Sound Investment

MEASURING THE RETURN ON HOWE SOUND'S ECOSYSTEM ASSETS

FEBRUARY 2015

David Suzuki Foundation

SOUND INVESTMENT: MEASURING THE RETURN ON HOWE SOUND'S ECOSYSTEM ASSETS

February 2015

by Michelle Molnar

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PHOTO: KRIS KRÜG

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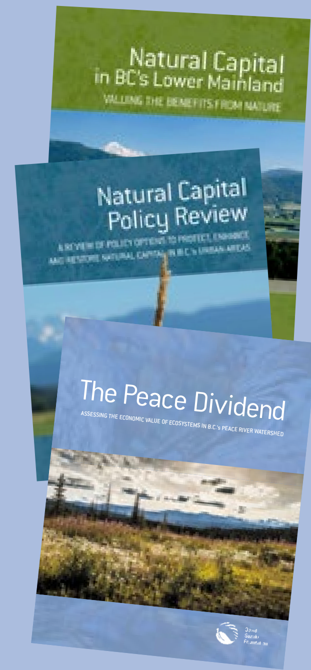
Finally, thank you to photographer Kris Krüg, and to Howe Sound residents and visitors for sharing their stunning photography of the region with us through Flickr Creative Commons.

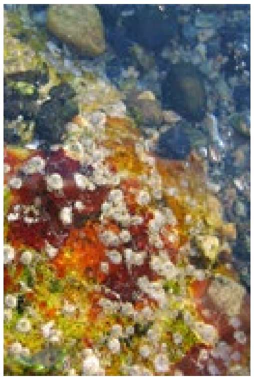
DISCLAIMER

This study should be considered a baseline and coarse-scale natural capital account for the Howe Sound. It is a first step toward a more comprehensive accounting of natural capital assets in the region and the ecosystem services provided by its ecosystems and natural areas. More Canadian research is required to determine a full range of ecosystem service values relevant to Canadian ecoregions and land cover types. This work is intended to encourage others to consider the value of natural capital assets and ecosystem services and to stimulate dialogue on the values of natural capital, ecosystem services, stewardship and conservation.

The content of this study is the responsibility of its author and does not necessarily reflect the views and opinions of those acknowledged above. Every effort has been taken to ensure the accuracy of the information contained in this study. However, it is important to acknowledge that ecosystems have many values that cannot be monetized and that ecosystem service research and valuations are approximations with inherent uncertainty. It is also important to remember that although we can place a monetary value on ecosystems and ecosystem services, we cannot replace the ecosystems provided by the Earth.



Executive Summary



Composed of a network of fjords, islands and surrounding mainland communities, the Howe Sound region hosts some of the most spectacular scenery in the world.

TOP PHOTO COURTESY TIM GAGE/ FLICKR CREATIVE COMMONS

BOTTOM: TIDAL POOL AT PARADISE VALLEY, PHOTO COURTESY ROB PONGSAJAPAN/ FLICKR CREATIVE COMMONS

HOWE SOUND IS AN AREA OF REGIONAL SIGNIFICANCE, but it has rarely been considered as a region. As one of the most southern sound inlets on the mainland coast of British Columbia, it provides habitat and sheltered access to a range of species and is high in biological diversity. Connecting to the Georgia Strait and the larger Salish Sea, the region is an ecosystem of critical importance to keeping our environment in balance. Composed of a network of fjords, islands and surrounding mainland communities, it hosts some of the most spectacular scenery in the world — the result of glaciers, earthquakes, volcanoes and mountain-building from a past geological era.

The rugged topography of the region has restricted settlement to the coastline and the valleys (see map). Within this limited footprint lies an assortment of municipalities, towns, villages and island communities that fall under the jurisdiction of three regional districts and the Islands Trust. In addition, it is the traditional territory of the Coast Salish First Nations, who have resided here for thousands of years. Its influence extends to Vancouver — a large adjacent urban population — and two recreation- and tourism-focused population centres that lie on two sides of it, Whistler to the north and the Sunshine Coast to the west.

This large estuary, nestled among B.C.'s most populated city and the region's highest tourism destinations, is also of high ecological significance. Humpback, killer and grey whales, pods of Pacific white-sided dolphins, spawning salmon and herring are all returning after decades of low numbers. The cumulative impact of pollution from past industrial activity created a dead zone, a hypoxic (low-oxygen) area of the ocean, where marine life was hard to find. As the natural systems were degraded, costly investments were needed to replace the lost services of ecosystems and to rehabilitate the damaged environment. Recovery efforts, which began in 1988, have been effective. The marine dead zone has shrunk and life is returning to the sound, signalling ecosystem recovery. This recovery is of great interest to scientists around the world, as little is known of the dynamics of marine recovery.

This all-too-rare good news story could be short-lived. Numerous industrial development projects, from proposed gravel mines in estuaries to waste garbage incinerators and pulp mills to liquid natural gas (LNG) facilities, are on the horizon. The projects are at various stages of consideration.

The purpose of this study is to estimate the economic value of the ecosystem services provided by the land and marine ecosystems and their uses within the region. Although many ecosystem services do not appear on the market, balance sheets or decision-making frameworks, they are essential for life, societal well-being and our economies. Breathable air, drinkable water, nourishing food, minerals and raw materials are just a few "ecosystem services". Without understanding this value, critical natural systems could be lost at great cost to communities today and into the future. Understanding these values can set the stage for building an economy that maintains and cares for our world.

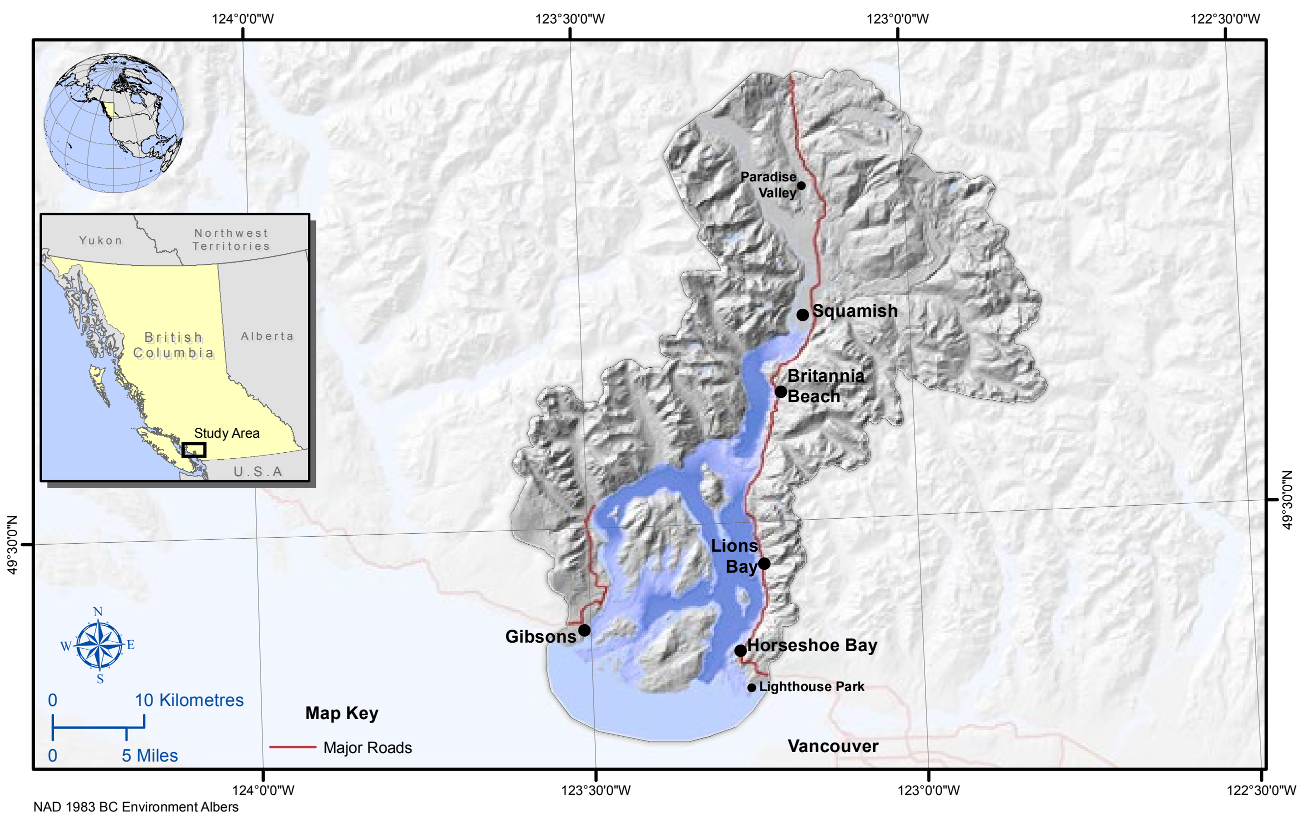
Natural systems are only recently beginning to be viewed as economic assets, providing economically valuable goods and services. Within the past decade, considerable progress has been made to systematically link functioning ecosystems with human well-being. For this study we employed the ecosystem services framework, which was developed within ecological economics as a tool for including nature's value in economic decision-making.

The study's findings reveal that the Howe Sound watersheds provide an estimated annual value of $800 million to $4.7 billion in ecosystem services. The study area's natural systems provide residents with food, clean water, a stable climate, protection from natural disasters and a place to relax, recreate and reconnect with nature. The region's ecosystems produce a flow of valuable services across time. In this sense, the environment of Howe Sound can be thought of as a capital asset. This analogy can be extended by calculating the net present value of the future flows of ecosystem services, just as the asset value of a traditional capital asset (or large project) can be approximately calculated as the net present value of its future benefits. If we were to treat the region's ecosystems as an economic asset, providing a stream

Howe Sound has been the traditional territory of the Coast Salish First Nations, for thousands of years.

PHOTO : KRIS KRÜG

STUDY AREA OF HOWE SOUND NATURAL CAPITAL VALUATION



HOWE SOUND / TXWNUWUTS STUDY AREA: This map shows the study area, known as *Howe Sound* to the non-indigenous population or *Txwnuwuts* to the Squamish First Nations. It is recognized as the traditional territory of the Coastal Salish Nations. The area runs from Lighthouse Park, up the eastern coastline of the fjord, past the northern border of Squamish and Paradise Valley, and back down the western coastline to Gibsons. The study area also includes the marine area and islands within.

of benefits over 50 years, the present value would range between $15 billion and $91 billion, using a conventional discount rate.

The table below provides a summary of the estimated value of individual ecosystems in Howe Sound. The highest valued land/water covers on a per hectare basis include beaches (valued at a maximum of $225,105 annually) and wetlands (valued at a maximum of $172,946 annually). Beaches are highly valuable for tourism and recreation, as well as disturbance regulation. Wetlands, on the other hand, exhibit value across a range of services including disturbance regulation, waste treatment, water supply, habitat and tourism and recreation.

SUMMARY OF VALUES OF ECOSYSTEM BENEFITS BY LAND/WATER COVER (2014 C$)

Land/water cover type	Total value/year ($/yr)		Value per hectare per year ($/ha/yr)	
	Low	High	Low	High
Beach	$100,457	$32,640,226	$693	$225,105
Estuary	$179,370	$462,600	$685	$1,766
Forest	$682,526,262	$1,599,254,118	$5,045	$11,820
Lakes and rivers	$3,271,323	$117,643,415	$1,925	$69,243
Marine	$102,005,609	$2,811,105,944	$715	$19,712
Riparian buffer	$3,979,334	$156,128,608	$945	$37,085
Wetland	$329,165	$22,482,905	$2,532	$172,946
Eelgrass beds	$152,775	$566,821	$23,504	$87,203
Total	**$792,544,295**	**$4,740,284,637**	**$36,044**	**$624,880**

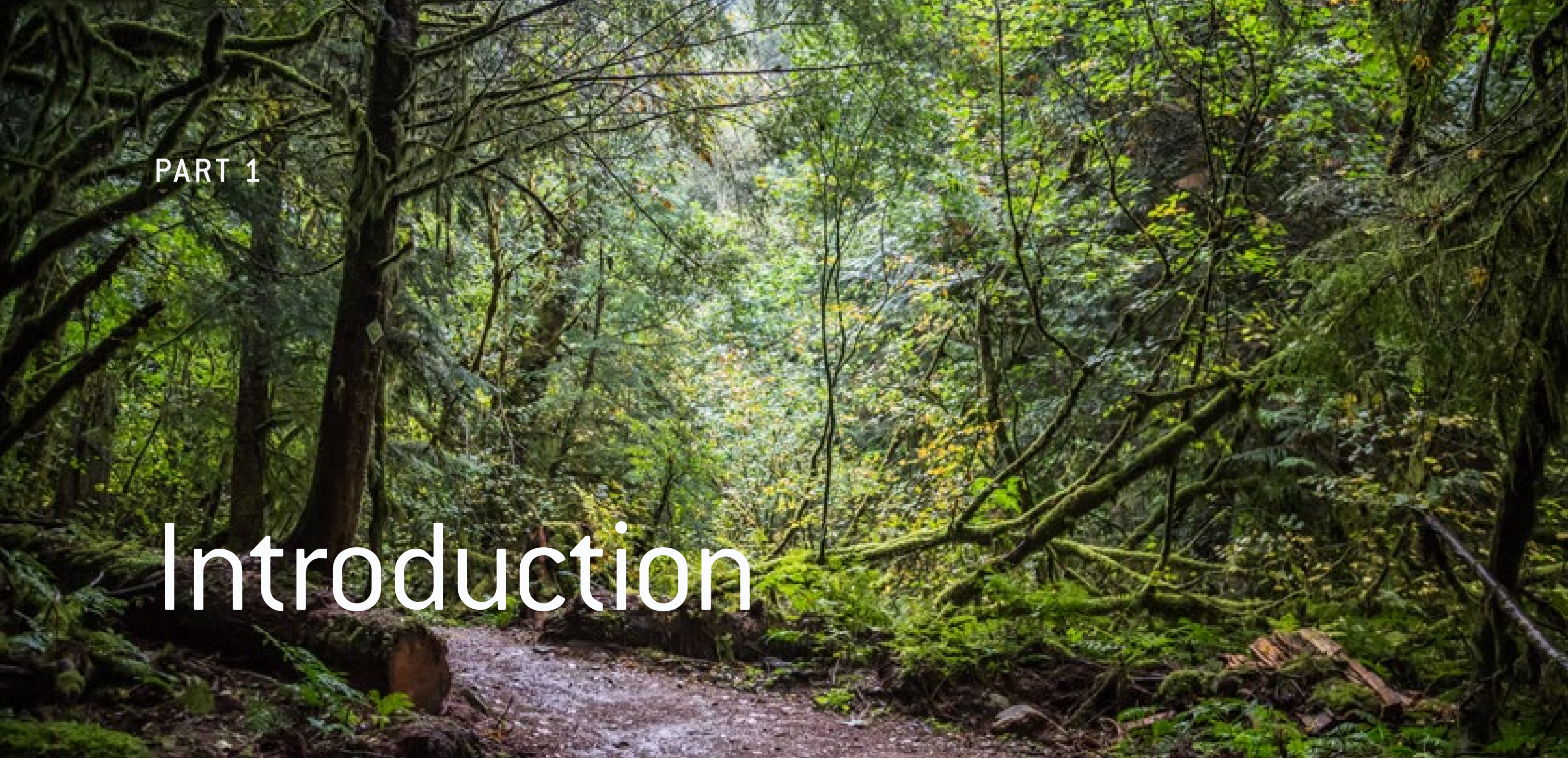
Beaches are highly valuable for tourism and recreation, as well as disturbance regulation.

GIBSONS BEACH PHOTO COURTESY TREC_LIT/FLICKR CREATIVE COMMONS

The value of intact ecosystems can also be calculated according to the services or benefits they provide. We found the highest valued services to be tourism and recreation (valued at a maximum of $304,000/hectare/year) and disturbance regulation (valued at a maximum of $84,000/hectare/year).

Information on the economic value of natural systems will not on its own provide a solution to the degradation of ecosystems. The real challenge is to use this information to remedy failures in markets, policies and resource management. This valuation can be used in many ways. In addition to identifying conservation needs and drawing attention to the importance of ecosystem services and the natural capital they rely on, the results of this study can be used to help evaluate the trade-offs this region is facing with respect to industrial development decisions. It can also be used to support ecosystem accounting, to inform the development of tax policies and to assist in the evaluation of financial assurances to decommission and restore sites after major resource projects have ended.

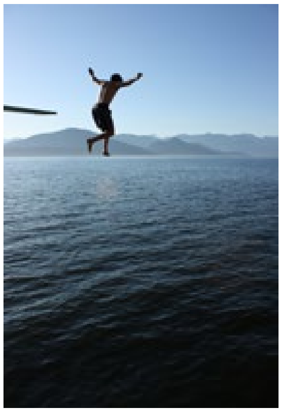
Industrial resurgence and nature recovery must be considered together — not in the current piecemeal approach that could set them on a collision course. The future of Howe Sound's environment and economy is intricately connected. Careful choices must be made to ensure a healthy and sustainable future for natural systems and the economy.



Ecosystem Services and Natural Capital Explained

While the terms "natural capital" and "ecosystem services" are relatively new, the concepts are not. These concepts refer to the reality that humanity and nature are intricately intertwined. As biological beings, we depend on nature for many life-sustaining and life-affirming processes. We depend upon vegetation to clean the air we breathe; we depend upon healthy soils to grow the food that nourishes us, and clean water to hydrate us and maintain healthy functioning of our bodies. As social beings, we depend upon minerals and raw materials to fuel our economies, and it is in nature that our culture finds its roots and sense of place. Scientists and economists refer to the vast collection of benefits provided by nature as "ecosystem services", which all flow from healthy ecosystems.

Nature is the foundation of our social and economic prosperity. As such, we need to manage it in much the same way we do other forms of capital. Just as an investor relies on financial capital to generate a flow of profits or on built capital to generate a flow of goods, we all rely upon natural capital (or nature) to produce a flow of ecological goods and services (or ecosystem services). And just as we watch over the health of our children and our economies, we need to watch over that which supports them. By maintaining the health of the ecosystems that surround us, we are taking care of that which takes care of us.



As biological beings, we depend on nature for many life-sustaining and life-affirming processes.

TOP PHOTO: KRIS KRÜG
BOTTOM: LIONS BAY, COURTESY T604/FLICKR CREATIVE COMMONS

Why is it important to measure natural capital?

Conventional economics have been largely detached from the environmental sciences. The discipline devoted to the "allocation of scarce resources" has remained silent about the natural foundation of production and the biophysical limits to growth. For instance, although ecosystems assimilate the waste by-products of economic production, there are no generally agreed-upon rules or mechanisms to ensure that emissions do not exceed the capacity of the ecosystem to process waste. While this position may have been justifiable in the early days of the discipline when nature appeared inexhaustible, today we are experiencing increasing scarcity in the supply of natural resources, indicating that nature has become a resource ripe for economic consideration.

Today, everyone from farmers and fishermen to bankers and financiers are waking up to two important facts: We depend on nature in far more complex ways than we knew, and nature is not inexhaustible.

PHOTOS: KRIS KRÜG

Today, everyone from farmers and fishermen to bankers and financiers are waking up to two important facts: We depend on nature in far more complex ways than we knew, and nature is not inexhaustible. Little did we know that the Green Revolution in agriculture would result in depleted soils and local health impacts associated with insecticides or that we could deplete a population of once-abundant fish such as North Atlantic cod. Likewise, bankers and insurers are growing increasingly concerned about costs related to extreme weather events, which threaten to disrupt supply chains and commodity prices.

Despite growing awareness about the importance of intact, healthy ecosystems, as well as commitments by various levels of government to reduce biodiversity loss, ecosystems continue to be mismanaged, misunderstood and destroyed. There are many reasons for the gap between what we want and what we have, but a key underlying reason is that our economic frameworks fail to value biodiversity or conservation of ecosystems. With few exceptions, there is little financial reward for conserving nature, nor much penalty for destroying it.

This study is a first step in remedying this situation. By assessing the stocks and state of ecosystems and providing an economic value to the functions or services they provide, it aims to illuminate the connections between the economy and nature. This is a vital step toward designing the economy to be more compatible with natural systems. This assessment helps lay the groundwork for an informed discussion of how public and private decision-making can incorporate a wider range of interests into economic policies to improve prosperity for all.

Study Area Rationale

The Howe Sound region of British Columbia is experiencing a remarkable ecological rebirth. Humpback, killer and grey whales, pods of Pacific white-sided dolphins, spawning salmon and herring are all returning after decades of low numbers. The cumulative impact of pollution from pulp mills, untreated sewage, chlorine spills and acid drainage from an abandoned copper mine created a dead zone, a hypoxic (low-oxygen) area of the ocean, where marine life was hard to find. Recovery efforts, which began in 1988 with upgrades to the Howe Sound Pulp and Paper Mill, and later included a water-treatment plant at the former Britannia Beach mine site and most recently, the wrapping of creosote-covered wood pilings at docks, have been effective. To the delight of local residents, the marine dead zone has shrunk and life is returning to the sound, signalling ecosystem recovery.

The recovery of the sound — this all-too-rare good news story — could be short-lived. Numerous industrial development projects, from proposed gravel mines in estuaries to waste garbage incinerators and pulp mills to liquid natural gas (LNG) facilities, are on the horizon. The projects are at various stages of consideration, but industrial resurgence and nature recovery must be considered together — not in the current piecemeal approach that could set them on a collision course.

Howe Sound is an area of regional significance. As one of the most southern sound inlets on the mainland coast of B.C. (the other being Indian Arm), it provides habitat and sheltered access to a range of species and is high in biological diversity. Connecting to the Georgia Strait (and the larger Salish Sea), the region is essentially one large estuary, an ecosystem of critical importance to keeping our environment in balance. Its influence extends to Vancouver — a large urban population that sits adjacent to it — and to two major population centres known for their recreation and tourism amenities that lie on two sides of it, Whistler to the north and the Sunshine Coast to the west. As such, a big-picture view is required to care for the ecological and economic maintenance of the region.

This study strives to inform the discussion of how the sound should be developed by articulating the economic value of the services provided by the region's natural resources. These resources provide essential goods and services required by all people of the sound. Without understanding this value, critical natural systems could be lost at great cost to humanity today and into the future. Understanding these values can set the stage for building an economy that maintains and cares for our world and what we've developed from it. The future of Howe Sound's environment and economy are intricately connected. Careful choices must be made to ensure a healthy and sustainable future for natural systems, societal well-being and the economy.

In addition to drawing attention to the importance of ecosystem services and the natural capital they rely on, the results of this study can be used to help evaluate the trade-offs this region is facing with respect to industrial development decisions and identify conservation and restoration needs.

PHOTO COURTESY RYAN/FLICKR CREATIVE COMMONS

A Living Document

This study provides preliminary results of the economic value of the functioning ecosystems of Howe Sound. It is a rough estimate based on data obtained for the David Suzuki Foundation's *Nearshore Natural Capital Valuation*. Due to resource restraints, the values are based on existing studies completed for similar ecosystems and the mapping is at a 1:80,000 scale. In addition, many of the services could not be valued because appropriate studies do not exist. Consequently, it is recommended that this be regarded as a living document to be edited and updated with new information. As the resolution of maps and data sources are improved, they can be used to update and improve the scale of analysis and ecological values. It is anticipated that over time this document will evolve through updates, as well as expanded analysis and intended applications.

This valuation can be used in many ways. In addition to drawing attention to the importance of ecosystem services and the natural capital they rely on, the results of this study can be used to help evaluate the trade-offs this region is facing with respect to industrial development decisions and identify conservation and restoration needs. It can be used to support ecosystem accounting, to inform the development of tax policies and to assist in the evaluation of financial assurances to decommission and restore sites after major resource projects have ended.[1]

1 Statistics Canada, 2013.

PART 2

Overview of Study Area

Geography

Although the region has never been formally defined in legal terms, the approximate boundaries are dictated by the waters that flow through it, from the inlet entrance at the Georgia Strait, extending 44 kilometres northwest to the Squamish estuary.

HOWE SOUND PHOTO COURTESY KYLE PEARCE/FLICKR CREATIVE COMMONS

The Howe Sound region of British Columbia, Canada — an area that encompasses approximately 200,000 hectares — is located in the southwest portion of the province, just north of the Fraser River delta and the city of Vancouver. Although the region has never been formally defined in legal terms, the approximate boundaries are dictated by the waters that flow through it. These waters run from the inlet entrance at the Georgia Strait (part of the trans-regional Salish Sea), which divide West Vancouver from the Sunshine Coast, and extend 44 kilometres northwest to the Squamish estuary. Composed of a network of fjords, islands and surrounding mainland communities, this region hosts some of the most spectacular scenery in the world, the result of glaciers, earthquakes, volcanoes and mountain-building from a past geological era.

This ancient riverbed — where forested mountains climb from the sea to heights of up to 2,678 metres (8,786 feet)[2] and where saltwater meets freshwater — supports productive ecosystems that are home to a diversity of marine and terrestrial wildlife, as well as a growing human population. Above sea level, forests of fir and arbutus inhabit the southern portion, whereas hemlock, cedar and fir are found inland, at higher elevations and in northern portions. The deep waters of the fjord, which plunge to 290 metres at its deepest point, support a different assemblage of species from the rest of the Georgia Strait.[3] The fjord is fed by the Squamish River and its major tributaries, which together drain over 3,600 km^2 into the sound.[4] These rivers deliver sediment to the sound, creating deltas and wetland communities, as well as delivering nutrients to fertilize the base of the food chain.

The rugged topography of the region has restricted settlement to the coastline and the valleys. Within this limited footprint lies an assortment of municipalities, towns, villages, island communities that fall under the jurisdiction of three regional districts (Metro Vancouver, Sunshine Coast Regional District, and Squamish-Lillooet Regional District) and the Islands Trust, which is responsible for planning on the islands. In addition, it is the traditional territory of the Coast Salish First Nations, who have resided here for thousands of years. Also of

2 Edwards, 2000.
3 Howe Sound Round Table, 1996, p.41.
4 DFO, 2013.

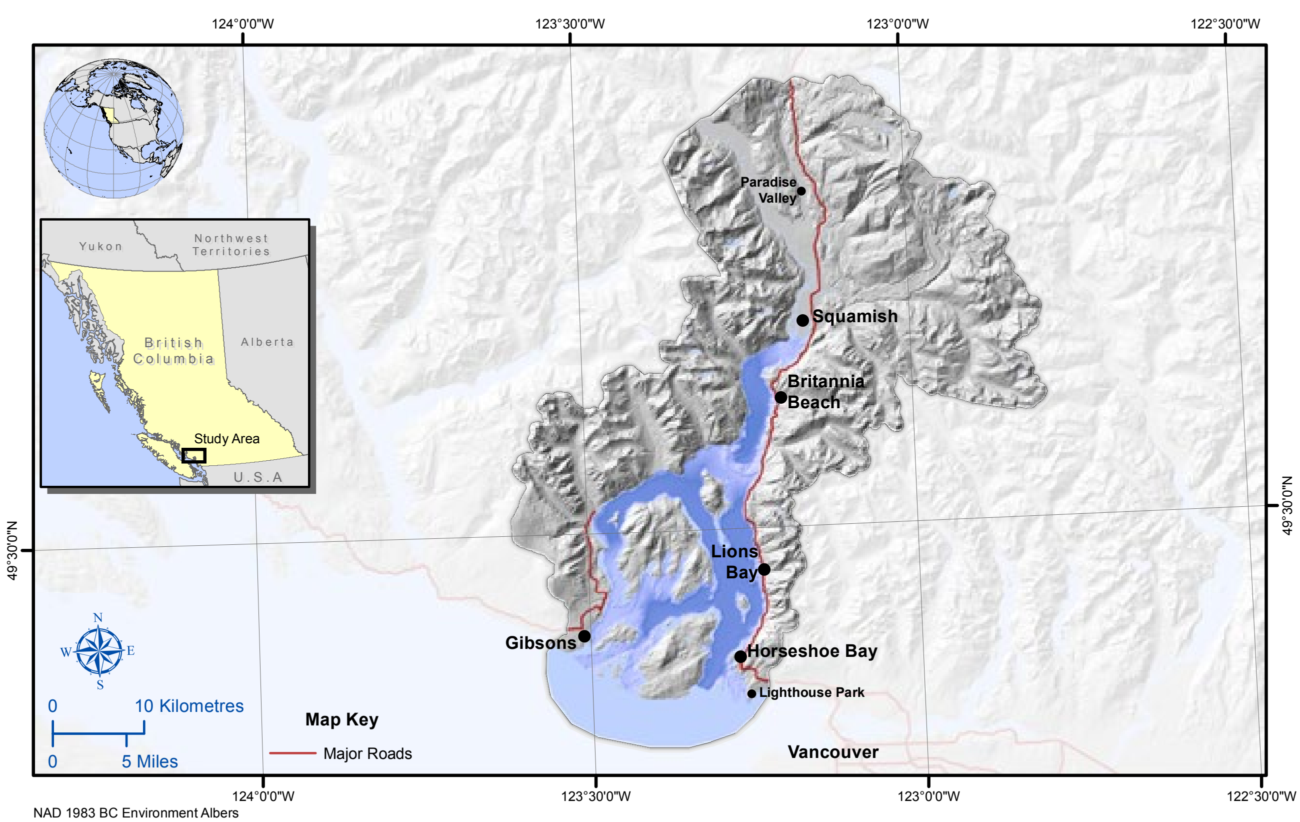
significance is the region's proximity to Vancouver, whose residents not only view it as a recreational destination in their backyard, but also increasingly as a bedroom community given the short commute from some of the towns.

For the purposes of this report, the study region runs from Lighthouse Park, up the eastern coastline of the fjord, past the northern border of Squamish and Paradise Valley, and back down the western coastline to Gibsons. The study area also includes the marine area and islands (see Figure 1). The boundaries were guided by the approximate boundaries of the Squamish watershed or the height of land on the east and west side of Howe Sound.

Of significance is the region's proximity to Vancouver, whose residents not only view it as a recreational destination in their backyard, but also increasingly as a bedroom community given the short commute from some of the towns.

GAMBIER ISLAND PHOTO: KRIS KRÜG

FIGURE 1: HOWE SOUND STUDY AREA



HOWE SOUND / TXWNUWUTS STUDY AREA: This map shows the study area, known as *Howe Sound* to the non-indigenous population or *Txwnuwuts* to the Squamish First Nations. It is recognized as the traditional territory of the Coastal Salish Nations. The area runs from Lighthouse Park, up the eastern coastline of the fjord, past the northern border of Squamish and Paradise Valley, and back down the western coastline to Gibsons. The study area also includes the marine area and islands within.

Population and Economy

COMMUNITY PROFILE

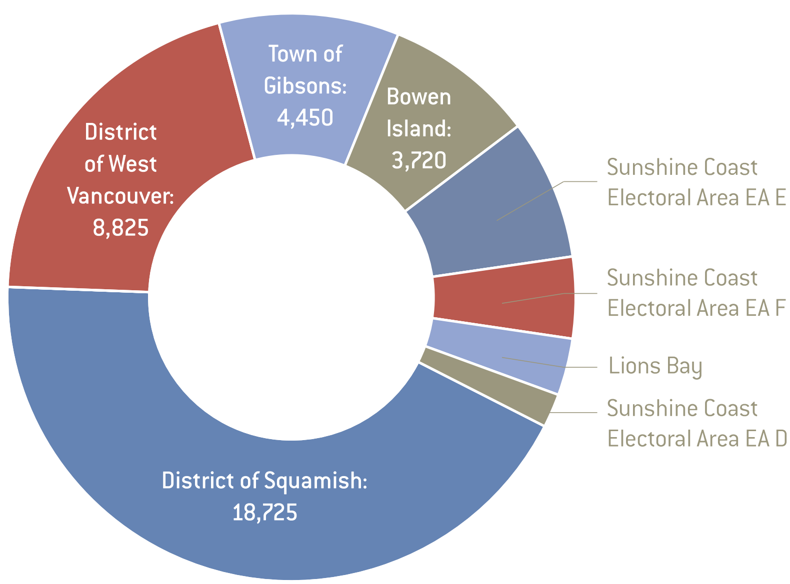
Prior to 1791, when first contact was made between local First Nations and Europeans, Howe Sound was the exclusive home of First Nations as it had been for thousands of years.[5] Many of the island and coastal communities were used as summer outposts, places to hunt, fish and farm. The sound remained outside of the interests of colonists until the 1880s, when Union Steamships and completion of the Canadian Pacific Railway opened the area to settlement and tourism. First Nations people still live throughout the region and maintain their right to have a say on whether or not industrial development proceeds on their lands.

Today the communities of Howe Sound are distinct, ranging from quiet islands to a historic mining town to urban municipalities. Figure 2 shows community populations, totalling approximately 80,000 within Howe Sound. Note that most of West Vancouver lies outside the watershed and only that proportion of the city (about 20 per cent) within the watershed is included in the population figures.[6]

Prior to 1791, Howe Sound was the exclusive home of First Nations people, who still live throughout the region and maintain their right to have a say on whether or not industrial development proceeds on their lands.

SQUAMISH NATION PHOTO: KRIS KRÜG

FIGURE 2: COMMUNITIES OF THE HOWE SOUND STUDY AREA



Source: Compiled from Lionsgate Consulting, 2013.

Most population centres in Howe Sound are small, under 5,000 people. Although these locales are as unique as any community in the province, their identities are all tied to the sound and the quality of life offered here. Although many people commute across the sound daily to work in the Vancouver region, a growing number are working within their communities — an opportunity stemming from the substantial percentage of highly educated, self-employed knowledge workers, artists and artisans living throughout the area. Additionally, the sound has attracted retirees. Compared to provincial averages, the region has a larger share of residents in the over-65 age category and a smaller share of residents in the 20- to 34-year range, signalling an out-migration of young adults, coupled with an in-migration of retirees.

5 BC Spaces for Nature, 2011 (unpublished document).

6 Percentage of West Vancouver within Howe Sound watershed obtained from Howe Sound Round Table, 1996.

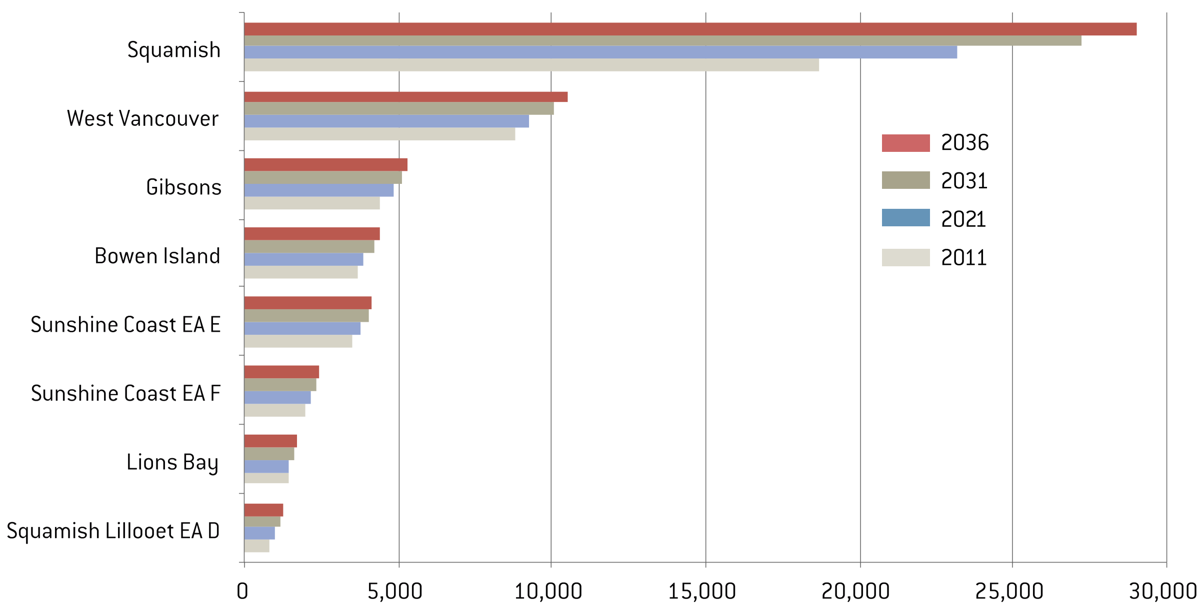
In terms of land use, approximately 85 per cent of the region is Crown land, with the remainder private.[7] Environmental, institutional, industrial and commercial recreation constitute the major land uses, with residential and community uses occupying very little of the Crown land. Unlike most regions in British Columbia, which have undergone Land and Resource Management Planning (LRMP), the majority of Howe Sound has not undergone comprehensive planning. A small part of the region is subject to the Sea-to-Sky LRMP approved in 2008, but most of this is in the Sunshine Coast and Chilliwack forests districts[8], neither of which is subject to an LRMP.

Projections indicate the region's population will grow by 28.2 per cent or to 22,245 between 2011 and 2036, which is just behind the provincial average of 29.9 per cent for the same period.[9] The growth rate varies within the region, with Squamish anticipated to experience higher growth rates than the Sunshine Coast and West Vancouver. Figure 3 shows the projected growth rates for the period 2011 — 2036.

Growth rates vary within the region, with Squamish anticipated to be higher than the Sunshine Coast and West Vancouver.

SQUAMISH PHOTO COURTESY ARNOUD SCHLICK: FLICKR/ CREATIVE COMMONS

FIGURE 3: PROJECTED GROWTH RATES, 2011 – 2036



Source: Lionsgate Report.

Note: Sunshine Coast EA F = Sunshine Coast Electoral Area F; Sunshine Coast EA E = Sunshine Coast Electoral Area E; Squamish Lillooet EA D = Squamish Lillooet Electoral Area D.

7 Lionsgate Consulting, 2013, p. ii.

8 The Chilliwack forest district is bordered by Bowen Island to the west, Manning Park to the east, Boston Bar to the north and the United States border to the south.

9 Lionsgate Consulting, 2013.

HOWE SOUND ECONOMY

The economy of Howe Sound has shifted considerably over the past century. The region has been transformed from the home of the Coast Salish Nations, which maintained a subsistence economy, to later include European settlers who relied heavily upon resource-based industries. Today, the economy is largely shaped by its proximity to Metro Vancouver and is concentrated in service industries.

Following the arrival of European settlers, the economy of Howe Sound developed through resource extraction. Fur trading, forestry, fishing and mining were dominant industries in the early 1900s. By 1950, the area hosted multiple timber companies, log-booming businesses, two pulp mills, the largest copper mine in the British Empire (at Britannia Beach) and commercial salmon, shellfish and shrimp fishing.

In more recent history, the collapse of the salmon fishery and restrictions on the shellfish fishery, the closure of the Britannia mine and Western Forest Products Woodfibre Pulp Mill, and the reduction in forestry have driven the need to develop a more diversified economy. A recent report by BC Stats on local area economic dependencies for the Sunshine Coast and Squamish confirms the decline in primary industry income and points to an increased dependence on tourism and other service industries.[10] Although manufacturing, transportation, forestry, agriculture and fisheries continue to make important contributions in the Sunshine Coast, the growing percentage of other service industries include residential development for retirees and commuters from Vancouver, in addition to jobs in arts, culture, recreation and sports. Another trend found in the local economy is an increase in small businesses, which is likely due to the influx of highly skilled residents who no longer wish to commute to Vancouver. Table 1 below provides more detailed information on the labour force in the region as compared to the province.

The collapse of the salmon fishery and restrictions on the shellfish fishery, the closure of the Britannia mine and Western Forest Products Woodfibre Pulp Mill, and the reduction in forestry have driven the need to develop a more diversified economy.

HOWE SOUND PULP & PAPER
PHOTO COURTESY MICHAEL KANKA/
FLICKR CREATIVE COMMONS

TABLE 1: EXPERIENCED LABOUR FORCE BY OCCUPATION, 2006

Occupation	Study area		BC
	# employed	% of labour force	% of labour force
Management occupations	6,190	16.4%	10.5%
Business, finance and administration occupations	6,765	17.9%	17.1%
Natural and applied sciences and related occupations	2,630	7.0%	6.3%
Health occupations	1,775	4.7%	5.5%
Occupations in social science, education, government service and religion	3,600	9.5%	8.1%
Occupations in art, culture, recreation and sport	2,275	6.0%	3.5%
Sales and services occupations	8,850	23.5%	25.3%
Trades, transport and equipment operators and related occupations	4,225	11.2%	15.5%
Occupations unique to primary industry	915	2.4%	3.9%
Occupations unique to processing, manufacturing and utilities	510	1.4%	4.2%
Total experienced labour force 15 years and over	37,735	100%	100%

Source: Lionsgate Consulting, 2013; Statistics Canada 2007.

10 Horne, 2009.

Being a part of the coastal zone, it is among the most biologically diverse regions of the province — home to 78 per cent of all mammal species, 64 per cent of breeding birds and 67 per cent of freshwater fish.

TOP: SEALS AT PORTEAU COVE
COURTESY GLOBAL VILLAGE CANADA

BOTTOM: EAGLE AT BRACKENDALE
PHOTO COURTESY JDB PHOTOGRAPHY

Regional Biodiversity

Biological diversity is defined as the variability in the number and types of species and the ecosystems they make up. It is measured at gene, population, species, ecosystem and regional levels.[11] For all ecosystems, biodiversity is both a precondition of the flow of ecosystem services and an ecosystem service in itself.[12] It is a precondition because the loss of certain key species can lead to reduced ecosystem function and stability if the remaining species cannot adequately replace the functions they once filled.[13] Furthermore, a damaged ecosystem tends to be more vulnerable to threats and external shocks.[14] Biodiversity is also an ecosystem service in itself because novel products have been derived from the genetic and chemical properties of species, it provides a secure food base (multiple sources of food with different seasonal availability), and people ascribe value to it simply for its existence.

Although there is general consensus on the linkages between biodiversity and ecosystem services, biodiversity is poorly understood. In B.C., the status of only a handful of species is regularly monitored. Many provincial species — 46,200 out of 50,000 — have not had their conservation status assessed because basic information such as provincial distribution is incomplete or unknown.[15] Our knowledge is limited to broad trends and extrapolations based upon the health of indicator species and ecosystems. What we know about the biodiversity of the study area is a mixed story. Being a part of the coastal zone, it is among the most biologically diverse regions of the province — home to 78 per cent of all mammal species, 64 per cent of breeding birds and 67 per cent of freshwater fish.[16] However, provincial studies suggest that coastal biodiversity is declining, particularly in the populated southern portions.[17] While this decline was apparent in Howe Sound, the return of key indicator species, such as herring, salmon and humpback whales, suggests ecosystem health is rebounding.

11 Magurran, 1988.
12 UNEP, 2006.
13 Paine, 1974; Solan et al., 2004.
14 Zavaleta and Hulvey, 2004.
15 Ibid.
16 Ministry of Environment, 2006.
17 Ibid.

The study area falls within two terrestrial biogeoclimatic zones and one marine ecoregion. Both classification systems were developed in B.C. and are biogeographic classifications of patterns of biodiversity. The terrestrial biogeoclimatic zones include Coastal Western hemlock and mountain hemlock. The marine ecoregion is the Georgia Basin. The health of these regions and the species that reside in them vary widely, with some information simply unknown.

TERRESTRIAL & FRESHWATER BIODIVERSITY

The Howe Sound region contains diverse habitat types, which support a variety of wildlife.

CRAB AT PORTEAU COVE PHOTO COURTESY KYLA DUHAMEL/ FLICKR CREATIVE COMMONS

The Howe Sound region contains diverse habitat types (see Figure 4), which support a variety of wildlife. Mountain goats, Columbia black deer, cougars, bobcats, black bears, raptors and small furbearers can be found in the timbered mountain slopes and flat bottomland.[18] The freshwater ecosystems support populations of waterfowl, shorebirds, waders and numerous fish species, most notably juvenile salmon and anadromous trout. The health of these species is highly dependent upon the integrity of the ecosystems in which they reside. Areas of heightened importance include riparian corridors and small streams, the loss or degradation of which can result in a large net loss to overall productivity.[19]

Table 2 provides a snapshot of the health of the terrestrial biogeoclimatic zones. It provides the provincial extent of the zone in square kilometres, the conservation status (which is based on criteria that include rarity, trends and the level of threat from human activity),[20] and the number of species of global and provincial conservation concern. Lastly, the conservation status of ecological communities provides a finer level of detail, through the classification of ecosystems contained within a zone.

The Coastal Western hemlock zone covers over 100,000 square kilometres of B.C. and is the most common biogeoclimatic zone in the study area. Its conservation status is "apparently secure," which indicates some cause for long-term concern; the zone is uncommon but not rare, and widespread where it is found. Although it contains the highest number of species of conservation concern, and lists over 80 per cent of its ecological communities of provincial concern, the shear extent of the zone prevents it from receiving a listing of higher conservation concern. Within the study area, the loss of low-elevation old growth forests is a concern shared by many. What remains of these forests is essential for wildlife corridors and wintering habitat.[21]

The mountain hemlock zone occurs sporadically throughout the study region, primarily inland and at higher elevations of the Lower Mainland. It is listed as "apparently secure," yet only half of the ecological communities within the zone have been assessed. Although the number of species of conservation concern is relatively low, it is likely that many of the species of the zone have not been assessed.

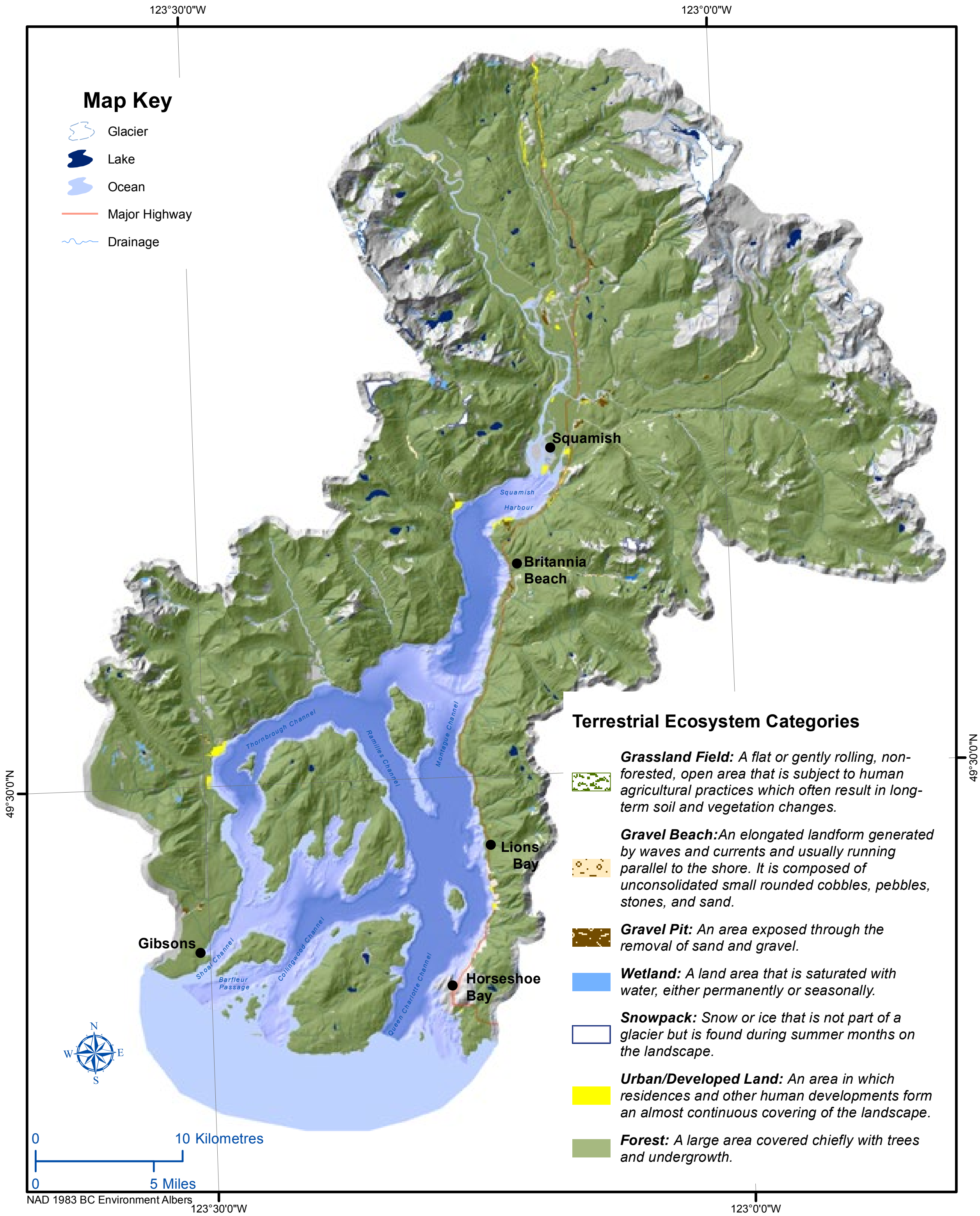
TABLE 2: STATUS OF BIOGEOCLIMATIC ZONES WITHIN THE STUDY AREA

Biogeoclimatic zone	Area (km^2)	Conservation status	Number of species of conservation concern		Status of ecological communities
			Global	Provincial	
Coastal Western Hemlock	102,253	Apparently secure	40	242	100% assessed, of which 83% are of provincial concern
Mountain Hemlock	36,572	Apparently secure	13	45	51% assessed, of which 19% are of provincial concern

Source: Adapted from Austin et al., 2008.

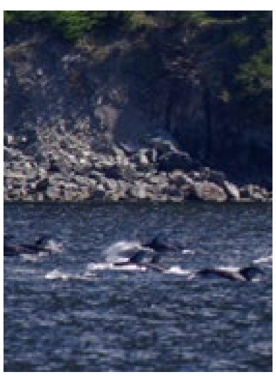
18 Ministry of Environment, 1979.
19 Ibid.
20 Ibid.
21 Howe Sound Round Table, 1996.

FIGURE 4: TERRESTRIAL RESOURCES OF HOWE SOUND



HOWE SOUND TERRESTRIAL ECOSYSTEM: This map, based upon data obtained from the BC Ministry of Environment's Terrestrial Ecosystem Mapping and the BC Ministry of Forest's Vegetation Resources Inventory, shows the distribution of important terrestrial ecosystems within the study area.

The sound's aquatic environments support over 650 different species of fish and invertebrates, including rock cod, salmon, shellfish and herring. Marine mammals include seals, sea lions, dolphins, orcas and humpback whales.



TOP: MUSSELS AT GIBSONS, ZACK LEE
BOTTOM: DOLPHINS AT LIONS BAY, KC DYER
FLICKR CREATIVE COMMONS

AQUATIC BIODIVERSITY

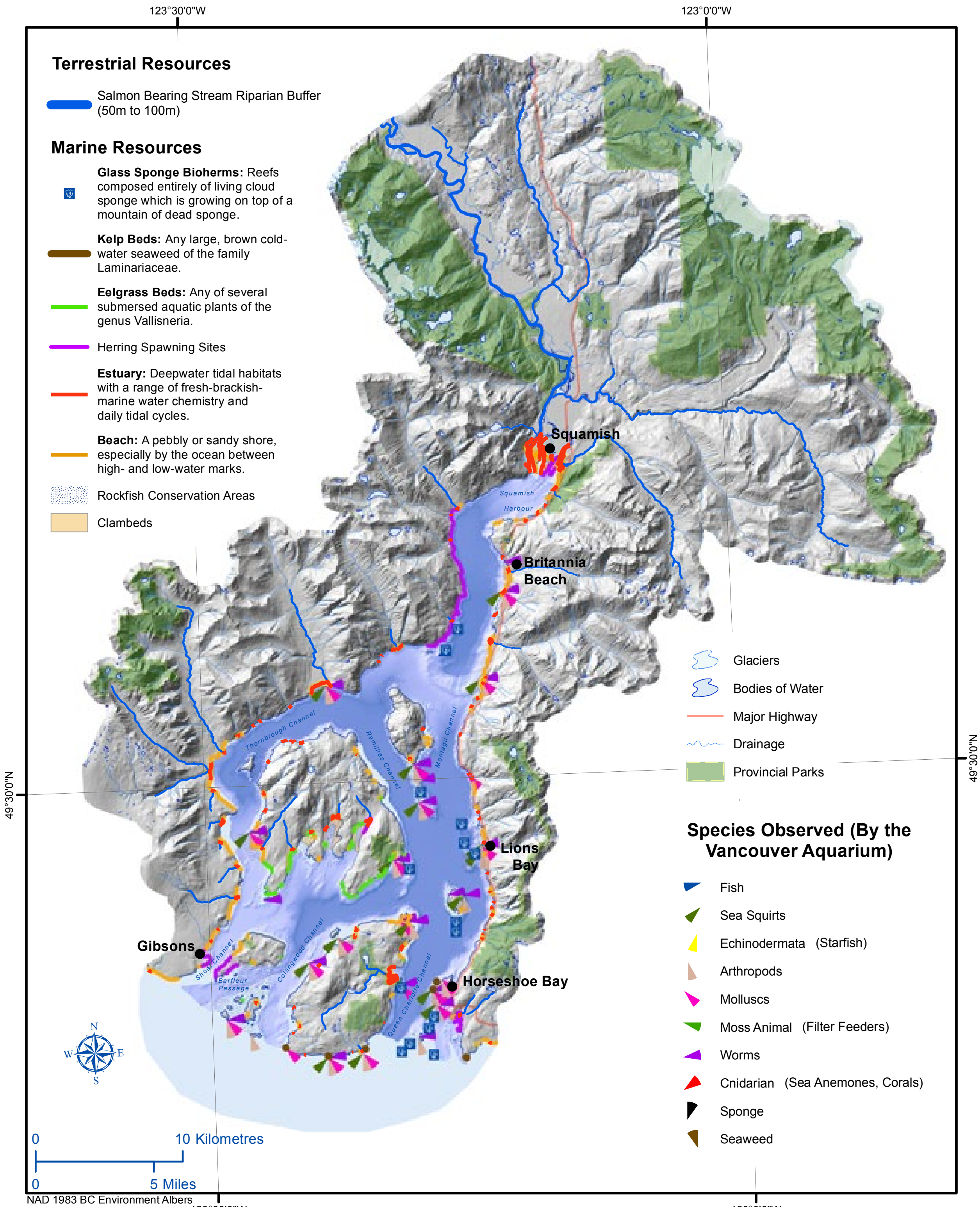
Howe Sound has some natural limitations on productivity due to the natural turbidity of surface waters, the naturally hypoxic (reduced oxygen supply) deep waters of the inner basin and the steep rocky shorelines.[22] The restructuring of shorelines and estuaries over the past half-century, as well as industrial pollution, exacerbated these natural limitations on productivity. Fortunately, those areas unaffected by natural and artificial impacts support well-developed, productive biological communities.

The sound's aquatic environments support over 650 different species of fish and invertebrates, including rock cod, salmon, shellfish and herring.[23] Marine mammals include seals, sea lions, dolphins, orcas and humpback whales. One can estimate the health of the aquatic ecosystems by considering the status of salmon and orcas, which are keystone or indicator species that are sensitive to changes in water quality, trophic webs and pollution levels. The closure of the salmon fishery and rarity of orca sightings over the past few decades appear to fit the classic ecosystem theory that size of organisms declines with degraded ecosystems.[24] To the amazement of all, this trend is reversing. The salmon fishery has re-opened, orcas have returned and humpback whales have been sighted.

Estuaries, kelp forests and eelgrass meadows are vital ecosystems to aquatic species and crucial to the maintenance of fishery resources. The Squamish estuary accounts for 96 per cent of estuarine habitat in the sound, providing habitat, rearing areas and food for the migrating anadromous fish populations of six river systems (the Squamish, Mamquam, Cheakamus, Elaho, Ashlu and Stawamus).[25] The brackish waters of the estuary also acclimatize seagoing salmonids to the salt levels of the Pacific Ocean. Likewise, the nearshore kelp and eelgrass beds provide intertidal and subtidal habitat for invertebrates, fish, birds and mammals.[26] Figure 5 shows the locations of several significant species.

22 Ibid.
23 BC Spaces for Nature, 2011.
24 Levings et al., 1992.
25 Ministry of Environment, 1979.
26 Ibid.

FIGURE 5: MARINE RESOURCES IN HOWE SOUND



HOWE SOUND MARINE RESOURCES: This map, based upon data obtained from the Department of Fisheries and Oceans, BC Ministry of Environment (Ecosystem Branch), Islands Trust, and the Vancouver Aquarium, shows the distribution of important marine ecosystems within the study area.

Threats to Regional Biodiversity

> "It seems clear that, while the Sound remains in a productive and diverse marine environment, it has changed to a less desirable state."
>
> — L.E. Harding, from Levings et al., 1992.

Threats to the biodiversity of Howe Sound include industrial impacts, indirect threats of climate change and the cumulative impacts of these threats. The legacy of past industrial impacts still remains. Biological communities that exist near the closed pulp mills and the Britannia mine have been greatly modified. Mussels and oysters exhibited increasing levels of heavy metals in the 1990s, and mercury from the chlor-alkali plant caused the closure of some fisheries. While many of these threats are receding, thanks to decades of recovery efforts, new threats are emerging.

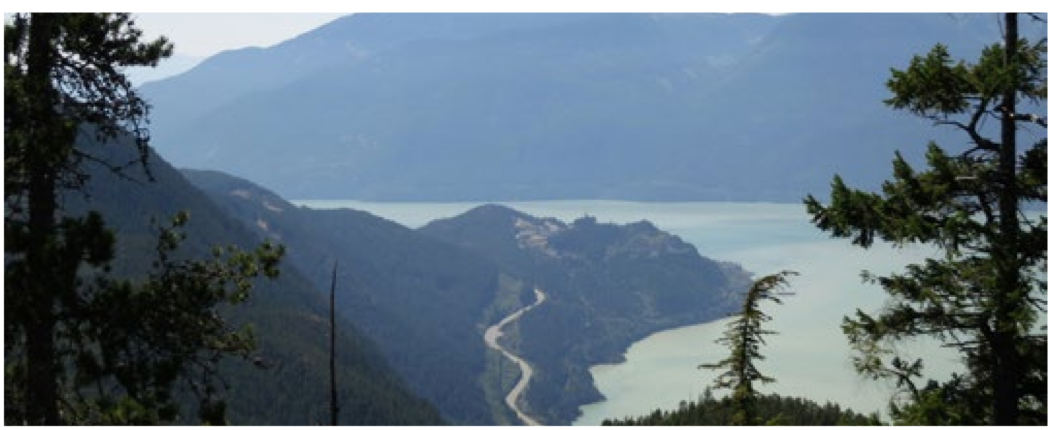
Government is currently considering over $2 billion in industrial projects in the Howe Sound fjord. Proposals are underway for an aggregate (gravel) mine in McNab Creek, a liquefied natural gas (LNG) plant in Woodfibre, logging allowances on Gambier Island and a waste incinerator in Port Mellon. These potential industrial projects will be situated along the western coastline of the study area (see Figure 6). Under various stages of consideration, these industrial infrastructures could compromise the marine revival that has been so recently and delicately accomplished by public and private efforts.

Threats to the biodiversity of Howe Sound include industrial impacts, indirect threats of climate change and the cumulative impacts of these threats.

TOP: LOGS AT SQUAMISH
BOTTOM: SEA TO SKY HIGHWAY
RUTH HARTNUP/FLICKR
CREATIVE COMMONS

In response, communities of the sound are calling for coordinated planning. In September 2013, the Union of British Columbia Municipalities (UBCM) passed a resolution, forwarded by 18 municipal and regional district representatives of the sound, to "urge the provincial government to support the development of a Comprehensive Management Plan for Howe Sound that facilitates a coordinated land and marine use planning process between First Nations, senior and local governments, and other local bodies to ensure ongoing recovery and responsible land use planning within Howe Sound."[27]

The impacts to biodiversity from a growing human population and proposed industrial projects are exacerbated by climate change, which threatens to increase fire and insect outbreaks and bring about ecological shifts that may occur at a faster pace than species can adapt to.[28] A recent publication documenting over 40 years of taxonomic monitoring of the shallow seawaters provides clues to the speed and extent of climate change impacts in the study region.[29] The study findings are encouraging, showing biodiversity of the shallow seabed to be relatively stable over time, with seaweeds experiencing the greatest shifts. This good news should be tempered with our experience and knowledge of how the sound's ecosystems can shift and how we can influence those shifts.

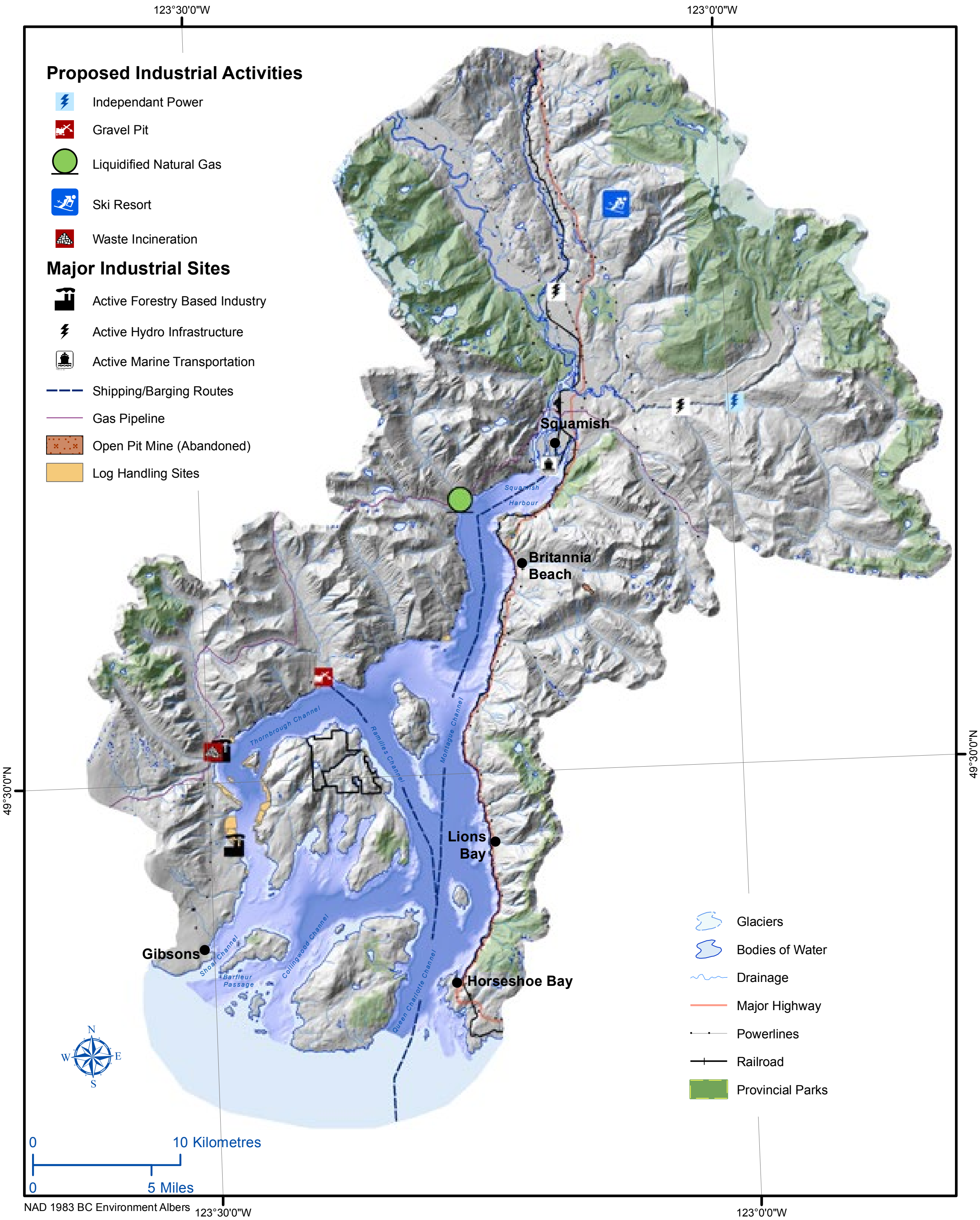


27 Ministry of Community, Sport and Cultural Development, 2014.

28 McKenzie et al., 2004; Opdam and Wascher, 2004.

29 Marliave et al., 2011.

FIGURE 6: PROPOSED INDUSTRIAL ACTIVITIES IN THE STUDY AREA

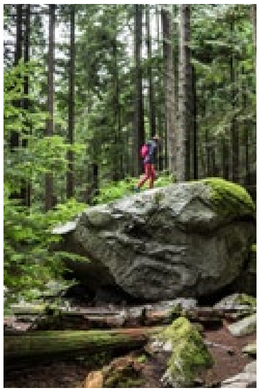


CURRENT AND POTENTIAL INDUSTRIAL ACTIVITY WITHIN HOWE SOUND: This map shows the location of some of the major industries around Howe Sound that are still active, as well as future sites such as the proposed LNG site at Woodfibre and the proposed independant power producers.

PART 3

Methodology

Natural Capital Valuation Framework



These ecosystem services can be further broken down into sub-categories: for example, recreation contains boating, fishing, birding, hiking, swimming and other activities.

PHOTOS: KRIS KRÜG

Within the past decade, considerable progress has been made to systematically link functioning ecosystems with human well-being. Work completed by de Groot et al. (2002), the Millennium Ecosystem Assessment (UNEP, 2005) and The Economics of Ecosystems and Biodiversity (TEEB, 2010) have marked key advancements in this task. Although all recognize that the linkages are a simplification of reality and consequently further research and refinement is needed, their studies have provided a conceptual framework for valuing natural capital and its related (ecosystem) goods and services.

The TEEB framework has been adopted for this study. The typology classifies ecosystem goods and services into four groups, including provisioning, regulating, habitat and cultural. Table 3 provides a brief explanation of the groups, as well as examples of services. It should be kept in mind that these services can be further broken down into sub-categories; for example, recreation contains boating, fishing, birding, hiking, swimming and other activities. Every year, ecosystem services are added to the more detailed categories.

ESTIMATING VALUES FOR ECOSYSTEM SERVICES

Economists have developed a number of techniques for putting dollar values on the non-market goods and services provided by ecosystems. Different approaches are used depending upon the ease of obtaining direct measures of the flow of ecosystem services. There is no universal best approach. An approach that is suitable to assess the health of one service — for instance, the market cost of artificially providing flood mitigation — may not be appropriate for others. The techniques can be grouped into three broad categories: 1) direct market valuation approaches; 2) revealed preference approaches; and 3) stated preference approaches.[30] Direct market valuation methods derive estimates of ecosystem goods and services from related market data. Revealed preference methods estimate economic values for ecosystem goods and services that directly affect the market prices of some related good, and stated preference methods obtain economic values by asking

30 Pascual and Muradian, 2010.

TABLE 3: TEEB TYPOLOGY FOR ECOSYSTEM SERVICES	
Service	Definition
PROVISIONING SERVICES provide basic materials, mostly ecosystem service goods. Forests grow trees that can be used for lumber and paper, berries and mushrooms for food, and other plants for medicinal purposes. Rivers provide fresh water for drinking and fish for food.	
Drinking water	Water for human consumption.
Food	Biomass for human consumption.
Raw materials	Biological and geological materials used for fuel, art and building.
Medicinal resources	Biological materials used for medicines.
REGULATING SERVICES are benefits obtained from the natural control of ecosystem processes. Intact ecosystems provide regulation of climate, water and soil, and keep disease organisms in check.	
Gas and climate regulation	Regulation of greenhouse gases, absorption of carbon and sulphur dioxide, and creation of oxygen, evapotranspiration, cloud formation and rainfall provided by vegetated and oceanic areas.
Disturbance regulation	Protection from storms and flooding, drought recovery.
Soil erosion control	Erosion protection provided by plant roots and tree cover.
Water regulation	Water absorption during rains and release in dry times, temperature and flow regulation for plant and animal species.
Biological control	Natural control of pest species.
Water quality and waste processing	Absorption of organic waste, filtration of pollution.
Soil formation	Formation of sand and soil through natural processes.
Nutrient cycling	Transfer of nutrients from one place to another, transformation of critical nutrients from unusable to usable forms.
Pollination	Fertilization of plants and crops through natural systems.
HABITAT SERVICES relate to the refuge and reproductive habitat ecosystems provide to wild plants and animals. Intact ecosystems provide commercially harvested species, and the maintenance of biological and genetic diversity.	
Habitat	Providing for the life-history needs of plants and animals.
Primary productivity	Growth by plants provides basis for all terrestrial and most marine food chains.
CULTURAL SERVICES provide humans with meaningful interaction with nature. These services include spiritually significant species and natural areas, natural places for recreation and opportunities to learn about the planet through science and education.	
Aesthetic	The role natural beauty plays in attracting people to live, work and recreate in an area.
Recreation and tourism	The contribution of intact ecosystems and environments in attracting people to engage in recreational and tourist activities.
Scientific and educational	Value of natural resources for education and scientific research.
Spiritual and religious	Spiritual and religious use of nature for religious or historic purposes.

Source: Compiled from Daly and Farley, 2004; de Groot, 2002; and TEEB, 2009.

people to make trade-offs among sets of ecosystem or environmental services or characteristics.[31] Table 4 provides descriptions of generally accepted techniques.

TABLE 4: VALUATION METHODS USED TO VALUE ECOSYSTEM SERVICES IN PRIMARY STUDIES

Valuation method	Description
DIRECT MARKET VALUATION APPROACHES	
Market prices	Estimates the economic value of ecosystem goods and services that are bought and sold in markets. For example, the value of subsistence food can be based upon the market value of commercially available food.
Replacement cost	Estimates value of ecosystem services based on the costs of replacing ecological services or the cost of providing substitute services. For example, waste treatment provided by wetlands can be replaced with built treatment systems.
Avoided cost	Estimates value of ecosystem services based on the cost that would have been incurred in the absence of these services. For example, storm protection provided by barrier islands avoids property damages along the coast.
Production approaches	Estimates values of ecosystem services based on the economic value of the service that contributes to the production of market goods. For example, water-quality improvements increase commercial fisheries catch and therefore fishing incomes.
REVEALED PREFERENCE APPROACHES	
Opportunity cost	Estimates value of ecosystem services based on the next best alternative use of resources. For example, travel time is an opportunity cost of travel because this time cannot be spent on other pursuits.
Travel cost	Estimates value of ecosystem service based on economic use values associated with an ecosystem. For example, recreation areas can be valued at least by what visitors are willing to pay to travel to it, including the imputed value of their time.
Hedonic pricing	Estimates value of ecosystem service based on ecological services that directly affect market prices. For example, housing prices along the coastline tend to exceed the prices of inland homes.
STATED PREFERENCE APPROACHES	
Contingent valuation	Estimates value of ecosystem service by posing hypothetical scenarios that involve some valuation of alternatives. For instance, people generally state that they are willing to pay for increased preservation of beaches and shoreline.
Group valuation	Estimates value of ecosystem service through discourse-based contingent valuation, which results from bringing a group of stakeholders together to discuss societal values. For example, a First Nations group comes together to discuss the cultural values of an area.
Conjoint analysis	Estimates value of ecosystem services by asking people to rank different service scenarios or ecosystem conditions. For example, choosing between different tax increases for varying levels of flood protection associated with wetland remediation efforts.

Economists have developed a number of techniques for putting dollar values on the non-market goods and services provided by ecosystems. Different approaches are used depending upon the ease of obtaining direct measures of the flow of ecosystem services. There is no universal best approach.

PHOTO:KRIS KRÜG

31 Daly and Farley, 2004.

BENEFIT TRANSFER

The benefit-transfer approach was used for valuing a range of services in this study. Benefit transfer can be used to evaluate non-market ecosystem services by transferring existing benefit estimates from primary studies already completed for another study area.[32] When using this method, care must be taken to ensure values being transferred exhibit similarities within the specific ecosystem good or service characteristics.

A combination of in-house calculations and transferred studies has been used in this report. This combination of studies was necessary due to the lack of primary valuation studies in the study area. In addition, because ecosystem services are physically different and more or less amenable to markets, a variety of different valuation techniques are required. By utilizing such an approach, great cost and time can be saved. Existing studies were required to meet a set of three criteria to be included in this valuation.

- All primary studies included a peer-review process. The vast majority of primary studies were drawn from academic journals, but we also include commissioned reports for governments and non-profit organizations, and graduate dissertations.
- Primary study locations were restricted to North America. This ensured similar demographics and ecosystem characteristics. We made two exceptions: we included studies that adopted global averages for nutrient cycling and gas and climate regulation, since both of these processes occur on a global scale.
- Primary studies met methodology recommendations. We based our methodology recommendations upon Farber et al., 2006, but made adjustments for those services not included (e.g., habitat refugium and nursery and educational values), valuation methods not considered (e.g., opportunity cost), and valuation methods that are gaining wider acceptance.

Benefit transfer can be used to evaluate non-market ecosystem services by transferring existing benefit estimates from primary studies already completed for another study area.

TABLE 5: VALUATION METHOD USED BY BENEFIT TYPE

Ecosystem service	Valuation approach	Recommended valuation method	Transferability across sites
Food provisioning	In-house calculation	M, P	High
Fresh water	Benefit transfer	AC, RC, M, TC, **CV, OC**	Medium
Disturbance regulation	Benefit transfer	AC, **RC, H**	Medium
Nutrient cycling	Benefit transfer	CV, AC, **RC, P**	Medium
Gas and climate regulation	In-house calculation & benefit transfer	CV, AC, RC	High
Clean air	In-house calculation & benefit transfer	AC	Medium
Waste processing	Benefit transfer	RC, AC, CV	Medium – high
Habitat	Benefit transfer	CV, P, AC, H, **OC**	
Tourism and recreation	Benefit transfer	TC, CV, H, OC	Low
Education	In-house calculation	TC	

Note: AC = avoided cost; CV = contingent valuation; H = hedonic pricing; M = market pricing; P = production approach; RC = replacement cost; TC = travel cost; OC = opportunity cost. **Bold** = Valuation method added by author.

Source: Adapted from Farber, et al., 2006.

32 Daly and Farley, 2004.

Study Limitations

Valuation exercises have limitations that must be noted, although these should not detract from the core finding that ecosystems produce significant economic value to society. These concerns can be divided into general limitations, limitations of benefit transfer, GIS limitations and primary study limitations.

It is clear from inspection of the tables that the final estimates are not extremely precise. However, they are much better estimates than the alternative of assuming that ecosystem services have zero value or, alternatively, of assuming they have infinite value.

PHOTO: KRIS KRÜG

Natural capital valuations have a narrow focus. By adopting an economic perspective, they focus on the value of functioning ecosystems to *people*, and do not consider intrinsic values. In addition, gaps in knowledge about ecosystem interdependencies and dynamics must be recognized. The existence of trade-offs among ecosystem services (e.g., using forests for lumber means you can't use them for carbon storage) implies that values should not be added together. Although this report presents a static analysis — a "snapshot" value at one point in time — it is more useful when considered alongside information on ecosystem trends and used in combination with other tools to inform decision-making.

The remaining limitations relate to the accuracy of the data informing the study. The quality and accuracy of primary studies, as well as the accuracy of GIS data, will impact study results. As employed here, the studies we analyzed encompass a wide variety of time periods, geographic areas, investigators and analytic methods. Many provide a range of estimated values rather than single-point estimates. The present study preserves this variance; no studies were removed because their estimated values were deemed to be "too high" or "too low," although studies that used antiquated methods and data were removed.

In this report, we have displayed our study results in a way that allows one to appreciate the range of values and their distribution. It is clear from inspection of the tables that the final estimates are not extremely precise. However, they are much better estimates than the alternative of assuming that ecosystem services have zero value or, alternatively, of assuming they have infinite value. Pragmatically, in estimating the value of ecosystem services, it seems better to be approximately right than precisely wrong.

PART 4

Ecosystem Services of Howe Sound

Food Provisioning

> *"I'm 43 years old, and I grew up here. I remember herring boats coming into the Sound. As kids we used to jig them. We would just drop a line with three hooks on it and pull the fish out. We'd go home with half a bucket of fish in just a couple hours of fishing."*
>
> *— comments from a long-term resident in Howe Sound Round Table, 1996.*

Healthy ecosystems provide the conditions necessary for growing food. While Howe Sound doesn't support large areas of agro-ecosystems, it does support marine and freshwater fisheries. Historically, the region was a major harvest area for salmon — in particular, chum, pink and chinook salmon — herring, shellfish, shrimp and rockfish. Commercial, recreational and First Nations fisheries not only fed the local population, but they were also a key economic driver of the sound, with products shipped across the country and, in the case of salmon, around the world.

The health of fisheries experienced a precipitous drop beginning the mid-1900s. The commercial salmon fishery closed in 1963, herring stopped spawning in 1969, the commercial shellfish fishery closed in 1988 and recreational catch limits were imposed for salmon and rockfish.[33] The effects rippled throughout the sound. In addition to the direct impact on commercial fisheries employment, sports fishing charters experienced significant drops in business, and residents — particularly First Nations — for whom fishing was a way of life, had no choice but to adjust.

With the recent return of ecologically valuable species, most notably herring and salmon, our understanding of the causes behind fisheries decline and areas of significance in Howe Sound is advancing. In addition to fisheries closures, pollution-remediation efforts ranging from a water-treatment plant to the wrapping of creosote-covered wood pilings, and a management plan for the Squamish Estuary have assisted in the return of healthy schools of herring and re-opening of the commercial salmon fishery. The recovery of fisheries will require continued vigilance in terms of controlling and monitoring marine and freshwater pollution, fisheries catch levels and protection of sensitive areas, such as streams, estuaries and eelgrass beds, which are key nursery areas for several species.

While Howe Sound doesn't support large areas of agro-ecosystems, it does support marine and freshwater fisheries.

TOP PHOTO: CAMP FIRCOM, GAMBIER ISLAND PHOTO KRIS KRÜG. BOTTOM: GIBSONS HARBOUR, PHOTO REBECCA BOLLWITT/FLICKR CREATIVE COMMONS

33 Howe Sound Round Table, 1996.

While commercial fisheries and aquaculture have a well-established market value, the value of recreational and First Nations subsistence fisheries have no market value. The non-market value of First Nations and recreational fisheries were estimated through primary research for the purposes of this report.[34] Landing prices from commercial fisheries were transferred to catch data for approximately 20 recreational and subsistence fisheries within Pacific Management Area 28. By transferring the per hectare value of $0.67 to the marine region, we arrived at a total value of approximately $95,073 per year in non-market food provisioning. This value is likely an underestimate as the data represent only what has been reported and recorded from 2001 to 2010, which does not capture the re-opening of salmon fisheries and their associated non-market values.

The recovery of fisheries will require continued vigilance in terms of controlling and monitoring marine and freshwater pollution, fisheries catch levels and protection of sensitive areas.

SALMON FISHING ON THE SQUAMISH RIVER, PHOTO COURTESY DARREN BAREFOOT/ FLICKR CREATIVE COMMONS

TABLE 6: STUDIES USED TO VALUE FOOD PROVISIONING

Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
MARINE			
In-house calculation (based on 2001-2010 DFO data)	Pacific management Area 28	Production approach	$0.67

Clean Water

Watersheds provide fresh water for human consumption, agriculture and industry. The ecosystem service of clean water refers to the benefits associated with the filtering, retention and storage of water that occurs primarily in forests, streams, lakes and aquifers of watersheds. These ecosystems trap and retain nutrients and pollutants, effectively cleaning or purifying water. The increasing loss of forest cover and wetlands around the world has decreased water supply, due to lower groundwater recharge and to lower flow reliability.[35]

The study area's drinking water comes from streams, rivers and aquifers. The southern mainland area benefits from Metro Vancouver's large, protected watersheds (the Lower Seymour and Capilano watersheds) that are capable of supplying more than two million people in the Lower Mainland with water that is naturally filtered. The remainder of the region relies on surface waters and aquifers, some of which have persistent water-shortage problems. On the mainland, Squamish has experienced leaking reservoirs,[36] Britannia Beach is grappling with inadequate water supplies for a growing population[37] and Gibsons is trying to gain understanding of the capacity, operation and boundary limits of its aquifer.[38] On the islands, the main concern is water storage. With the majority of rainwater flowing to the sea, only a small amount makes it to lakes and wetlands to recharge the limited zone of fresh groundwater.[39]

The value of water supply is estimated for four land/water classes, including estuaries, forests, lakes and rivers, and wetlands. Table 7 lists the primary studies used to develop the range of values, including the study location, methodology and per hectare value in 2014 Canadian dollars. A number of authors estimated the value of water supply by surveying residents on their willingness to pay for cleaner water (e.g., Bockstael et al., Croke et al., Pate and Loomis, Hauser and van Kooten, and Whitehead et al.). Others used travel cost methods, which examine the value of improvements in water quality through travel expenditures (e.g., Ribaudo and Epp; Creel and Loomis). Wilson uses avoided cost to value water supply by comparing the cost

34 Catch data for First Nations and recreational fisheries were obtained from the Department of Fisheries and Oceans for the period 2001-2010.

35 Syvitski, 2005.

36 Raldous, 2012.

37 Ghuman, 2013.

38 Town of Gibsons, 2014.

39 Watershed Sentinel, 2005.

of naturally filtered water with that of an alternative water source. Gupta and Foster, who used the opportunity cost method to compare the cost of wetland water with that of an alternative water source, provided the highest value for the service of water supply. Further details of the primary studies can be found in Appendix B, which provides an annotated bibliography of all studies used. The total value for water supply services in Howe Sound ranges from approximately $300 million to $770 million per year.

The ecosystem service of clean water refers to the benefits associated with the filtering, retention and storage of water that occurs primarily in forests, streams, lakes and aquifers of watersheds.

STREAM ON THE CHIEF TRAIL, PHOTO COURTESY KUTBI_0/ FLICKR CREATIVE COMMONS

TABLE 7: STUDIES USED TO VALUE CLEAN WATER PROVISIONING

Author(s) and date of study	Location of study	Methodology	Value/hectare/year (2014 C$)
ESTUARY			
Bockstael, N.E., et al., 1989	Baltimore-Washington	Contingent valuation	$239 – $425
Whitehead, J.C., et al., 1997	North Carolina	Contingent valuation	$19 – $72
FOREST			
Ribaudo., M. and Epp, D.J., 1984	St. Albans Bay, Vermont	Travel cost	$4,449 – $5,601
Wilson, S.J., 2010	British Columbia	Replacement cost	$2,216 (no range)
LAKES/RIVERS			
Bouwes, N.W. and Scheider, R., 1979	Pike Lake, Wisconsin	Travel cost	$2,052 (no range)
Croke, K., et al., 1986	Chicago	Contingent valuation	$1,880 (no range)
Ribaudo., M. and Epp, D.J., 1984	St. Albans Bay, Vermont	Travel cost	$2,803 (no range)
WETLAND			
Creel, M. and Loomis, J., 1992	California	Travel cost	$1,803 (no range)
Gupta, T.R., and Foster, J.H., 1975	Massachusetts	Opportunity cost	$5,640 – $39,480
Hauser, A. and van Kooten, C., 1993	Abbotsford, B.C.	Contingent valuation	$120 – $487
Hayes, K.M., et al., 1992	Rhode Island	Contingent valuation	$4,492 – $6,983
Pate, J. and Loomis, J., 1997	California	Contingent valuation	$11,957 (no range)
Wilson, S.J., 2010	Lower Mainland Watershed, B.C.	Avoided cost	$2,216 (no range)

Disturbance Regulation

Estuaries and bays, coastal wetlands, headlands, seagrass beds, rock reefs and kelp forests provide protection from storms, storm surges, tsunamis and other disturbances. These ecosystems are able to absorb and store large amounts of rainwater or water runoff during a storm, in addition to providing a buffer against coastal waves and high winds. Estuaries, bays and wetlands are particularly important for absorbing floodwaters.[40]

Changes in land use to accommodate a growing population, combined with the potential for higher frequency storm events due to climate change, make this service one of the most important for economic development in Howe Sound. Maintaining the land's absorptive capacity through retention of forest cover and restoration of floodplains and wetlands will mitigate the impacts of extreme weather, reducing property and infrastructure damage, lost work time, injury and loss of life.

While many areas within the study area are naturally protected from extreme weather by steep cliffs, most communities lie close to shore and are vulnerable to flooding and storm surges. For instance, Britannia Beach experienced severe flooding in 1991, causing the Sea to Sky Highway to close for 36 hours, with damage estimates of $7 to $11 million ($12 to $19 million in 2014 dollars).[41] Bank erosion, channel erosion and slide debris associated with mining road construction were hypothesized as leading factors in the flooding.[42] And in 2003, Squamish — another community familiar with flooding — experienced flooding that cost approximately $40 million ($70 million in 2014 dollars) and directly affected 800 people.[43]

Estuaries and bays, coastal wetlands, headlands, seagrass beds, rock reefs and kelp forests provide protection from storms, storm surges, tsunamis and other disturbances.

The value of disturbance regulation was estimated for four land classes: beach, forest, riparian buffer and wetlands. The studies we drew from used avoided cost and hedonic pricing methodologies to value the service of disturbance regulation (see Table 8). The hedonic approach studies measured the value of beaches for storm protection through price differentials (Parsons and Powell; Pompe and Rinehart), whereas the avoided cost studies estimated the value of wetlands for flood protection by surveying the amount of flood damage avoided when wetlands are left intact (Rein; Wilson; U.S. Army Corps).

The total value of disturbance regulation services in Howe Sound ranges from approximately $98 million to $250 million per year. We found beaches to be the highest per hectare value land class for disturbance regulation.

ESTUARY PHOTO COURTESY JORDAN DAWE/FLICKR CREATIVE COMMONS

40 Costanza et al., 2008; UNEP, 2005.

41 Levings et al., 1992.

42 Ibid.

43 Gardner, 2011.

TABLE 8: STUDIES USED TO VALUE DISTURBANCE REGULATION			
Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
BEACH			
Parsons, G.R. and Powell, M., 2001	Delaware	Hedonic pricing	$73,811 (no range)
Pompe, J.J. and Rinehart, J.R., 1995	North Carolina	Hedonic pricing	$170 – $450
FOREST			
Wilson, S.J., 2010	Lower Mainland, B.C.	Avoided cost	$719 – $1,756
RIPARIAN BUFFER			
Rein, F.A., 1999	Elkhorn Slough, Monterey Bay, California	Avoided cost	$25 – $783
WETLAND			
U.S. Army Corps, 1971	Charles River, Massachusetts	Avoided cost	$1,212
Leschine, T.M., et al., 1997	Washington State	Avoided cost	$1,620 – $7,398

Nutrient Cycling

There are 22 elements essential to the growth and maintenance of living organisms. While some of these elements are needed only by a small number of organisms, or in small amounts in specific circumstances, all living things depend on the nutrient cycles of carbon, nitrogen, phosphorous and sulphur in relatively large quantities. These are the cycles that human actions have most affected.[44] Silicon and iron are also important elements in ocean nutrient cycles because they affect phytoplankton community composition and productivity. Living things facilitate the movement of nutrients between and within ecosystems and turn them from biologically unavailable forms, such as rocks or atmospheric gases, into forms that can be used by other forms of life. Without functioning nutrient cycles, life on this planet would cease to exist.

The loss or degradation of forests, riparian areas, and wetlands has had a significant impact upon nutrient cycles, as they are no longer able to trap and retain nutrients that would otherwise run off into streams and rivers, and ultimately into the ocean. Likewise, the reduction in the numbers of large animals, which move nutrients in the form of excrement, and through the decomposition of their bodies after death, has affected nutrient cycling. Species such as the black bear, the coastal blacktail deer and Roosevelt elk in the study area perform this service. Of particular importance to this region are salmon, which return nutrients from the open Pacific Ocean to coastal rivers and forests. Research conducted at the University of Victoria (B.C.) has found the nitrogen of salmon can be tracked throughout entire forest ecosystems on the coast.[45]

The total value of nutrient cycling in the study area was estimated to range from approximately $19,000 to $50,000 per year. We were able to estimate the value of this service for estuaries and eelgrass beds using the production approach and replacement cost method. Newell et al. employed an innovative approach to arrive at a value for nutrient cycling. They estimated the possible effect of stocks of sub-tidal eastern oysters on the watershed-level nitrogen and phosphorus budgets for the Choptank River (U.S.). The authors assessed the cost of alternative ways of obtaining these same nutrient reductions. Costanza et al. estimated the

The loss or degradation of forests, riparian areas, and wetlands has had a significant impact upon nutrient cycles, as they are no longer able to trap and retain nutrients that would otherwise run off into streams and rivers, and ultimately into the ocean.

STRAWBERRIES BY THE STREAM
PHOTO COURTESY RUTH HARTNUP/
FLICKR CREATIVE COMMONS

44 Rockstrom et al., 2009.
45 Reimchen, 2001.

value of eelgrass beds for nutrient cycling by calculating the replacement cost to remove nitrogen and phosphorus. We found eelgrass beds to be the highest per hectare value land class for this service, ranging in value from $18,000 to $51,000 per hectare per year.

TABLE 9: STUDIES USED TO VALUE NUTRIENT CYCLING

Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
ESTUARY			
Newell, R.I.E., et al., 2005	Chesapeake Bay, U.S.	Production approach	$281 (no range)
EELGRASS BEDS			
Costanza, R., et al., 1997 (based on Daily, G. 1997)	Global estimate	Replacement cost	$18,299 – $51,242

Gas and Climate Regulation

During the sequestration of carbon dioxide, trees, marine algae and seaweeds use photosynthesis to convert carbon dioxide into biomass, organic matter used to fuel the plant. This sequestration contributes to the "flow" of carbon.

HOWE SOUND FROM ST. MARK'S SUMMIT, PHOTO COURTESY TIM GAGE/ FLICKR CREATIVE COMMONS

CARBON SEQUESTRATION

The service of carbon sequestration refers to the removal of carbon dioxide (CO_2) from the atmosphere (gas regulation). During the sequestration of carbon dioxide, trees, marine algae and seaweeds use photosynthesis to convert carbon dioxide into biomass, organic matter used to fuel the plant. This sequestration contributes to the "flow" of carbon.

New research is revealing that the ocean's vegetated habitats rank among the most intense carbon sinks on the planet.[46] Similar to forests, aquatic environments such as mangroves, salt marshes and seagrasses are incredibly productive at sequestering carbon, but they do so much more efficiently — up to 90 times the uptake for a comparative area. Coastal wetlands sequester carbon within standing biomass, but significantly more is stored within soils, which can remain undisturbed for thousands, if not millions, of years. Currently, CO2 emissions and sequestration associated with coastal wetlands are not accounted for in national greenhouse gas (GHG) inventories. Incentives for restoration or disincentives for degradation of coastal marine ecosystems do not exist in international climate change policy frameworks.

In this report, the value of carbon sequestration was calculated for three land/water classes: forests, eelgrass beds and estuaries (see Table 10). Sequestration rates were identified from several recent publications on the value of aquatic ecosystems for carbon removal. The value used for sequestered carbon was from the Intergovernmental Panel on Climate Change (IPCC) at $60.97 Canadian 2014 per tonne per hectare per year (an average within a large range from voluntary and enforced markets), meaning, for every tonne of carbon released into the atmosphere it costs the economy $60.97 in physical, social and natural capital annually to offset the damage done by undesirable carbon dioxide levels. The dollar value attributed to an ecosystem can be determined by the land/water type and location. The total value of carbon sequestration is approximately $6 million per year.

46 Duarte et al., 2005; Nellemann et al., 2009; Laffoley et al., 2009; Crooks et al., 2011.

TABLE 10: STUDIES USED TO VALUE CARBON SEQUESTRATION			
Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
ESTUARY			
Duarte, C. et al., 2005	Global average	Avoided cost	$27 (no range)
FOREST			
Wilson, S.J., 2010	British Columbia	Avoided cost	$46 (no range)
EELGRASS BEDS			
Crooks, S. et al., 2011	Global average	Avoided cost	$27 – $116
Laffoley, D., and Grimsditch, G., 2009	Global average	Avoided cost	$244 – $498

New research is revealing that the ocean's vegetated habitats rank among the most intense carbon sinks on the planet.

PORTEAU COVE PHOTO: ALYSON HURT/FLICKR CREATIVE COMMONS

CARBON STORAGE

Carbon storage is another important global service related to gas and climate regulation. The storage of greenhouse gases contributes to the build-up of carbon "stocks." Just as living plants sequester and store carbon dioxide, non-living biomass, organic matter, sediments and rocks can store carbon stocks without consuming it.[47] Because the mass of stored carbon is so great with respect to its host, large amounts of carbon are expelled from decaying organic matter. Thus, dying species of terrestrial and marine plants are replaced with healthy ones, which sequester and store carbon for the next generation.

The value of carbon storage was estimated for five ecosystems, including estuaries, forests, marine, wetlands and eelgrass beds. Similar to carbon sequestration, values were based on data from the IPCC. Table 11 lists the primary studies used to arrive at an estimated value for. The total value of carbon storage is approximately $270 million dollars per year.

TABLE 11: STUDIES USED TO VALUE CARBON STORAGE			
Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
ESTUARY			
Nellemann, C., et al., 2009	Global average	Avoided cost	$30 (no range)
FOREST			
Wilson, S.J., 2010	Lower Mainland, B.C.	Avoided cost	$2,003 (no range)
MARINE			
Nellemann, C., et al., 2009	Global average	Avoided cost	$0.01 (no range)
WETLAND			
Wilson, S.J., 2010	Lower Mainland, B.C.	Avoided cost	$759–$2,801
EELGRASS BEDS			
Nellemann, C., et al., 2009	Global average	Avoided cost	$34 – $111
Laffoley, D., and Grimsditch, G., 2009	Global average	Avoided cost	$50 – $81

47 The biomass of the average tree is approximately 50 per cent carbon by weight (NSFA, 2002).

Air Purification

Clean air is essential to the health of all people. The ecosystem service of air purification refers to the ability of forests to clean the atmosphere by intercepting airborne particles and absorbing pollutants such as carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter (PM) and ozone (O_3). A single tree can absorb approximately five kilograms of air pollution annually, and produce enough oxygen to support two people.[48] In addition to the effects on human health, air pollution affects crops, climate, visibility and man-made materials. Figure 7 shows the distribution of forests in the study area and their relative ages, which is correlated to the amount of pollution they can intercept.

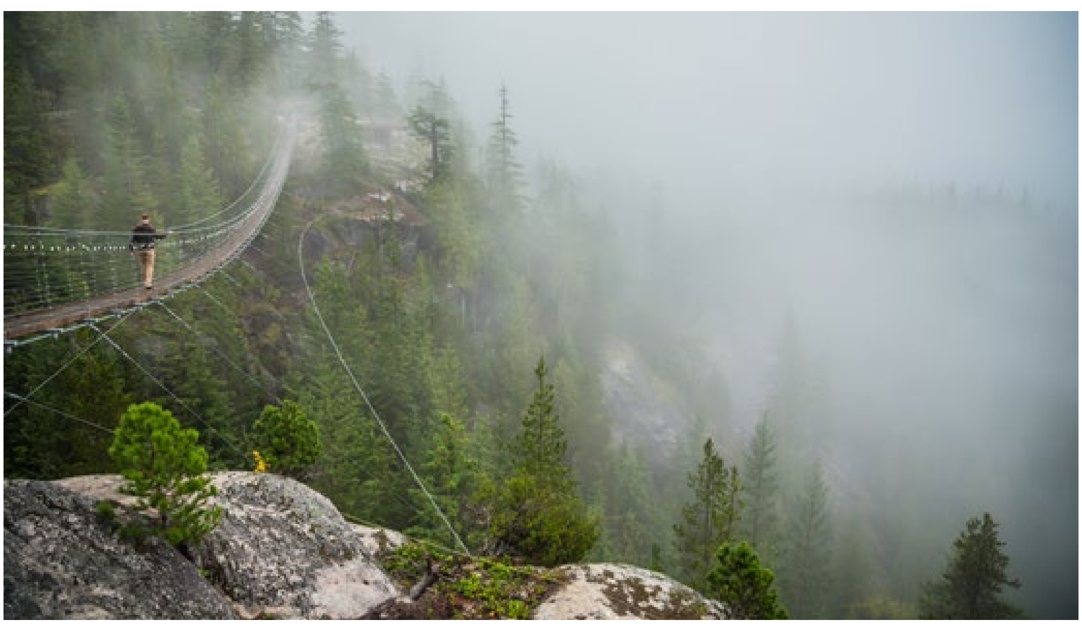
The value of air purification was estimated for the forests of the study area using avoided cost methodology. The in-house calculation was based on a recent study by Nowak et al. It employed four types of analysis to estimate the avoided health impacts and associated dollar benefits of air pollution removal by trees and forests in the U.S. The per hectare values for Washington State were transferred to the study region, due to similarities in forest composition and ratio of urban to treed areas.[49] Wilson estimated the value of air purification based on avoided costs from an EPA study which is used by CITYgreen software. This software calculates the quantity of air cleansing by trees using average pollution-removal rates across the U.S. The removal rates were then used to assess the amount of air pollutants removed by the tree canopy across the study area. The total value of air purification for the study area was estimated at $2 million to $78 million per year.

A single tree can absorb approximately five kilograms of air pollution annually, and produce enough oxygen to support two people.

TABLE 12: STUDIES USED TO VALUE AIR PURIFICATION

Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
FOREST			
In-house calculation (based on Nowak, D.J. et al., 2014)	Washington State	Avoided cost	$15 (no range)
Wilson, S.J., 2010	Lower Mainland, B.C.	Avoided cost	$580 (no range)

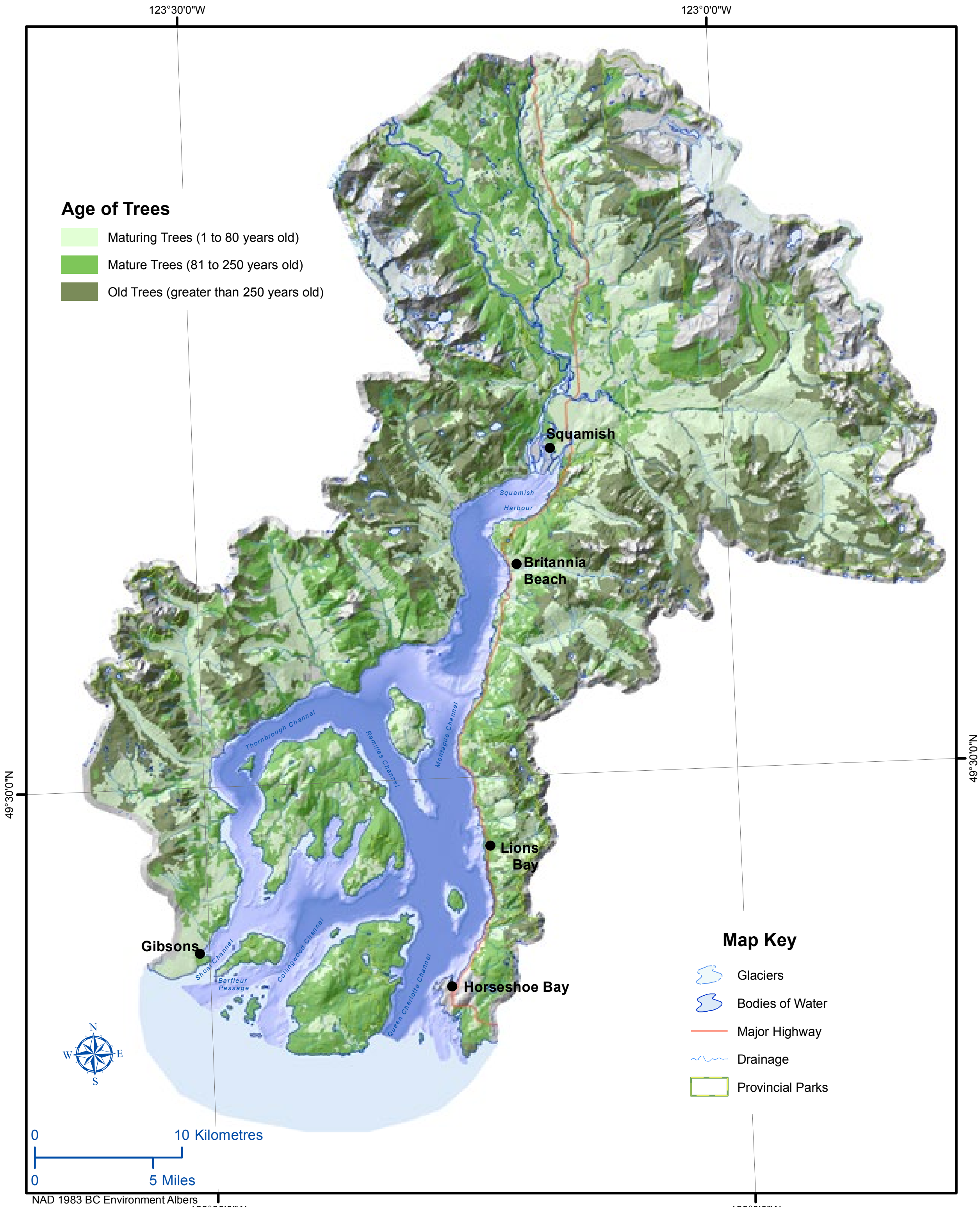
SEA TO SKY SUSPENSION BRIDGE PHOTO: KRIS KRÜG



48 American Forests, 2014.

49 The WA ratio is 3.6% urban and 47.2% treed, whereas the study area is approximately 1% urban and 47% treed.

FIGURE 7: AGE OF TREES IN STUDY AREA



AGE DISTRIBUTION OF FORESTS IN HOWE SOUND: This map shows the distribution of different ages of the forest within the study area. West Coast forests are considered 'old' when they have reached 250+ years of age and 'mature' when they have reached 80+ years of age. (Source: BC Forest Practices Code Guidebook, 1995)

Waste Treatment

Microorganisms in sediments and mudflats of estuaries, bays and nearshore areas break down human and other animal wastes.[50] They can also detoxify petroleum products. The physical destruction of habitat, alteration of food webs or overload of nutrients and waste products disrupt disease-regulation and waste-processing services, increasing the economic costs of damage from waste materials. Changes to ecosystems can also create breeding sites for disease vectors where they were previously nonexistent. People can be exposed to disease in coastal areas through direct contact with bacterial or viral agents while swimming or washing in fresh or saltwater, and by ingesting contaminated fish, seafood or water. The recent rise of cholera outbreaks in the southern hemisphere is associated with degradation of coastal ecosystems.[51]

The total value of waste-processing services in the study area ranges from approximately $4 million to $12 million per year. We were able to estimate the value of this service for riparian buffers and wetlands using the replacement cost approach and contingent valuation. Breaux et al. estimated cost savings from using coastal wetlands as a substitute waste treatment, whereas Wilson measured the costs of removing nitrogen and phosphorus by waste-treatment plants. Pate and Loomis surveyed residents of the San Joaquin Valley about their willingness to pay for three proposed environmental programs. We found wetlands to be the highest per hectare value land class for waste processing, ranging in value from $260 to $65,000 per hectare, per year.

Microorganisms in sediments and mudflats of estuaries, bays and nearshore areas break down human and other animal wastes.

TABLE 13: STUDIES USED TO VALUE WASTE TREATMENT

Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
RIPARIAN BUFFER			
Zhongwei, L., 2006	Little Miami River watershed, Ohio	Replacement cost	$830 – $833
WETLAND			
Breaux, A., et al., 1995	Louisiana	Replacement cost	$555 – $64,404
Pate, J., and Loomis, J., 1997	California	Contingent valuation	$260 – $1,175
Wilson, S.J., 2008	Vancouver, B.C.	Replacement cost	$1,640 – $5,002
Olewiler, N., 2004	Vancouver, B.C.	Replacement cost	$546 – $1,534

WETLAND NEAR SQUAMISH, PHOTO COURTESY RHIANNON BOYLE/ FLICKR CREATIVE COMMONS

50 Weslawski et al., 2004.

51 UNEP, 2006.

Habitat

Habitat is the biophysical space in which wild species meet their needs — a healthy ecosystem provides physical structure, adequate food availability, appropriate chemical and temperature regimes, and protection from predators. Habitat may provide refugium and nursery functions. A refugium refers to general living space for organisms, while nursery habitat is specifically habitat where all the requirements for successful reproduction occur.[52] In addition to the physical structure provided to species, food web relationships are important components of habitats that support all species.

In recognition of Howe Sound's natural conservation values, four provincial parks, one provincial ecological reserve, regional parks on Bowen and Gambier islands, and a number of municipal parks have been established [see Figure 8]. In addition, a bird sanctuary on Christie Islet and rookeries on the west side of Passage Island and on Pam Rocks exist to support seabird colonies and seal populations.

Of significant concern are those areas where the land meets the water — the riparian corridors, estuaries and eelgrass beds — which are vital habitat zones. Residents have voiced misgivings about urban development that could affect moose and deer populations on an important wildlife corridor along the river.[53] The habitat of the Squamish Estuary, upon which so much of the life in the sound depends, has been reduced by almost 50 per cent since the 1960s.[54] And eelgrass beds, also known as "salmon highways" have been affected by filling of shallow waters, dredging and eutrophication.[55]

The total value of habitat refugium and nursery services was estimated to range from approximately $1 million to $12 million per year. We were able to estimate the value of this service for seven land/water classes, including estuaries, forests, lakes and rivers, marine, riparian buffer, wetlands and eelgrass beds.

The production approach was predominantly used. This approach measures the ability of healthy habitats to enhance income. For instance, the value of healthy wetlands for commercial fisheries was estimated by Batie and Wilson, Kahn and Buerger, Johnston et al. and Knowler et al. We found eelgrass beds to be the highest per hectare value land class for habitat refugium and nursery, ranging in value from $5,110 to $35,300 per hectare per year.

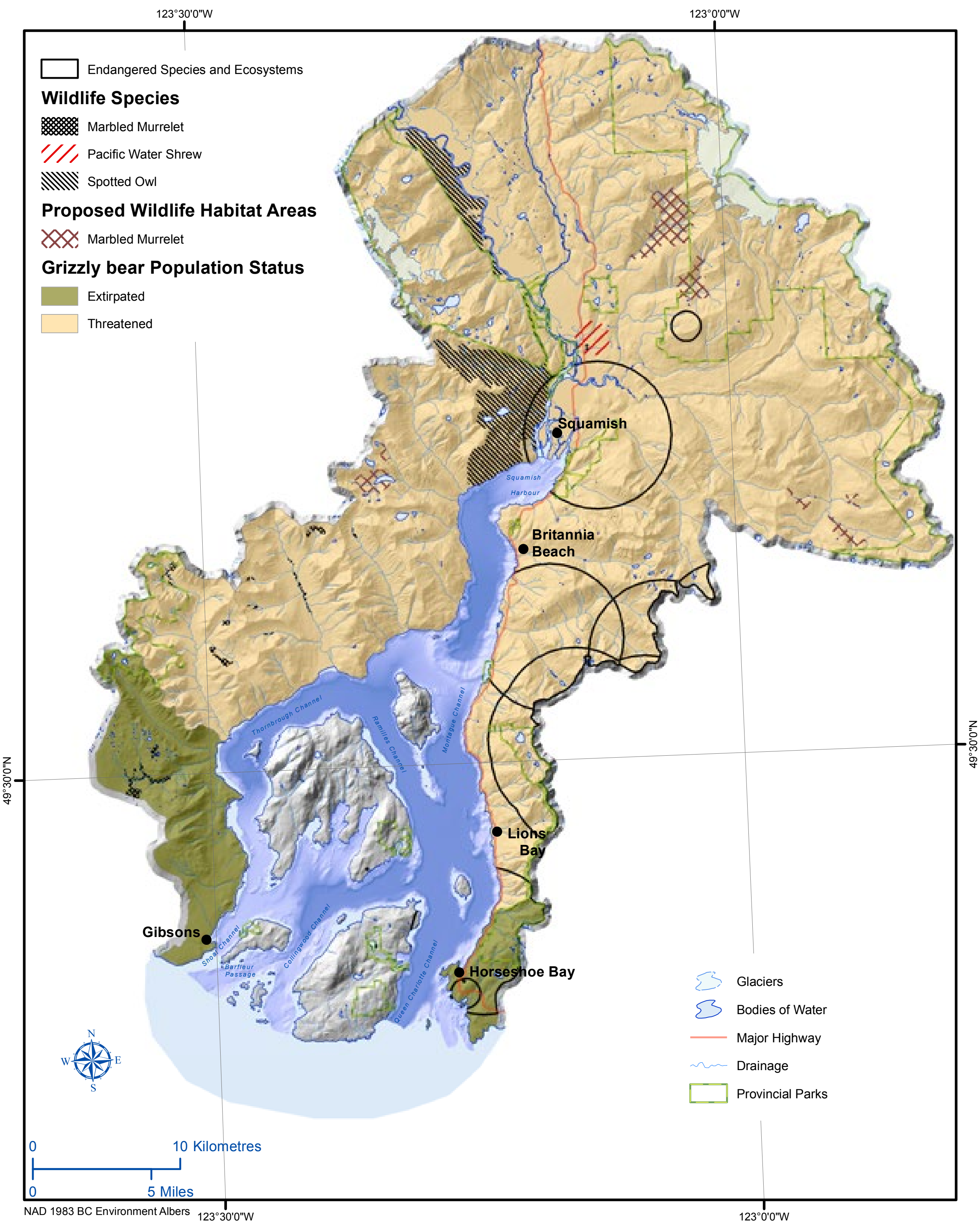
A healthy ecosystem provides physical structure, adequate food availability, appropriate chemical and temperature regimes, and protection from predators.

TOP PHOTO: EAGLE AT BRACKENDALE, COURTESY JDB SOUND PHOTOGRAPHY.

CHIPMUNK PHOTO COURTESY JOSHNV/ FLICKR CREATIVE COMMONS

52 De Groot et al., 2002.
53 Howe Sound Round Table, 1996, p.48.
54 Ibid, p. 41; Levings et al., 1992
55 Wright, et al., 2013.

FIGURE 8: WILDLIFE RESOURCES



HOWE SOUND THREATENED WILDLIFE: This map shows the known habitat of extirpated, threatened, and endangered species and ecosystems based upon information from BC Species and Ecosystems Explorer. The site also lists the Northern Goshawk, Olive-sided Flycatcher, Northern Abalone, Western Branded Skipper, and Barn Swallow. The known habitat of these species encompasses the entire study area.

In addition to the physical structure provided to species, food web relationships are important components of habitats that support all species.

PHOTO COURTESY EYESPLASH/ FLICKR CREATIVE COMMONS

TABLE 14: STUDIES USED TO VALUE HABITAT

Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
ESTUARY			
Johnston, R.J., et al., 2002	Peconic Estuary, New York	Production approach	$290 (no range)
FOREST			
Haener, M. K. and Adamowicz, W. L., 2000	Alberta	Contingent valuation/ production approach	$5 – $34
Knowler, D.J. et al., 2003	British Columbia	Production approach	$4 (no range)
LAKES/RIVERS			
Kahn, J.R. and Buerger, R.B., 1994	Lake Montauk, New York	Production approach	$8 – $61
Streiner, C. and Loomis, J., 1996	California	Hedonic pricing	$950 (no range)
MARINE			
Knowler, D.J. et al., 2003	British Columbia	Production approach	$2 – $10
RIPARIAN BUFFER			
Knowler, D.J. et al., 2003	British Columbia	Avoided cost and production approach	$29 – $133
WETLAND			
Knowler, D.J. et al., 2003	British Columbia	Production approach	$29 – $133
Mazzotta, M., 1996	Peconic Estuary, New York	Contingent valuation	$29,106 (no range)
Pate, J. and Loomis, J., 1997	San Joaquin Valley, California	Contingent valuation	$340 – $1,082
Streiner, C. and Loomis, J., 1996	California	Hedonic pricing	$730 (no range)
Wilson, S.J., 2008	Great Lakes, Canada	Avoided cost	$6,537 (no range)
EELGRASS BEDS			
Johnston, R.J., et al., 2002	Peconic Estuary, New York	Production approach	$5,110 (no range)
Mazzotta, M., 1996	Peconic Estuary, New York	Contingent valuation	$35,319 (no range)

Recreation and Tourism

The ecosystem service of recreation and tourism refers to the ability of natural areas to attract people to engage in recreational activities, often leading to increased property values and attractiveness for business. Tourism and recreation are related to, but not totally encompassed by, aesthetic values. People travel to beautiful places for vacation, but they also engage in specific activities associated with the ecosystems in those places. Recreational fishing, scuba diving, surfing, biking, swimming, kayaking, whale and bird watching, hunting, enjoying local seafood and wines, and beachcombing are all activities that would not occur or be thoroughly enjoyed without intact shorelines, healthy fish and wildlife populations, and clean water.

Howe Sound's dramatic natural beauty and outdoor recreational features, as well as its location, lying just outside of Vancouver, make it a popular destination for tourism and recreation. The region's 11 recreational sites, four recreational trails and six parks and reserves draw thousands of visitors annually (see Figure 9). Accessible glass sponge reefs attract divers from around the world. Porteau Cove is one of B.C. Parks' busiest, hosting almost half a million visitors in 2010-11.[56] The region gained further visibility during the 2010 Winter Olympics, as visitors passed through the area between the host sites of Vancouver and Whistler.

The value of recreational services was estimated for seven land/water classes, including beach, estuaries, forests, lakes and rivers, marine, riparian buffer and wetlands. The studies predominantly relied on the travel cost, contingent valuation and hedonic pricing methods, but one study used the opportunity cost approach (Gupta and Foster, 1975). Travel cost and contingent valuation are well-accepted valuation methods for recreational services, whereas the hedonic pricing method is routinely used to estimate aesthetic value. These methods measure the associated costs of recreation, willingness to pay for increased recreational services, and price differentials in housing located near recreational sites, respectively. Although opportunity cost is not an often-used approach for this service, we believed it worthy of inclusion. Gupta and Foster measured wetland value based on actual purchases of wetlands for recreation by towns in Massachusetts, U.S.

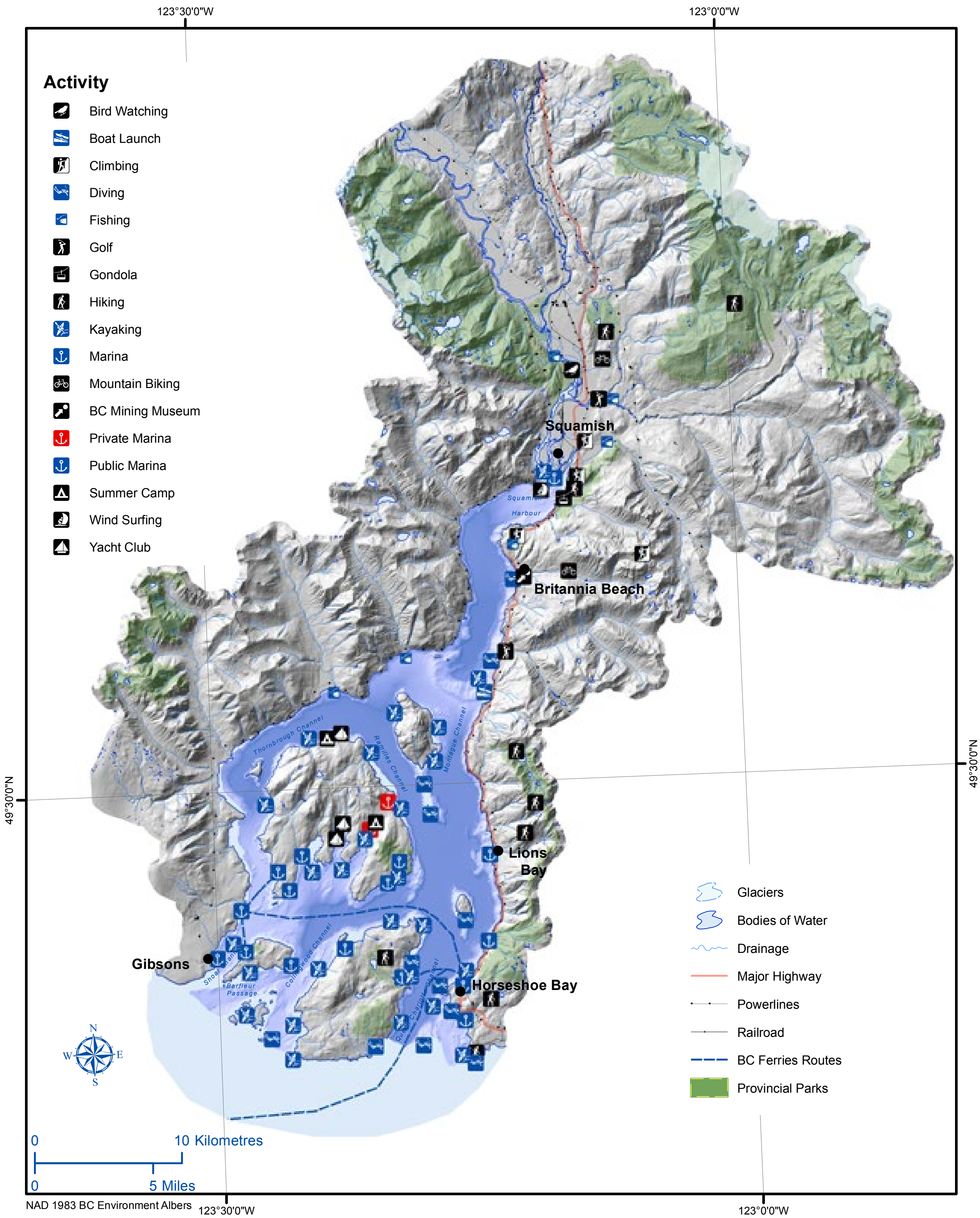
We calculated the total value of aesthetic and recreational services in the study area to range from approximately $100 million to $3 billion per year. We found beaches to be the highest per hectare value land class for this service, ranging in value from $490 to $150,000 per hectare per year. It should be noted that this is likely an underestimate as no study valued the totality of services provided in the study area.

Howe Sound's dramatic natural beauty and outdoor recreational features, as well as its location, lying just outside of Vancouver, make it a popular destination for tourism and recreation.

TOP PHOTO: BOWEN ISLAND, GOVERNMENT OF BC/FLICKR CREATIVE COMMONS
BOTTOM: KRIS KRÜG

56 Lionsgate Report, p.15.

FIGURE 9: TOURISM ACTIVITIES WITHIN HOWE SOUND



TOURISM ACTIVITIES IN HOWE SOUND: This map shows some of the recreation and tourism activities that take place in Howe Sound. The region is recognized for its outdoor activities, such as boating, biking, and climbing, which take place throughout the Sound.

TABLE 15: STUDIES USED TO VALUE RECREATION AND TOURISM

Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
BEACH			
Kline, J.D. and Swallow, S.K., 1998	Gooseberry, Massachusetts	Contingent valuation	$117,209 – $151,261
Silberman, J., et al., 1992	New Jersey	Contingent valuation	$70,681 (no range)
Taylor, L.O. and Smith, V.K., 2000	North Carolina	Hedonic pricing	$1,341 (no range)
Edwards, S.F. and Gable, F.J., 1991	Rhode Island	Hedonic pricing	$489 (no range)
In-house calculation (based on federal, provincial, and territorial governments of Canada, 2014.)	Howe Sound, B.C.	Travel cost	$679 (no range)
ESTUARY			
Johnston, R.J., et al., 2002	Peconic Estuary, New York	Hedonic pricing and travel cost	$523 (no range)
Leggett, C.G. and Bockstael, N.E., 2000	Anne Arundel County, Maryland	Hedonic pricing	$143 (no range)
Whitehead, J.C., et al., 1997	Albemarie-Pamlico Estuary, North Carolina	Contingent valuation	$4 – $30
In-house calculation	Howe Sound, B.C.	Travel cost	$679 (no range)
FOREST			
Shafer, E.L., et al., 1993	Pennsylvania	Travel cost and contingent valuation	$9 – $1,726
Knowler, D.J. et al., 2008	Fraser Timber Supply Area, B.C.	Contingent valuation	$134 (no range)
In-house calculation	Howe Sound, B.C.	Travel cost	$679 (no range)
LAKES/RIVERS			
Burt, O.R. and Brewer, D., 1971	Missouri	Travel cost	$1,535 (no range)
Cordell, H.K. and Bergstrom, J.C., 1993	North Carolina	Contingent valuation	$630 – $2,647
Kahn, J.R. and Buerger, R.B., 1994	Chesapeake Bay, New York	Travel cost	$4 – $13
Kealy, M.J. and Bishop, R.C., 1986	Lake Michigan, Wisconsin	Travel cost	$43 (no range)
Loomis, J.B., 2002	Washington	Travel cost	$36,987 – $65,457
Piper, S., 1997	South Dakota and Wyoming	Travel cost	$798 (no range)
Shafer, E.L., et al., 1993	Pennsylvania	Travel cost	$3,527 (no range)
Ward, F.A., et al., 1996	Sacramento, California	Travel cost	$66 – $6,144
In-house calculation	Howe Sound, B.C.	Travel cost	$679 (no range)
MARINE			
Mazzotta, M., 1996	Peconic Estuary, New York	Contingent valuation	$19,668 (no range)
In-house calculation	Howe Sound, B.C.	Travel cost	$679 (no range)

CLIMBING THE CHIEF PHOTO COURTESY TJFLEX2/FLICKR CREATIVE COMMONS

Table 15 continued

Author(s) and date of study	Location of study	Methodology	Value/hectare/ year (2014 C$)
RIPARIAN BUFFER			
Bowker, J.M., et al., 1996	North Carolina and South Carolina	Travel cost	$14,689 – $35,303
Duffield, J.W., et al., 1992	Montana	Contingent valuation and travel cost	$1,049 – $17,794
Greenley, D., et al., 1981	South Platte River Basin, Colorado	Contingent valuation	$28 (no range)
Kulshreshtha, S.N. and Gilles, J.A., 1993	Saskatoon, Saskatchewan	Hedonic pricing	$236 (no range)
Mullen, J.K. and Menz, F.C., 1985	Adirondack Mountain region of northern New York	Travel cost	$2,596 (no range)
Rein, F.A., 1999	Monterey Bay, California	Travel cost	$148 – $647
Sanders, L.D., et al., 1990	Rocky Mountain region of Colorado	Contingent valuation	$7,357 (no range)
In house calculation	Howe Sound, B.C.	Travel cost	$679 (no range)
WETLAND			
Costanza, R., et al., 1989	Terrebonne Parish, Louisiana	Travel cost	$305 – $1,201
Doss, C.R. and Taff, S.J., 1996	Minnesota	Hedonic pricing	$14,609 – $16,139
Hayes, K.M., et al., 1992	Rhode Island	Contingent valuation	$4,231 – $8,086
Kreutzwiser, R., 1981	Long Point and Point Pelee, Ontario	Travel cost	$602 (no range)
Mahan, B.L., et al., 2000	Portland, Oregon	Hedonic pricing	$117 (no range)
Whitehead, J.C., 1990	Kentucky	Contingent valuation	$3,346 – $6,727
Whitehead, J.C., et al., 2009	Michigan	Contingent valuation	$646 (no range)
Knowler, D. and Dust, K., 2008	Fraser Timber Supply Area, B.C.	Contingent valuation	$134 (no range)
Gupta, T.R., and Foster, J.H., 1975	Massachusetts	Opportunity cost	$282 – $3,807
Thibodeau, F.R. and Ostro, B.D., 1981	Charles River Basin, Massachusetts	Contingent valuation and travel cost	$29,635 (no range)
In house calculation	Howe Sound, B.C.	Travel cost	$679 (no range)

Education

Nature provides opportunities for cognitive development through education and research about organisms and habitats. Information gleaned from the environment can be adopted, harnessed and mimicked by humans for a variety of purposes.[57] The study of ecology, whether understood in a traditional context (e.g., through indigenous experiences) or in a formal context (e.g., as a natural science), helps humankind to appreciate the services of nature, to discern the limits and the thresholds of ecosystems, to appreciate the diversity of life and to apply and transfer this knowledge onto the human experience.

Howe Sound has become an educational base for thousands of children attending one of the 10 summer camps that can be found on the various islands and shores of the region;[58] the Vancouver Aquarium, which conducts natural history studies and baseline documentary work, and monitors depleted groundfish stocks;[59] the Sea to Sky Outdoor School; as well as short nature excursions offered by the First Nations of the region.

The estimated value of nature-based education was based on the 2012 Canadian Nature Survey, which provided a per person value for this service. To arrive at a per hectare value, we multiplied the per person value by the total population of the study area. We then divided this total by the total hectares of the various land classes to arrive at a per hectare value. The resulting value relies upon the assumption that the service was spread evenly across the various land classes. Using this approach, we arrived at a total value of approximately $9.5 million per year.

The study of ecology helps humankind to appreciate the services of nature, to discern the limits and the thresholds of ecosystems, to appreciate the diversity of life and to apply and transfer this knowledge onto the human experience.

TABLE 16: STUDIES USED TO VALUE EDUCATION

Author(s) and date of study	Location of study	Methodology	Value/hectare/year (2014 C$)
ALL ECOSYSTEMS			
In-house calculation (based on federal, provincial and territorial governments of Canada, 2014.	Howe Sound, B.C.	Travel cost	$33 (no range)

CAMP FIRCOM PHOTO: KRIS KRÜG

57 Beaumont et al., 2007; UNEP, 2005.
58 BC Spaces for Nature, 2011, p.47
59 Vancouver Aquarium, 2014.

PART 5

Valuation of Howe Sound

The valuation of ecosystem services in Howe Sound can be divided into the following steps:

- QUANTIFICATION OF LAND COVER CLASSES: Geographical Information Services (GIS) data is used to assess the hectares of each land/water cover class within the study region. Examples of land/water cover classes include marine, estuary, forests and wetlands.

- IDENTIFICATION OF ECOSYSTEM SERVICES: The ecosystem services provided within the study area are identified.

- VALUATION OF LAND/WATER COVER CLASSES: Using a database of peer-reviewed ecosystem service valuation studies, a range of studies for each specific land/water cover class are selected depending on the geographic and land/water cover match to the site, as well as the valuation method utilized. Each land/water cover class has a table of values based on the ecosystem services provided. The valued services can be totalled from the peer-reviewed academic literature showing high and low annual per-hectare values for each land/water cover type.

- VALUATION OF THE ECOSYSTEMS OF HOWE SOUND: The total high and low annual values of ecosystem services for each land/water cover class is multiplied by the hectares of that land/water cover class to arrive at total high and low annual value estimates. Land/water class values are summed to arrive at a total value for the study area. Net present values are calculated for the study area over 50 years at a range of discount rates: zero (no discount), three per cent (commonly used in socio-economic studies) and five per cent (a more conventional rate).

TOP PHOTO: KRIS KRÜG

BOTTOM: BARNACLES AT PORTEAU COVE COURTESY ALISON HURT / FLICKR CREATIVE COMMONS

Quantification of Terrestrial and Aquatic Cover Classes

To help estimate the value of ecosystem goods provided in Howe Sound, land/water cover assets were analyzed through the use of Geographic Information Systems (GIS) data. The GIS data is used to assess and categorize the water/land cover in the study area. It is gathered through aerial and/or satellite photography and can be classified according to several classification systems or "layers". We used the Earth Economics database of peer-reviewed valuation studies organized by land/water cover classes, which typically requires GIS data from several sources. The following datasets were compiled for the region's land and water cover classes (see Appendix A for details):

- TOPOLOGY: derived from numerous freely available 1:50,000 scale NTS map sheets obtained from Geogratis.
- WATERSHEDS: Data obtained from the Province of B.C.'s DataBC shows the location of watershed within B.C. and project area.
- BATHYMETRIC IMAGE: Spatial image of the bathymetry of Howe Sound used with permission of NRCAN.
- BIOGEOCLIMATIC ZONE DATA: The Biogeoclimatic Zone/Subzone/Variant Map (BGC) was obtained from the Ministry of Forests, Lands and Natural Resource Operations, Forest Analysis and Inventory.
- SHORELINE DATA: The Biophysical Shore-Zone Mapping System dataset was obtained from the Integrated Land Management Bureau (ILMB) of the B.C. government.
- TERRESTRIAL ECOSYSTEM MAPPING: Data obtained from the B.C. Ministry of Environment maps units are classified according to climate, physiography, surficial material, bedrock geology, soil and vegetation.
- VEGETATION RESOURCE INVENTORY: Data obtained from the B.C. government Forest Analysis and Inventory Branch provides spatial datasets containing information on the forest cover. The data contains information on age of trees, species, volume, height, land forms, etc.

PARADISE VALLEY PHOTO COURTESY CGEHLEN/FLICKR CREATIVE COMMONS

- SENSITIVE ECOSYSTEM INVENTORY: Data sets, which map rare and fragile terrestrial ecosystems, were obtained from Metro Vancouver, the Islands Trust and the B.C. Ministry of the Environment.
- FORESTRY DATA: Used various datasets containing information on forest reserves, age, species, volume, height, old growth management areas, etc. The datasets are maintained by the B.C. Ministry of Forests, Lands and Natural Resources Operations.
- MARINE RESOURCES: Spatial dataset showing the location of various marine resources within Howe Sound is based on information from the Islands Trust and diving observations provided by the Vancouver Aquarium. This data is constantly changing as the marine conditions within Howe Sound change.
- FISHERIES DATA: The data contain information on historical and recent fisheries and was obtained from Fisheries and Oceans Canada and the B.C. government Ecosystem Branch.
- WILDLIFE DATA: The wildlife habitat areas dataset contains approved legal boundaries for wildlife habitat areas and specified areas for species at risk and regionally important wildlife and was obtained from the Province of B.C.
- ENDANGERED SPECIES DATA: Spatial layer containing the Conservation Data Centre's known confidential locations of endangered species and ecosystems, masked for public viewing and download was obtained from the B.C. government Ecosystem Branch.

- INDUSTRIAL SITES: Locations of known industrial sites such as pipelines, log-handling sites and other industries within Howe Sound were drawn from data obtained from B.C. Ministry of Forests, Lands and Natural Resource Operations, numerous public documents, Tantalus Gator and the B.C. Oil and Gas Commission.
- TOURISM ACTIVITIES: Data was compiled from various public sources such as the Squamish website, guidebooks and Tourism B.C. on the primary recreation activities within the study area.

Land/water cover types found in the study area are referenced in Table 17, which presents the final land/water cover classes and hectares that make up the study area as categorized for this report, and a description of the layers.

TABLE 17: TOTAL HECTARES BY LAND/WATER COVER CLASS IN THE STUDY AREA

Land/water cover class	Hectares	% of study area	Data source(s) / Layers used
Beach	145	< 1%	B.C. Biophysical Shore-Zone mapping System; B.C. Ministry of Forest's Vegetation Resources Inventory; B.C. Ministry of Environment's Terrestrial Ecosystem Mapping
Forest	135,300	47%	B.C. Ministry of Forest's Vegetation Resources Inventory; B.C. Ministry of Environment's Terrestrial Ecosystem Mapping; B.C. Ministry of Forests, Lands and Natural Resources Operations datasets
Wetlands	130	< 1%	B.C. Ministry of Forest's Vegetation Resources Inventory; B.C. Ministry of Environment's Terrestrial Ecosystem Mapping
Lakes and rivers	1,699	< 1%	B.C. Ministry of Environment's Terrestrial Ecosystem Mapping; B.C. Ministry of Forest's Vegetation Resources Inventory; Province of B.C.'s DataBC
Riparian buffer	4,210	1%	Applied 70- to 100-metre buffers to salmon-bearing streams. (Salmon-bearing streams identified by Ministry of Environment, 1979, p. 75)
Marine	142,612	50%	Province of B.C.'s DataBC; Department of Fisheries and Oceans, B.C. Ministry of Environment (Ecosystem Branch), Islands Trust, and the Vancouver Aquarium
Estuary	262	< 1%	Department of Fisheries and Oceans, B.C. Ministry of Environment (Ecosystem Branch)
Eelgrass beds	6.5	< 1%	Obtained linear calculations from Ministry of Agriculture and Lands, Vancouver Aquarium, and Islands Trust. Obtained area calculations from the Pacific Estuary Conservation Program dataset.
Urban*	269	< 1%	B.C. Ministry of Forest's Vegetation Resources Inventory; B.C. Ministry of Environment's Terrestrial Ecosystem Mapping
Permanent snow & glaciers	644	< 1%	B.C. Ministry of Forest's Vegetation Resources Inventory; B.C. Ministry of Environment's Terrestrial Ecosystem Mapping
TOTAL	**204,894****	**100%**	

* Areas classified as Urban/Developed Land use the Terrestrial Ecosystem Mapping definition of urban. This is why areas such as Squamish and West Vancouver are not considered as urban even if they are perceived to be by the general public.

** The study area size does not equal the total hectares of each land/water class, as many of these ecosystems overlap.

Land/Water Cover Class Values

The stock of ecosystems — or natural capital — in Howe Sound generates a flow of value, comparable to an annual stream of income. As long as the natural infrastructure of these ecosystems is not degraded or depleted, this flow of value will likely continue into the distant future. This flow of value is expressed in CDN$/hectare/year, which represents the dollar value generated by a single ecosystem service on a particular land/water cover class. For example, based on a specific peer-reviewed scientific report, urban wetlands in Abbotsford, B.C., were shown to provide up to $487/hectare/year in water supply benefits.[60]

The full suite of ecosystem services produced by a particular land/water cover class yield a total flow of value for that land/water cover class, yet this report is focused on non-market services. In the case of wetlands, this means summing all of its known non-market ecosystem service values (i.e., water regulation, habitat, recreation, etc.), for which valuation studies have been completed. This number can then be multiplied by the number of hectares of wetlands in Howe Sound for a value in $/year.

This study provides specific references for every value provided for every land cover type. See Appendix B for an annotated bibliography of primary studies applied in this valuation. Due to limitations in the range of primary valuation studies conducted on ecosystem services, not all ecosystem services that were identified on each land/water cover class in the previous section could be assigned a known value from the database. For example, the land/water cover class "marine" has only been valued for four ecosystem services — habitat refugium and nursery, food provisioning, tourism and recreation, and nature-based education — though such areas also clearly provide medicinal resources, genetic resources, gas and climate regulation, water regulation, water supply, biological control, waste treatment, spiritual and cultural values, and a number of other important benefits. While we were able to complete in-house calculations, based on local data for food provisioning and gas and climate regulation, resource limitations restricted our ability to carry out more valuations.

A matrix that summarizes the suite of ecosystem services identified by each land/water cover type in the study area, compared with those that were actually valued in this study, is provided in Table 18. Where ecosystem services do not exist, such as pollination in underwater marine systems, there is a white box. Where ecosystem services exist and provide value to people, but there are no valuation studies available, the box is coloured blue. Where valuable ecosystem services exist and values are available, the box is grey and has an x.

The stock of ecosystems — or natural capital — in Howe Sound generates a flow of value, comparable to an annual stream of income. As long as the natural infrastructure of these ecosystems is not degraded or depleted, this flow of value will likely continue into the distant future.

PHOTO COURTESY TIM GAGE/ FLICKR CREATIVE COMMONS

60 Hauser and van Kooten, 1993.

TABLE 18: ECOSYSTEM SERVICES VALUED AND/OR IDENTIFIED IN HOWE SOUND

	Beach	Estuary	Eelgrass beds	Wetland	Marine	Lakes and rivers	Riparian buffer	Forest
Food					x			
Water supply		x		x		x		x
Raw materials								
Medicinal resources								
Genetic resources								
Ornamental resources								
Carbon sequestration		x	x					x
Carbon storage		x	x	x	x			x
Air purification								x
Disturbance regulation	x			x			x	x
Soil erosion control								
Water regulation								
Biological control								
Waste processing				x			x	
Soil formation								
Nutrient cycling		x	x					
Pollination								
Habitat refugium and nursery		x	x	x	x	x	x	x
Aesthetic information								
Recreation and tourism	x	x		x	x	x	x	x
Science and education	x	x	x	x	x	x	x	x
Spiritual and religious								
Maintenance of culture								

KEY

Ecosystem service produced by land/water cover class but not valued in this report	
Ecosystem service produced by land/water cover class and valued in this report	X
Ecosystem service not produced by land/water cover class	

A large number of ecosystem services (for each land cover/water class) have yet to be valued in a primary study. This suggests that the valuation is a significant underestimate of the true value, because many ecosystem services identified as valuable do not have an associated valuation study. As further primary studies are added to the database, the combined known value of ecosystem services in Howe Sound will rise.

Summary of Values

VALUE OF ECOSYSTEM SERVICES BY LAND/WATER COVER CLASS

Aggregating the dollar values of ecosystem services across ecosystems and land/water cover types provides a partial estimate of the total flow of economic value that natural systems in Howe Sound provide to people. The total value estimated for 11 ecosystem services over eight land/water classes ranges from approximately $790 million to almost $5 billion per year. This is a tremendous value by any measure. A large number of ecosystem services (for each land/water cover class) have yet to be valued in primary studies. This suggests that the valuation is a significant underestimate of the true value. Many ecosystem services identified as valuable do not have an associated valuation study. As further primary studies are added to the database, the combined known value of ecosystem services in Howe Sound will rise. Detailed tables of ecosystem service values (Tables 23-24) are provided in Appendix C.

Table 19 provides the total value for the ecosystem services measured by land/water class. The values are provided as both total values per year and value per hectare per year. The top three land/water cover classes in terms of ecosystem service total values are marine, estimated at upwards of $2.8 billion per year; forests, estimated at upwards of $1.6 billion per year; and riparian buffers, estimated at upwards of $156 million per year. This is primarily a function of the relative size of each land/water class however (see Table 17). It is more informative to review the top land/water cover types in terms of value per hectare, as this allows us to compare the land/water classes of high value against the remaining parcels of land/water and existing policy measures. Beaches (valued at a maximum of $225,105 per hectare per year), wetlands (valued at a maximum of $172,946 per hectare per year), and eelgrass beds (valued at a maximum of $87,203 per hectare per year) provide the greatest value per hectare per year.

TABLE 19: SUMMARY OF VALUES OF ECOSYSTEM BENEFITS BY LAND/WATER COVER (2014 C$)

Land/water cover type	Total value/year ($/yr)		Value per hectare per year ($/ha/yr)	
	Low	High	Low	High
Beach	$100,457	$32,640,226	$693	$225,105
Estuary	$179,370	$462,600	$685	$1,766
Forest	$682,526,262	$1,599,254,118	$5,045	$11,820
Lakes and rivers	$3,271,323	$117,643,415	$1,925	$69,243
Marine	$102,005,609	$2,811,105,944	$715	$19,712
Riparian buffer	$3,979,334	$156,128,608	$945	$37,085
Wetland	$329,165	$22,482,905	$2,532	$172,946
Eelgrass beds	$152,775	$566,821	$23,504	$87,203
Total	**$792,544,295**	**$4,740,284,637**	**$36,044**	**$624,880**

GAMBIER ISLAND PHOTO: KRIS KRÜG

Table 20 provides a synopsis of beach and wetland values per hectare per year. Beaches are highly valuable for select services — three of a possible 11. They are highly valuable for tourism and recreation and disturbance regulation. Wetlands, on the other hand, exhibit value across a range of services. We were able to estimate values for seven of a possible 11 services. They are particularly important for disturbance regulation, waste treatment, water supply, habitat and tourism and recreation, with high estimates in the range of tens of thousands per hectare per year.

TABLE 20: HIGH AND LOW $/HECTARE ESTIMATES FOR WETLAND AND BEACH (2014 C$)

Ecosystem service	BEACH Value per hectare per year ($/ha/yr)		WETLAND Value per hectare per year ($/ha/yr)	
	Low	High	Low	High
Clean water			$120	$39,480
Disturbance regulation	$170	$73,811	$1,212	$7,398
Carbon storage			$759	$2,891
Waste treatment			$261	$64,404
Habitat			$29	$29,106
Tourism and recreation	$489	$151,261	$117	$29,635
Nature-based education	$33	$33	$33	$33
Total	**$692**	**$225,105**	**$2,531**	**$172,947**

VALUE OF ECOSYSTEM SERVICES BY BENEFIT

The value of intact ecosystems can also be calculated by the services or benefits they provide. This is provided in Table 21. The top three highest values are tourism and recreation, estimated at upwards of $3 billion per year; water supply, estimated at upwards of $773 million per year; and carbon storage, valued at upwards of $270 million per year. Looking once again at the top values per hectare, we found the top three services to be tourism and recreation (valued at a maximum of disturbance regulation $304,000/hectare/year), disturbance regulation (valued at a maximum of $84,000/hectare/year), and habitat (valued at a maximum of $66,000/hectare/year). These values can change dramatically if ecosystems are degraded. A detailed table of ecosystem services by benefit is also provided in Appendix C.

TABLE 21: SUMMARY OF VALUES OF ECOSYSTEM SERVICES BY BENEFIT (2014 C$)

Benefit	Total value/year ($/yr)		Value per hectare per year ($/ha/yr)	
	Low	High	Low	High
Food provisioning	$95,073	$95,073	$1	$1
Clean water	$302,991,496	$773,244,842	$4,235	$48,348
Disturbance regulation	$97,584,983	$252,587,935	$2,127	$83,748
Nutrient cycling	$192,466	$406,594	$18,580	$51,522
Carbon sequestration	$6,191,928	$6,194,987	$101	$571
Carbon storage	$271,130,488	$271,408,056	$2,827	$5,036
Air purification	$2,057,913	$78,498,354	$15	$580
Waste treatment	$3,526,635	$11,879,824	$1,090	$65,237
Habitat	$989,557	$12,335,826	$5,471	$65,842
Tourism and recreation	$98,331,481	$3,324,180,870	$1,332	$303,728
Nature-based education	$9,452,276	$9,452,276	$266	$266
Total	**$792,544,296**	**$4,740,284,637**	**$36,045**	**$624,879**

Tourism and recreational services are the highest ecosystem service on a per hectare basis. This is not surprising in Howe Sound, an area renowned for its natural beauty. As well as recreational benefits, health benefits are also associated with healthy ecosystems. Nature's long-known and discussed value as a key contributor to health is gaining greater scientific support. A recent research paper by Francis (Ming) Kuo, a faculty member at the University of Illinois, states, "In the face of the tremendously diverse and rigorous tests to which the nature-human health hypothesis has been subjected, the strength, consistency, and convergence of the findings are remarkable."[61]

The second-highest valued ecosystem service on a per hectare basis is disturbance regulation. This is partly a function of the rise in studies on the value of intact ecosystems for mitigating extreme weather events. As our local news broadcasts report on the multitude of major weather events and the costs in lives, infrastructure and business losses, and as we learn of the compounding risks associated with global warming, the case for maintaining and restoring key ecosystems is becoming stronger. This has led to a significant increase in the economic analysis of the role intact ecosystems play in disturbance regulation. Forests and wetlands play a key role in mitigating such disasters in Howe Sound. Marine ecosystems have traditionally not been seen as providing great value for flood protection. Yet sea-level rise reduces the slope of rivers and the speed and volume of floodwaters received by marine waters. Marine systems are crucial to flood-risk reduction, yet their value for receiving floodwaters has yet to be calculated.

61 Kuo, 2010, p.4.

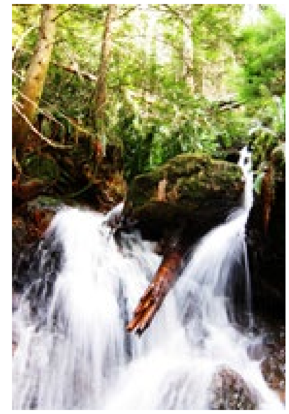
NET PRESENT VALUES FOR ECOSYSTEM BENEFIT VALUES

How to compare the value provided by built capital (bridges, power plants, schools) against natural capital (water supply, flood protection, recreation benefits) into the future against present benefits over time is an area of increasing debate and importance in economics. Natural capital typically appreciates over time. For instance, the value of the watersheds that provide and filter water for Howe Sound communities is far greater on a per-litre basis or in total value today than 100 years ago. A built capital alternative, a filtration plant, would have depreciated and required replacement several times during the same period. The critical difference in how value is provided across time by natural and built capital can be reflected through discounting.

Discount rates are used to assess the economic benefits of investments across time. The logic behind using a discount rate reflects: 1) that people generally value benefits in the present over benefits in the future (this is referred to as the "pure time preference of money") and 2) that a dollar in one year's time is assumed to have a value of less than a dollar today, because it is assumed that a dollar today could be invested for a return in one year that is greater than the original investment amount (this is referred to as the "opportunity cost of investment"). An ecosystem produces a flow of valuable services across time. In this sense it can be thought of as a capital asset. This analogy can be extended by calculating the net present value of the future flows of ecosystem services, just as the asset value of a traditional capital asset (or large project) can be approximately calculated as the net present value of its future benefits. This calculation is analogous, because ecosystems with all their realized public returns are not bought and sold in markets.

Using a discount rate assumes that the benefits humans reap in the present are more valuable than the benefits provided to future generations. Renewable resources should be treated with lower discount rates than built capital assets because they provide a rate of return over a far longer period of time. Most of the benefits that a natural asset such as the ecosystems of Howe Sound provide reside in the distant future, whereas most of the benefits of built capital (like a litre of gasoline) reside in the very near term, with few or no benefits provided into the distant future. Both types of assets are important to maintain a high quality of life, but each also operates on a different time scale. It would be unwise to treat human time preference for a forest like it was a building, or a building like it was a disposable coffee cup. While there is much academic debate on the use and specific rate chosen for natural capital discount rates, there is no clear resolution on how to treat natural capital.

The analysis in this report recognizes this debate and utilizes three discount rates over a 50-year period, five per cent, three per cent and zero per cent to give an understanding to the reader of the impact of discounting on economic valuation. Even with the flaws of discounting, natural capital has tremendous value. Recognizing part of the total value of natural capital is superior to giving it zero value by excluding the value of natural capital in asset analysis. Over a 50-year period, the net present value is $40 billion to $242 billion at a zero per cent discount rate, $21 billion to $127 billion at a three per cent discount rate, and $15 billion to $91 billion at a five per cent discount rate. Table 22 shows the net present values by discount rates and values per capita.



Natural capital typically appreciates over time. For instance, the value of the watersheds that provide and filter water for Howe Sound communities is far greater on a per-litre basis or in total value today than 100 years ago. A built capital alternative, a filtration plant, would have depreciated and required replacement several times during the same period.

STREAM NEAR GIBSONS, PHOTO COURTESY CHAIWALLA/FLICKR CREATIVE COMMONS

TABLE 22: NET PRESENT VALUES FOR ECOSYSTEM BENEFITS (2014 C$)

Discount rate	Net present value(50-year period) billion $		**Value per capita***	
	Low	High	Low	High
0%	$40	$242	$513,202	$3,069,509
3%	$21	$127	$268,976	$1,608,770
5%	$15	$91	$193,768	$1,158,946

* Based on population of 78,760

PART 6

Conclusions

In addition to identifying conservation needs and drawing attention to the importance of ecosystem services and the natural capital they rely on, the results of this study can be used to help evaluate the trade-offs this region is facing with respect to industrial-development decisions.

PHOTO: KRIS KRÜG

THE ECOSYSTEMS OF HOWE SOUND support an incredible wealth of services. The sound's beaches, streams, forests, wetlands and nearshore ecosystems provide residents with food, clean water, a stable climate, protection from natural disasters and a place to relax, recreate and reconnect with nature. These services underpin our health, economy and culture, yet they are not included in decision-making in any systematic manner. As these natural systems are degraded, costly investments are needed to replace the lost services of ecosystems or to rehabilitate the damaged environment. The lack of market signals to alert us of changes in the supply of services or ecosystem deterioration means we don't appreciate their value until they are lost and it is too late.

This report conservatively estimates the value of 11 services across land and marine-based ecosystems at approximately $800 million to $4.7 billion per year. The results are compelling. If we were to treat the regions' ecosystems as an economic asset, providing a stream of benefits over 50 years, the present value would range between $15 billion and $91 billion, using a five per cent discount rate. If we were to translate this into the value per household, the value ranges between approximately $500,000 and $3 billion. This demonstrates the tremendous value of natural systems to Howe Sound residents.

As the population of B.C.'s Lower Mainland is expected to grow to more than three million by 2020, the Howe Sound region will become an increasingly attractive locale for industrial development. The sound acts as the lungs and circulatory system for the entire Lower Mainland region, maintaining air quality and nutrient cycling. As the sound's residents know from past experience, heavy development in the nearshore environment can threaten marine ecosystem revival.

Information on the economic value of natural systems will not on its own provide a solution to the degradation of ecosystems. The real challenge is to use this information to remedy failures in markets, policies and resource management. This valuation can be used in many ways. In addition to identifying conservation needs and drawing attention to the importance of ecosystem services and the natural capital they rely on, the results of this study can be used to help evaluate the trade-offs this region is facing with respect to industrial-development decisions. It can also be used to support ecosystem accounting, to inform the development of tax policies and to assist in the evaluation of financial assurances to decommission and restore sites after major resource projects have ended.[62]

62 Statistics Canada, 2013

This valuation can play a role in guiding future development by incorporating the study results into planning documents. It can also assist municipalities with infrastructure management and guide local research. Each of these uses is discussed below:

- Large-scale proposed developments for the sound must go through an environmental impact assessment and a cumulative effects assessment and may have to obtain financial assurances for environmental risks. A first step for local governments is to clearly define desired environmental outcomes for the region by identifying priority ecosystem services in a cumulative-effects framework. Once these values are articulated, determining how the planning framework can secure these values will become a clearer task. For instance, modifying environmental assessments to incorporate critical ecosystem services prior to development approval, as well as setting financial assurances in line with the assessed non-market values, will bring natural capital into the development discussion.
- Local governments are beginning to explore techniques for incorporating natural capital into their asset-management programs. We are currently working with municipalities in the region to (i) incorporate natural capital into infrastructure management software and (ii) use this information to evaluate the ability of natural infrastructure to increase the resilience of municipalities to external stressors, enhance the protection of municipal natural assets and increase the well-being of citizens.
- Lastly, this study can be used to direct future research in the region. Numerous research gaps remain in terms of ecosystem functioning (e.g., absorptive capacity of soils), the measuring of ecosystem services (e.g., the quantification of medicinal resources), and how the benefits of ecosystem services are distributed.

Information on the economic value of natural systems will not on its own provide a solution to the degradation of ecosystems. The real challenge is to use this information to remedy failures in markets, policies and resource management.

LEAVING LANGDALE PHOTO COURTESY KEVIN MCMILLAN/FLICKR CREATIVE COMMONS

Land/Water Cover Sources

Map Projection and Datum: NAD83 B.C. Environment Albers

Topography

The topographic base was derived from numerous freely available 1:50,000 scale NTS map sheets that can be obtained from Geogratis (www.geogratis.gc.ca/geogratis). Data sets are maintained by Natural Resources Canada. The project uses NTS Vector datasets.

B.C. HillShade Image

The hillshade image of Howe Sound is courtesy of the B.C. government. Data sets can be obtained from GeoBC (http://geobc.gov.bc.ca/base-mapping/imagery/products/hillshade.html).
Shoreline Data

Polyline dataset of the physical characteristics of the shoreline for B.C. The dataset is maintained by the Integrated Land Management Bureau (ILMB) of the B.C. government. It is not freely available to the public. Permission to use the dataset was given by the ILMB. The Howe Sound dataset was clipped from the B.C. dataset.

Biogeoclimatic Zone Data

BEC BIOGEOCLIMATIC POLY is the spatial representation of the "regional" level of the Biogeoclimatic Ecosystem Classification (BEC) and is commonly referred to as the Biogeoclimatic Zone/Subzone/Variant Map (BGC). At this "regional" level, vegetation, soils and topography are used to infer the climate and to identify geographic areas that have relatively uniform climate. These geographic areas are termed biogeoclimatic units. The basic biogeoclimatic unit is the subzone. These units are grouped into zones and may be further subdivided into variants based on further refinements of climate (e.g., wetter, drier, snowier). The units of the biogeoclimatic map are mapped to the highest possible thematic resolution — subzone or variant. In some cases, where further sampling is required to define the unit climatically, polygons are labelled as an undifferentiated unit (e.g., CWH un).

The dataset is maintained by the Ministry of Forests, Lands and Natural Resource Operations, Forest Analysis and Inventory. (www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173506&recorduid=173506&title=Biogeoclimatic%20Ecosystem%20Classification%20%28%20BEC%20%29%20Map)

Endangered Species

Spatial layer containing the Conservation Data Centre's known confidential locations of endangered species and ecosystems, masked for public viewing and download. For information or details about Masked Occurrence Records, please contact the CDC at cdcdata@gov.bc.ca or 250-356-0928. When referencing a particular occurrence record, please use the FEATURE_ID number (if accessing via the B.C. Geographic Warehouse or ArcMap) or Shape ID (if accessing via i-Map or CDC Mapping Service). The dataset is maintained by the B.C. government Ecosystem Branch.

Fisheries Data

This dataset consists of points, lines and polygon data within Howe Sound. The data contain information on historical and recent fisheries. The datasets are maintained by Fisheries and Oceans Canada and the B.C. government Ecosystem Branch. The point data on fish observations was linked to the 1:50,000 scale stream network.

Fisheries information can be obtained from: www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173706&recorduid=173706&title=Known%20BC%20Fish%20Observations%20and%20BC%20Fish%20Distributions
www.dfo-mpo.gc.ca/index-eng.htm

Forestry Data

Various datasets containing information on forest reserves, age, species, volume, height, old growth management areas, etc. The datasets are maintained by the B.C. Ministry of Forests, Lands and Natural Resources Operations.

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173748&recorduid=173748&title=Old%20Growth%20Management%20Areas%20-%20Legal%20-%20Current

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173885&recorduid=173885&title=VRI%20-%20Forest%20Vegetation%20Composite%20Polygons%20and%20Rank%201%20Layer

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173784&recorduid=173784&title=RESULTS%20-%20Forest%20Cover%20Inventory

Industrial Sites

Spatial layers showing the locations of known industrial sites such as pipelines, log-handling sites and other industries within Howe Sound. Data obtained from B.C. Ministry of Forests, Lands and Natural Resource Operations, numerous public documents, Tantalus Gator and the B.C. Oil and Gas Commission.

ftp://ftp.bcogc.ca/outgoing/OGC_Data/Pipelines/

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173838&recorduid=173838&title=TANTALIS%20-%20Crown%20Tenures

Sensitive Ecosystem Inventory

Spatial layers showing the location and attributes of sensitive and important ecosystems throughout Metro Vancouver, the Sunshine Coast and Bowen-Gambier Island.

SEI_Polygons contains Sensitive Ecosystems Inventory polygons with key and amalgamated (concatenated) attributes derived from the RISC (Resource Inventory Standards Committee) standard attributes. SEI identifies and maps rare and fragile terrestrial ecosystems. Ecosystems mapped may include (but are not limited to) older forests, woodlands, coastal bluffs, herbaceous and sparsely vegetated ecosystems, grasslands, riparian ecosystems and wetlands. SEI methods include manual air photo interpretation or theming of other Ecosystem Mapping, each supported by selective field checking. This layer is derived from the STE_TEI_ATTRIBUTE_POLYS_SP layer by filtering on the PROJECT_TYPE attribute.

Data sets were obtained from Metro Vancouver, the Islands Trust and the B.C. Ministry of the Environment.

www.metrovancouver.org/planning/development/ecologicalhealth/sei

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173798&recorduid=173798&title=Sensitive%20Ecosystems%20Inventory%20%28SEI%29%20Detailed%20Polygons%20with%20Short%20Attribute%20Table%20Spatial%20View

http://mapit.islandstrust.bc.ca/ecosystems.html

Terrestrial Ecosystem Mapping

Spatial layers showing the terrestrial Ecosystem Inventory of the landscape. Map units are classified according to climate, physiography, surficial material, bedrock geology, soil and vegetation. The data are maintained by the B.C. Ministry of Environment.

Terrestrial Ecosystem Mapping (TEM) contains attributes describing each project (project level metadata), plus links to the locations of other data associated with the project (e.g., reports, polygon datasets, plotfiles, field data, legends).TEM divides the landscape into units according to a variety of ecological features including climate, physiography, surficial material, bedrock geology, soils and vegetation. This layer is derived from the STE_TEI_PROJECT_BOUNDARIES_SP layer by filtering on the PROJECT_TYPE attribute.

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173874&recorduid=173874&title=Terrestrial%20Ecosystem%20Mapping%20%28TEM%29%20Project%20Boundaries

Vegetation Resource Inventory

Spatial dataset containing information on the forest cover. The data contain information on age of trees, species, volume, height, land forms, etc. The dataset is maintained by the B.C. government Forest Analysis and Inventory Branch.

Geospatial forest inventory dataset updated for depletions, such as harvesting, and projected annual growth. Sample attributes in this dataset include age, species, volume, height. The data are not freely downloadable by the public.

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173885&recorduid=173885&title=VRI%20-%20Forest%20Vegetation%20Composite%20Polygons%20and%20Rank%201%20Layer

Watersheds

Spatial dataset showing the location of watershed within B.C. and project area.

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173491&recorduid=173491&title=BC%20Major%20Watersheds

Wildlife Data

The bird spatial dataset shows the distribution of the bald eagle habitat in coastal B.C. showing relative abundance (RA) and overall relative importance (RI). RI is based on project region and not on the province as a whole. British Columbia has been collecting coastal resource data in a systematic and synoptic manner since 1979. Resource information is collected using peer-reviewed provincial Resource Information Standards Committee, which include standards for data management and analysis.

The wildlife habitat areas dataset contains approved legal boundaries for wildlife habitat areas and specified areas for species at risk and regionally important wildlife.

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173479&recorduid=173479&title=Bald%20Eagles%20-%20Coastal%20Resource%20Information%20Management%20System%20%28CRIMS%29

www.data.gov.bc.ca/dbc/catalogue/detail.page?config=dbc&P110=recorduid:173906&recorduid=173906&title=Wildlife%20Habitat%20Areas

Marine Resources

Spatial dataset showing the location of various marine resources within Howe Sound. The dataset does not contain information on migratory species such as whales and dolphins. The data is based on information from the Islands Trust and diving observations provided by the Vancouver Aquarium. The data are constantly changing as marine conditions within Howe Sound change.

Tourism Activities

Spatial dataset of the primary recreation activities within the study area. Data is compiled from various public sources such as the Squamish website, guidebooks, Tourism B.C.

Bathymetric Image

Spatial image of the bathymetry of Howe Sound used with permission of NRCAN.

Primary Studies

Bockstael, N.E., McConnell, K.E., Strand, I.E., (1989). Measuring the benefits of improvements in water quality: the Chesapeake Bay. *Marine Resource Economics*, 6(1), 1-18.

This study estimates the value of a moderate improvement in water quality in Chesapeake Bay, U.S. A contingent valuation survey was administered to a random subset of residents in the Baltimore-Washington region of the U.S. Respondents were asked whether they would be willing to pay an amount ($A) in additional taxes per year, providing the water quality was improved to a level acceptable for swimming. The amount of money ($A) varied randomly from $5 to $50 per year. When the authors aggregated the results for the identified population, they found the total annual benefits of improved water quality to amount to just under $10 million ($910,000 1984 dollars).

Bouwes, N. W., and Scheider, R. (1979). Procedures in estimating benefits of water quality change. *American Journal of Agricultural Economics*, 61(3), 635-639.

This paper presents a method for estimating, ex ante, the benefits of water quality change by presenting a model including recreators' ratings of water quality. A decline in water quality in Pike Lake, Wisconsin, can be prevented by the construction of a storm-sewer diversion project. This undertaking can be accomplished for a fixed cost. The question being asked is whether the benefits to be derived from preserving the present high level of water quality will justify the project cost. The demand curve for recreation is measured by the number of trips under various scenarios.

Bowker, J. M., English, D.B.K. and Donovan, J.A. (1996). Toward a value for guided rafting on southern rivers. *Journal of Agricultural and Applied Economics*, 28(2), 423-432.

This study examines per trip consumer surplus associated with guided whitewater rafting on two southern rivers in the U.S. in order to provide information about the value of guided rafting on rivers for management decisions dealing with such rivers and their corridors. An independent travel cost model was developed. A six-page questionnaire was sent to a random selection of names drawn from outfitter records.

Breaux, A., Farber, S., and Day, J. (1995). Using Natural Coastal Wetlands Systems for Waste Water Treatment — An Economic Benefit Analysis. *Journal of Environmental Management*, 44(3), 285-291.

This paper reports on estimates of cost savings from using coastal wetlands for substitute treatment in Louisiana (U.S.). It reports on a set of three existing or proposed wetland wastewater treatment projects in Louisiana. The focus of this paper is the economic benefit of these projects. Estimates of discounted cost savings ranged from $785 to $34,700 per acre of wetlands used for treatment.

Burt, O. R. and Brewer, D. (1971). Estimation of Net Social Benefits from Outdoor Recreation. *Econometrica*, 39(5), 813-827.

This study estimates the value of a new outdoor recreational site in Missouri (U.S.). Consideration for the influence that existing recreation developments had on the demand for the new site was built into the study. Respondents were asked about the number of days spent at each site, expenditures on each trip, mileage driven for each trip, and family income.

Cordell, H. K. and Bergstrom, J.C. (1993). Comparison of recreation values among alternative reservoir water level management scenarios. *Water Resources Research*, 29(2), 247-258.

This policy-informing study measured the change in recreational value of four reservoirs in North Carolina (U.S.) under three alternative water-level management scenarios. Recreational user surveys were used to determine the extent users value higher water levels held longer into the summer and fall. This was compared to the value of using these reservoirs as they were managed at the time of the study.

Costanza, R., Farber, S.C. and Maxwell, J. (1989). Valuation and management of wetland ecosystems. *Ecological Economics*, 1(4), 335-361.

This study used the travel cost method to estimate the value of wetland recreation in Terrebonne Parish, Louisiana (U.S.). A survey of recreational user costs was conducted over a one-year period to elicit willingness to pay to preserve wetlands for recreational purposes.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., and van den Belt, M. (1997). The value of the world's ecosytem services and natural capital. *Nature*, 387(15), 253-260.

This groundbreaking study estimated the economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) was estimated to be in the range of US$16 to $54 trillion ($10^{12}$) per year, with an average of US$33 trillion per year. At the time of the study, global gross national product total was around US$18 trillion per year.

Creel, M., and Loomis, J. (1992). Recreation Value of Water to Wetlands in the San Joaquin Valley: Linked Multinomial Logit and Count Data Trip frequency Models. *Water Resources Research*, 28(10), 2597-2606.

This study values the recreational benefits from providing increased quantities of water to wildlife and fisheries habitats using linked multinomial logit site selection models and count data trip frequency models. The study encompasses waterfowl hunting, fishing and wildlife viewing at 14 recreational resources in the San Joaquin Valley, including the national wildlife refuges, the state wildlife management areas, and six river destinations. The economic benefits of increasing water supplies to wildlife refuges were also examined by using the estimated models to predict changing patterns of site selection and overall participation due to increases in water allocations. Estimates of the dollar value per acre foot of water are calculated for increases in water to refuges. The resulting model is a flexible and useful tool for estimating the economic benefits of alternative water allocation policies for wildlife habitat and rivers.

Croke, K., Fabian, R., and Brenniman, G. (1986). Estimating the value of improved water quality in an urban river system. *Journal of Environmental Systems*, 16, 13-24.

This article estimates the value that cleaner rivers would have to Chicago citizens, and thus measures an important component of value to which the Chicago Deep Tunnel project was expected to contribute. In a contingent value survey, average annual household values ranging from $30 to $50 were observed for various degrees of improvement. An important result is that from two-thirds to nine-tenths of these reflect the intrinsic value of the river's non-use values related to the existence of clean rivers or the option to use them in the future. A comparison with similar published studies confirms the credibility of the results.

Crooks, S., Herr, D., Tamelander, J., Laffoley, D., and Vandever, J. (2011). *Mitigating Climate Change through Restoration and Management of Coastal Wetlands and Near-shore Marine Ecosystems: Challenges and Opportunities*. Environment Department paper 121, World Bank, Washington, DC.

This study was commissioned and overseen by a team at the World Bank. In light of rapidly evolving policy on the eligibility of REDD+ activities under the UNFCC, this activity was designed to inform policy-makers and climate change practitioners on the capture and conservation of blue carbon in natural, coastal carbon sinks. This report consolidates information from the literature and provides analysis on the climate change mitigation potential of seagrasses and coastal wetlands, including coastal peats, tidal freshwater wetlands, salt marshes and mangroves.

Daily G.C. (1997). *Nature's Services: Societal Dependence on Natural Ecosystems*. Island Press. 392 pp.

This book is a collection of different essays divided by chapters by distinct authors. It provides a significant introduction to what ecosystem services are and also explains many of the methodologies used in order to value these services in different land cover types. Some of the authors participating are Jane Lubchenco, Sandra Postel, Norman Myers, Robert Costanza and many more. Apart from explaining key concepts to understanding ecological economics, some chapters give detailed synthesis of preliminary assessment of services economic value.

Doss, C. R. and Taff, S.J. (1996). The Influence of Wetland Type and Wetland Proximity on Residential Property Values. *Journal of Agricultural and Resource Economics*, 21(1), 120-129.

This study estimated the value of wetlands in Minnesota (U.S.) through the hedonic pricing method. The authors used detailed residential housing pricing data and wetland location to determine relative preferences for proximity to four broad classes of wetlands.

Duarte, C., Middelburg, J., and Caraco, N. (2005). Major role of marine vegetation on the oceanic carbon cycle. *Biogeosciences*, 2, 1-8.

The carbon burial in vegetated sediments was evaluated using a bottom-up approach derived from upscaling a compilation of published individual estimates of carbon burial in vegetated habitats (seagrass meadows, salt marshes and mangrove forests) to the global level and a top-down approach derived from considerations of global sediment balance and a compilation of the organic carbon content of vegetated sediments.

Duffield, J. W., Neher, C.J., and Brown, T.C. (1992). Recreation benefits of instream flow: Application to Montana's Big Hole and Bitterroot Rivers. *Water Resources Research*, 28(9), 2169-2181.

A framework for estimating the recreational value of in-stream flows was developed for two Montana rivers (U.S.). The valuation survey employed in this study was specifically designed to examine the influence of stream-flow levels on willingness to pay for recreational trips.

Edwards, S. F., and Gable, F.J. (1991). Estimating the value of beach recreation from property values: An exploration with comparisons to nourishment costs. *Ocean and Shoreline Management*, 15(1), 37-55.

This paper explores how the economic value of recreation at local public beaches can be estimated from nearby property values. The negative effect of distance from the nearest public beach on coastal property values was used to reveal recreational value. Estimates of recreational value were also compared to the costs of beach nourishment that were calculated from a simulation of beach erosion caused, in part, by increases in relative sea-level. Although a complete benefit-cost analysis was not feasible, the results suggest that potential losses of recreational value by local users alone could establish the efficiency of beach nourishment projects.

Federal, Provincial, and Territorial Governments of Canada. 2014. *2012 Canadian Nature Survey: Awareness, participation, and expenditures in nature-based recreation, conservation, and subsistence activities.* Ottawa, ON: Canadian Councils of Resource Ministers.

This study seeks to provide evidence of the contribution that nature makes to the national economy and individual Canadians' quality of life. A survey was administered to a representative sample of Canadian adults during 2012-2013, which sought information on nature-related expenditures. For the purposes of this study, per person results for British Columbia were used to estimate population-based estimates for the study region, which were then broken down into per hectare values.

Greenley, D. A., Walsh, R.G., and Young, R.A. (1981). Option Value: Empirical Evidence from a Case Study of Recreation and Water Quality. *Quarterly Journal of Economics*, 96(4), 657-673.

This study aims to measure the preservation value of water quality in the presence of potential irreversible water-quality degradation due to mining activity in the South Platte River Basin, Colorado (U.S.). Survey respondents answered "yes" or "no" to dollar increments in willingness to pay, dependent on hypothetical change in water quality.

Gupta, T.R., and Foster, J.H. (1975). Economic Criteria for Freshwater Wetland Policy in Massachusetts. *American Journal of Agricultural Economics*, 57(1), 40-45.

The authors of this article demonstrate that comparison of benefit value with opportunity cost of wetland preservation can be used as the basis for decisions concerning permits for wetland alteration. The approach used for measuring municipal water supply benefit from preserved wetlands compares the cost of wetland water with that of an alternative water source. The study found that an average acre of wetland could supply water at a savings of $2,800 per year compared to other water sources.

Haener, M. K., and Adamowicz, W.I. (2000). Regional forest resource accounting: a northern Alberta case study. *Canadian Journal of Forest Research*, 30(2), 264-273.

This study outlines the development of a resource accounting system for a region of public forestland in northern Alberta. The purpose of this exercise is to provide a clearer picture of the market and nonmarket benefits provided by the forest. The services valued include commercial activities such as forestry, trapping, and fishing plus non-commercial or non-market activities. Non-market services include recreational activities (fishing, hunting and camping), subsistence resource use and environmental control services (carbon sequestration and biodiversity maintenance). Habitat value is measured using two different approaches: contingent valuation and net factor income.

Hauser, A., and van Kooten, G.C. (1993). *Benefits of Improving Water Quality in the Abbotsford Aquifer: An application of contingent valuation methods*. Environment Canada.

Given risks to health and lack of knowledge concerning the benefits of improved water quality, a contingent valuation survey was conducted in the Abbotsford region. The survey sought to elicit respondents' willingness to pay for improvements in water quality. As well, defence expenditures (actual outlays on bottled water and water filters) and a ranking method were used to determine the value of improved water quality in Abbotsford. The survey was mailed to 347 households in the Central Fraser Valley region in May of 1993.

Hayes, K. M., Tyrrell, T.J., and Anderson, G. (1992). Estimating the Benefits of Water Quality Improvements in the Upper Narragansett Bay. *Marine Resource Economics*, 7(1), 75-85.

This study estimated the benefits to Rhode Island residents using the contingent valuation approach and responses from 435 residents to a 1985 survey about swimming and shell-fishing. Aggregate annual benefits were estimated to be in the range of $30 million to $60 million for "swimmable" and $30 million to $70 million for "shell-fishable" water quality, depending on the type of measure (mean or median) and survey format.

Intergovernmental Panel on Climate Change (IPCC). (2007). Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.I. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7-22.

This assessment of current scientific understanding of the impacts of climate change on natural, managed and human systems deals primarily with the capacity of these systems to adapt and their vulnerability in doing so. As a follow-up document of past IPCC assessments, this recent version incorporates new knowledge gained since. This report includes data on anthropogenic impacts on acidification, regional climate change, temperature rise in oceans, etc., explaining not only the ecological concerns but also the health issues related to these conflicts. A conglomeration of factual data is presented, such as the social cost of carbon calculated by the damages caused by climate change across the globe.

Johnson, R. J., Grigalunas, T.A., Opaluch, J.J., Mazzotta, M., and Diamantedes, J. (2002). Valuing Estuarine Resource Services using Economic and Ecological models: The Peconic Estuary System Study. *Coastal Management*, 30(1), 47-65.

This study estimates the value of wetlands for recreation and habitat using a variety of methods:

- A property-value study examines the contribution of environmental amenities to the market price of property. Using the Town of Southold as a case study, this study was designed to measure the implicit values of policy-relevant scenic amenities to nearby residents.
- A travel-cost study estimates the economic value that users have for four key PES outdoor recreation activities. This study also examines the impact of (1) water quality on the number of trips by and the value of swimming to participants and (2) catch rates on recreational fishing.
- A wetlands productivity value study provides estimates of the economic value of eelgrass, intertidal salt marsh and sand/mud bottoms, based on the value of the fish, shellfish and bird species that these ecosystems help produce. The focus is on the nursery and habitat services of wetland ecosystems in the production of commercial fisheries.
- A resource-value study uses contingent choice methodology to estimate the relative preferences that residents and second homeowners have for preserving and restoring key PES natural and environmental resources, including open space, farmland, unpolluted shellfish grounds, eelgrass beds and intertidal salt marsh. This study also provides an estimate of the public's willingness to pay, or economic value for these resources.

Kahn, J. R. and Buerger, R.B. (1994). Valuation and the Consequences of Multiple Sources of Environmental Deterioration: The Case of the New York Striped Bass Fishery. *Journal of Environmental Management*, 40(3), 257-273.

The value of Chesapeake spawned striped bass to New York commercial fisherman was calculated by estimating demand and supply functions for striped bass caught in New York waters, where the supply function relates to the abundance of Hudson River spawned fish and Chesapeake-spawned fish. Travel-cost demand is estimated for charter-boat fishing in general.

Kealy, M.J., and Bishop, R.C. (1986). Theoretical and Empirical Specifications Issues in Travel Cost Demand Studies. *American Journal of Agricultural Economics Association*, 68(3), 660-667.

A travel cost demand model is derived from a utility function, which postulates that individuals choose the optimal total number of site recreation days given by the product of the number and length of their recreation trips. By relaxing the assumption that on-site time is constant across recreationists, the applicability of the travel cost method is extended. A mail survey of Lake Michigan sports anglers was used to estimate recreational value. The estimated opportunity cost of a day of fishing was modelled to include both a monetary-cost component and a time-cost component.

Kline, J.D. and Swallow, S.K. (1998). The demand for local access to coastal recreation in southern New England. *Coastal Management*, 26(3), 177-190.

This study examines the demand for coastal access to a local, free-access site in Gooseberry, Massachusetts, through onsite interviews. One set of interviews involved determining the number of individuals interested in key beach activities, whereas a second set of interviews focused on individuals' willingness to pay to access the beach.

Knowler, D.J., MacGregor, B.W., Bradford, M.J., and Peterman, R.M. (2003). Valuing freshwater salmon habitat on the west coast of Canada. *Journal of Environmental Management*, 69(3), 261-273.

This paper presents a framework for valuing the benefits for fisheries from protecting areas from degradation, using the example of the Strait of Georgia coho salmon fishery in southern British Columbia, Canada. The authors use a bioeconomic model of the coho fishery to derive estimates of value that are consistent with economic theory. Then they estimate the value of changing the quality of fish habitat by using empirical analyses to link fish population dynamics with indices of land use in surrounding watersheds. Sensitivity analyses suggest that these values are relatively robust to different assumptions, and if anything, are likely to be minimum estimates.

Knowler, D., and Dust, K. (2008). *The Economics of Protecting Old Growth Forest: An Analysis of Spotted Owl Habitat in the Fraser Timber Supply Area of British Columbia*. School of Resource and Environmental Management. Simon Fraser University.

The values of protecting old growth forests in the Fraser Timber Supply Area of B.C. are drawn from the Outdoor Recreation Survey from 1989/1990. The survey measures the amount consumers value outdoor recreation beyond how much they spend on outdoor recreation. According to this report, 52 per cent of the recreation user days occur in the Vancouver forest region, worth an estimated $79.19 per hectare per year.

Kreutzwiser, R. (1981). The Economic Significance of the Long Point Marsh, Lake Erie, as a Recreational Resource. *Journal of Great Lakes Research*, 7(2), 105-110.

This study sought to assess the economic significance of recreational use of the Long Point and Point Pelee National Park (Cdn) marshes. The authors used the travel-cost method by interview and mail-back questionnaires. In addition to providing data on the nature and extent of wetland recreational use and user characteristics and motivations, the surveys provided data on user-party travel and other expenditures necessary for estimating the economic value of the wetland recreational benefits.

Kulshreshtha, S. N. and Gillies, J.A. (1993). Economic Evaluation of Aesthetic Amenities: A Case Study of River View. *Journal of the American Water Resources Association*, 29(2), 257-266.

This study estimated the value of aesthetic amenities provided by the South Saskatchewan River to the residents of Saskatoon (Cdn). Differences in property value associated with a river view were estimated using a hedonic price model. Actual market data were obtained to determine residents' willingness to pay for higher property taxes or higher rents.

Laffoley, D., and Grimsditch, G. (2009). *The Management of Natural Coastal Carbon Sinks*. International Union for Conservation of Nature and Natural Resources (IUCN).

This report focuses on management of natural coastal carbon sinks. To construct this report, leading scientists were asked for their views on the carbon management potential of a number of coastal ecosystems: tidal salt-marshes, mangroves, seagrass meadows, kelp forests and coral reefs. The resultant chapters written by these scientists form the core of this report and are scientists' views on how well such habitats perform a carbon-management role.

Leggett, C. G., and Bockstael, N.E. (2000). Evidence of the Effects of Water Quality on Residential Land Prices. Journal of Environmental Economics and Management, 39(2), 121-144.

This article assesses the effect of water quality on property values along the Chesapeake Bay (U.S.). The authors use a measure of water quality — fecal coliform bacteria — for which spatially explicit data is publically accessible. The data used in the analysis consists of waterfront property sales in Anne Arundel County, Maryland, that occurred between July 1993 and August 1997. The dependent variable was the actual sales price adjusted to constant dollars using the CPI. After accounting for omitted variable bias and after correcting for spatial autocorrelation, the authors concluded that waterfront homeowners have a positive willingness to pay for improved water quality.

Leschine, T. M., Wellman, K.F., and Green, T.H. (1997). *The Economic Value of Wetlands: Wetlands' Role in Flood Protection in Western Washington*. Washington State Department of Ecology. 68pp.

This study estimates the dollar-per-acre values of wetland systems for flood protection in two Western Washington communities currently experiencing frequent flooding, Lynnwood and Renton. This is done via a variant of the alternative/substitute cost method. Cost estimates for engineered hydrologic enhancements to wetlands currently providing flood protection are used to establish proxies for the value of the flood protection these same wetlands currently provide. A simple "ratio analysis" scheme is employed, making the method easily transferable to other communities, which, like Lynnwood and Renton, are seeking ways to enhance the flood protection their remaining wetlands provide. The proxy values estimated are in the range of tens of thousands per acre in current dollars, suggesting that communities are likely to pay an increasingly high price for flood protection if they allow their remaining natural systems capable of attenuating flood flows to become further compromised in their ability to do so.

Loomis, J. (2002). Quantifying recreation use values from removing dams and restoring free-flowing rivers: A contingent behavior travel cost demand model for the Lower Snake River. *Water Resources Research*, 38(6), 1066, doi:10.1029/2000Wr000136.

A travel-cost demand model that uses intended trips if dams are removed and the river restored is presented as a tool for evaluating the potential recreation benefits in this counterfactual but increasingly policy-relevant analysis of dam removal. The model is applied to the Lower Snake River in Washington using data from mail surveys of households in the Pacific Northwest region. This gain in river recreation exceeds the loss of reservoir recreation but is about $60 million less than the total costs of the dam removal alternative. The analysis suggests this extension of the standard travel-cost method may be suitable for evaluating the gain in river recreation associated with restoration of river systems from dam removal or associated with dam relicensing conditions.

Mahan, B. L., Polasky, S., and Adams, R.M. (2000). Valuing Urban Wetlands: A Property Price Approach. *Land Economics*, 76(1), 100-113.

This study estimates the value of wetland amenities in the Portland, Oregon (U.S.), metropolitan area using the hedonic property price model. Residential housing and wetland data are used to relate the sales price of a property to structural characteristics, neighbourhood attributes and amenities of wetlands and other environmental characteristics.

Mazzotta, M. J. (1996). *Measuring public values and priorities for natural resources: An application to the Peconic Estuary system*. ETD Collection for university of Rhode Island (dissertation).

A survey was administered to 968 residents of the area surrounding the Peconic Estuary in New York State (U.S.) to estimate the value of the regions' natural resources. The survey presented sets of hypothetical alternatives, described their effects on natural resources and the associated cost to the household. The alternatives included "no new action", and two different programs to protect or enhance natural resources.

Mullen, J. K. and Menz, F.C. (1985). The Effect of Acidification Damages on the Economic Value of the Adirondack Fishery to New York Anglers. *American Journal of Agricultural Economics Association*, 67(1), 112-119.

The purpose of this study was to estimate the effect of acidification damages on the economic value of the recreational fishery in the Adirondack mountain region of northern New York. A travel-cost model was used with cross-sectional data to estimate angling demand and economic value of the fishery. Acidification damages were assumed to cause the loss of certain ponded water angling sites, leading to changes in site use and reducing the fishery's value to anglers.

Nellemann, C., Corcoran, E., Duarte, C.M., Valdés, I., De Young, C., Fonseca, I., Grimsditch, G. (Eds). (2009). *Blue Carbon. A Rapid Response Assessment*. United Nations Environment Programme (UNEP), Grid-Arendal, www.grida.no.

This report explores the potential for mitigating the impacts of climate change by improved management and protection of marine ecosystems and especially the vegetated coastal habitat, or blue carbon sinks. Carbon burial rates are presented per hectare and globally, as reported ranges of mean rates of global carbon burial derived using different methods. The data are for vegetated coastal areas and their percentage contribution to carbon burial in the coastal and global ocean.

Newell, R.I.E., Fisher, T.R., Holyoke, R.R., and Cornwell, J.C. (2005). Influence of Eastern Oysters on Nitrogen and Phosphorus Regeneration in Chesapeake Bay, U.S. NATO Science Series: IV: *Earth and Environmental Sciences*, 47, 93-120.

This paper estimates the possible effects of stocks of subtidal eastern oysters on the watershed-level nitrogen and phosphorus budgets for the Choptank River, a tributary of Chesapeake Bay (U.S.). The authors develop an elementary "spread-sheet" model to assess the influence of eastern oysters on removal of N and P inputs to the Choptank River estuary, a mesohaline Maryland tributary to Chesapeake Bay. They estimated the monthly amount of P buried and N removed due to burial and coupled nitrification-denitrification resulting from the biodeposition activity of adult eastern oysters.

Nowak, D.J., Hirabayashi, S., Bodine, A., and Greenfield, E. (2014). Tree and forest effects on air quality and human health in the United States. *Environmental Pollution,* 193, 119-129.

This study employs four types of analysis to estimate the avoided health impacts and associated dollar benefits of air pollution removal by trees and forests in the U.S. The types of analysis included (1) total tree cover and leaf area daily indices; (2) hourly pollutant fluxes to and from leaves; (3) impact of hourly pollution removal on pollutant concentration in the atmosphere; and (4) health impacts and monetary value of the change in pollutants. The authors found that current tree cover amounted to the avoidance of over 850 incidences of human mortality and 670,000 incidences of acute respiratory systems, a value of US$6.8 billion.

Olewiler, N. (2004). *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited and Nature Conservancy of Canada.

This study estimates the value of waste treatment by wetlands, based on the replacement cost method. The costs of removing phosphorus vary from $21.85 to $61.20 per kilogram at Vancouver's primary and secondary waste-treatment plants, while costs for nitrogen vary from $3.04 to $8.50 per kilogram. The annual value of waste treatment of phosphorus and nitrogen produced by one hectare of the Fraser Valley's wetlands is estimated to be at least $452 and may be as high as $1,270. The annual nitrogen and phosphorus waste-treatment benefits received from the existing 40,000 hectares of wetlands in the Lower Fraser Valley's wetlands could thus amount to between $18 million and $50 million per year.

Parsons, G. R. and Powell, M. (2001). Measuring the Cost of Beach Retreat. *Coastal Management*, 29, 91-103.

This study estimates the cost over the next 50 years of allowing Delaware's ocean beaches to retreat inland. Since most of the costs are expected to be land and capital loss, especially in housing, the focus is on measuring that value. A hedonic price regression is used to estimate the value of land and structures in the region using a data set on recent housing sales. Then, using historical rates of erosion along the coast and an inventory of all housing and commercial structures in the threatened coastal area, the authors predict the value of the land and capital loss assuming that beaches migrate inland at these historic rates. Then the losses of any amenity values due to proximity to the coast are purged, because these are merely transferred to properties further inland. These estimates are then compared to the current costs of nourishing beaches. The authors conclude that nourishment makes economic sense, at least over this time period.

Pate, J. and Loomis, J. (1997). The effect of distance on willingness to pay values: a case study of wetlands and salmon in California. *Ecological Economics*, 20(3), 199-207.

The overall goal of this study was to determine if distance affects willingness to pay for public goods with large non-use values. The data used came from a contingent valuation study regarding the San Joaquin Valley, CA. Respondents were asked about their willingness to pay for three proposed programs designed to reduce various environmental problems in the valley. A logit model was used to examine the effects of geographic distance on respondents' willingness to pay for each of the three programs. Results indicate that distance affected WTP for two of the three programs (wetlands habitat and wildlife, and the wildlife contamination control programs).

Piper, S. (1997). Regional Impacts and Benefits of Water-Based Activities: An Application in the Black Hills Region of South Dakota and Wyoming. *Impact Assessment*, 15, 335-359.

This study estimates the value of water-related recreation as part of a framework for evaluating water-management scenarios in regions of South Dakota and Wyoming (U.S.). A national survey of fishing, hunting and wildlife-associated recreation was used to estimate recreation expenditures.

Pompe, J.J. and Rinehart, J.R. (1995). Beach Quality and the Enhancement of Recreational Property-Values. *Journal of Leisure Research*, 27(2), 143-154.

This study uses the hedonic pricing technique to examine the contribution of beach quality, as measured by beach width, to property values in two South Carolina coastal towns. Using two separate models, the authors estimate the values of wider beaches to vacant lots and single homes, both with and without water footage. The willingness to pay for wider beaches is an indication of the size of the storm protection and recreational values produced by wider beaches.

Rein, F. A. (1999). An Economic Analysis of Vegetative Buffer Strip implementation. Case Study: Elkhorn Slough, Monterey Bay, California. *Coastal Management*, 27(4), 377-390.

Vegetative buffer strips (VBS) are being proposed as a tool to protect water quality from nonpoint pollution nationwide, yet no studies have investigated the economics of implementing VBS. This study evaluates environmental costs and benefits of implementing VBS, both to the grower and to society as a whole, as a means of capturing non-market ecosystem values and informing decision-making. Most values were determined by evaluating actual market prices gathered from the region or by the replacement-cost method, in which values are determined by comparison with the value of a marketed substitute.

Ribaudo, M.O., and Epp, D.J. (1984). The importance of Sample Discrimination in Using the Travel Cost Method to Estimate the Benefits of Improved Water Quality. *Land Economics*, 60(4), 397-403.

An application of the travel-cost method with emphasis on surveying current and former users was made at St. Albans Bay in Vermont. Increased phosphorus loading in the bay has resulted in declines in recreational use. The authors estimated the value of improvements in water quality using a sample consisting of those who currently use the subject site despite the pollution problem and those who refuse to use the site under current conditions but may return if it were to become cleaner. They concluded that substantial benefits would be generated for both current and non-users if the bay's water quality were improved to a level matching local substitute sites.

Sanders, L.D., Walsh, R.G., and Loomis, J.B. (1990). Toward Empirical Estimation of the Total Value of Protecting Rivers. *Water Resources Research*, 26(7), 1345-1357.

This study estimates the value of rivers for recreation use, with the intent of assisting decision-makers with the larger problem of estimating how much they should pay for the protection of resources. The authors used the contingent-valuation approach to determine the demand for rivers by both users and non-users. A sample of the residents of the Rocky Mountain region of Colorado (U.S.) were asked direct questions about the value of changes in the quantity or quality of the river.

Shafer, E.I., Carline, R., Guldin, R.W., and Cordell, H.K. (1993). Economic amenity values of wildlife: Six case studies in Pennsylvania. *Environmental Management*, 17(5), 669-682.

The travel cost method (TCM) and contingent valuation method (CVM) were used to evaluate the economic value of six different ecotourism activities involving observation of wildlife in Pennsylvania. The six activities were catch-and-release trout fishing; catch-and-release trout fishing with fly-fishing equipment; viewing waterfowl; watching elk; observing migration flights of raptors; and seeing live wildlife in an environmental education setting. TCM results provided significant statistical relationships between level of use and travel costs for the two types of trout-fishing activities. CVM provided estimates of consumer surplus for the other four sites. The economic amenity values of the six activities compare favourably with similarly derived values in other studies for hunting, fishing, hiking and backpacking in dispersed recreation environments and wilderness areas in western states.

Silberman, J., Gerlowski, D.A., and Williams, N.A. (1992). Estimating Existence Value for Users and Nonusers of New Jersey Beaches. *Land Economics*, 68(2), 225-236.

This study reports empirical evidence on existence value for beach nourishment. The focus is an analysis of respondents who intend to use the beach to be nourished and those who do not. Two contingent valuation method (CVM) surveys were designed to measure the existence value of beach nourishment from Sea Bright to Ocean Township, New Jersey. Large sections of this 12-mile stretch of beach experienced substantial erosion so that beach recreation is very limited. People using the beaches at sites in the vicinity of the beach nourishment were the respondents in the on-site survey. A telephone survey queried persons not using the New Jersey beaches.

Streiner, C. and Loomis, J. (1996). Estimating the Benefits of Urban Stream Restoration Using the Hedonic Price Method. *Rivers*, 5(4), 267-278.

This study used the hedonic price method to estimate the value of stream restoration measures such as reduced flood damage and improved fishing habitat. The authors examined California's Department of Water Resources Urban Stream Restoration Program. They extracted data on property transactions, property characteristics and demographics from seven projects in three counties.

Taylor, L.O. and Smith, V.K. (2000). Environmental Amenities as a Source of Market Power. *Land Economics*, 76(4), 550-568.

Using estimates from hedonic-price equations and residual-demand models, this study recovers firm-specific estimates of price markups as measures of market power, and uses these markups to estimate the implied marginal value for access to coastal beaches. The application involves rental price and occupancy data for several thousand beach properties along a portion of the North Carolina coastline during the 1987 to 1992 rental seasons.

Thibodeau, F.R. and Ostro, B.D. (1981). An Economic Analysis of Wetland Protection. *Journal of Environmental Management*, 12, 19-30.

This paper quantifies some of the economic benefits of wetlands in the Charles River Basin in Massachusetts (U.S.). The benefits resulting from flood control, pollution reduction, water supply and recreation were monetized. The value of flood control was estimated by the cost of property damage that would occur if the wetlands were filled. Pollution reduction was estimated by estimating the replacement cost of wastewater plants. Water-supply value was calculated as the difference between the cost of wetland wells and the cost of providing water from the next best source. Lastly, recreational value was estimated using a mixture of travel-cost and contingent valuation.

U.S. Department of the Army Corps of Engineers, New England Division. *Charles River Massachusetts, Main Report and Attachments*. Waltham, Massachusetts, 1971.

In this study, the economic valuation method used to assign a dollar amount per wetland for this flood control function is based on the amount of flood damage avoided when the wetland is left intact. Benefits are estimated as the difference between annual losses under present land-use conditions and those associated with the projected 1990 loss of 30 per cent of valley storage. The loss of valley storage is based on hydrographic analysis to determine the effect of shrinking natural valley storage on flood flows.

Ward, F.A., Roach, B.A., and Henderson, J.E. (1996). The Economic Value of Water in Recreation: Evidence from the California drought. *Water Resources Research*, 32(4), 1075-1081.

The question of how recreational values change as reservoir levels change is explored in this study. Reservoir visitor data from Sacramento, California (U.S.), during the 1985-1991 drought was analyzed to isolate water's effect on visits from price and other effects.

Whitehead, J.C. (1990). Measuring Willingness-to-Pay for Wetlands Preservation with the Contingent Valuation Method. *Wetlands*, 10, 187-201.

Preservation of bottomland hardwood forest wetlands is threatened by pressure from surface coal-mining activities in the western Kentucky coalfield. The contingent valuation survey method was used to measure the economic benefits (willingness to pay) of preserving the Clear Creek wetland, the largest wetland area in the coalfield, from surface coal mining. Results indicated that Kentucky households are willing to pay in the form of voluntary contributions to a hypothetical "wetland preservation fund".

Whitehead, J.C., Hoban, T.I., and Clifford, W.B. (1997). Economic analysis of an estuarine quality improvement program: The Albemarle-Pamlico system. *Coastal Management*, 25(1), 43-57.

This article presents an economic-efficiency analysis of a proposed management plan for the Albemarie-Pamlico Estuary in North Carolina (U.S.). A survey was used to estimate benefits of estuary quality improvements. Respondents were asked if their household would pay higher taxes to control pollution, monitor water quality, protect habitat and educate people. The authors concluded that the management plan would be an efficient government program if the negative externalities associated with the economic growth of the region are controlled.

Whitehead, J.C., Groothuis, P.A., Southwick, R., and Foster-Turley, P. (2009). Measuring the Economic Benefits of Saginaw Bay Coastal Marsh with Revealed and Stated Preference Methods. *Journal of Great Lakes Research*, 35(3), 430-437.

This study used both the travel-cost method and contingent-valuation method to value the Saginaw Bay coastal marsh in Michigan (U.S.). While the travel-cost approach measured actual recreation expenses, the contingent valuation method asked a random sample of Michigan hunting and fishing licence holders hypothetical survey questions. The authors found the two methods yielded complementary results.

Wilson, S.J. (2008). *Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services*. Prepared for the David Suzuki Doundation. 70 pp.

Habitat (wetland and forest): The annual value for wetland habitat services is based on the average annualized wetland habitat-restoration costs for a group of relevant Great Lakes Sustainability Fund projects. The annualized value of restoring habitat represents the value of wetland habitat in terms of the avoided cost of damages to habitat.

Wilson, S.J. (2010). *Natural Capital in B.C.'s Lower Mainland: Valuing the Benefits from Nature*. Prepared for the David Suzuki Foundation. 67 pp.

Water Supply (Forest and Wetland): This study estimated the value of water-filtration services by forests and wetlands in the study area's watersheds. The economic value for the benefit of water filtration was based on the potential increase in water-treatment costs if the current forest/wetland cover declined from its current average cover. Thus, the value is based on the additional cost for water treatment if the current natural cover declined.

Air Purification (Forest): This study estimated the value of air purification based on avoided costs from an EPA study that is used by CITYgreen software. This software calculates the quantity of air cleansing by trees using average removal rates of carbon monoxide, nitrogen dioxide, particulate matter and sulphur dioxide, using a U.S. average of many urban studies. The removal rates were then used to assess the amount of air pollutants removed by the tree canopy across the study area.

Carbon Storage (Forest): This study quantified the value of carbon per hectare of forest based on analysis of the B.C. Vegetation Resources Inventory database, which provides forest cover by age-cover class. Carbon stored by forest greater than 250 years old was quantified based on Keith et al. 2009 field studies. The value of carbon storage was based on the average social cost of carbon from IPCC reports. A range of values was reported based on the age for forest and respective amount of carbon stored by each age-class cover.

Carbon Storage (Wetlands): The annual amount of carbon stored in soils/peat of wetlands was analyzed using primary data from the Canadian Soil Organic Database. The value of stored carbon was then estimated using the average social cost of carbon from the IPCC.

Carbon Sequestration (Forest): The annual uptake of carbon was calculated using CITYgreen software. CITYgreen's carbon module estimated average carbon sequestration using forest canopy based on the estimated age distribution. The social carbon cost was used to value sequestration.

Disturbance Regulation (Forest): The economic value of water regulation by forests is calculated as an avoided cost value using CITYgreen software. Analysis of the study area's total forest cover was assessed in terms of the avoided construction costs for water runoff control if the current forest cover was removed and converted for urban land use.

Waste Treatment (Wetlands): The low end of the amounts of nitrogen and phosphorus that wetlands can remove are used to estimate a wetland's capacity to treat waste. The costs of removing N and P by waste-treatment plants were transferred from the Olewiler (2004) study. The respective average replacement costs can be used as a proxy for the value of wetland waste treatment services.

Zhongwei, L. (2006). *Water Quality Simulation and Economic Valuation of Riparian Land-Use Changes*. Division of Research and Advanced Studies of the University of Cincinnati (dissertation).

This report estimates the value of riparian forest buffer zones based on the cost of nitrogen and phosphorus removal through wastewater treatment plants in Little Miami River watershed, Ohio. The replacement cost method was used to estimate the value of riparian forest buffer zones based on the cost of nitrogen and phosphorus removal through wastewater treatment plants.

Detailed Ecosystem Service Tables

TABLE 23: SUMMARY OF VALUES OF ECOSYSTEM SERVICES BY BENEFIT (2014 C$)

Benefits	Land/water cover type	Total value per year ($/yr)		Value per hectare per year ($/ha/yr)	
		Low	High	Low	High
Food provisioning	Marine	$95,073.47	$95,073.47	$0.67	$0.67
	Total	$95,073.47	$95,073.47	$0.67	$0.67
Clean water	Estuary	$4,946.56	$111,294.98	$18.88	$424.79
	Forest	$299,776,092.00	$763,239,477.00	$2,215.64	$5,641.09
	Lakes and rivers	$3,194,850.57	$4,761,702.35	$1,880.43	$2,802.65
	Wetlands	$15,606.50	$5,132,367.50	$120.05	$39,479.75
	Total	$302,991,495.63	$773,244,841.83	$4,235.00	$48,348.28
Disturbance regulation	Beach	$24,719.60	$10,702,596.45	$170.48	$73,811.01
	Forest	$97,296,936.00	$237,626,037.00	$719.12	$1,756.29
	Riparian buffer	$105,713.10	$3,297,608.80	$25.11	$783.28
	Wetland	$157,614.60	$961,693.20	$1,212.42	$7,397.64
	Total	$97,584,983.30	$252,587,935.45	$2,127.13	$83,748.22
Nutrient cycling	Eelgrass beds	$118,943.37	$333,071.57	$18,298.98	$51,241.78
	Estuary	$73,522.44	$73,522.44	$280.62	$280.62
	Total	$192,465.81	$406,594.01	$18,579.60	$51,522.40
Carbon sequestration	Eelgrass beds	$178.30	$3,237.52	$27.43	$498.08
	Estuary	$7,186.66	$7,186.66	$27.43	$27.43
	Forest	$6,184,563.00	$6,184,563.00	$45.71	$45.71
	Total	$6,191,927.96	$6,194,987.18	$100.57	$571.22
Carbon storage	Eelgrass beds	$221.91	$721.18	$34.14	$110.95
	Estuary	$7,985.76	$7,985.76	$30.48	$30.48
	Forest	$271,022,136.00	$271,022,136.00	$2,003.12	$2,003.12
	Marine	$1,426.12	$1,426.12	$0.01	$0.01
	Wetland	$98,718.10	$375,787.10	$759.37	$2,890.67
	Total	$271,130,487.89	$271,408,056.16	$2,827.12	$5,035.23

Table 23 continued					
Benefits	Land/water cover type	Total value per year ($/yr)		Value per hectare per year ($/ha/yr)	
		Low	High	Low	High
Air purification	Forest	$2,057,913.00	$78,498,354.00	$15.21	$580.18
	Total	$2,057,913.00	$78,498,354.00	$15.21	$580.18
Waste treatment	Riparian buffer	$3,492,742.30	$3,507,308.90	$829.63	$833.09
	Wetland	$33,892.30	$8,372,514.80	$260.71	$64,403.96
	Total	$3,526,634.60	$11,879,823.70	$1,090.34	$65,237.05
Habitat	Eelgrass beds	$33,215.13	$229,574.74	$5,110.02	$35,319.19
	Estuary	$77,880.44	$75,880.44	$289.62	$289.62
	Forest	$473,550.00	$4,640,790.00	$3.50	$34.30
	Lakes and rivers	$12,810.46	$1,613,846.12	$7.54	$949.88
	Marine	$268,110.56	$1,431,824.48	$1.88	$10.04
	Riparian buffer	$122,216.30	$560,182.60	$29.03	$133.06
	Wetlands	$3,773.90	$3,783,728.00	$29.03	$29,105.60
	Total	$989,556.79	$12,335,826.38	$5,470.62	$65,841.69
Tourism and recreation	Beach	$70,918.05	$21,932,810.20	$489.09	$151,260.76
	Estuary	$1,139.70	$178,021.14	$4.35	$679.47
	Forest	$1,217,700.00	$233,545,389.00	$9.00	$1,726.13
	Lakes and rivers	$7,186.77	$111,211,392.03	$4.23	$65,456.97
	Marine	$96,900,575.64	$2,804,837,197.32	$679.47	$19,667.61
	Riparian buffer	$118,722.00	$148,623,567.10	$28.20	$35,302.51
	Wetlands	$15,238.60	$3,852,492.80	$117.22	$29,634.56
	Total	$98,331,480.76	$3,324,180,869.59	$1,331.56	$303,728.01
Nature-based education	Beach	$4,819.80	$4,819.80	$33.24	$33.24
	Eelgrass beds	$216.06	$216.06	$33.24	$33.24
	Estuary	$8,708.88	$8,708.88	$33.24	$33.24
	Forest	$4,497,372.00	$4,497,372.00	$33.24	$33.24
	Lakes and rivers	$56,474.76	$56,474.76	$33.24	$33.24
	Marine	$4,740,422.88	$4,740,422.88	$33.24	$33.24
	Riparian buffer	$139,940.40	$139,940.40	$33.24	$33.24
	Wetlands	$4,321.20	$4,321.20	$33.24	$33.24
	Total	$9,452,275.98	$9,452,275.98	$265.92	$265.92
Grand total		$792,544,295.19	$4,740,284,637.75	$36,043.74	$624,878.87

TABLE 24: LAND/WATER COVER VALUES FOR HOWE SOUND ECOSYSTEMS

Land/water cover	Total value ($)		Value per hectare per year ($/ha/yr)	
	Low	High	Low	High
BEACH				
Aesthetic and recreation	$70,918.05	$21,932,810.20	$489.09	$151,260.76
Disturbance regulation	$24,719.60	$10,702,596.45	$170.48	$73,811.01
Nature-based education	$4,819.80	$4,819.80	$33.24	$33.24
Total	$100,457.45	$32,640,226.45	$692.81	$225,105.01
EELGRASS BEDS				
Nutrient cycling	$118,943.37	$333,071.57	$18,298.98	$51,241.78
Carbon sequestration	$178.30	$3,237.52	$27.43	$498.08
Carbon storage	$221.91	$721.18	$34.14	$110.95
Habitat	$33,215.13	$229,574.74	$5,110.02	$35,319.19
Nature-based education	$216.06	$216.06	$33.24	$33.24
Total	$152,774.77	$566,821.06	$23,503.81	$87,203.24
ESTUARIES				
Clean water	$4,946.56	$111,294.98	$18.88	$424.79
Nutrient cycling	$73,522.44	$73,522.44	$280.62	$280.62
Carbon sequestration	$7,186.66	$7,186.66	$27.43	$27.43
Carbon storage	$7,985.76	$7,985.76	$30.48	$30.48
Habitat	$75,880.44	$75,880.44	$289.62	$289.62
Recreation and tourism	$1,139.70	$178,021.14	$4.35	$679.47
Nature-based education	$8,708.88	$8,708.88	$33.24	$33.24
Total	$179,370.44	$462,600.30	$684.62	$1,756.65
FOREST				
Clean water	$299,776,092.00	$763,239,477.00	$2,215.64	$5,641.09
Disturbance regulation	$97,296,936.00	$237,626,037.00	$719.12	$1,756.29
Carbon sequestration	$6,184,563.00	$6,184,563.00	$45.71	$45.71
Carbon storage	$271,022,136.00	$271,022,136.00	$2,003.12	$2,003.12
Air purification	$2,057,913.00	$78,498,354.00	$15.21	$580.18
Habitat	$473,550.00	$4,640,790.00	$3.50	$34.40
Tourism and recreation	$1,217,700.00	233,545,389.00	$9.00	$1,726.13
Nature-based recreation	$4,497,372.00	$4,497,372.00	$33.24	$33.24
Total	$682,526,262.00	$1,599,254,118.00	$5,044.54	$11,820.06

Table 24 continued				
Land/water cover	Total value ($)		Value per hectare per year ($/ha/yr)	
	Low	High	Low	High
LAKES AND RIVERS				
Clean water	$3,194,850.57	$4,761,702.35	$1,880.43	$2,802.65
Habitat	$12,810.46	$1,613,846.12	$7.54	$949.88
Tourism and recreation	$7,186.77	$111,211,392.03	$4.23	$65,456.97
Nature-based education	$56,474.76	$56,474.76	$33.24	$33.24
Total	$3,271,322.56	$117,643,415.26	$1,925.44	$69,242.74
MARINE				
Food provisioning	$95,073.47	$95,073.47	$0.67	$0.67
Carbon storage	$1,426.12	$1,426.12	$0.01	$0.01
Habitat	$268,110.56	$1,431,824.48	$1.88	$10.04
Tourism and recreation	$96,900,575.64	$2,804,837,197.32	$679.47	$19,667.61
Nature-based education	$4,740,422.88	$4,740,422.88	$33.24	$33.24
Total	$102,005,608.67	$2,811,105,944.27	$715.27	$19,711.57
RIPARIAN BUFFER				
Disturbance regulation	$105,713.10	$3,297,608.80	$25.11	$783.28
Waste treatment	$3,492,742.30	$3,507,308.90	$829.63	$833.09
Habitat	$122,216.30	$560,182.60	$29.03	$133.06
Tourism and recreation	$118,722.00	$148,623,567.10	$28.20	$35,302.51
Nature-based education	$139,940.40	$139,940.40	$33.24	$33.24
Total	$3,979,334.10	$156,128,607.80	$945.21	$37,085.18
WETLANDS				
Clean water	$15,606.50	$5,132,367.50	$120.05	$39,479.75
Disturbance regulation	$157,614.60	$961,693.20	$1,212.42	$7,397.64
Carbon storage	$98,718.10	$375,787.10	$759.37	$2,890.67
Waste treatment	$33,892.30	$8,372,514.80	$260.71	$64,403.96
Habitat	$3,773.90	$3,783,728.00	$29.03	$29,105.60
Tourism and recreation	$15,238.60	$3,852,492.80	$117.22	$29,634.56
Nature-based education	$4,321.20	$4,321.20	$33.24	$33.24
Total	$329,165.20	$22,482,904.60	$2,532.04	$172,945.42
GRAND TOTAL	$792,544,295.19	$4,740,284,637.75	$36,043.74	$624,878.87

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British Columbia's Howe Sound watershed is an ancient riverbed where forested mountains climb from the sea and saltwater meets freshwater. The ecosystems of the region are home to a diversity of marine and terrestrial wildlife, as well as a growing human population, which includes Coast Salish First Nations who have resided in the area for thousands of years. The well-being of the region's communities are intimately tied to the health of the Howe Sound watershed and its surrounding ecosystems, which provide ecological benefits such as recreation, flood control, clean water, carbon storage and nature-based education.

This report provides the first-ever valuation of Howe Sound's ecosystem services and makes recommendations on how the region's natural capital should be stewarded and sustained into the future.

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