# TOWARDS A BIODIVERSITY CONSERVATION STRATEGY FOR BOWEN ISLAND/NEX̱WLÉLEX̱WM

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COASTRANGE ENVIRONMENTAL

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# PREFACE

The Bowen Island Conservancy (the "Conservancy") was established in 1997 as a land trust and registered charity that works to protect and preserve the natural environment of the island.

Today, in the face of ongoing residential development and related activities, the Conservancy sees a critical need to scientifically identify and formalize a connected network of areas important to biodiversity on Bowen Island. They also see a need to learn more about the methodologies and conservation tools that can be used to identify and protect these areas, respectively, and explore opportunities for collaboration. With the growing momentum towards such a mapping initiative, there is also a need to educate and engage the Bowen Island community, including citizens, landowners, municipal staff, and municipal Council, about the importance of protecting biodiversity and connectivity.

In this spirit, the Conservancy retained CoastRange Environmental Ltd. to conduct a scoping study with the goal of learning more about complementary initiatives, opportunities for collaboration, modelling methodology, data availability, conservation tools, and case studies throughout British Columbia. The findings of that study are presented herein.

# EXECUTIVE SUMMARY

Biodiversity refers to the variety of life on Earth, including the diversity of species, ecosystems, and genetic variation within species. Biodiversity is crucial for the functioning and resilience of ecosystems and provides numerous benefits to both human society and the natural world. Biodiversity is currently facing unprecedented threats. Habitat loss, fragmentation and the impediment of wildlife movement are among the main threats to biodiversity.

The unique biodiversity of Bowen Island and the surrounding region, combined with growing development pressure, has drawn the attention and conservation efforts of many. Among these efforts is a growing initiative to scientifically map and formally establish a connected network of areas important to biodiversity on Bowen Island.

In 2008, Bowen Island Municipality's Greenways Advisory Committee developed a draft "Greenways Strategy" for an informal greenways system that had evolved over time, rather than being deliberately planned. In 2011, the Bowen Island Municipality updated the Official Community Plan which now includes numerous objectives and policies that support and prioritize the protection of greenways, biodiversity, and connectivity. In 2011 and 2018, the Islands Trust identified important natural areas throughout the Islands Trust Area, including on Bowen Island. In 2021, the Metro Vancouver Regional District modelled ecosystem connectivity for eight focal species throughout the region, including on Bowen Island. Also in 2021, the Átl'ka7tsem Howe Sound Biosphere Region (the "Biosphere"), which includes Bowen Island, was approved as a UNESCO Biosphere Reserve. In 2022, at the United Nations Biodiversity Conference (COP15), governments from around the world jointly established a landmark agreement to protect 30 percent of Earth's lands, oceans, coastal areas, and inland waters by 2030. In that same year, the Squamish Environment Society partnered with the Howe Sound Biosphere Region Initiative Society on a wildlife connectivity study that focuses on the northern half of the Biosphere (north of Bowen Island) and includes a regional context study area that overlaps with Bowen Island. . Also in 2022, the University of British Columbia (UBC) partnered with the Biosphere Region Initiative Society to develop an integrative biodiversity assessment framework for the whole Biosphere, including Bowen Island. This year, 2023, the Metro Vancouver Regional District is embarking on a Green Infrastructure Network mapping initiative that may or may not include Bowen Island. Opportunities to collaborate with existing initiatives to scientifically map and formally establish a connected network of areas important to biodiversity on Bowen Island are abundant and promising.

Methods for identifying such areas have evolved significantly over the past fifteen years as several communities in and near British Columbia have embarked on this task. Almost all of these initiatives utilize landscape or habitat modelling; however, the methodological details used vary depending on the spatial scope, the focus of the initiative, available data, and resources. The study area of Bowen Island is relatively small, but situated within a larger regional context. Available spatial data for Bowen Island include common provincial layers, Terrestrial Ecosystem Mapping (TEM), Sensitive Ecosystem Inventories (SEI), and a relatively rich assortment of other relevant datasets derived from the aforementioned initiatives. Ongoing

initiatives, such as the UBC's Biodiversity Modelling project, may result in additional relevant datasets. A summary of methodological options and common spatial analysis tools is provided herein.

Model outputs, including maps of high-value biodiversity lands and connectivity networks, can serve as decision-support tools in urban and regional planning, conservation, forestry planning, and sustainable development, and are often used to inform the development of conservation strategies, growth strategies, and other local government policies. Conservation tools that can be used by local and senior governments to protect these areas are summarized herein. Conservation Strategies and Development Permit Areas are the most commonly implemented conservation tools used by similar initiatives in British Columbia.

As this initiative proceeds, it is recommended: (1) that the Bowen Island Conservancy continue to explore opportunities to collaborate and pool resources; (2) that involved parties explore the development of a dynamic model that has predictive capabilities and can be easily updated when new data becomes available; (3) that the data used in the model be field verified wherever possible, (4) that model inputs include a robust assortment of available data, thereby building upon work completed by former initiatives; (5) that the model incorporates inputs from expert groups, focal species experts, Indigenous Knowledge, and contributions from stakeholders and land managers wherever possible; (6) that the Bowen Island Conservancy continue to educate the community about the importance of understanding and protecting biodiversity; (7) that a robust engagement plan be implemented to support recommendation #5 and #6 above; and (8) that policy tools for the protection of identified areas continue to be explored, including but not limited to a new or amended Development Permit Area.

# 1 BOWEN ISLAND/NEX̲WLÉLEX̲WM

## 1.1 Geographic Context

Bowen Island/Nex̲wlélex̲wm is located near the mouth of Howe Sound, approximately 3 kilometres west of the mainland. The island spans an area of approximately 50 square kilometres (6 kilometres wide by 12 kilometres long). Bowen features a rugged coastline with numerous bays, coves, and rocky shores. On the island, there are several hills and mountains that contribute to its diverse topography. Mount Gardner, the highest peak on Bowen Island, rises to an elevation of around 720 meters. Bowen has numerous freshwater lakes and streams. Killarney Lake and Grafton Lake, the largest lakes on the island, are approximately 40 and 20 hectares in size, respectively, including their wetland margins. With its proximity to the ocean, Bowen experiences a temperate coastal climate and is within the Coastal Western Hemlock Biogeoclimatic Zone of British Columbia. Winters are mild and wet, while summers are warm and dry. The island is heavily forested, comprising mainly of Douglas-fir (*Pseudotsuga menziesii*), Western Redcedar (Thuja plicata), Western Hemlock (*Tsuga heterophylla*), Bigleaf Maple (*Acer macrophyllum*), and Arbutus (*Arbutus menziesii*) trees.

## 1.2 Before Colonialism

The Squamish Nation, also known as the Skwxwú7mesh Úxwumixw, has inhabited the Lower Mainland and surrounding areas, including Bowen Island, for thousands of years. Bowen Island also falls within the consultation area of the Tsleil-Waututh Nation (Tsleil-Waututh Nation 2023).

Bowen Island, known as Nex̲wlélex̲m or Xwlíl'xhwm in the Squamish language, has long been used for hunting, gathering, and seasonal habitation by Indigenous peoples. Xwililxhym means “fast drumming ground”. Some attribute the name to the historic abundance of deer on Bowen and the sound that deer hooves make when running (Bowen Island Museum 2023), while others attribute it to the sound made by the ocean as it rushes past the island’s most northern point (Bowen Heritage 2023). In the Squamish creation story, Xwlíl’xhwm is often referred to as the place where the deer were created (Bowen Heritage 2023). The profusion of life on the island, including deer, duck, salmon, herring, and clams, made Bowen a valuable seasonal hunting ground (Bowen Island Museum 2023). The Squamish people and other Indigenous groups also used Bowen as a stopping ground on long voyages along the coast (Bowen Island Museum 2023).

## 1.3 Settlement

Bowen Island was renamed in 1860 in honour of Rear Admiral James Bowen, an officer of the Royal Navy. Around that same time, Britain introduced a system of land pre-emption (a method for acquiring Crown land) as a way to settle its colonies. Settlers willing to clear and fence land, build a home, and produce crops could claim title to the land. The first settler to pre-empt land on Bowen did so in 1874. From that time

until the turn of the century, Bowen was a hive of forestry, mining, and other industrial activity. (Bowen Heritage 2023)

The arrival of colonial settlers brought significant changes to the island's ecosystem, including deforestation, the introduction of non-native species, loss of large mammal predators, and alterations in land use practices. These changes have had and continue to have impacts on the biodiversity of the island.

## 1.4 Growth + Management

Nowadays, Bowen Island is a municipality, a residential community, and a popular destination, offering opportunities for swimming, picnicking, hiking, biking, sea kayaking, and enjoying the serene surroundings. The island's population of approximately 4,250 people (Statistics Canada 2021) is seeing a growing number of visitors per year, increasing from approximately 6,000 in 2015 to over 30,000 in 2019 (Bowen Island Municipality 2020).

Bowen has experienced increased development and population pressure due to its scenic beauty, proximity to Vancouver, and desirable lifestyle. Development pressures have raised discussions about preserving the island's natural beauty and protecting its unique ecological features. There is a strong community focus on conservation and environmental stewardship, with efforts to protect sensitive habitats, maintain trails, and promote sustainable practices. The island's Official Community Plan (OCP) aims to maintain a balance between development and environmental preservation, and contains numerous policies and objectives that support the protection of areas important to biodiversity and connectivity (see Section 4 of this report).

Bowen Island Municipality is part of the Metro Vancouver Regional District and within the jurisdiction of the Islands Trust. It is situated within the southern extent of the Átl'ka7tsem Howe Sound UNESCO Biosphere Region and, as noted above, it is within the Traditional Territory of the Skwxwú7mesh Úxwumixw (Squamish Nation) and the consultation area of the Tsleil-Waututh Nation.

## 1.5 Biodiversity on Bowen Island/Nexwlélexwm

Bowen Island is home to a unique array of plant and animal species. The island's diverse geography, encompassing forests, coastlines, and freshwater ecosystems, provides habitats for a variety of flora and fauna. The marine waters of Howe Sound surround the island, serving as a saltwater moat that impacts on- and off-island migration (see Section 2.3 for more information on island biogeography). Nearly 2,200 species have been recorded on Bowen Island or along its shoreline (iNaturalist 2023). The uniqueness of Bowen Island's biodiversity is not just driven by the species that are present, but also the species that are absent. The absence of some species, including apex predators, has cascading impacts on the trophic cascade and Bowen's ecosystems. This makes the ecological character of Bowen Island and the other islands in Howe Sound different from each other and different from the mainland. A high-level summary of Bowen Island's biodiversity is provided as follows:

- **Sensitive Ecosystems:** As of 2017, approximately 54% (3,000 ha) of Bowen Island was classified as a sensitive ecosystem. Sensitive ecosystems on Bowen are largely dominated by mature forests, but also include wetlands, freshwater, riparian areas, and other vegetated lands (Islands Trust Conservancy 2018).

- **Forests + Plants:** As noted above, the forests of Bowen Island are characterized by Douglas-fir, Western Redcedar, Western Hemlock, Bigleaf Maple, and Arbutus. These forests support a variety of understory plants, including Salal (*Gaultheria shallon*), Sword Fern (*Polystichum munitum*), mosses, and lichens. Despite the small size of Bowen Island, its diverse coast-to-mountain topography is home to three different Coastal Western Hemlock (CWH) Biogeoclimate sub-zones. The majority of the island is characterised by a CWHdm (Dry Maritime) subzone, while the southern coastline is CWHxm1 (Eastern Very Dry Maritime) and the two mountain tops are CWHvm2 (Montane Very Wet Maritime; Forest Service British Columbia 2023). A total of 952 plant and fungi species have been recorded on Bowen (iNaturalist 2023). Some plant species are naturally absent on Bowen Island, such as Black Cottonwood (*Populus trichocarpa*), Vine Maple (*Acer circinatum*) and Indian Plum (*Oemleria cerasiformis*).

- **Mammals**: The forested areas provide shelter and forage for numerous wildlife species. A total of 19 mammal species have been recorded on Bowen, including Mule Deer (*Odocoileus hemionus*), American Mink (*Neogale vison*), Canadian Beaver (*Castor canadensis*), Mouse-eared Bat (*Myotis* sp.), Western Deer Mouse (*Peromyscus sonoriensis*), Long-tailed Shrew (*Sorex* sp.), and Meadow Vole (*Microtus* sp.), among others (iNaturalist 2023). The island's nearshore waters support a variety of marine mammals, such as Harbour Seal (*Phoca vitulinal*).

- **Amphibians + Reptiles:** The island's freshwater, riparian and forested areas support a variety of amphibians and reptiles. A total of 10 such species have been recorded on Bowen, including Northern Red-legged Frog (*Rana aurora*; Blue-listed, 1-SC), Northern Pacific Tree Frog (*Pseudacris* regilla), Ensatina (*Ensatina eschscholtzii*), Northwestern Salamander (Ambystoma gracile), Rough-skinned Newt (*Taricha granulosa*), Long-toed Salamander (*Ambystoma macrodactylum*), Northern Alligator Lizard (*Elgaria coerulea*), and three species of Garter Snake (*Thamnophis* spp.; iNaturalist 2023).

- **Birds:** The island is an ideal habitat for a diverse avian population. Birdwatchers can spot Bald Eagle (*Haliaeetus leucocephalus*), Great Blue Herons (*Ardea herodias fannini*; Blue-listed, 1-SC), Red-tailed Hawks (*Buteo jamaicensis*), other raptors, owls, woodpeckers, warblers, and various waterfowl. The coastal areas attract migratory birds, making it a haven for bird enthusiasts. A total of 165 bird species have been recorded on Bowen (Bowen Nature Club 2021).

- **Other Species Diversity:** A total of 918 insect and arachnid species, 47 mollusc species, 27 fish species, and 14 protozoa species have been recorded on Bowen Island and along its shorelines (iNaturalist 2023).

- **Species at Risk:** Environment and Climate Change Canada (2021) has mapped Critical Habitat for Marbled Murrelet (*Brachyramphus marmoratus*) on Bowen Island, and the B.C. Conservation Data Centre (Province of BC 2023b) has recorded observations of the Blue Dasher (*Pachydiplax longipennis*; Blue-listed) and the Common Wood-nymph (*Cercyonis pegala incana*; Blue-listed). Northern Red-legged Frog, Great Blue Heron (Blue-listed, 1-SC), and other species at risk have also been observed on Bowen Island (iNaturalist 2023). A total of 247 species at risk, including 14 amphibians and reptiles, 22 mammals, and 41 ecological communities at risk have potential to occur on Bowen Island (Province of BC 2023a).

- **Predator-Prey Relationships**: Some islands, including Bowen, lack apex predators such as Black Bear, Grizzly Bear, Wolves, Cougars and Coyotes. The lack of predators impacts the abundance of prey species. On Bowen Island, the absence of apex predators makes the island safe for deer. Deer are herbivores and their grazing is said to impact tree regeneration on Bowen Island; few Western Redcedar or Bigleaf Maple saplings survive and many understory plants are heavily browsed, including Salmonberry, Huckleberry and Thimbleberry.

## 1.6 Threats + Protections

As of 2018, approximately 14% (730 ha) of Bowen Island's land was protected; including 8% classified as an ecological reserve, 4% as regional park, and the remainder as other types of parks, nature reserves or under conservation covenants (Islands Trust Conservancy 2018).

Bowen Island is particularly vulnerable to the loss of natural ecosystems to residential and associated uses, and has ecosystem disturbance levels that are higher than average within the Islands Trust Area. As of 2017, approximately 14% (722 ha) of Bowen was classified as a modified ecosystem. These modified areas are largely dominated by rural residential development with a lesser extent of roads, cultivated fields, a golf course, and other anthropogenic land uses. (Islands Trust Conservancy 2018)

# 2 BIODIVERSITY BACKGROUND + THEORY

## 2.1 What is Biodiversity and Why is it Important?

Biodiversity refers to the variety of life on Earth, including the diversity of species, ecosystems, and genetic variation within species. It encompasses the full range of living organisms, from microorganisms to plants, animals, and humans, as well as the intricate ecological relationships they form.

Biodiversity is crucial for the functioning and resilience of ecosystems and provides numerous benefits to both human society and the natural world. Here are some key reasons why biodiversity is important:

1. Ecosystem services: Biodiversity plays a fundamental role in providing ecosystem services, which are the benefits that humans derive from nature. These services include the purification of air and water and regulation of climate, among other services, as described in Section 2.6 below. Biodiversity is essential for maintaining the functioning and productivity of ecosystems that support these services.

2. Ecological Balance: Biodiversity helps maintain ecological balance and stability within ecosystems. Each species has a unique role and contributes to the overall functioning of the ecosystem. Interactions between different species, such as predation, competition, and mutualism, help regulate populations and maintain a healthy balance within ecosystems.

3. Resilience and Adaptation: Biodiversity increases the resilience of ecosystems to environmental changes and disturbances. A diverse ecosystem is better able to withstand and recover from natural disasters, such as floods, droughts, or disease outbreaks. Biodiversity also enhances the ability of ecosystems to adapt to long-term changes, such as climate change, by providing a wider range of genetic traits and adaptations.

4. Cultural and Aesthetic Values: Biodiversity has significant cultural and aesthetic value. It is deeply intertwined with the cultural practices, traditions, and spiritual beliefs of many societies around the world. Biodiversity also contributes to the beauty and inspiration we derive from nature, whether it is through the enjoyment of wildlife, natural landscapes, or recreational activities in natural areas.

5. Ethical and Intrinsic Value: Biodiversity has intrinsic value, meaning that it has worth and deserves to be conserved for its own sake, independent of its usefulness to humans. Each species has a right to exist, and the preservation of biodiversity is an ethical responsibility to future generations.

## 2.2 Declining Biodiversity

Biodiversity is currently facing unprecedented threats due to human activities. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019), global extinction rates are at least tens to hundreds of times higher than over the past 10 million years, with as many as 1 million species facing extinction, many within decades, unless action is taken to address the underlying causes of biodiversity loss. Habitat loss, fragmentation and the impediment of wildlife movement are among the main underlying causes. Protecting natural habitat and maintaining and restoring connectivity are essential steps toward slowing biodiversity loss, especially in the face of climate change and climate-driven species' range shifts. (Pither et al. 2021)

## 2.3 Island Biogeography

Island biogeography is a field of study that explores the patterns of species distribution and diversity on islands. It considers factors such as island size, distance from the mainland, and isolation to understand how these factors influence the number of species present on an island and their interactions. Larger islands tend to support more diverse ecosystems due to the availability of varied habitats and resources, while smaller islands may have fewer species. Islands that are closer to the mainland often have higher species richness as they are more accessible to potential colonizers. However, the isolation of some islands can lead to the evolution of unique species or unique genetic populations that are found nowhere else. Human activities, such as habitat destruction and the introduction of invasive species, can exacerbate the challenges faced by island biodiversity, leading to species extirpations and ecosystem disruption.

The saltwater moat that surrounds islands, such as Bowen, can limit re-establishment after extirpation of breeding populations on islands. For example, should populations of freshwater species, such as freshwater mussels or salamanders, be extirpated from an area on the mainland, individuals of that species can potentially re-populate that area by in-migration from different waterways or watersheds. Should such a species become extirpated from an island, individuals of that species must pass a saltwater moat in numbers large enough to facilitate breeding in order to reinhabit an island.

Understanding island biogeography is crucial for implementing effective conservation strategies to preserve the delicate and unique ecosystems found on islands.

## 2.4 Habitat Core Areas + Connectivity

Intact habitat, otherwise known as habitat core areas (Figure 1), provide essential resources for longer-term species survival, such as access to food, water, shelter from weather and predation, and provide areas that support reproductive requirements. Although maintaining habitat intactness is important, it is crucial that these core areas are connected. Connectivity allows animals to move between habitat core areas, helping to maintain genetic diversity, providing access to required resources and refugia, allowing for adaptation to changing environmental conditions, and ultimately supporting species resilience, thereby reducing the risk of local extinction.

## 2.5 Land + Sea Connectivity

In coastal regions and on islands, maintaining connectivity between terrestrial and marine habitats is essential for the survival of some species. Serval species on Bowen move between terrestrial, estuarine, shoreline, and nearshore habitat to live out their lifecycles or evade predation. For example, Harbour Seals make use of specific shoreline locations on the island to emerge, rest, and, possibly, evade predators such as Orcas (Orcinus orca). Deer, Otter, Mink, Merganser chicks, and fledgling Herons are other examples of species that move between these diverse habitat types on Bowen Island.

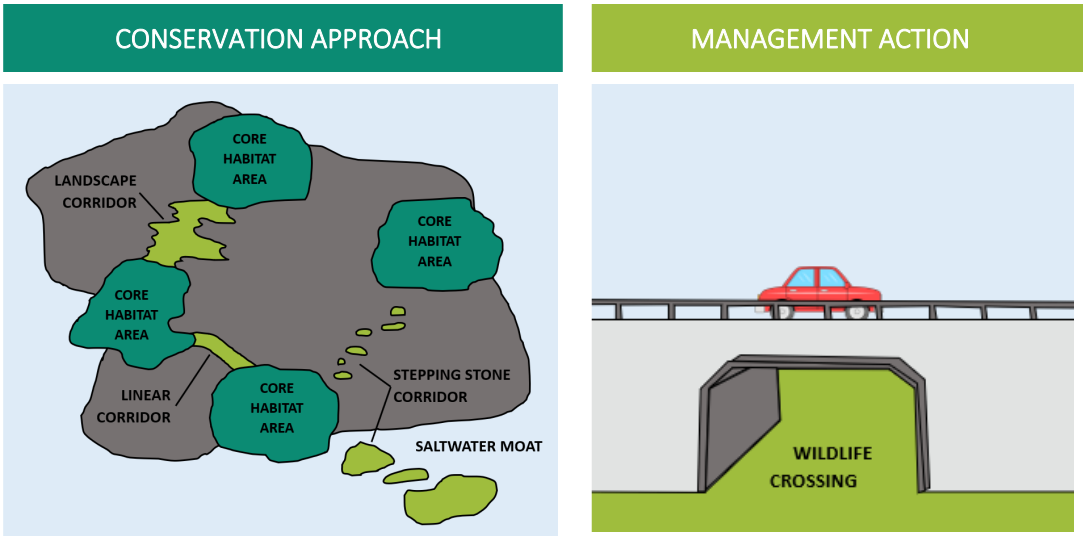


*Figure 1. The left diagram shows an ecological corridor composed of habitat core areas, a larger landscape corridor, a smaller linear corridor, and a stepping stone corridor. The right diagram shows a wildlife underpass.*

## 2.6 Key Definitions

Ecological Corridors, also known as habitat corridors or wildlife corridors, are natural or artificial strips of habitat that connect two or more core habitat areas (Figure 1). They are an area-based conservation approach designed to facilitate natural movement and are often established in areas where natural habitats have been fragmented by human activities.

Wildlife Crossings are an example of a management action that can occur within an ecological corridor or in other areas (Figure 1). They are specific structures or features, such as tunnels, bridges or culverts, that allow animals to cross roads or other human-made barriers safely.

Stepping Stones are smaller patches of habitat or refugia that allow species to 'hop' through an otherwise developed landscape (Figure 1).

Ecosystem Services are the benefits that people obtain from ecosystems, such as natural pollination of crops, natural cleansing of air and water, mitigation of climate change impacts and extreme weather, space for recreation, facilitating human mental and physical well-being, provision of food, the decomposition of wastes, and the storage and natural filtration of stormwater. These benefits are provided by large healthy ecosystems, such as natural forests and wetlands, and by smaller natural and semi-natural features, such as urban forests, swales and ditches, street trees, and urban parks. Typically, areas that support wildlife also provide ecosystem services; however, not all areas that provide ecosystem services are capable of supporting wildlife.

Green Infrastructure Networks tend to be established in urban communities where habitat and connectivity for large mammals are limited. These networks include smaller features such as urban parks, greenways, swales, green roofs, and areas that deliver a wide range of ecosystem services, including social and

economic benefits. Larger intact habitats that support wildlife can be included in green infrastructure networks; however, not all areas within a green infrastructure network are capable of supporting wildlife.

# 3 COMPLEMENTARY INITIATIVES

The unique biodiversity and serene natural environment of Bowen Island and the surrounding region have drawn the attention and conservation efforts of many. Opportunities to collaborate with existing initiatives are abundant and promising. This section presents a summary of some salient, relevant, and recent initiatives.

## 3.1 Island Trust Conservancy's Regional Conservation Plan

The Islands Trust Conservancy assists in the preservation and protection of the islands and waters within Howe Sound and the Strait of Georgia, including Bowen Island. They have been doing conservation planning since the early 1990s and published Regional Conservation Plans in 2005, 2011, and 2018 (Islands Trust 2023). The most recent Regional Conservation Plan (2018-2027), includes profiles for each island. Each profile includes a map of important natural areas (Figure 2) and provides a summary of protected areas, species at risk, threats, and ecosystems that are either sensitive, forested, modified, or disturbed. Within this plan, conservation priorities for Bowen Island were ranked as follows:

| | |
|---|---|
| Need for Sensitive Ecosystem Protection | High |
| Disturbance Threat | High |
| Need for Forest Protection | Medium |
| Level of Unprotected Land | Medium |
| Need for Eelgrass Shoreline Protection | Low |
| Overall Priority | Medium |

The Islands Trust mapped important natural areas in 2011 using a multiple-criteria decision analysis (MCDA) coupled with geographical information systems (GIS; Island Trust Fund 2011). These maps were updated in 2018 with more recent data and revised methods (Greene et al. 2013). MCDA is a suite of methodologies that can help decision-makers and analysts combine multiple factors, resulting in the rating or ranking of alternatives (Islands Trust Fund 2011). Model inputs included sensitive ecosystems, representative ecosystems, species and ecosystems at risk, and protected areas (Islands Trust Fund 2011). Foundational data layers included, but were not limited to, Sensitive Ecosystem Inventory (SEI) and Terrestrial Ecosystem Mapping (TEM; Islands Trust Fund 2011).

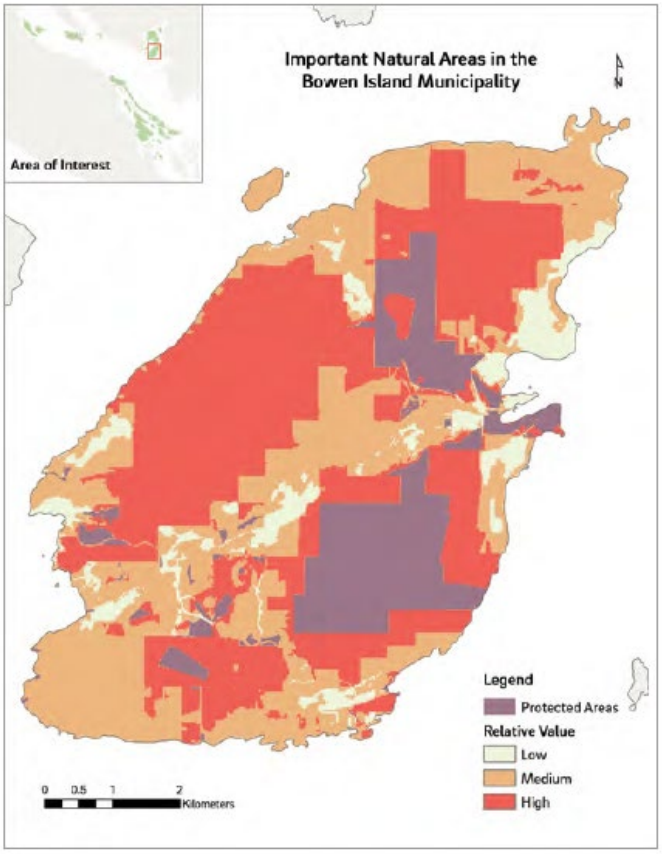


*Figure 2. Map of Important Natural Areas in the Bowen Island Municipality, extracted from the Island Trust Conservancy's Regional Conservation Plan (Islands Trust Conservancy 2018).*

## 3.2 Metro Vancouver's Connectivity Analysis

The Metro Vancouver Regional District worked with a master's student at the University of British Columbia and Diamond Head Consulting to evaluate and model regional ecosystem connectivity for eight focal species using Conefor and Zonation (two spatial analysis tools), as detailed in Metro Vancouver's Evaluation of Regional Ecosystem Connectivity (Diamond Head Consulting 2021). The study area included Bowen Island. The focal species included Red-backed Vole (*Clethrionomys gapperi*), Red-backed Salamander (*Plethodon cinereus*), Long-toed Salamander, Muskrat (*Ondatra zibethicus*), Great Blue Heron (fannini ssp.), Brown Creeper (*Certhia americana*), Rufous Hummingbird (*Selasphorus rufus*), and Pileated Woodpecker (*Dryocopus pileatus*). Important habitat patches were identified for each species and connectivity was assessed. The findings from all eight species were combined into a composite map. Maps showing areas of connectivity importance were produced (Figure 3).

Bowen was identified as a highly ranked stepping stone, and as having some of the largest composite key-hub patches (i.e., key habitat for 7 or 8 of the focal species). Bowen was identified as providing a relatively rare habitat patch for Red-backed Vole, and the western portion of Bowen Island was identified as a key-hub patch for Red-backed Salamander and Rufus Hummingbird. (Diamond Head Consulting 2021)

Metro Vancouver is now embarking on modelling of a green infrastructure network. The study area may or may not include Bowen Island (pers. comm. Laurie Bates-Frymel, Metro Vancouver, January 20, 2023).

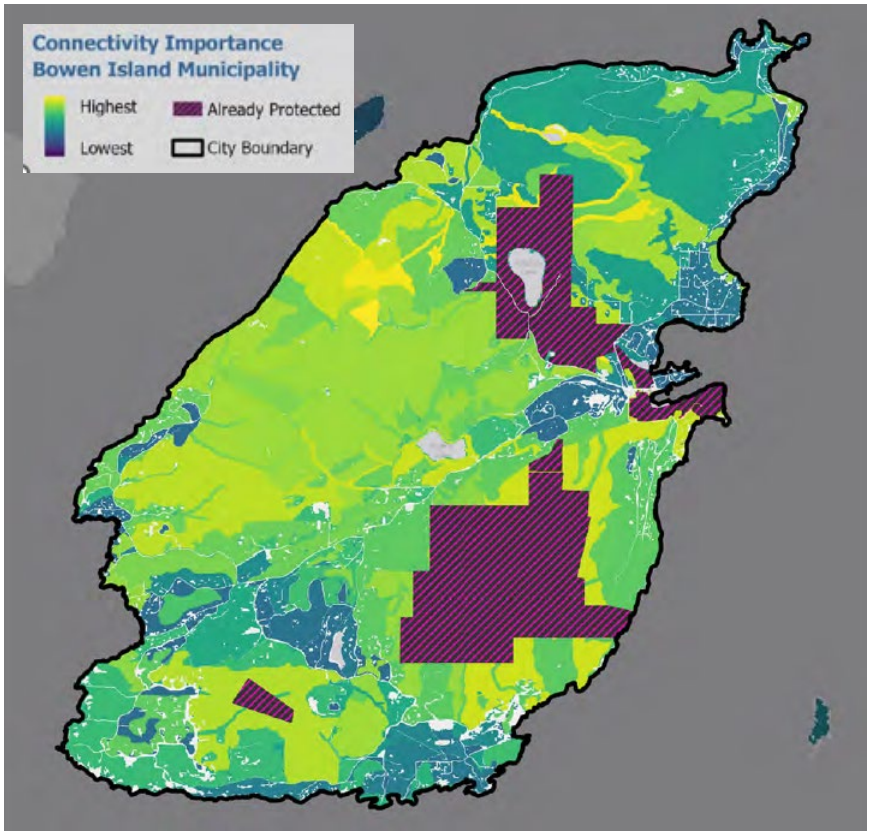


*Figure 3. Map of Connectivity Importance on Bowen Island Municipality, extracted from Metro Vancouver's Evaluation of Regional Ecosystem Connectivity (Diamond Head Consulting 2021).*

## 3.3 Átl'ka7tsem Howe Sound Biosphere Region's Biodiversity Modelling

Andrew Simon, Ph.D. candidate, and the O'Connor Lab at the University of British Columbia have embarked on a four-year plan (2022-2026) to develop an integrative biodiversity assessment framework for the Átl'ka7tsem Howe Sound Biosphere Region. This work intends to synthesize available biodiversity data, map biodiversity, model and map habitat suitability for priority species and ecosystem communities, validate and improve models through systematic field sampling and hypothesis testing, and develop visualizations for the public and land use decision-making.

## 3.4 Bowen Island's Greenways Strategy

In 2008, the Municipality's Greenways Advisory Committee developed a draft "Greenways Strategy" for strategic management of what was then an informal greenways system. Until that time, the greenways system had evolved without being deliberately planned. It had gaps and missing links, and some portions of the greenways were not protected in perpetuity. The Greenways Strategy intended to connect wildlife habitats to each other and people to nature. The strategy was used to inform and update Bowen Island's Official Community Plan (OCP), including but not limited to the objectives and policies within *Section 6.4* of the OCP which addresses greenways. (Bowen Island Municipality 2014)

The OCP defines greenways as linkages of natural land, some owned by public agencies, and some in private ownership. It also notes that neighbourhood greenways could incorporate elements such as natural microhabitats and community outdoor gathering spaces, as well as pedestrian, equestrian, and biking trails. Neighbourhood Greenways are encouraged to incorporate green infrastructure features, wildlife habitats, and environmentally friendly landscaping. There is also an emphasis on maintaining natural connectivity and unrestricted movement of biota. The OCP states that Municipality may create and apply specific protection mechanisms in particular greenway areas that are deemed environmentally sensitive. (Bowen Island Municipality 2014)

The Parks, Trails and Greenways Advisory Committee advises Bowen Island Municipal Council and staff regarding issues related to Bowen Island greenways (Bowen Island Municipality 2023a).

## 3.5 Global + Federal Commitments (30 by 2030)

Governments around the world are acknowledging the importance of ecological connectivity (Pither et al. 2021). In December 2022, representatives from 188 governments from around the world gathered at the United Nations Biodiversity Conference (COP15) and jointly established a landmark agreement to protect 30 percent of Earth's lands, oceans, coastal areas, and inland waters by 2030 (Convention on Biodiversity 2022). In alignment with COP15's 30 by 2030 agreement, Canada continues their commitment to conserve 25 percent of lands, freshwater, and oceans by 2025, and 30 percent by 2030 (Government of Canada 2023). Canada has invested significant funds towards achieving these goals, including $2.3 billion over five years (2021 onwards) in Environment and Climate Change Canada's Enhanced Nature Legacy Initiative

(Government of Canada 2023). Of which, $60.6 million is funding the National Program for Ecological Corridors (Parks Canada 2021) and $11.3 million is funding biodiversity conservation efforts in nineteen UNESCO biosphere reserves across Canada (Government of Canada 2022). Local and regional initiatives, such as those summarized above, are essential for realizing these global and federal commitments.

## 3.6 British Columbia's Together for Wildlife Strategy

Recognizing the richness, rareness and importance of British Columbia's biodiversity, the province initiated a Together for Wildlife strategy in 2020. This strategy intends to improve wildlife and habitat stewardship across British Columbia. The Together for Wildlife strategy is said to include additional funding, proactive objectives, and improved data and knowledge - all supported by new policies, strong partnerships, and dedicated resources. The strategy includes five goals and 24 actions relating to engagement, investing in data collection, effective stewardship, accountability and transparency, and reconciliation. (Province of BC 2023c)

# 4 SUPPORTING POLICY

## 4.1 Official Community Plan

The Bowen Island Official Community Plan (Bylaw No. 282, 2010; consolidated December 2014) contains numerous objectives and policies that support the protection of the natural environment (Section 2) and greenways (Section 6.4), and are directly relevant to the protection of biodiversity and connectivity. Some examples of salient objectives and policies are as follows:

### Collaboration

- To work with Community Groups, such as the Bowen Island Conservancy, to identify and manage the island's biodiversity (Objective 4).
- To collaborate and coordinate with the Islands Trust, other governments, non-governmental organizations, and community members to identify, inventory, map, set priorities, and manage Greenway areas (Policy 345).

### Connectivity

- To maintain and enhance natural connectivity in Greenways corridors for the movement of biota and ecological processes (Objective 146).
- To work towards an extensive, interconnected network of protected natural lands for environmental conservation and protection, recreation and eco-tourism, community health and wellness purposes (Objective 144).

Land Use Management

- To create and apply specific protection mechanisms in particular Greenway areas that are deemed environmentally sensitive. These include coastlines, streams, watershed and wetland areas, steep slope areas, older forests and mature trees, critical wildlife corridors and habitats, and other identified special biodiversity areas (Policy 353).
- In order to maintain natural connectivity and unrestricted movement of biota, the Municipality discourages barriers such as fences, lawns, roads, or other modified or non-native vegetation in Greenway areas (Policy 354).
- To promote neighbourhood Greenways development in new and existing neighbourhoods to help link up the island-wide Greenways system (Objective 147).

The Official Community Plan (OCP) also contains a section on the Natural Environment, including Development Permit Areas (DPAs) for environmentally sensitive areas and aquatic resources. Guidelines that support these Development Permit Areas (DPAs) are included within the Land Use Bylaw (No. 57, 2002; consolidated May 2023). The potential exists for the development of a DPA that specifically maps and protects areas of importance to biodiversity and connectivity (e.g., greenways or a green infrastructure network).

## 4.2 Islands Trust Policy Statement

Above Bowen's OCP is the Islands Trust Policy Statement, a supporting policy umbrella with a mandate to preserve and protect the Trust Area, including but not limited to ecosystems. Directive policies within the Policy Statement guide the development of the regulatory land-use bylaws of local trust committees and Bowen Island Municipality. For example, the directive policies state that local trust committees and island municipalities shall, in their official community plans and regulatory bylaws, address:

- The identification and protection of the environmentally sensitive areas and significant natural sites, features and landforms in their planning area.
- The planning, establishment, and maintenance of a network of protected areas that preserve the representative ecosystems of their planning area and maintain their ecological integrity.
- The protection of unfragmented forest ecosystems15 within their local planning areas from potentially adverse impacts of growth, development and land-use.

## 4.3 Other Supporting Policy

Bowen Island Municipality has several other policies and bylaws that support the protection of natural areas. Examples of these policy tools include:

- Conservation Development Policy No. 22-02, 2022
  In 2022, the Bowen Island Municipality enacted the Conservation Development Policy (Policy No. 22-02). This policy clarifies and emphasizes OCP objectives and policies to achieve the goal of "*Nature Needs Half*."

- Parks Plan (2018-2028)
  The Bowen Island Parks Plan provides an updated community vision for municipal parks, trails, and beaches. The goals, objectives and recommendations outlined in the Parks Plan provide a guide to ensure that the community's priorities are achieved over the next ten years. For example, it states that "*Bowen Island's interconnected parks, trails and beaches protect marine and terrestrial ecosystems, conserve biodiversity, inspire stewardship, support outdoor education and contribute to the Island's peaceful, natural character*."

- Land Use Bylaw No. 57, 2002
  The Land Use Bylaw regulates the use of land, building, and structures on Bowen Island, and must be consistent with policies contained in the Official Community Plan.

- Use of Beaches and Water Areas Bylaw No. 418, 2016

- Use of Public Places Bylaw No. 537, 2021

- Pesticide Use Control Bylaw No. 556, 2021

- Outdoor lighting on municipal and institutional use properties, Bylaw No. 272, 2010

- Site Alteration Bylaw No. 568, 2022

# 5 SPATIAL ANALYSIS

This section provides a high-level description of methods and datasets that are commonly used to identify areas important to biodiversity and connectivity, and is intended for a non-technical audience.

## 5.1 Spatial Models

Methods for identifying areas important to biodiversity and connectivity have evolved significantly over the past fifteen years as several communities in and near British Columbia have embarked on this task. Almost all of these initiatives utilize landscape or habitat modelling; however, the methodological details used vary depending on the spatial scope (e.g., municipal, regional or transboundary), the focus of the initiative (e.g., specific focal species, biodiversity at large, or ecosystem services), available data, and resources.

Generally speaking, Geographic Information Systems (GIS) and spatial analysis tools are used to analyze or 'model' spatial data, including land cover, land use, topography, areas of disturbance, and other relevant information. Datasets derived from Terrestrial Ecosystem Mapping (TEM) and Sensitive Ecosystem

Inventories (SEI) studies are often utilized. Commonly, the digital landscape is divided into polygons or grid cells. Thresholds, rating, or ranking systems are applied to evaluate factors such as the size, proximity, or quality of each polygon or cell.

Models often identify suitable habitat (e.g., core habitat areas or patches) and measure connectivity based on *resistance* or *landscape impedance* (e.g., how easy or difficult it is for species to move between these areas). Resistance can increase in areas of human development or due to the presence of natural barriers, such as rivers or cliffs. (Greenaway 2016)

Some models focus on identifying potential biodiversity hotspots, such as the one currently being developed for the Átl'ka7tsem Howe Sound Biosphere Region (see Section 3.3).

Models can be...

- Species-specific, meaning that the model focuses on habitat value and ease of movement for focal species (e.g., Northern Red-legged Frog) or groups of species (e.g., carnivores). Species-specific models require significant information about the species' habitat use and biological requirements which can be derived from literature, expert opinion, empirical data (e.g., GPS locations). Species-specific connectivity is referred to as *functional connectivity.* (Greenaway 2016)

- Non-species-specific, meaning that the model assumes a multi-species approach or a species generalist approach. The focus is on the naturalness of the landscape, where intactness (less human disturbance) is used as a proxy for the potential of species to move through the landscape. This may be desirable if species-specific information is lacking and habitat loss and fragmentation are a major concern. Non-species-specific connectivity is referred to as *structural connectivity.* (Greenaway 2016)

- Composite, meaning the model combines or 'rolls up' the results for multiple priorities into a combined map. For example, maps showing high-value habitat for individual focal species can be rolled up into a single map that identifies areas that offer high value for the greatest number of species. Composite maps can also include non-species-specific or landscape components.

- Static, meaning that the model produces a snapshot of conditions at a particular point in time. Static modelling methods are widely used, may be more affordable, and offer great insights into environmental conditions. In some cases, static models may be costly or time-consuming to update.

- Dynamic, meaning that the model is easy to update when new data becomes available or may be automatically updated on a regular cycle. These models allow for more efficient tracking of change over time which better facilitates adaptive land management. Dynamic modelling methods are more 'cutting edge' and may have higher upfront costs.

- **Predictive**, meaning that the model can predict landscape change in the future based on current trends, or can be used to visualize future landscapes based on various land management scenarios.

## 5.2 Spatial Analysis Tools

There are several different spatial analysis tools that can be used to model and map areas important to biodiversity and connectivity. Some commonly used tools are listed below and described in depth within the Conservation Corridor website (Conservation Corridor 2023). Selection of a spatial analysis tool will depend on the goals of the mapping initiative, the spatial scope of the study, resources, and data availability.

- Circuitscape
- Conefore
- Gnarly Landscape Utilities
- Linkage Mapper
- Marcan Connect
- TerrAdapt
- Zonation

## 5.3 Data

It is important to remember that model outputs are only as good as the model inputs; specifically, the outputs are only as good as the spatial datasets that are used. In some cases, data may be several years out of date, may have been published in different years, may have been produced at a mesoscale or be lacking accuracy for the study area, or may not have been field verified. Using accurate data is always important, and using current data becomes increasingly important in a rapidly changing landscape.

Model inputs vary between initiatives based on the type of model used, the goals of the initiative, project resources, the required scale, and data availability. Datasets derived from previous Terrestrial Ecosystem Mapping (TEM) and Sensitive Ecosystem Inventories (SEI) studies are often utilized, and are described as follows:

- **Terrestrial Ecosystem Mapping** provides a broad-scale understanding of ecosystem distribution and composition across a landscape; considering factors such as vegetation composition, soil types, topography, hydrology, climate and other factors. Methods are documented within the Standard for Terrestrial Ecosystem Mapping in British Columbia (Province of BC 1998).

- **Sensitive Ecosystem Inventories** aim to identify and delineate specific areas that are ecologically sensitive or vulnerable to disturbance, and typically take into account additional factors such as the presence of rare or threatened species, habitat quality, connectivity, and vulnerability to human

activities or environmental changes. Sensitive Ecosystem Inventories can utilize the results of Terrestrial Ecosystem Mapping as a foundational layer of information but are not solely based on those results. Methods are documented within the Standards for Mapping Ecosystems at Risk in British Columbia (Ministry of Environment 2006)

A non-exhaustive summary of available datasets for Bowen Island is provided in Appendix 1. Available spatial data for Bowen Island include common provincial layers as well as a relatively rich assortment of other relevant datasets derived from the habitat and natural areas mapping initiatives implemented by the Islands Trust Conservancy and Metro Vancouver. Ongoing initiatives, such as the Átl'ka7tsem Howe Sound Biosphere Region's Biodiversity Modelling, may result in additional relevant datasets. A dynamic model could be designed to incorporate additional datasets once available.

Examples of relevant datasets available for Bowen Island include:

- Terrestrial Ecosystem Mapping (2017)
- Sensitive Ecosystems (2017)
- Important Natural Areas (2017)
- Modified and Disturbed Ecosystems (2017)
- Habitat Patches (for eight species; 2021)
- Areas Important to Regional Connectivity (2021)

## 5.4 Other Model Inputs

Model inputs and outputs should include more than just spatial data, and, in some cases, model outputs are refined through an iterative process. Contributions and verification from the following sources should be included, where relevant and available:

- Expert Groups
- Focal Species Experts
- Indigenous Knowledge Holders
- Stakeholder Engagement and Consultation
- Land Managers
- Field Verification

# 6 CONSERVATION TOOLS

Model outputs, including maps of high-value biodiversity lands and connectivity networks, can be used as decision-support tools in urban and regional planning, conservation, forestry planning, and sustainable development, and are often used to inform the development of conservation strategies, growth strategies, and other local government policies. Model outputs can be supplemented by or complimented by site-specific assessments. Education and outreach programs help to build understanding and a willingness to protect areas that offer high ecological value within a community. This section summarizes the conservation tools that can be used by local and senior governments to protect areas important to biodiversity and connectivity.

## 6.1 Local Government Tools

There are numerous relevant policy and regulatory tools available to local governments (Table 1). Of these, regional growth strategies, official community plans, development permit areas, zoning, development cost charges, density bonus zoning and community amenity contributions have been identified as the most relevant and effective tools.

Table 1. Relevant policy and regulatory tools available to local governments

**Plans, Strategies and Services**

- Regional growth strategies*
- Official community plans, including neighbourhood and local area plans*
- Sustainability strategies
- Biodiversity conservation strategies
- Regional and municipal park plans
- Greenways plans
- Transportation plans
- Conservation fund services
- Stormwater plans
- Watershed plans
- Sustainable community plans
- Liquid waste management plans
- Water management plans
- Community wildfire protection plans
- Habitat banking

**Discrete Land Use Authorities**

- Zoning bylaws*
  - Conservation zoning
  - Density bonus/amenity zoning*
  - Community amenity contributions*
- Development permit areas*
- Development approval information areas
- Development approval procedures bylaw
- Subdivision and servicing bylaws
  - Approving officer public interest authority
- Tree protection bylaws
- Landscaping bylaws
- Soil deposit and removal bylaws
- Invasive species bylaws
- Development cost charges*
- Community amenity contributions*
- Section 219 covenants
- Bare land strata subdivisions to preserve larger remainder parcels for conservation
- Phased development agreements to enforce any development conditions, including potential community amenity contributions
- Highway dedication, reservation, or development as trails

*Short-listed as key tools and important incentives.

Several of these tools have already been earmarked by Bowen Island Municipality. Policy 341 of the OCP states that the Municipality will, in appropriate circumstances, secure and protect lands for Greenways, using administrative and regulatory measures such as:

- purchasing or designating significant natural areas;
- promoting private dedications and donations;
- creating supportive policies and regulations through bylaw;
- securing environmental or green space conservation covenants;
- negotiating statutory right of ways and easements;
- encouraging amenity contributions at the time of rezoning;
- exploring the use of density re-allocation mechanisms;
- creating special review processes that require permits for environmentally sensitive areas;
- establishing stewardship partnerships;
- supporting community Greenway initiatives; and
- encouraging the consolidation of parkland dedications to achieve larger parcels of parkland and Greenways areas.

## 6.2 Senior Government Tools

Crown Lands make up approximately 40% of Bowen Island's land base (Dunster & Associates 2000), composed largely of the Bowen Island Ecological Reserve, Mount Gardner Crown Land parcel, Mount Collins Crown Land parcel, and a few other notably sized parcels (Figure 4). These Crown Lands, as well as Crippen Regional Park, West Coast Nature Refuge, and regional parklands at Cape Roger Curtis recently acquired by Metro Vancouver Parks, compose and connect a significant portion of Bowen Island. Mindful management of these lands offers significant opportunities for supporting biodiversity resilience.

There are numerous federal and provincial Acts and Regulations that support the protection of areas important to biodiversity and connectivity (Table 2). Some of these tools offer protections on private lands (e.g., the *Riparian Areas Protection Regulation*), while others offer stronger protections for land owned by senior governments (e.g., the *Species at Risk Act*) or land used for forestry (e.g., the *Forest and Range Practices Act*).

These tools allow the provincial government to establish and manage ungulate winter ranges, wildlife habitat areas, wildlife management areas, old growth management areas, parks, conservancies, ecological reserves, riparian areas, motorized area restrictions and wildlands. The Bowen Island Ecological Reserve, which was established in 1973, is an example of a provincial initiative enabled under the *Ecological Reserve Act.*

The use of these tools for the protection of areas important to biodiversity and connectivity can require a high degree of collaboration between senior governments, local governments and driving non-governmental organizations.

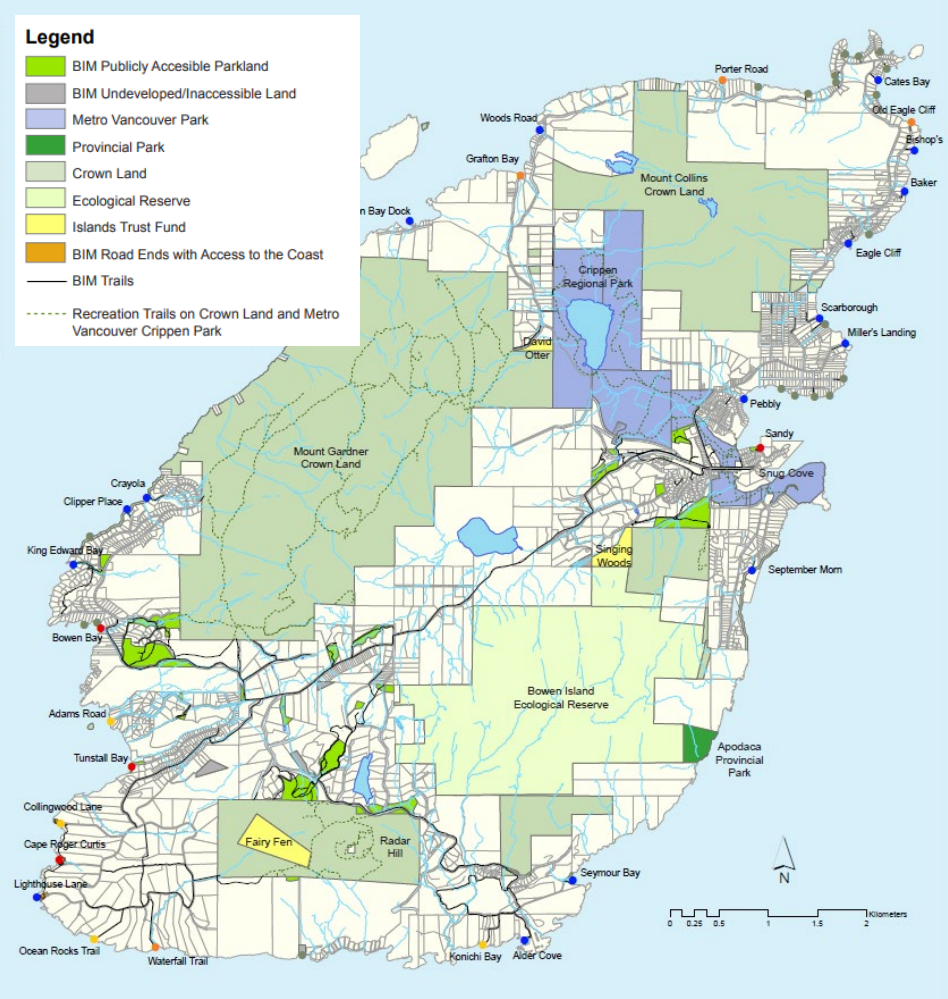


*Figure 4. Map of land classification and trails on Bowen Island Municipality (repurposed from Bowen Island Municipality 2023b)*

Table 2. Relevant Acts and Regulations enacted by senior governments

**Federal**

- Environmental Assessment Act
- Environmental Protection Act
- National Parks Act
- Wildlife Act
- Fisheries Act
- Migratory Birds Convention Act
- Species at Risk Act

**Provincial**

- Agricultural Land Commission Act
- Community Charter
- Ecological Reserve Act
- Environmental Assessment Act
- Environment and Land Use Act
- Fish Protection Act
- Forest Act
- Forest and Range Practices Act
- Land Act
- Local Government Act
- Park Act
- Protected Areas of British Columbia Act
- Riparian Areas Protection Regulation
- Water Sustainability Act
- Wildlife Act

# 7 CASE STUDIES

Several communities in and near British Columbia have mapped areas important to biodiversity and connectivity. These initiatives tend to be led by local governments or non-governmental organizations. The spatial scope of these initiatives ranges from local (e.g., within municipal boundaries) to regional (e.g., within a regional district) to transboundary (e.g., spanning multiple regions or countries). The analysis methods used also vary between initiatives, as discussed in Section 5 of this report, as do the conservation tools developed to protect the identified areas. Table 3 provides a non-exhaustive list of similar initiatives in and near British Columbia. The paragraphs following Table 3 highlight some exemplary initiatives.

Table 3. A non-exhaustive list of similar initiatives in and near British Columbia, including the mapping initiative (🗺) and conservation tools (📄).

| Lead Organization | Mapping Initiative + Conservation Tools |
|---|---|
| City of Surrey | 🗺 Green Infrastructure Network (2014)<br>📄 Biodiversity Conservation Strategy (Diamon Head Consulting 2014)<br>📄 Official Community Plan policy section dedicated to the GIN (City of Surrey 2013)<br>📄 Development Permit Area triggered by applications within 50 m of the GIN (City of Surrey 2013)<br>📄 Parkland Development Cost Charges to fund land acquisition (City of Surrey 2022)<br>📄 Alignment of Infrastructure and Land Use Plans with their conservation strategy<br>📄 Utilization of existing protections under the Riparian Areas Protection Regulation, Water Sustainability Act, Park and Urban Dedication bylaws, Tree Protection Bylaw and Soil Conservation and Protection Bylaw to assist with protection of the GIN |
| City of New Westminster | 🗺 Green Infrastructure Network (2022)<br>📄 Biodiversity and Natural Areas Strategy (Diamon Head Consulting 2022)<br>📄 Development Permit Area for the Brunette River (City of New Westminster 2020) |
| City of Richmond | 🗺 Ecological Network (2015)<br>📄 Richmond's Ecological Network Management Strategy (City of Richmond 2015) |
| Squamish Environment Society | 🗺 Wildlife Corridors in the northern half of the Átl'ka7tsem Howe Sound Biosphere Region (*in progress)*<br>📄 Biodiversity Conservation Strategy (*in progress*) |
| Town of Comox | 🗺 Wildlife Corridors (Focal Species: Deer)<br>📄 Development Permit Area that triggers review for application in or near the wildlife corridor (Town of Comox 2011) |

| Lead Organization | Mapping Initiative + Conservation Tools |
|---|---|
| Township of Langley | Ecological Greenways<br><br>Wildlife Habitat Conservation Strategy (Township of Langley 2008)<br>Yorkson Neighbourhood Plan (Township of Langley 2001)<br>Willoughby Community Plan (Township of Langley 1998) |
| Metro Vancouver Regional District | Habitat Patches and Areas Important to Connectivity (Diamond Head Consultants 2021)<br>Green Infrastructure Network (*in progress*)<br><br>Regional Growth Strategy 2050 (Metro Vancouver 2022)<br>Policy development by member municipalities (*future work*) |
| City of Vancouver | Green Infrastructure Network (*in progress*) |
| Okanagan (various) | Wildlife Corridors (OCCP and SOSCP 2014)<br><br>Biodiversity Conservation Strategy for the Okanagan Region (OCCP and SOSCP 2014)<br>Development Permit Area (District of Lake Country 2018)<br>Development Permit Area (City of Kelowna 2021) |
| Washington State (various) | Numerous wildlife habitat connectivity mapping initiatives (*complete and ongoing*)<br><br>Numerous conservation tools are in place or under development. |
| Cascadia Partnership Forum + TerrAdapt Cascadia | Species-specific and non-species-specific connectivity throughout the Cascadia region |
| Kootenay Connect | Ecological Corridors (Columbia Valley)<br><br>Provincial conservation tools, such as Wildlife Management Areas, Provincial Conservation Lands, Wildlife Habitat Areas, Wildlife Habitat Features, Ungulate Winter Range under the Forest and Range Practices Act, and crown lands with Notations of Interest. (pers. comm., Marcy Mahr, Kootenay Connect Manager, February 2023) |

| Lead Organization | Mapping Initiative + Conservation Tools |
|---|---|
| Kootenay Conservation Program | Ecological Corridors (seven focal areas within the East and West Kootenay)<br><br>Provincial conservation tools, such as Wildlife Management Areas, Provincial Conservation Lands, Wildlife Habitat Areas, Wildlife Habitat Features, Ungulate Winter Range under the Forest and Range Practices Act, and crown lands with Notations of Interest. (pers. comm., Marcy Mahr, Kootenay Connect Manager, February 2023) |
| Yellowstone to Yukon Conservation Initiative | Large-landscape, transboundary habitat connectivity modelling spanning from Yellowstone National Park to the Yukon (Yellowstone to Yukon Conservation Initiative 2023). |

A lot can be learned from each of the initiatives listed within Table 3. The following paragraphs highlight some *exemplary* initiatives to use as a starting place for exploring methodological and conservation tool options.

## 7.1 Collaboration + Spatial Analysis: Washington State

Of the initiatives included in Table 3, the Washington State initiatives exemplify a high degree of collaboration between government agencies, non-government organizations, consultants and academic institutions. Involved parties include but are not limited to the Cascades to Coast Landscape Collaborative, Washington Wildlife Habitat Connectivity Working Group, Southwestern Washington Habitat Connectivity Working Group, Conservation Biology Institute, and Conservation Northwest.

This collective uses some of the most established and scientifically rigorous spatial analysis methods and have a wealth of experience with both challenging and successful projects at both the local and regional scales. The Washington Wildlife Habitat Connectivity Working Group has been in existence for nearly 15 years and is composed of State agencies and subject experts. It is science-based with a core function of supplying good science to regional connectivity initiatives. Their spatial analysis methods often involve species-specific and non-species-specific modelling using Linkage Mapper, including the Centrality Mapper and PinchPoint Mapper tools, as well as Gnarly Landscape Utilities and Circuitscape (pers. comm. Brian Stewart, Conservation Northwest, October and November 2022).

## 7.2 Dynamic Modelling: TerrAdapt

TerrAdapt is a cloud-based platform that utilizes remote sensing and machine learning capabilities of Google's Earth Engine to dynamically monitor historical patterns of land cover change and habitat connectivity over time (1990-2023), to project how these patterns are likely to change based on future climate and land use scenarios, and to help prioritize areas for conservation (TerrAdapt 2023). The TerrAdapt platform offers cutting-edge dynamic modelling capabilities. It is relatively new and shows great

potential. The Squamish Environment Society and Howe Sound Biosphere Region Initiative Society are currently exploring the application of the TerrAdapt platform for the northern half of the Biosphere.

## 7.3 Local-level Planning + Conservation Tools: City of Surrey

The spatial analysis performed by the City of Surrey for development of their Green Infrastructure Network (GIN) provides a good example of the integration of local-level planning issues, such as real estate values, private land ownership, land use plans, and the practicality (or impracticality) of acquiring certain parcels of land. They also use a wide array of funding and conservation tools, including a Biodiversity Conservation Strategy (Diamond Head Consulting 2014), a policy section dedicated to the GIN in their Official Community Plan (City of Surrey 2013), a Development Permit Area that governs and protects the GIN (City of Surrey 2013), Parkland Development Cost Charges that fund land acquisition within the GIN (City of Surrey 2022), alignment of Infrastructure and land use plans with their conservation strategy, and utilization of existing protections, such as the *Riparian Areas Protection Regulation*, *Water Sustainability Act*, Park and Urban Dedication bylaws, Tree Protection Bylaw, and Soil Conservation and Protection Bylaw to assist with the protection of the GIN.

# 8 RECOMMENDATIONS

Based on the work conducted during this scoping study, there appears to be political and community support for increasing our understanding of biodiversity, identifying areas important to biodiversity and connectivity, and developing strategies to better protect these areas on Bowen Island. The following recommendations reflect the findings from this scoping study:

1. Collaborate + Pool Resources: Continue to explore opportunities to collaborate and pool resources.

2. Dynamic + Predictive Modelling: Explore options for the development of a dynamic model that has predictive capabilities and can be easily updated when new data becomes available.

3. Field Verification: Where possible, field verify spatial datasets that are being used as model inputs.

4. Use all Relevant and Accurate Data: Include a robust assortment of available data, thereby building upon work completed by former initiatives.

5. Other Model Inputs: Include other model inputs, such as expert groups, focal species experts, Indigenous Knowledge, and contributions from stakeholders and land managers.

6. Community Education: Continue to educate the community, including citizens, landowners, municipal staff, and municipal Council, about the importance of biodiversity and options to protect it in order to build upon existing awareness, understanding and support.

7. Engage: implement a robust engagement plan to support recommendation #5 and #6 above. Engage early and often.

8. Conservation Tools: Continue to explore policy tools for the protection of identified areas, including but not limited to a new or amended Development Permit Area.

# 9 SIGNATURE

Please do not hesitate to contact the undersigned should you have any questions.

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# Appendix 1: Available Data for Bowen Island

Appendix 1. Relevant spatial datasets available for Bowen Island

| DATASET | SOURCE[1] | YEAR | COMMENTS |
|---|---|---|---|
| **Landscape** | | | |
| Important Natural Areas | Islands Trust | 2017 | Islands Trust GIS Department data analysis derived from 2017 TEM data. Methods described by Greene et al. (2013). |
| Protected Areas Distribution | Islands Trust | 2018 | Islands Trust GIS Department data analysis derived from parks and protected areas data in 2018. |
| Sensitive Ecosystems | Islands Trust | 2017 | Islands Trust GIS Department data analysis derived from 2017 TEM data. |
| Terrestrial Ecosystem Mapping | Islands Trust | 2017 | Updated by Madrone Environmental Services in 2017 from previous TEM mapping projects by Madrone and B.A. Blackwell and Associates Ltd. in 2011, 2009 and 2008. |
| Species and at Risk | Islands Trust | 2017 | Suspected composite dataset developed by Islands Trust GIS Department in 2017, derived from occurrence data from the BC Conservation Centre and terrestrial critical habitat data from the Canadian Wildlife Services. Noted as incomplete. |
| Forested Ecosystems | Islands Trust | 2017 | Islands Trust GIS Department data analysis derived from 2017 TEM data. |
| Modified Ecosystems | Islands Trust | 2017 | Islands Trust GIS Department data analysis derived from 2017 TEM data. |
| Ecosystem Disturbance | Islands Trust | 2004-2014 | Islands Trust GIS Department data analysis derived from SEM/TEM Mapping Updates and Disturbance Mapping prepared by Madrone in 2017. |
| Invasive Alien & Problematic Native Species | Islands Trust | 2017 | Suspectedly modelled by Islands Trust GIS Department using road proximity. |
| Species Disturbance & Mortality | Islands Trust | 2017 | Suspectedly modelled by Islands Trust GIS Department using road proximity. |
| Eelgrass (ESA) | Islands Trust / BIM | - | - |
| Proposed Parks | BIM | 1994 | Schedule E (Parks and Trails) of Bowen Island's Official Community Plan (Bylaw No. 282, 2010) identifies general areas of proposed parks derived from the Bowen Island Parks Master Plan (1994). |
| LidarBC | LidarBC | 2023 | LiDAR (Light Detection And Ranging) point cloud data can be used to inform mapping of forest stands, floodplains, infrastructure, transportation features, etc. |
| **Wildlife** | | | |
| Heron Nests (ESA) | BIM | - | - |
| Forage Fish Habitat (ESA) | BIM | - | - |
| Red-Backed Vole (habitat patches) | Metro Van | 2021 | Modelled by Diamond Head Consulting using Conefor and Zonation spatial analysis tools. |
| Red-Back Salamander (habitat patches) | Metro Van | 2021 | |
| Long-Toed Salamander (habitat patches) | Metro Van | 2021 | |
| Muskrat (habitat patches) | Metro Van | 2021 | |
| Great Blue Heron (fannini ssp.; habitat patches) | Metro Van | 2021 | |
| Brown Creeper (habitat patches) | Metro Van | 2021 | |

| | | | |
|---|---|---|---|
| Rufous Hummingbird (habitat patches) | Metro Van | 2021 | |
| Pileated Woodpecker (habitat patches) | Metro Van | 2021 | |
| Key-hub Composite (habitat patches) | Metro Van | 2021 | |
| Areas Important to Regional Connectivity | Metro Van | 2021 | |
| Species observations | iNaturalist | - | Crowdsourced species observational data. |
| Species and Ecosystems at Risk - Publicly Available Occurrences - CDC | DataBC | 2023 | Includes minimal species occurrences on Bowen Island and suspectedly incomplete. |
| Critical Habitat for federally-listed species at risk (posted) | DataBC | 2023 | Critical habitat is only designated for species listed on Schedule 1 of SARA. Polygons are often mapped at the mesoscale and subject to field verification. |
| Wildlife Species Inventory (WSI; multiple datasets) | DataBC | 2022 | Limited data for the Bowen Island. |
| Wildlife Habitat Areas - Approved | DataBC | 2023 | None on Bowen Island. |
| Wildlife Habitat Areas - Proposed | DataBC | 2023 | None on Bowen Island. |
| **Topography** | | | |
| Contour (1 meter) | BIM | 2023 | Derived from LiDAR, therefore accurate to the date of survey |
| NTS BC Contour Lines 1:250,000 - Digital Baseline Mapping (NTS) | DataBC | 2023 | Coarse-scale. |
| **Freshwater Atlas** | | | |
| Freshwater Atlas Assessment Watersheds (1:20,000) | DataBC | 2023 | - |
| Freshwater Atlas Stream Network | DataBC | 2023 | Small streams may not be included or may be mapped incorrectly on Bowen Island. |
| Freshwater Atlas Lakes | DataBC | 2023 | Relatively high level of detail. |
| Freshwater Atlas Wetlands | DataBC | 2023 | Many wetlands are not included. |
| **Forestry** | | | |
| Old Growth Management Areas – Legal - Current | DataBC | 2023 | Five legal OGMs are mapped; all on the northern half of the Bowen Island. |
| Old Growth Management Areas – Non-Legal - Current | DataBC | 2023 | Two non-legal OGMAs are mapped within the Bowen Island Ecological Reserve and Apodaca Provincial Park. |
| Forest Tenure Cutblock Polygons (FTA 4.0) | DataBC | 2023 | Three small polygons in and near Radar Hill. |
| Forest Tenure Road Segment Lines | DataBC | 2023 | None on Bowen Island |
| Harvested Areas of BC (Consolidated Cutblocks) | DataBC | 2023 | Approximately 10 small polygons throughout Bowen Island. |
| Reporting Silviculture Updates and Land Status Tracking System (RESULTS) | DataBC | - | Numerous datasets available. |
| **Roads** | | | |
| Digital Road Atlas (DRA) – Master Partially-Attributed Roads | DataBC | 2023 | Appears to be complete for Bowen Island. |
| **Forest Fire** | | | |
| Fire Perimeters – Historical | DataBC | 2023 | Five polygons throughout on Bowen Island. |

| | | | |
|---|---|---|---|
| **Water Rights** | | | |
| Water Rights Licences - Public | DataBC | 2023 | Numerous data points throughout Bowen Island. |
| Water Rights Applications - Public | DataBC | 2023 | One data point on Bowen Island. |
| **Pipelines** | | | |
| OGC Pipeline Rights-of-Way Permits | DataBC | 2023 | None on Bowen Island. |
| OGC Pipeline Rights-of-Way Applications | DataBC | 2023 | None on Bowen Island. |
| **Land Use (Other)** | | | |
| Baseline Thematic Mapping Present Land Use Version 1 Spatial Layer | DataBC | 2023 | Mesoscale resolution. |
| TANTALIS - Crown Tenures | DataBC | 2023 | Includes multiple polygons on Bowen Island representing tenures for watershed reserves, ecological reserves. recreation reserves, quarries, etc. |
| Placer tenures | DataBC | - | Numerous datasets available |
| Vegetation Resources Inventory (VRI) | DataBC | - | Numerous datasets available |
| **Governance, Zoning + Ownership** | | | |
| First Nation Community Locations | DataBC | 2023 | Shows location of main community only. None on Bowen Island |
| First Nations Treaty Lands | DataBC | 2023 | None shown in on Bowen Island. |
| Indian Reserves - Administrative Boundaries | DataBC | 2023 | None shown in on Bowen Island. |
| ParcelMap BC Parcel Fabric | DataBC | 2023 | Includes land ownership data (e.g., private, municipal or crown) |
| ALC Agricultural Land Reserve Lines | DataBC | 2023 | Four polygons within Bowen Island. |
| Zoning | BIM | - | - |

[1] References:


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DataBC: Province of British Columbia. 2023. BC Data Catalogue. Last accessed on June 15, 2023 from https://catalogue.data.gov.bc.ca/

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