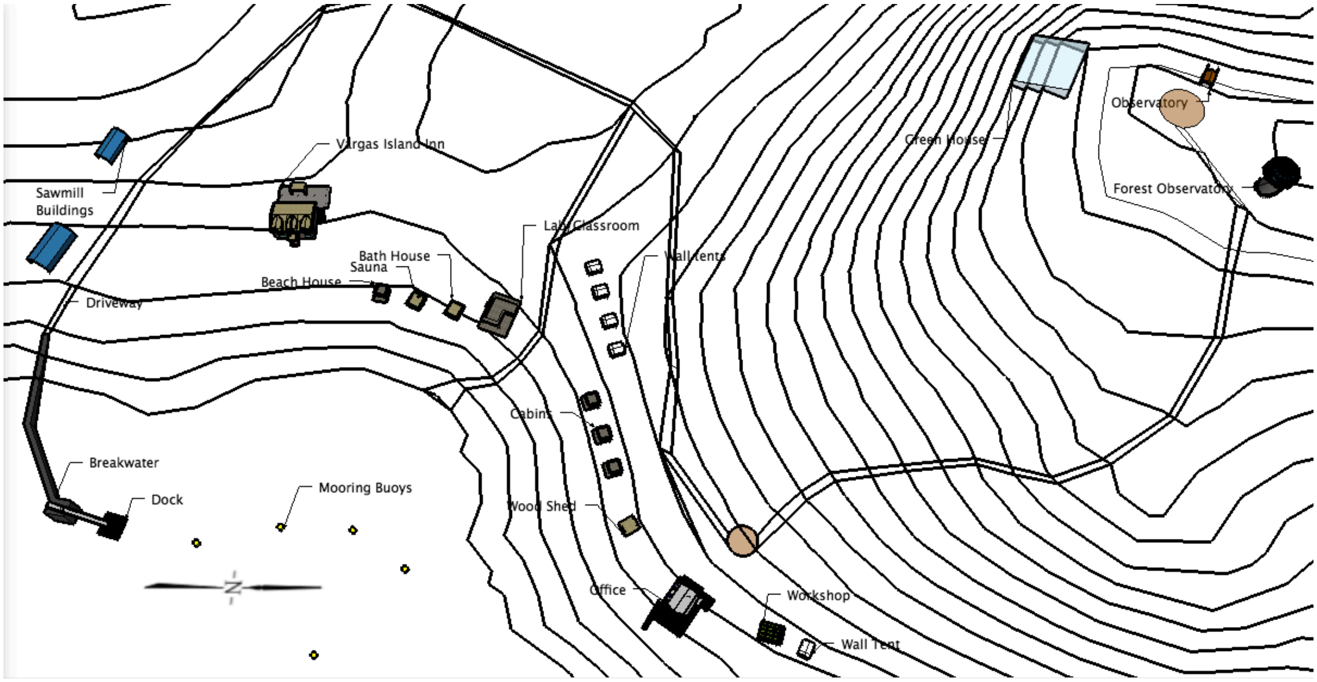


Figure 1. Birds eye view of Cedar Coast Field Station including existing and planned construction. Detailed images are included in Appendix B.

In 1934, Aldo Leopold made the following prophetic statement about the future of educational facilities: “If civilization consists of cooperation with plants, animals, soil, and men, then a university which attempts to define that cooperation must have, for the use of its faculty and students, places which show what the land was, what it is, and what it ought to be” (Meine & Knight, 1999). Providing visitors with a sense of the past, present, and future states of the ecological systems of Clayoquot Sound is a central focus of the development plan at the CCFS. Infrastructure and facilities will be designed as much as possible to work within the flows and cycles of nature in order to create a positive interface between visitors and the surrounding ecosystem. A report by the Organization of Biological Field Stations (OBSF) emphasizes the influence of facility design, stating that, "there is a growing appreciation that the architectural and social contexts of a scientific institutions can have a significant impact on scientific productivity" (Billick et al., 2013). The station's development process will occur in multiple stages, allowing ample flexibility to adapt to changing circumstances. Below is a description of the station and its facilities, as they are planned for the final stage of development.

## Learning Spaces

**Multi-purpose room (current):** The main lodge building contains a large communal space that serves as a multi-purpose room for group discussions, presentations, and live arts performances. The multi-purpose room will be equipped with a ceiling mounted projector and seating for up to 30 people.

**Lab/Classroom (current):** A 600 square foot beachfront cabin currently serves as the classroom and lab the CCFS. The classroom will be equipped with a large seminar style table designed for classroom sessions with up to 20 people. The classroom will also be equipped with a table mounted projector, and a large covered deck for outdoor classroom sessions. The back room of the cabin will serve as a basic life sciences lab.

**Workshop (Current):** A large metal/woodworking shop serves two primary purposes: First, it provides a well-equipped workshop for maintenance and development of the station's various facilities and systems. Second, it serves as a workshop for students and researchers working on various projects. By providing access to a well-equipped workshop, we will encourage students and researchers to involve themselves in further refining the Station's everyday operations, as well as come up with innovative solutions for their own research projects.

**Potting/Glass blowing shed (future):** Beside the main studio/classroom space there will be a small pottery and glass blowing studio. The studio will be made available to all guests wishing to pursue the arts of pottery and glass blowing. The studio will also produce much of the ceramics and glassware for the station, in an effort to highlight the processes involved in sustaining our lifestyles.

**Forest observatory (future):** The highest point on the southeast side of Vargas Island is an old growth Western red cedar (*Thuja plicata)* forest that lies in the middle of the field station's property. A covered observatory platform built amongst the forest canopy will allow for up close observation of the otherwise difficult to access canopy flora and fauna. The observatory will also provide a view of Father Charles channel and the Vancouver Island Mountain Ranges to the east, and Ahous Bay and the open Pacific Ocean to the west.

**Astrology observatory (future):** Positioned on the western sloping aspect of the property – to gain shelter from the subtle light pollution from Tofino—will be a small building with a powerful telescope built into the bedrock. The building will resemble a log cabin, with the exception of a roof that slides along an I-beam track to expose the night's sky. The telescope will be available to researchers, educators, and students in an effort to situate local ecology within a much broader cosmic context.

**Common Grounds:** While the field sites, multi-purpose room, classroom and workshop will be designated learning spaces, all of the station's infrastructure and facilities will be designed in a way that is interactive and user friendly. This will be done in an effort to engage visitors with the everyday operation of the station, and provide them with an understanding of how the station's infrastructure interacts with the surrounding ecosystem. Food production (gardens), solar energy harnessing, rainwater catchment and waste disposal systems will all provide an opportunity for visitors to better understand their impact and dependence on ecological health.

**Gardens:** Food, floral, and medicinal gardens will play an important role in the everyday operation of the field station. Due to the highly acidic local soil, gardens will rely on a mixture of sand and seaweed to create productive gardening soil. This method has been shown to be highly effective by the field station's neighbors. Greenhouses will be utilized year-round to grow crops that require warmer temperatures than are generally experienced in Clayoquot Sound. Native species will be given preference, and wherever possible they will be grown in place of more conventional imported crops. For each imported crop that is grown, special care will be taken to study its potential impact on the ecosystem. Imported crops will be concentrated in the middle of the gardens, while native species will provide a gradual transition from our cultivated gardens into the surrounding environment. In addition to the native flora, abundant local seafood, such as crab, mussels, clams and fish, will provide valuable protein for the station's daily food menu.

**Apiary (future):** The station will keep a small apiary that provides honey, beeswax, and bee pollen to the stations staff and visitors. The apiary will also provide ample pollination for the stations gardens, and a valuable educational opportunity for visitors.

**Cooking (current):** A large industrial kitchen in the main lodge will be equipped to provide food for all of the station's occupants. This kitchen will be made accessible to groups wishing to cook their own meals. Alternatively, station coordinators will offer catering services for specific programs and groups. The kitchen appliances will run primarily off of solar electric energy, with a propane stove for cooking.

**Dining (future):** The main dining hall will have one long dining table designed to seat up to 30 guests. The large communal table will provide an opportunity for researchers, education groups and station staff to get to know one another in a casual setting. In particular, this will be a unique opportunity for young students to speak with researchers that are working in their area of interest. A recent report filed by the Organization of Biological Field stations supports the concept of communal areas with the following statement: "given that one of the valuable features of a research station is the highly interactive and collaborative environment… [field stations and marine laboratories] should provide facilities that support informal and serendipitous exchanges of information (Billick et al. 2013).

**Water Collection:** Using the rainwater calculation formula: SUPPLY = A × P × C × 0.623— where supply = volume of available water (gal), P = annual precipitation (in), A = collection surface area ($ft^2$) C = runoff coefficient (efficiency)—and based of the CCFS roof catchment area of 2500 $ft^2$, a catchment efficiency of 75%, and precipitation of 3000 ml annually, the CCFS will be able to collect approximately 138, 000 Gallons annually (Novak et al., 2014, pg. 83). This works out to approximately 378 Gallons per day, which, with an average occupancy of 20 people provides each person with 19 gallons per day to cover all bathing, cooking and cleaning needs. This water supply is much lower than the average of 80-100 gallons consumed daily by the average American, and will require a drastic decrease in water consumption for some visitors. Toilets will be composting, which will greatly decrease water consumption. There is also a well on-site that provides ample non-potable water for gardening purposes.

**Energy Production and consumption**

Solar energy will be the primary source of electric and heat energy in the research and education seasons (spring through fall). Solar electric panels will provide ample electric energy for all of the station's lights, appliances, lab equipment, and guest equipment (laptops etc.). Solar hot water heating coils will provide hot water in summer months, while heating coils in the wood stoves will supply hot water in the colder winter months. New buildings will be well insulated with south facing windows to utilize passive solar energy. Wood stoves will provide supplementary heating in the winter months when solar input is low. Carbon emissions from wood burning will be partially or fully offset by the station's 45 acres of managed forest land. While the station will be well equipped to keep up with the energy needs of its facilities, guests will be made aware of their energy consumption and encouraged to conserve energy wherever possible.

The average commercial/Industrial building on the Pacific coast uses approximately 1 GJ/$m^2$ every year (Natural Resources Canada, 2009). Based on a CCFS's current indoor square footage of approximately 372 $m^2$, this means the station would need to produce 372 GJ's, or 103, 333 kWh annually to keep up with the stations energy needs. The average PV solar collection potential for a 1 kW panel in B.C. is 1200 kWh/year meaning that powering the station completely with solar power would require an 86 kW PV solar electric system (B.C. Hydro, 2017). Based on wholesale pricing the panels alone for this system would cost approximately $30, 000 (Solar

Wholesaler, 2017). This system would also require a batter bank with approximately 3,000 Ah of storage which would cost approximately $7000 (We go solar, 2017). However, much of this estimated 372 CJ of energy will be supplied in the form of wood heat in the winter months, which will greatly reduce the size and cost of the electrical system required to power the station. Also, visitors to CCFS will be encourage to monitor their energy consumption in order to stay within the stations energy production capacity. CCFS also has a 5 kW gasoline generator for backup power.

## Accommodation

The station will provide a variety of accommodations in order to attract a broad demographic of visitors.

**Tent platforms (current):** Tent platforms will provide private, quiet and affordable accommodation for self-sufficient visitors wishing to increase their sense of connection to the natural environment surrounding the station. Tent platform occupants will have full access to all of the station's communal facilities, including cooking and dining facilities, washing facilities, hot showers, toilets, and communal living spaces.

**Wall tents (future):** Wall tents will provide a comfortable and convenient living space, while providing a more intimate sense of connection to the sights, sounds, and smells of the surrounding environment. Each wall tent will be equipped with wood decking, wood stove, table and chairs, dresser and some combination of queen, single, and bunk beds. Wall tents will provide accommodation from early spring through late fall. Occupants will have full access to all of the station's communal facilities.

**Cabins (future):** Visitors wanting a more self-sufficient living and working space may opt to stay in one of our private cabins. Cabins will range from 8'x10' single rooms with a bed and desk, to fully furnished units with private kitchen and bath. Cabin occupants will also have the option of using the station's communal facilities. The cabins will be well equipped for year round occupancy.

**Main lodge (current):** The main lodge has 6 small dormitory style rooms, and sleeps up to 20 guests. These rooms are furnished with a variety of single, double, and bunk beds. Occupants of these rooms will have full access to all of the station's communal facilities. The lodge is also equipped with a large shower house for use by all of the stations guests and residents.

## TRANSPORTATION

**Mooring facilities:** Research vessels currently tie up to a series of mooring buoys directly in front of the field station. CCFS will provide visitors wishing to bring their own boats with additional mooring buoys for the duration of their stay. The station will also offer round trip water taxi service from Tofino, priced at $40.00 per person. Future plans for moorage include a seasonal floating dock with ramp access to shore. Construction of the dock is planned for Spring of 2018.

**'Songgaar':** is a 21' welded aluminum v-bottom boat with a center pilothouse. The boat is fitted with GPS navigation, VHF radio, a 225 horsepower mercury outboard engine, a 10 horsepower Yamaha outboard engine and welded bow bumpers for rocky shoreline landings. This a seaworthy vessel that is built for offshore waters, and is ideal for transporting up to 8 passengers to and from Tofino, and to various field sites in Clayoquot Sound.

**Señor Vargas:** is a 28′ custom built landing craft with a large indoor cabin. The vessel is powered by twin 175 HP Suzuki outboard engines and is fully equipped with VHF, GPS, and depth sounder. Señor Vargas is also equipped with a kitchen sink and table booth/bed for overnight trips.

**'Salal I':** is a 44′ Hans Christian ketch rigged pilothouse sailboat. 'Salal I' is fitted with GPS, radar, VHF radio, autopilot navigation, sonar, a 120 HP Isuzu inboard diesel engine, an 8 kW Volvo diesel generator, solar panels, 2 heads, shower, fridge, freezer, sleeping accommodation for 7, workshop/lab bench, electric anchor winch, life raft, 10′ rigid aluminum hulled inflatable boat with 9.9 horsepower mercury outboard engine, and all required safety equipment. 'Salal I' can accommodate up to 6 passengers on multi-day excursions, and up to 12 passengers on single day excursions. The vessel's cruising speed is 6.5 knots and the maximum hull speed is 8.2 knots. Given suitable wind conditions, students and researchers will have the opportunity to experience traveling in rhythm with the tides and wind patterns of Clayoquot Sound. Research and education groups are encouraged to have flexible schedules in order to increase the likelihood of sailing under suitable wind and tidal conditions.

**Sea Kayaks:** The station will have a fleet of Sea kayaks available for use by researchers and educational groups. The protected gravel beach in front of the station provides a safe and reliable spot for launching and landing kayaks. Sea kayaks allow groups to land on beaches that are inaccessible by motorboat, and paddle close to the shoreline in shallow water. Kayakers typically travel at a speed of 2-3 knots, which is ideal for in depth observation of one's surroundings on route to a "destination". The station will provide access to certified kayak instructors and guides, and we encourage groups to incorporate sea kayaking into their programs.

### Recreation and Well Being

In 1941 Aldo Leopold profoundly observed that, "the boundary between recreation and science, like the boundaries between park and forest, animal and plant, tame and wild, exists only in the imperfections of the human mind" (Meine & Knight, 1999, pg. 269).

While the station's focus is on ecological studies, we believe strongly in the power of recreational and relaxing activities to reinforce the lessons learned throughout the day. A 45-minute walk on the trail to Ahous bay provides reliable access to a remote and uncrowded surf break. The expansive white sand beaches of Ahous Bay will also provide ample room for a variety of physical activities and games. Surfing, Yoga, beach volleyball, badminton, lawn bowling, kayaking, paddle boarding, swimming, snorkeling, and scuba diving will all provide opportunities to unwind and have fun at the end of the work/study day.

Students and researchers can also recover from challenging classroom and fieldwork activities in the station's complimentary spa. Guests may warm up and relax in a wood fired sauna and steam room, which will be located along the shoreline so people can quickly cool off in the ocean between steams.

## Programs

### Research and Scientists in Residence

One of the factors limiting ecological research in Clayoquot Sound is the lack of a well-equipped research facility that is open to the public. By providing a well-equipped research facility, and marketing that facilities to a wide variety of organizations and institutions involved in ecological research, the Cedar Coast Field Station will work to expand ecological research in Clayoquot Sound. The CCFS is also looking to work closely with the local First Nations to develop research projects that incorporate traditional ecological knowledge in the design, operation, and interpretation of ecological studies.

CCFS will invite researchers from a diversity of disciplines to contribute to interdisciplinary ecological studies in Clayoquot Sound. Providing researchers with the resources they need to conduct holistic ecological research is a top priority of the CCFS. Researchers will also be encouraged to share their passion and expertise with younger budding researchers. Field school programs may benefit greatly from operating in close proximity to researchers working in the field. Synergistic interactions between researchers and students may be facilitated formally through presentations and classroom sessions, as well as informally through shared communal spaces such as cooking and dining areas.

## Field School

CCFS will operate as a field school for education groups ranging from Elementary school classes to University courses. Programs may vary in length from day trips for the local elementary schools to month long immersive university programs. The curriculum of these field school courses is entirely up to the visiting educational organization, but local programing in a variety of subject areas –particularly relating to local and traditional ecological knowledge—will be available.

**Single-day Programs:** Groups visiting Clayoquot Sound and wishing to schedule a short visit to the station may utilize our transportation systems, field site access, classroom space, and kitchen and washroom facilities. The field station is well situated to host field school day trips, as it is only 10 minutes from Tofino by boat. We recommend visits of no less than 6 hours in order to justify the monetary and ecological cost of transportation.

**Multi-day Immersive Programs:** Multi-day field courses will give students the opportunity to observe their surroundings in greater depth than single day excursions. Educators will have longer days to cover their curriculum, and extracurricular activities may be designed in a way that contributes to the overarching theme of the program. Courses run through the station will also allow students to interact with the Station's working systems, such as solar electric, solar hot water, waste water treatment, food production and harvesting, and rainwater collection. These systems will be designed to highlight the interconnectivity of students and the surrounding ecosystem.

**University Programs:** CCFS invites University programs and individual students to design learning experiences that are crafted around the ecology of Clayoquot Sound and the station facilities. Having educational resources – including research vessels, classroom space, lab space, recreation and accommodation – all in one place, provides an opportunity for programs to operate with a high level of flow. Programs will also benefit greatly from being in close proximity to ecologically rich field sites surrounding the station. Furthermore, having students doing their 'homework' in a space that is designed to foster ecological mindfulness may greatly benefit their productivity outside of organized classroom and field activities.

## Workshops and Artists in Residence

CCFS will offer a diversity of educational workshops run by independent educators wishing to teach in a nature-based setting. This format may cater to more skills and art based courses, as marketing extensive non-accredited life science courses may be difficult. Courses that focus on practical skillsets and artistic expression may be taught in a way that encourages students to incorporate ecological mindfulness into their work. Courses in woodworking, gardening, yoga, music, and visual arts could all benefit greatly from the addition of an ecological studies component.

Artistic workshops may be especially well-suited to facilitating a more intimate connection between students and the local ecology. Topophilia scholar Scott Sampson believes that because, "an affective sense of place can be evoked by such creative expressions as poetry, essays, song, theater, dance, painting, and sculpture, the full range of arts must also be brought to the vital task of reconnecting us to local nature" (Kahn & Hasbach, 2012, pg. 40). Aldo Leopold provided further support for incorporating art into an ecological field station when he asked the question, "could it be … that both good field science and fine art are rooted in the same medium, the ecotone between cultivated skill of careful observation and the wilds of the human imagination? (Meine & Knight, 1999, pg. 269) Inspired by these voices among others, the CCFS will work to promote a synergy between art and science by providing a space for the two worlds to coexist.

Artist residencies will be offered on a case by case basis, and artists will be encouraged to supplement their station fees by teaching workshops. Artists may also supplement their station fees by working 2-4 hours per day on various aspects of station maintenance such as gardening, cooking, and cleaning.

## Summer Camps

**Day Camps:** Day camps at the CCFS offer simplified logistics, while keeping camp costs at a minimum. It is recommended that day camps at the field station run for a minimum of 6 hours in order to justify the transportation time and cost. Summer camp groups could utilize the Field Station's transportation system, field site access, classroom space, washroom facilities, outdoor kitchen and dining tables, and recreational facilities.

**Multi-day Immersive Camps:** These camps could be similar to the multi-day immersive field school programs, with the added flexibility of not needing to satisfy B.C. School curriculum. Multi-day camps will increase the opportunity for leaders to incorporate a common theme's into all of the day's activities. The following are some potential summer camp activities:

- Hiking
- Intertidal investigation
- Snorkeling
- Gardening
- Visual arts and crafts
- Kayaking
- Surfing
- Paddle boarding
- Fishing
- Animal tracking
- Sailing

In addition to the curriculum and activities relating to camp themes, campers will also learn ecological lessons through their interactions with the station's facilities, including rainwater collection systems, energy harnessing systems, gardening and foraging for edible plants and seafood. While the cost of multi-day camps will be substantially higher than single day camps, discounts may be offered to Clayoquot Sound residents in order to increase local accessibility.

## VOLUNTEERING

Being a small, grass roots charitable organization, CCFS will be dependent on a steady supply of volunteer labor—especially during the summer months. Volunteers will help out in the gardening, kitchen and maintenance departments, or wherever their applicable interests lie. Volunteers may also assist in research projects if there is a need, or if there is extra room on research vessels. Volunteers will be asked to work a minimum of 4 hours per day, in return for room and board during their time at CCFS.

## STATION FEES

| Group | Item | Cost in $CAD |
|---|---|---|
| Station fee (accommodation, access to facilities, etc.) | Educational groups (Grade school/University) | $45/person/day |
| | Researchers/Artists | $45/person/day |
| | Guests | $60/person/day |
| Transportation | Taxi round trip from Tofino | $40/person |
| Charter | M/V Songgaar (8 person) | $125/hour |
| | Station skiff (12 person) | $125/hour |
| | Motor/Sailing Vessel Salal I (12 person) | $150/hour |
| Food | Breakfast | $10/person/day |

| | | |
|---|---|---|
| | Lunch | $10/person/day |
| | Dinner | $15/person/day |

*Financial aid is available on a needs basis in order to maintain accessibility.

# APPENDIX A—BUDGET

| | **Season 1 (August-October 2017)** | Timeline | Cost |
|---|---|---|---|
| Expenses | | | |
| Infrastructure: | Renovate 600' sq. ft. lab/classroom | Summer 2017- 3 weeks | ($15,000) |
| | Rock Breakwater reinforcement | Summer 2017- 1 week | ($5,000) |
| | Concrete walkway & pad | Summer 2017- 1 week | ($5,000) |
| | 12'x24'Floating dock with ramp | Summer 2017- 1 week | ($15,000) |
| | Floating breakwater | Summer 2017- 1 week | ($2,500) |
| | Driveway to future building sites | Summer 2017- 2 weeks | ($40,000) |
| | Renovate sauna | Summer 2017- 1 week | ($200) |
| | Commercial certification of Salal I | Fall/Winter 2017/2018 | ($25,000) |
| Subtotal | | | ($107,700) |
| Founder Contribution | | | $107,700 |
| Legal/Financial | Charitable society formation | Spring 2017- 4-6 months | ($8,000) |
| | Insurance | Annual Liability | ($1,225) |
| | Unemployment insurance | | |
| Marketing | Website development | Spring 2017 | $(1,000.00) |
| | Logo Design/marketing material | | $(500.00) |
| Staff Expenses | Station Coordinators X2 | Fall 2017 | ($15,000) |
| | Winter caretaker x1 | Nov 2017-Mar 2018 | ($7,500) |
| | Board members | Annual salary x 5 | ($2,500) |

| | | | |
|---|---|---|---|
| | Director | Annual salary | $0 |
| Leases | Vargas Island Inn | August-October | ($9,000) |
| | Lot 2 (lab/classroom/dock) | Annual | $0 |
| Purchases | Station Boat (Skiff with 90 HP) | Summer 2017 | ($20,000) |
| | Basic lab equipment & supplies | Summer 2017 | ? |
| Maintenance | Station Boat | | ($1,000) |
| Food | Staff/volunteer food | Fall 2017 | ($3,000) |
| Fuel | Station boat | Fall 2017 | ($1,800) |
| | Station propane | Fall 2017 | ($540) |
| | Generator fuel (Deisel) | Fall 2017 | ($270) |
| Services | Explorenet Internet 100GB | Annual | ($1,464.96) |
| Subtotal | | | ($72,800) |
| **Revenue** | | | |
| Station fees | $45/learner/day (half occupancy) | August-October | $40,500 |
| | $60/guest/day (2 guests/day) | | $21,600 |
| | Station Boat Charters ($125/hour) | August-October | $11,250 |
| Grants | | | ? |
| Donations | | | ? |
| Subtotal | | | $73,350 |
| Net Earnings | | | $550 |

**Season 2 (April-October 2018)**

| | | Timeline | Cost |
|---|---|---|---|
| **Expenses** | | | |
| Infrastructure: | 5 wall tent platforms and tents | Spring 2018- 2 weeks | ($20,000) |
| | Upgrade trail to Ahous Bay | Summer 2018- 6 months | ($20,000) |
| | Rainwater catch to 15,000 gal | Spring 2018- 2 weeks | ($20,000) |

| | | | |
|---|---|---|---|
| | Greywater treatment ponds | Spring 2018- 3 weeks | ($5,000) |
| | Fruit and nut orchard | Spring 2018- 1 week | ($5,000) |
| | Garden expansion | Summer 2018- 8 weeks | ($2,500) |
| | Wood fired hot tub | Summer 2018- 1 week | ($1,000) |
| | Aquarium/touch tank in lab | Fall 2018- 1 week | ($5,000) |
| | 29 kW Solar array and battery bank | Spring 2017- 2 weeks | ($30,000) |
| Subtotal | | | ($108,500) |
| Founder Contribution | | | $108,500 |
| Legal/Financial | Rezone property to P-1 Institutional | Fall/Winter 2018/2019 | ($10,000) |
| | Tax services | Spring 2018 | ($5,000) |
| | Unemployment insurance | | ? |
| | Insurance | Annual | ($1,225) |
| Staff Expenses | Station Coordinators x2 | April-Oct full time | ($38,500) |
| | Winter Caretaker | Nov 2018- Mar 2019 | ($7,500) |
| | Board members | Annual salary x 5 | ($2,500) |
| | Director | Annual Salary | $0 |
| Leases | Vargas Island Inn | April-October | ($21,000) |
| | Lot 2 (Lab/classroom/wall tents) | Annual | $0 |
| Maintenance | Station Boat | | ($2,000) |
| Food | Staff/Volunteer Food | Spring 2018-Fall 2018 | ($7,000) |
| Fuel | Station boat | Spring 2018-Fall 2018 | ($4,200) |
| | Station propane | | ($1,260) |
| | Generator fuel (Diesel) | Spring 2018-Fall 2018 | ($630) |
| | Explorenet Internet 100GB | Annual | ($1,464.96) |

| | | | |
|---|---|---|---|
| Subtotal | | | ($102,280) |
| **Revenue** | | | |
| Station Fees | $45/learner/day (half occupancy) | April-October | $94,500 |
| | $60/guest/day (2 guests/day) | April-October | $50,400 |
| | Station Boat Charters ($125/hour) | August-October | $26,250 |
| Grants | | | ? |
| Donations | | | ? |
| Subtotal | | | $171,150 |
| Net Earnings | | | $68,870 |

| | **Season 3 (April-October, 2019)** | Timeline | Cost |
|---|---|---|---|
| **Expenses** | | | |
| Infrastructure: | 2 large greenhouses | Spring 2019- 4 weeks | ($10,000) |
| | Conference Centre | Fall/winter 2019- 16 weeks | ($250,000) |
| | 5 small tent platforms | Summer 2019- 2 weeks | ($2,500) |
| | | | ($262,500) |
| Founder Contribution | | | $262,500 |
| Legal/Financial | Tax services | Spring 2019 | ($5,000) |
| | Unemployment insurance | | ? |
| Insurance | annual liability | | ($1,225) |
| Staff Expenses | Station Coordinators x2 | April-Oct full time | ($42,350) |

| | | | |
|---|---|---|---|
| | Winter Caretaker | Nov 2019- Mar 2020 | ($7,500) |
| | Board members | Annual salary x 5 | ($2,500) |
| | Director | Annual Salary | ($35,000) |
| Leases | Vargas Island Inn | April-October | ($21,000) |
| | Lot 2 (Conference Centre) | Annual | $0 |
| Maintenance | Station Boat | | ($2,000) |
| Food | Staff/Volunteer Food | | ($7,000) |
| Fuel | Station boat | | ($4,200) |
| | Station Propane | | ($1,260) |
| | Generator fuel (Diesel) | | ($630) |
| | Explorenet Internet 100GB | Annual | ($1,464.96) |
| Subtotal | | | ($131,130) |
| **Revenue** | | | |
| Station Fees | $45/learner/day (half occupancy) | April-October | $94,500 |
| | $60/guest/day (2 guests/day) | April-October | $50,400 |
| | Boat Charters ($125/hour) | August-October | $26,250 |
| Grants | | | ? |
| Donations | | | ? |
| Subtotal | | | $171,150 |
| Net Earnings | | | $40,020 |

*Founder contributions are for privately owned infrastructure and need not be paid back

# APPENDIX B—STATION FACILITY MODELS (EXISTING AND PLANNED)

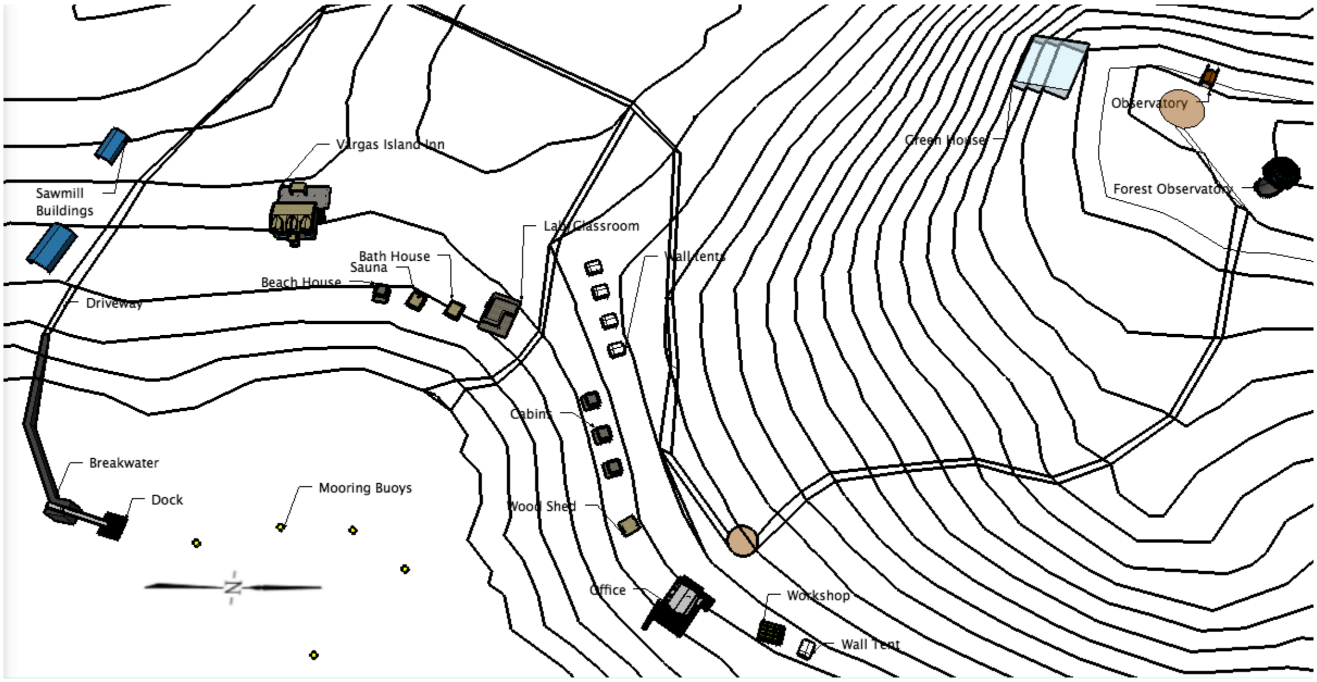


Figure 1. Birds eye view of Cedar Coast Field Station including existing and planned construction.

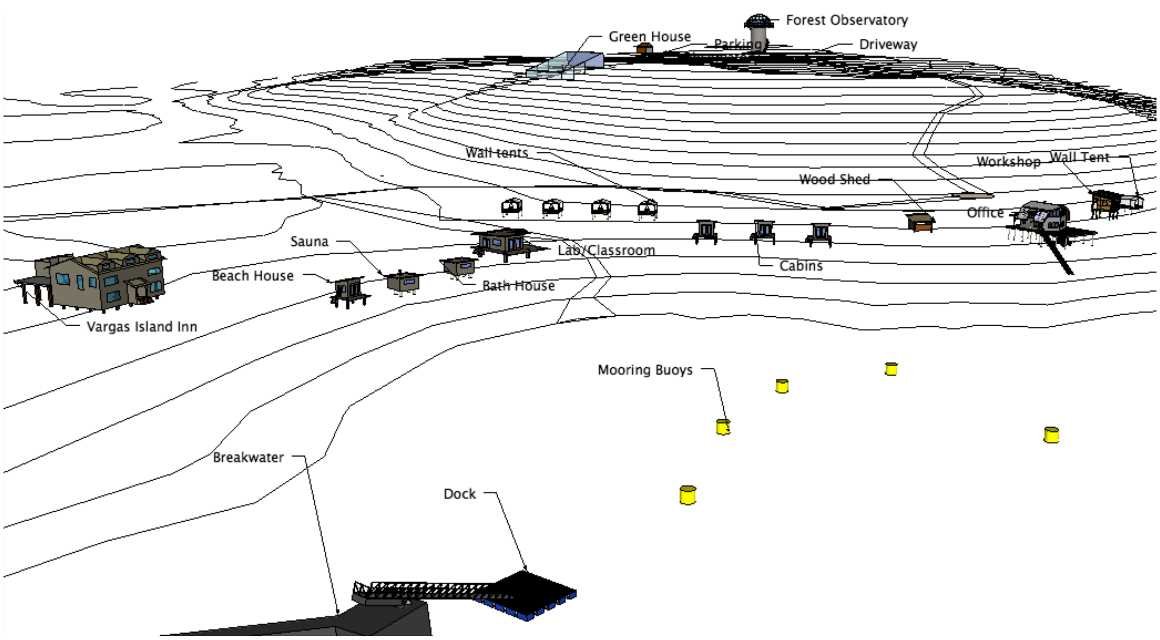


Figure 2. Existing and planned infrastructure at Cedar Coast Field Station (CCFS)

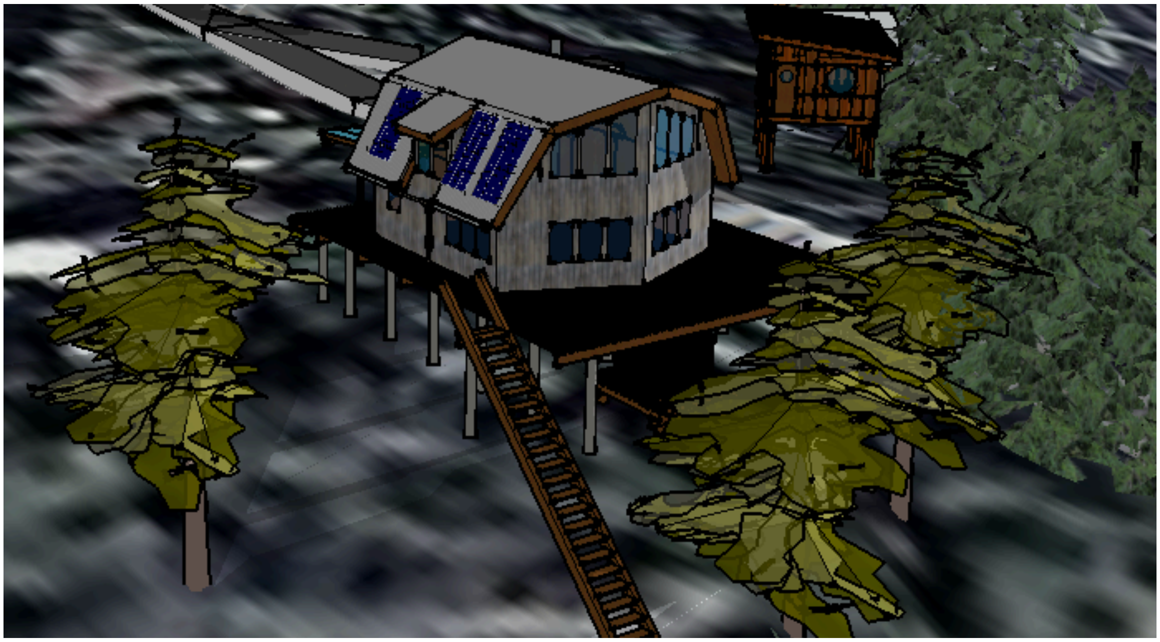

Figure 3. CCFS office and workshop with solar array and rainwater collection system.

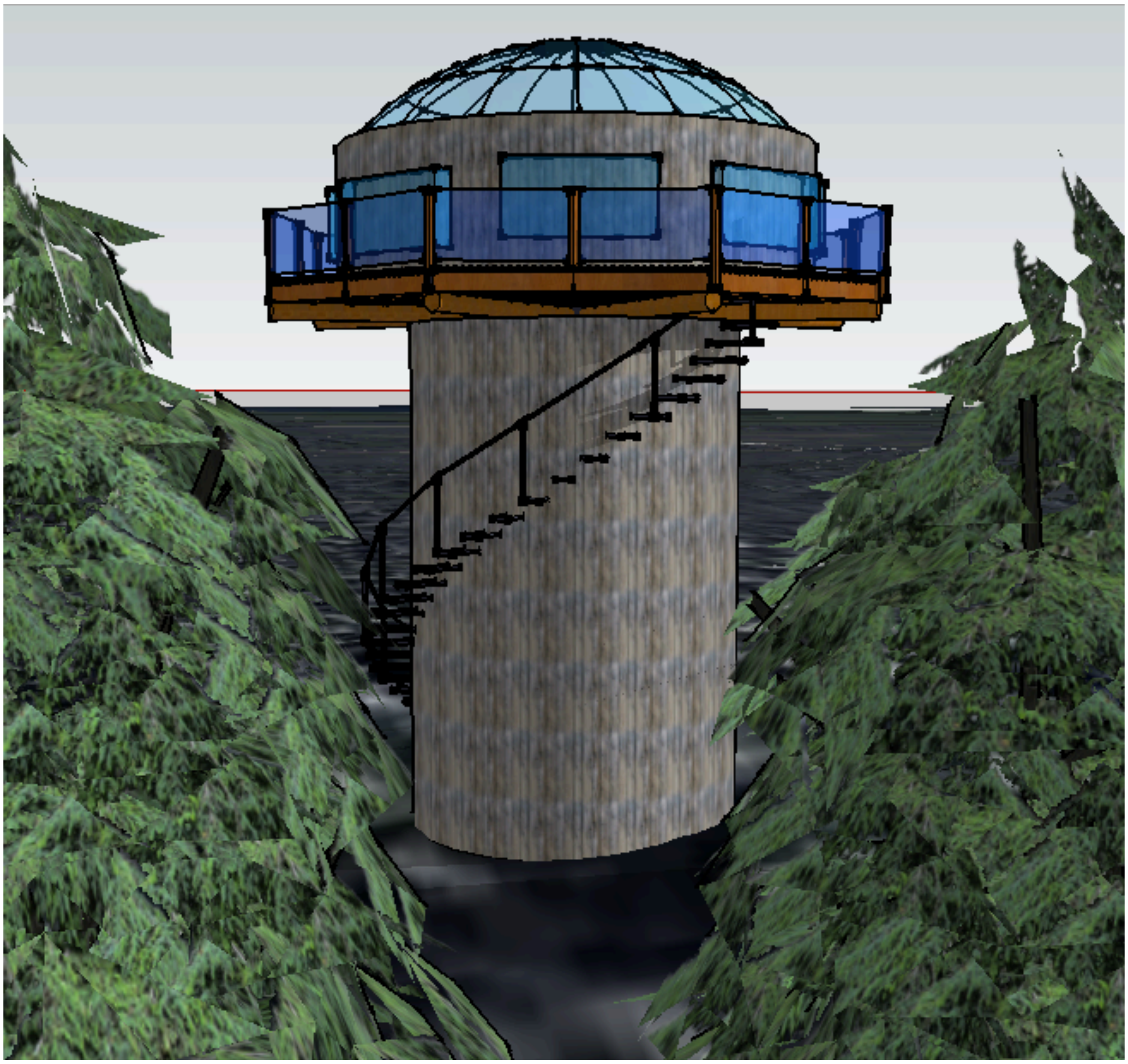

Figure 4. Forest Observatory perched atop a 10,000-gallon rainwater cistern.

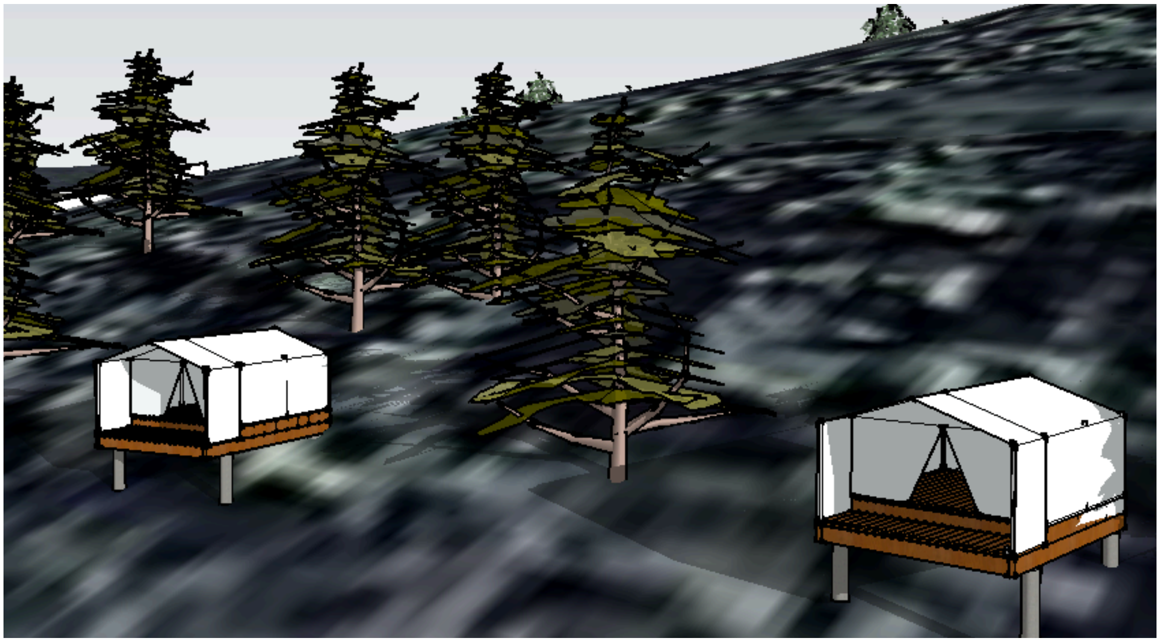

Figure 5. Wall tents on a south-facing forested slope.

## Appendix C—Research, Education and Management In Clayoquot Sound

There are many organizations currently working to preserve the ecological health of Clayoquot Sound, including the following:

- **Maaqutusiis Hahoulthee Stewardship Society (MHSS):** has recently implemented a resource guardian program similar to that of the Haida Watchmen program in Gwaii Haanas National Park, in which local first nations members serve as guardians and guides in their traditional territory (T. Atleo, Personal Communication, January 23, 2017).
- **B.C. Parks:** "The first duty of BC Parks is to make sure our natural treasures are protected by conservation measures so that

wildlife and wild habitats can flourish."

- **Central West Coast Forest Society:** works "with a variety of partners to restore forest and stream ecosystems, conduct research and monitoring projects, and engage with the community through education and employment" (CWCFS, 2017).
- **Clayoquot Action:** is "committed to protecting the biocultural diversity of Clayoquot Sound…through public education, citizen research and monitoring, and advocacy" (Clayoquot Action, 2017).
- **Clayoquot Biosphere Trust:** works "to assist the Clayoquot Sound UNESCO Biosphere Reserve Region Community to achieve its vision by providing funding and logistical support for research, education and training initiatives that promote conservation and sustainable development" (CBT, 2017).
- **Wickaninnish Community School:** In collaboration with Raincoast Education Society the Wickaninnish Community School provides its students with "regular Field School excursions…based in themes of sustainability, biodiversity or local ecosystem dynamics" (RES, 2017).
- **Friends of Clayoquot Sound:** has a mission, "to be peaceful, courageous advocates in protecting the ancient temperate rainforest, ocean, rivers and biodiversity of Clayoquot Sound" (FOCS, 2017).
- **High school and University Field Schools:** Research shows

that, "there are at least 30 universities already engaged in research on the west coast and approximately 75 High School groups visiting [the communities of Clayoquot Sound] annually for outdoor education experiences" (Loucks et al., 2014).

- **Parks Canada:** National Parks such as Pacific Rim "protect and present outstanding representative examples of natural landscapes and natural phenomena" (Parks Canada, 2017)
- **Strawberry Island Marine Research Society:** is "a group of dedicated naturalists living and working on the waters of west coast Vancouver Island BC, conducting primary research and monitoring of various marine ecosystems in Clayoquot Sound" (SIMRS, 2017).
- **Raincoast Education Society:** has "a mission to help shape an environmentally sustainable future for the Clayoquot and Barkley Sound region through education and community stewardship" (RES, 2017).
- **Tofino Salmon Enhancement Society:** has a number of ongoing programs including, "maintenance of hatchery and buildings, procurement of salmon eggs [and] hatching, rearing and transferring of salmon fry to local streams" (Donate2Charities, 2017)
- **Tofino Botanical Gardens Foundation:** is "dedicated to the creation of a living classroom where future generations will learn about the natural and cultural history of Clayoquot Sound

and the remaining coastal temperate rainforests of the world"

- **University of Victoria Field Station:** The University of Victoria has a small field station located across the water from the main Ahousaht village of Maaqutusiis. The university field station focuses primarily on marine biological research and education.

While each of these organizations is working to preserve the ecological health of Clayoquot Sound in different ways, none of them provide a facility that is open to the public and dedicated to ecological research and education in Clayoquot Sound. The lack of such a facility exposes a niche that could be filled by an ecological field station. The director of Raincoast Education Society (RES) has expressed a desire for such a facility that can operate as a "home base" for their field school and Raincoast Institute programs (Harrison, D., August, 2015). The director of Strawberry Isle Marine Research Society (SIMRS) has also expressed a desire to conduct research through such a facility, as their organization is currently lacking some resources- including consistent access to a boat (Edwards, J., personal communication, August 30th, 2016). Senior advisor to the Ahousaht Development Corporation—which operates in conjunction with the MHSS—has expressed support for the project as it is the first of its kind in the area that will work to actively engage local First Nations in the design, operation, and interpretation of research and education projects (Atleo, T., personal communication, January, 2017). The director of the Clayoquot Biosphere Trust has expressed support for the project as a way to increase local research and education capacity, and increase connectivity between the communities of Clayoquot Sound (Hurwitz, R., personal communication, September, 2016).

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