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Low Carbon Resilience and **Transboundary Municipal Ecosystem Governance:**

A CASE STUDY OF STILL CREEK

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This policy report is part of a suite of materials produced over the course of a year-long research project on Still Creek. Additional information can be found in the accompanying story map and infographic, via the ACT website: www.act-adapt.org/still-creek/.

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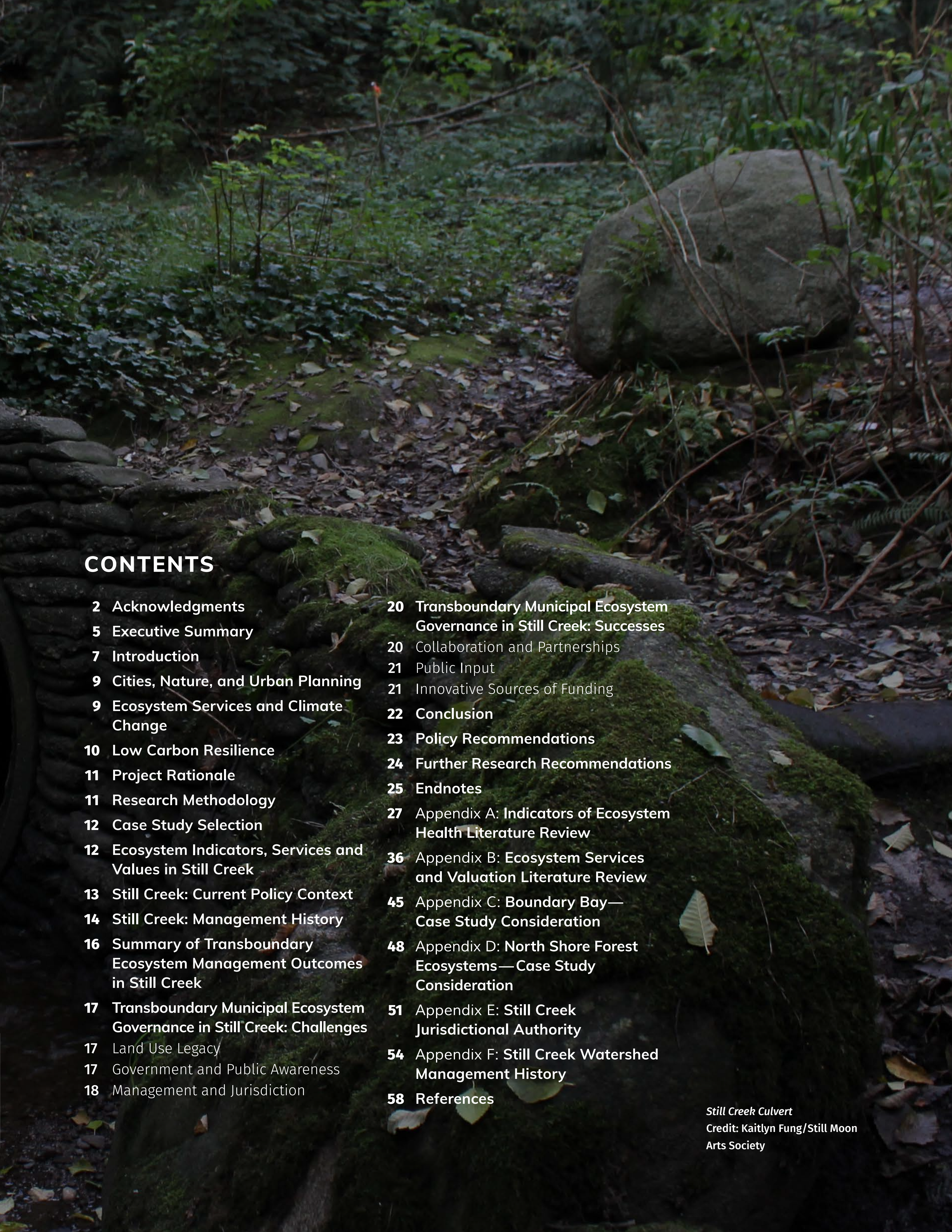

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Still Creek Culvert
Credit: Kaitlyn Fung/Still Moon Arts Society

A Heron in Still Creek
Credit: Svend-Erik Eriksen/ Still Moon Arts Society

EXECUTIVE SUMMARY

Ecosystem-based “green infrastructure” projects can help municipalities adapt to climate change impacts such as flooding and extreme heat, and offer multiple co-benefits. However, cities are not necessarily valuing ecosystem contributions to benefits such as improved property safety and prices; the cultural, spiritual, physical and mental health of residents; water, food and energy security; carbon emissions reductions; water and air pollution reductions, and recreational values. Furthermore, lack of capacity can make it difficult for neighbouring municipalities to collaborate on managing for ecosystem health across jurisdictional boundaries.

This project explored three case studies of transboundary municipal ecosystem governance in Metro Vancouver, and focused on the Still Creek watershed where it flows between the cities of Vancouver and Burnaby. One of only two daylit creeks remaining in Vancouver, Still Creek underwent significant environmental degradation as a result of urbanization, but has benefitted in recent years from a collaborative municipal rehabilitation process, resulting in the return of spawning salmon for the past four years and other benefits provided by ecosystem services.

> “Still Creek underwent significant environmental degradation as a result of urbanization, but has benefitted in recent years from a collaborative rehabilitation process, resulting in the return of spawning salmon for the past four years, and other benefits provided by ecosystem services.

These services are represented as four main categories: provisioning, regulating, habitat, and cultural. They can help both to reduce greenhouse gas emissions (mitigation), and increase resilience to climate change impacts (adaptation), which have traditionally been approached as separate processes. Integrating the two—an approach known as low carbon, or green, resilience—can achieve a variety of synergies and co-benefits and avoid building in vulnerability to climate impacts or inadvertently increasing emissions. The collaborative restoration of urban ecosystems by neighbouring municipalities provides an opportunity to achieve the benefits of low carbon resilience in a local transboundary context.

The Still Creek ecosystem is under the jurisdiction of several levels of government, as well as private property owners. Its health has been influenced by policy and management decisions that have shifted in scale and priority over time, revealing both challenges and successes in the context of transboundary ecosystem governance. Key challenges include the legacy of historical urban development, lack of awareness of the creek ecosystem's health and value to the region, and disparities between the management priorities of the neighbouring municipalities.

FIND OUT MORE

For additional information on the challenges and successes associated with transboundary ecosystem governance in Still Creek, see pages 17–22.

The project uncovered a number of successes that illustrate effective transboundary municipal governance, including collaboration and partnership between several levels of government, academic and private institutions, and community groups, leading to joint development of strategies and actions; and municipal efforts in both cities to engage the public and incorporate local knowledge into the planning process, educate and raise awareness, and thereby gain widespread support for policies and plans.

Visible improvements to ecosystem health can help galvanize additional public support for restoration; this was borne out by increased levels of community involvement due to the return of spawning salmon to Still Creek from 2012 onwards. The municipalities involved also capitalized on innovative sources of funding in order to advance their restoration initiatives.

Based on these findings, we identified four major recommendations for transboundary municipal ecosystem governance with applicability for other municipalities, as follows: reach out and form partnerships; establish a formal collective entity; access funding and resources from municipal sources; and engage the community.

Further information on recommendations can be found on pages 23–24.

Project results are available in three formats designed to communicate the findings in an accessible and engaging way for the public and decision-makers: this policy report, a policy timeline infographic, and an online story map. The infographic and story map visualize Still Creek's policy history in relation to landscape shifts, ecosystem health, and ecosystem services, and provide an alternative format to illustrate our conclusions.

The value healthy ecosystems bring to and across communities will continue to grow as climate change advances and urban growth expands. If we are to enjoy the benefits and avoid costly vulnerabilities, it is essential that we prioritize collaborative municipal governance approaches to ecosystem conservation and restoration, both within the urban context and at the regional scale within which cities are situated.

To access additional report deliverables visit: **act-adapt.org/still-creek/**.

INTRODUCTION

Climate change is challenging the ability of ecosystems to adapt throughout British Columbia. Extreme weather, including intense precipitation events, coastal storms, and long, hot, dry summers, is testing the resilience of species as they are forced to move northwards and higher on slopes, often colliding with human habitation just as they are similarly challenged by fragmentation and loss of habitat due to human development and resource extraction patterns. Pests and other ecosystem health challenges are further compromising the resilience of ecosystems.

Simultaneously, awareness is growing of the value of ecosystems as a factor in urban resilience. Healthy ecosystems assist with flood absorption and passive cooling for built infrastructure, while improving air quality, adding to recreational space, contributing to human physical and mental well being, and augmenting property prices. Ecosystem presence also helps to reduce greenhouse gas emissions through carbon absorption and storage and other factors such as reduction of the urban heat island effect, reducing the need for air conditioning.

Ecosystems are therefore increasingly recognized as a significant factor in adaptation to climate change and are emerging as city priorities under the heading of "blue-green infrastructure," and "greenshores" approaches in the coastal context. Cost-benefit analyses demonstrating monetary values that can be attributed to the benefits ecosystems bestow—while not necessarily designed to be used as literal dollar values—are beginning to provide convincing evidence for decision-makers that such considerations should be factored into development plans, municipal asset management, and other land and water use planning processes.

Researchers are studying ways to ensure these benefits are acknowledged and given appropriate status in decision making rather than being valued at zero, as has commonly been the case. However, many ecosystems span two or more municipalities and may become fragmented due to different or conflicting management approaches in neighbouring cities. As well, municipalities often lack the resources and capacity to collaborate for reasons we explore in the section on **Challenges**.

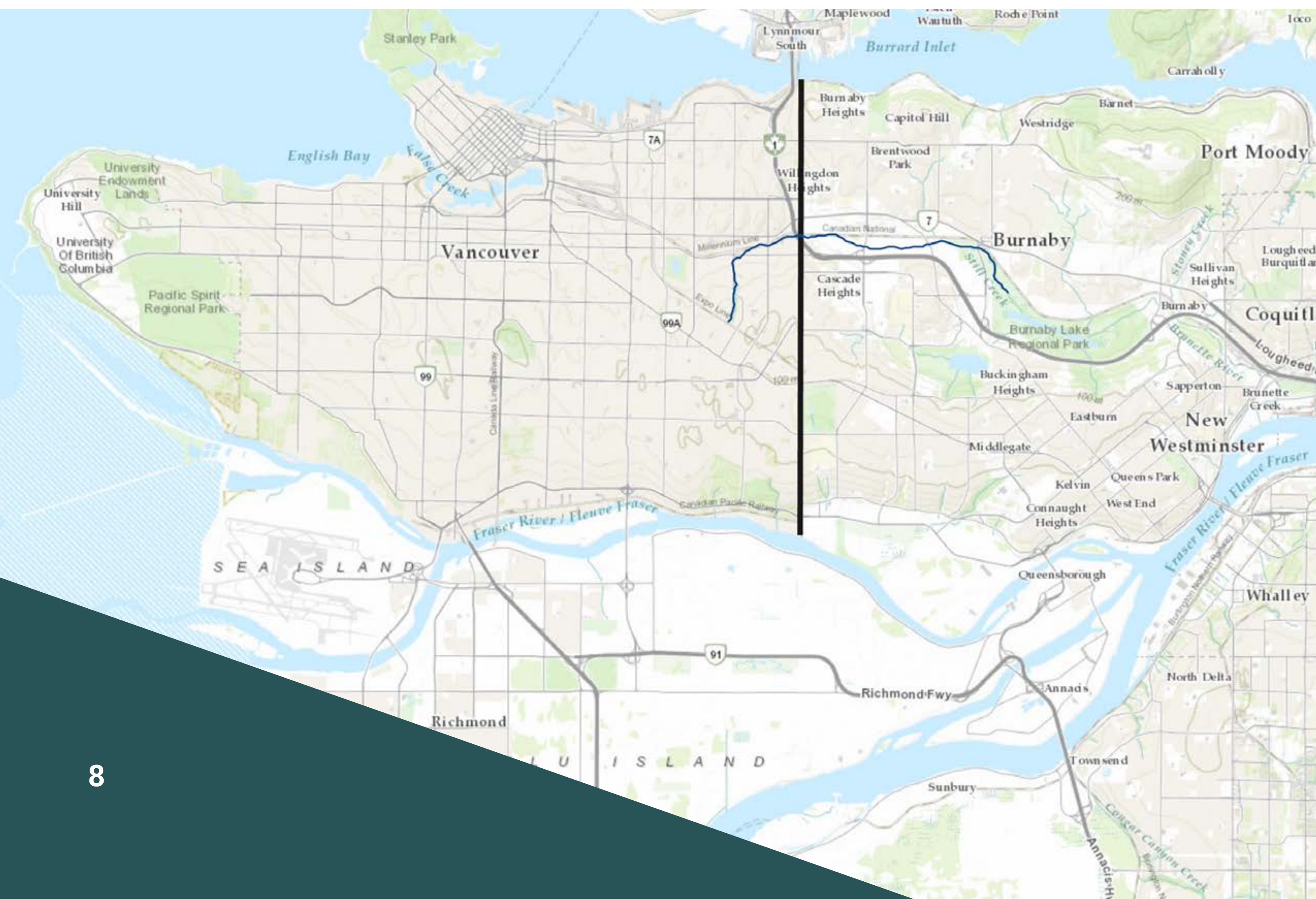
This project examined three urban ecosystem case studies in Metro Vancouver in order to explore municipal-level challenges and best practices for transboundary ecosystem governance in a changing climate. Case study areas considered include the North Shore forests on the boundary between the Districts of North and West Vancouver; the coastal foreshore on the boundary between Delta and Surrey; and the Still Creek watershed on the boundary between Vancouver and Burnaby.

Research revealed that the first two study areas were not suitable for this project, partly due to lack of data to confirm the impacts of municipal regulation and policy on ecosystem health, and partly due to challenges in isolating the impacts of municipal regulation where other levels of government were involved (see **Appendices C** and **D**). The influence of municipal decision making was clear in the Still Creek context, and this case study therefore became the project's main focus.

In order to assess the outcomes of transboundary decision-making, we selected indicators and values associated with ecosystem health and tracked changes in them over time by mapping historical archival materials and reviewing the region's policy and management history. Combined with the results of practitioner interviews, the findings revealed policy challenges and successes that are extrapolatable to other municipal jurisdictions.

This report presents the concepts that informed the project design, the research rationale and methodology, the history and management of Still Creek, and conclusions for transboundary municipal ecosystem governance.

Still Creek Main Channel and Municipal Boundaries



CITIES, NATURE, AND URBAN PLANNING

Cities are situated within and contain ecosystems upon which they rely for benefits and services such as water and air purification, flood buffering, heat mitigation, habitat for species, recreational amenities, improved health, and buoyant property values. However, these attributes are often overlooked or discounted to the point that they are valued at zero, despite the fact that replacing them with man-made infrastructure would be prohibitively costly.

The blending of urbanism and nature—a concept described as 'urban ecology'—has been gaining legitimacy since the late 1960s.[1] Recent theories and concepts such as landscape urbanism, biophilic cities, and bioregional planning acknowledge ecosystem benefits for cities, lend themselves well to regional or collaborative forms of municipal planning, and are being applied widely.

Historical patterns of development, such as building in flood plains and extensive use of asphalt and concrete, are exacerbating climate change impacts such as flooding and extreme heat. Recent paradigm shifts in landscape design and urban planning are beginning to acknowledge and include ecosystem benefits and services in this context, as well as their importance in a changing climate.

> "The blending of urbanism and nature—a concept often described as 'urban ecology'—has been gaining legitimacy since the late 1960s.

ECOSYSTEM SERVICES AND CLIMATE CHANGE

Climate change poses threats to municipal infrastructure, services and ecosystems that are directly experienced at the local or regional level,[2] such as increases in extreme precipitation, inland and coastal flooding, heat stress, drought, and water scarcity.[3] Climate change adaptation in urban areas is often focused on protecting public and private assets from impacts, as well as the safety and well-being of people. Urban ecosystems can play a significant role in these responses, for instance by buffering against impacts from floods, extreme heat, and other threats. Local government actions designed to conserve and enhance ecosystem presence and health can therefore increase community resilience while achieving a variety of co-benefits.[4]

In 2005, the Millennium Ecosystem Assessment (MA) defined Ecosystem Services (ES) as "the benefits that humans obtain from ecosystems."[5] Restoring and maintaining healthy ecosystems can provide equivalent function to that performed by municipal services such as stormwater management, flood protection, etc., and are often cheaper to install, maintain and operate than man-made alternatives.[6] The use of ecosystems and landscapes to provide these services is ecologically sustainable, achieves multiple policy goals, and is often more economically beneficial in the long term[7] than investments in hard infrastructure.

ES are categorized by *provisioning services* (the provision of goods from the natural environment, such as food and water), *regulating services* (which help to regulate environmental conditions, such as flood attenuation, air purification, etc.), *habitat services* (such as the maintenance of genetic diversity), and *cultural services* (such as opportunities for recreation, spiritual value, etc.).[8] Climate change threatens all four ES, and yet they are essential to adaptation.

For example, the *provisioning* of food, water, and medicinal plants becomes more unpredictable as climate change affects rainfall patterns and growing seasons; however, these services will become increasingly crucial as the planet warms and food supplies are threatened by climate change impacts around the globe.

Regulating services such as cooling and the absorption of both carbon and stormwater will also become more critical as temperatures rise and flooding becomes more severe and/or frequent, but are also impacted by climate change; for example, drought reduces the ability of the landscape to absorb stormwater during flash floods.

Habitat services, such as conditions conducive to fish presence in creeks, are impacted greatly by rising temperatures; for instance, salmon are highly sensitive to heat stress. However, healthy creeks, especially those that provide corridors to the ocean, benefit aquatic species along the food chain such as fish, birds, and whales. As climate change advances, wildlife are shifting ranges in order to adapt to changing climatic conditions, and the importance of maintaining connected habitat areas to enable this movement is crucial to the survival of many species.

Finally, the spiritual and holistic value bestowed by ecosystems is characterized as a *cultural* service, as are the recreational opportunities provided by green spaces such as parks and beaches. As Earth's systems struggle for survival in the face of climate change and other human-caused impacts, connections with nature will become ever more essential as we work to restore planetary health.

Research efforts that explore the connections between ES and ecosystem health are ongoing.[9] However, it is already widely accepted that the potential for ecosystems to provide the services outlined above is dependent on the health of their biological structures and functional processes.[10] Ecosystem integrity or health can be defined in a number of ways, but in general can be said to encompass the maintenance of community structure, functions, and characteristics; resilience to stress; and the absence of disease.[11]

LOW CARBON RESILIENCE

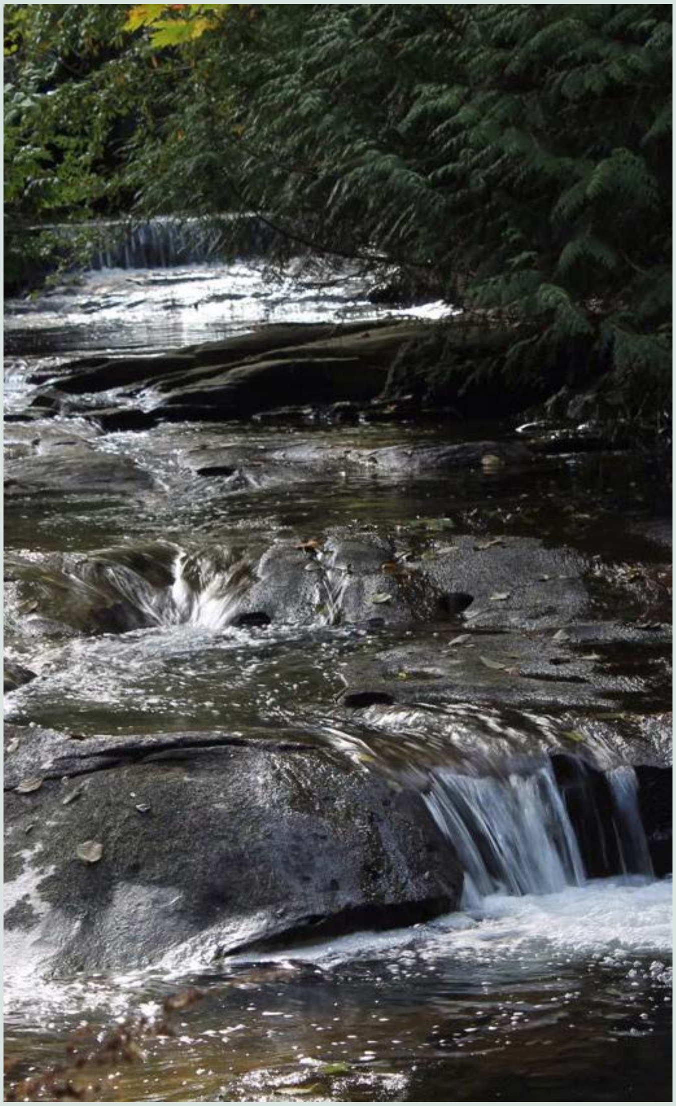
Historically, greenhouse gas reduction (climate change mitigation) and building resilience to climate change impacts (adaptation) have been approached as separate processes. Combining these strategies can achieve co-benefits and save time and money. Municipalities are moving forward on both adaptation and mitigation planning, and we have a limited window of opportunity in which to implement low carbon resilience to avoid the risk of both building in vulnerability to climate change impacts and inadvertently increasing emissions.

PROJECT RATIONALE

Municipal conservation and restoration of urban ecosystems can be integral to climate change adaptation strategies. With proactive planning, leadership, and collaboration, municipalities can use existing or restored natural systems to deliver ecosystem services that duplicate or complement those provided by hard infrastructure, such as stormwater management and flood protection.[12]

However, government boundaries are seldom aligned with ecological boundaries such as watersheds or river basins,[13] and actions in one area can have consequences that manifest themselves in another.[14] For example, upstream decision-making typically has downstream ramifications in a creek or watershed. Differing priorities, standards and capacity in neighbouring municipalities can have significant impacts on the health of forests, creeks and other ecosystem components where they cross municipal boundaries. Thus, transboundary ecosystems pose a unique and important challenge in the municipal governance context.

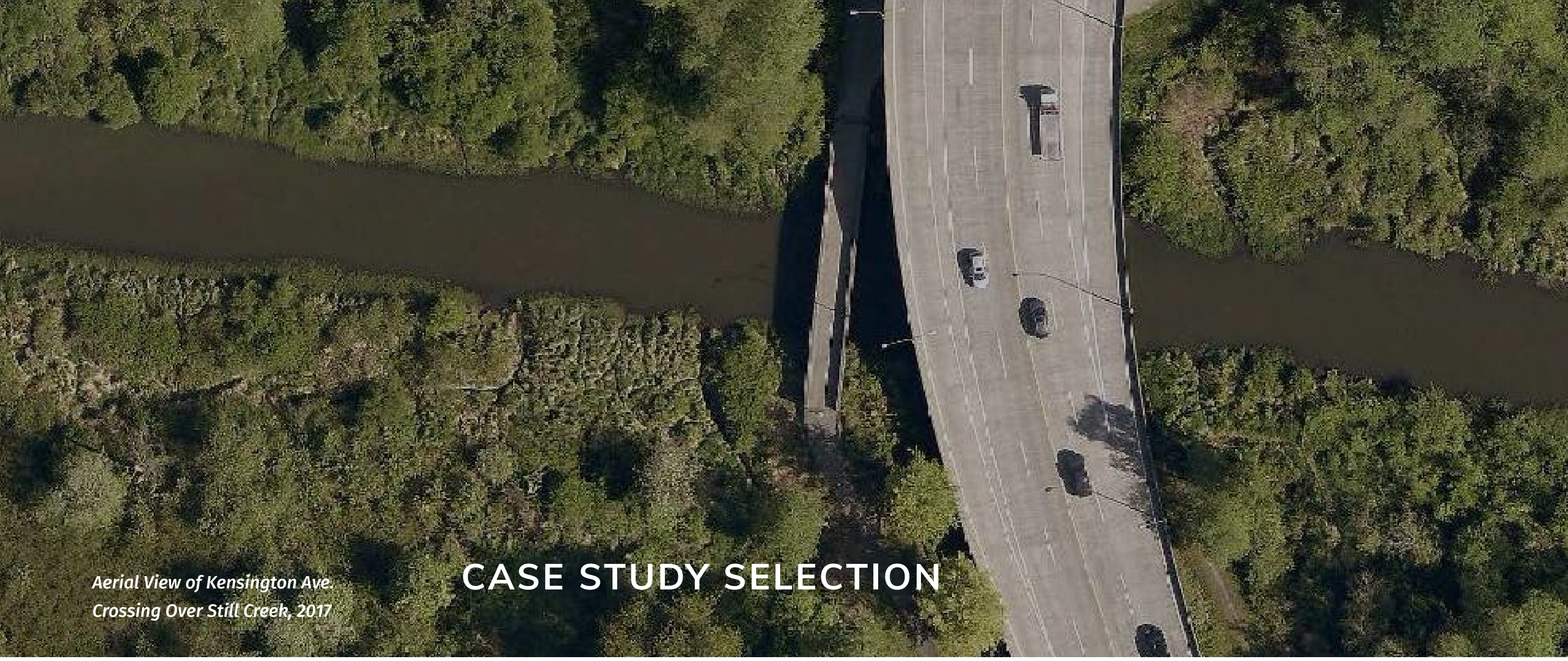
Municipalities often face infrastructure deficits and internal capacity issues, and may lack the resources required to address complex and costly climate change challenges. However, enhancing, restoring, and protecting urban ecosystems can help provide solutions, and partnering with neighbouring municipalities can result in the sharing of ideas and resources, as well as low carbon resilience benefits. The Still Creek case study demonstrates the value of municipal collaboration and key ways cities can work together to achieve success in this area.



RESEARCH METHODOLOGY

The research team conducted literature reviews on the indicators of ecosystem health (**Appendix A**), as well as ES and ecosystem valuation methods (**Appendix B**). Surveys of the policy context were completed for three transboundary ecosystems (North Shore forests—**Appendix C**; Boundary Bay—**Appendix D**; Still Creek—pages 13 and 14 of this policy report), and a comprehensive management history review and timeline analysis of governance in the Still Creek watershed (**Appendices E** and **F**). Research findings were groundtruthed with municipal and regional practitioners who have been involved in Still Creek management approaches, and include analysis of policy decisions that led to successes or challenges for ecosystem health, and recommendations for municipalities based on lessons learned.

Stream to Small Falls, Still Creek
Credit: Kaitlyn Fung/Still Moon Arts Society



Aerial View of Kensington Ave. Crossing Over Still Creek, 2017

CASE STUDY SELECTION

This project explored case studies of transboundary municipal governance for three types of ecosystems in Metro Vancouver: contiguous forest, coastal foreshore, and riparian. Areas initially identified included the North Shore forests between the districts of North and West Vancouver; the coastal foreshore in Boundary Bay between the cities of Surrey and Delta; and Still Creek between the cities of Burnaby and Vancouver. The forest and coastal case study areas were deemed not viable due to data gaps and jurisdictional issues related to non-local governments, as described in **Appendices C** and **D**. Research proceeded with the Still Creek case study as municipal decision making on transboundary ecosystem management in this region was clearly influential and identifiable.

ECOSYSTEM INDICATORS, SERVICES AND VALUES IN STILL CREEK

Ecosystem health can be measured and communicated through a wide range of indicators (see **Appendix A**). New research is beginning to allocate values to these factors, although this work is still nascent (see **Appendix B**). It is essential to develop accessible communications tools and materials that clearly demonstrate these values (and the ways that municipalities can benefit from investment in ecosystem-based responses), in order to ensure that residents, practitioners and decision makers understand the importance of maintaining healthy ecosystems in urban environments. The online story map and timeline infographic that accompany this policy report are two such examples of accessible communications tools.

Table 1 below illustrates the relationship between ecosystem indicators, services and values in Still Creek. Indicators of urban connectivity and impervious/pervious area encapsulate a variety of typical urban stressors. These indicators are measurable and comparable over time through an analysis of open/closed stream and grey/green buffer. Open/closed stream and grey/green buffer analysis allows us to draw conclusions about ecosystem health, as well as the effectiveness of ecosystem services.

Table 1: Indicators, Ecosystem Services, and Values Relevant to Still Creek

Ecosystem Health Indicator	Related Ecosystem Health Indicators/ Stressors	Measurable/ Mappable Indicator Chosen	Ecosystem Service: **Provisioning**	Ecosystem Service: **Regulating**	Ecosystem Service: **Habitat**	Ecosystem Service: **Cultural**	Applicable Valuation Methods
Ecosystem connectivity	Urban stream syndrome, hydrological alteration, stream burial, temperature and light trends, nutrient trends, ionic concentrations, terrestrial inputs, urban development/barriers, benthic/invertebrate health, fish production, ecosystem metabolism, runoff, flooding	Open/closed section of stream	Food, raw materials, fresh water, medicinal resources	Local climate and air quality, carbon sequestration and storage, moderation of extreme events, wastewater treatment, erosion prevention and maintenance of soil fertility, pollination, biological control	Habitat for species (such as benthic organisms, birds, small mammalls, amphibians, and chum salmon), maintenance of genetic diversity	Recreation, mental and physical health, tourism, spiritual experience and sense of place, aesthetic appreciation and inspiration for culture, art and design (as demonstrated through the work from community and art groups in Still Creek)	Avoided costs (carbon storage, water and air filtration), replacement costs (flood protection, water supply), production function value (pollination, salmon habitat), travel cost/tourism value (recreation, tourism), hedonic pricing (ammenity/ residential value), willingness to pay
Impervious area/pervious area		Grey/green buffer					

In the next two sections, we tell the story of the Still Creek watershed, and how its neighbouring municipalities worked towards the achievement of collaborative transboundary municipal governance.

STILL CREEK: CURRENT POLICY CONTEXT

Still Creek runs through the traditional territory of several Coast Salish First Nations, including the Musqueam, Tseil-Waututh, Kwikwetlem, and Squamish. The watershed is located within the Brunette Basin and forms the upper main stem, which continues through to Burnaby Lake, flows into the Brunette River, and drains into the Fraser River.[15] One third of the watershed lies in Vancouver and two thirds in Burnaby; overall, it is heavily urbanized, with approximately 20% remaining as undeveloped or open space.[16] The headwaters of the creek originated in the Metrotown area of Burnaby, but today they emerge in both municipalities through trunk sewers and culverts.[17]

Still Creek is influenced by management decisions under the jurisdiction of all levels of government as well as private property owners. Primary influences include land- and water-use regulation and policy from the federal government (Fisheries and Oceans Canada), the province of British Columbia's Ministry of Environment, Metro Vancouver through regional sewerage and drainage responsibilities, and the cities of Vancouver and Burnaby through their land-use planning authority.[18]

FIND OUT MORE

For further rationale and information related to the concepts outlined in this chart, see Appendices A and B.

For more detail on government jurisdictional authority in Still Creek, please see Appendix E.

Aerial View of Still Creek Entering Burnaby Lake (1969)

STILL CREEK: MANAGEMENT HISTORY

First Nations stories describe Still Creek as a travel corridor used to traverse the Lower Mainland.[19] As urban centres developed in Vancouver and Burnaby between the late 1800s to 1970s, little consideration was given to preserving the ecological integrity of Still Creek.[20] From the early 1900s until the late 1960s, the Vancouver portions were piped as wastewater drainage, while the Burnaby portion remained relatively open due to slower residential growth.[21]

These developments resulted in severe degradation of the stream ecosystem that became so toxic it threatened human health, and during the 1970s local and provincial government developed policies that were geared towards reversing the damage.[22] Examples include local open watercourse bylaws and the provincial *Waste Management Act*.[23] Plans and policies developed from the 1980s to the 1990s further promoted ecological integrity through provisions for enhancing urban greenspace and wildlife habitat and reducing urban pollutants. Regional land use and drainage plans acknowledged the importance of green spaces for community well-being, and plans for active transportation greenways were linked to restoration of the stream corridor. Concurrently, due to concerns over the destruction of fish habitat in waterways across British Columbia, the *Riparian Protection Regulation* was established under the provincial *Fish Protection Act* (1997).

In the late 1990s, the federal, provincial, regional, and both municipal governments, along with academic institutions, arranged to meet and discuss environmental issues in the Brunette Basin including Still Creek.[24] During the same timeframe, the Greater Vancouver Regional District released the first iteration of the *Liquid Waste Management Plan* (LWMP) (1996), a requirement under the provincial *Waste Management Act* (WMA) that outlined regional strategies to reduce pollution from liquid waste in the Lower Mainland.[25] The Brunette Basin Watershed Plan was collaboratively developed in order to coordinate actions under the LWMP, and included specific measures for management of Still Creek.[26]

In the early 2000s, municipal policies, including Burnaby's *Total Stormwater Approach* and Vancouver's *Still Creek Rehabilitation and Enhancement Plan*, guided local decisions.[27] The *Integrated Stormwater Management Plan* (ISMP) for Still Creek was produced jointly by local and regional governments with the intention of integrating stormwater management into local land use planning.[28] There has been no further collaborative planning focused explicitly on the ecological integrity of Still Creek since the ISMP was released 10 years ago; however, recent initiatives developed by Burnaby, Vancouver, and Metro Vancouver have included related objectives within broader environmentally-focused plans. For instance, Metro Vancouver released an updated LWMP in 2010 and the *Ecological Health Action Plan* in 2011, which together aim to improve the condition of urban ecosystems.[29]

Vancouver's *Greenest City Action Plan*, *Urban Forest Strategy*, and *Integrated Rainwater Management Plan* all outline actions for increasing urban vegetation and reducing rainwater-related pollution.[30] The Vancouver Parks Board also released *Rewilding* and *Biodiversity* strategies that focus on actions and programming within Vancouver's parks to raise awareness and benefit ecological integrity.[31] Finally, Burnaby has recently approved its *Environmental Sustainability Strategy*, the first ecologically-focused strategy for the city, which will be integrated with all other city plans and policies.[32] See **Appendix F** for a comprehensive analysis of the management history of Still Creek.

Studying ecological indicators in tandem with the historical policy and management actions described above allows us to draw conclusions from the effects of urban planning practices on the health of the Still Creek ecosystem. The management history also

FIND OUT MORE

See **Appendix F** for a comprehensive analysis of the management history of Still Creek.

Graffiti by Rushing Water, Still Creek
Credit: Kaitlyn Fung/Still Moon Arts Society

provides insights into how the ecosystem has been valued in relation to other municipal priorities, and when and how municipalities rated the importance of ES.

This exploration of the interconnections between historical changes in ecosystem health, relative changes in value based on ES, and the policy and management history of the area, reveals both challenges and successes. These are outlined below, followed by policy conclusions with applicability to other municipalities and regional bodies considering transboundary ecosystem governance.

SUMMARY OF TRANSBOUNDARY ECOSYSTEM MANAGEMENT OUTCOMES IN STILL CREEK

> "These changes likely resulted in increased costs to the municipality, decreased human health and well-being, decreased potential for resilience to climate change impacts such as flooding and extreme heat, and reduced ecosystem health.

The ecosystem management decisions in Still Creek outlined above led to notable changes in the creek corridor over time. We measured trends related to transboundary ecosystem health and the services and value they provide using the indicators identified in **Table 1**: open/closed stream, and grey (urban/hard infrastructure)/green (non-urban/vegetated) buffer.

From 1949–2003, Still Creek jurisdictions proceeded with policy and decision making individually, with little collaboration. During this period, the percentage of open creek sections in the main channel dropped from 97.9% to 74.4%, and the percentage of green creekside buffer decreased from 86.2% to 45.1%. The creek corridor was also significantly impacted by other aspects of urban development such as pollution. These changes likely resulted in increased costs to the municipality, decreased human health and well-being, decreased potential for resilience to climate change impacts such as flooding and extreme heat, and reduced ecosystem health.

From 2003–2014, there was an increase in collaborative decision making in a transboundary context, resulting in restoration actions such as vegetating of creek buffers and the daylighting of closed stream sections. The percentage of open creek section in the main channel rose from 74.4% to 75.5%. The amount of green buffer remained constant at 45.1% based on the 30 metre extent we had chosen as our baseline; however, the municipalities invested in restoration of native plants and community clean up programs and the green buffer percentage nearer to the creek increased. These improvements likely resulted in decreased costs, improvements to human health and well-being, increased resilience to climate change, and benefits to ecosystem health. In 2012, salmon returned to Still Creek for the first time in decades and have returned each year since then, spawning in the heart of East Vancouver.

For the full scope of this research, including in-depth visuals and additional details, see the infographic and story map online at **act-adapt.org/still-creek/**.

FIND OUT MORE

For in-depth visuals and additional details, see the **infographic** and **story map** online at **act-adapt.org/still-creek/**.

TRANSBOUNDARY MUNICIPAL ECOSYSTEM GOVERNANCE IN STILL CREEK: CHALLENGES

Land Use Legacy

Municipalities generally have a limited amount of developable space, with a variety of pending and competing land uses. The legacy of historical urban development, which has not traditionally benefited ecosystem health, remains a consistent challenge due to the pervasiveness of impermeable surfaces and other disruptive land uses, private land ownership issues, and reduced ecosystem health and function. As urban populations grow, municipalities often feel additional pressure to develop land. Typically, there is also continuous pressure from the business community to develop land for traditional economic development purposes,[33] as well as to maintain existing commercial and industrial land use.

Current land use patterns in Vancouver and Burnaby reflect their development history. Burnaby, whose population grew more slowly, has more undeveloped land, and over 90 streams and creeks remain uncovered. Neither municipality has the financial resources to purchase or expropriate land solely for ecological restoration purposes, and thus ecosystem health is impacted heavily by the practices of private property owners.[34]

Like many urban streams, Still Creek is surrounded by industrial lands. As residential housing booms threatened industrial zoning, these areas often became protected as hubs seen as necessary for maintaining the diversity and availability of locally-based employment within communities.[35] Municipalities are often reluctant to re-purpose industrial land (or land that could provide housing development revenues) for ecological restoration purposes, especially since the benefits of doing so are difficult to value in monetary terms.[36] Along Still Creek, certain industrial and residential developments are located entirely within the riparian zone.[37] Industrial encroachment in the riparian area can only change once areas are redeveloped and there is an opportunity to re-zone lands to create new requirements.[38]

"Industrial encroachment in the riparian area can only change once areas are redeveloped and there is an opportunity to re-zone lands to create new requirements.

Government and Public Awareness

Valuing ecosystems for their services requires a paradigm shift in the way governments think about urban ecosystems. Within Burnaby and Vancouver, planners tend to struggle with ways to categorize funding for restoration projects. At the local government level, "green infrastructure" (such as vegetated buffers, green space, or other related infrastructure with high ecosystem function), and the services it provides (such as flood absorption, water and air filtration), are difficult to quantify compared to man-made infrastructure such as pipes and seawalls. As noted above, research is underway on how to place a monetary value on ecosystems services in order to avoid discounting the benefits they provide, but these approaches are not yet well established in the municipal governance context.[39]

The general public may not have education in or experience with ecological concepts, and therefore may be likely to view maintaining ecological integrity as a lower priority than other municipal services.[40] With little understanding of ecosystem function, particularly in urban areas, it can be difficult for residents to make the connection between their individual actions, development practices, and the effects on ecosystems. This phenomenon can worsen over time; for example, the Shifting Baseline Theory describes the erosion of standards in subsequent generations as the accepted baseline for ecological health diminishes.[41] One illustration of this concept is when generations are raised without knowing that active watercourses once ran through their neighbourhood, since they have not been exposed to these natural systems in their current urban environment. In addition, residents in British Columbia municipalities often discard yard waste and plant invasive species immediately next to parks and green space simply due to lack of environmental awareness.

Without improved public awareness and understanding, elected officials (mayors and councillors) are unlikely to feel any pressure to champion policies and legislation designed to conserve and restore ecosystems.[42]

Public awareness can be influenced by many factors. In Burnaby, for instance, residents tend to be more aware of the effect of their individual actions on watercourses, perhaps because over 90 creeks remain open and visible to the community;[43] conversely, in Vancouver, there are only two open creeks, and stormwater is mainly conveyed through underground pipes. As residents become more aware of their location within a broader ecosystem their actions are likely to change; without education, however, citizens may remain largely unaware of their influence on, and benefits they are receiving from, the ecosystems that surround them.

The effectiveness of academia, local government, and stewardship organizations in raising public awareness remains largely untested.[44] Very few citizens are likely to be interested in reading technical studies, and public engagement requires innovative knowledge translation and communications. Meanwhile, building public interest in environmental issues remains challenging for those working in planning and policy development.[45] Lack of public awareness may be compounded by apathy due to absence of a sense of urgency, or burnout from involvement in other community-level consultation and engagement efforts.

The length of time required to achieve institutional change and for the public to experience tangible ecological benefits may also dissuade or discourage community members from participating in planning processes.[46]

Management and Jurisdiction

Ecosystems are often under the jurisdictional control of multiple political entities, and ecological health can fall within administrative cracks between different institutional mandates and focus.[47] Though the involvement of multiple jurisdictions may be considered a benefit if each is willing to contribute resources, individual authorities may not feel ownership or responsibility towards the ecosystem as a whole, and organizations may be reluctant to take the lead on projects that they do not believe will benefit them directly.

Some decisions that affect ecosystem health are made at the federal and provincial levels of government, outside the control of municipal planners and decision-makers. For instance, development of utility corridors, regional highways, and large federal infrastructure projects may include consultation of municipalities, but ultimately depend on decisions made by politicians outside local government, potentially resulting in unsustainable practices over which local planners may have no control.[48] One recent example in Burnaby is the federally-approved twinning of the Trans-Mountain oil pipeline, which will cross multiple streams. The municipality advocated fiercely against the project, which poses the risk of large-scale negative impacts to local streams, but was overruled by the federal approval.[49]

In the case of Still Creek, a further consideration is that Burnaby and Vancouver operate under different enabling legislation. For example, Burnaby must conform to the provincial *Riparian Area Regulation*, which requires development setbacks from open watercourses, and municipal policies related to the stream protection enhancement areas reflect this requirement.[50] Vancouver does not need to meet this requirement, because it operates under unique enabling legislation which provides more authority over land-use planning.[51] While this could be viewed as a more flexible arrangement to the benefit of Vancouver, it means that it may be harder for Vancouver to implement a large riparian setback from a political perspective because it cannot rely on the provincial government to mandate the requirement.[52]

Still Creek Culvert
Credit: Kaitlyn Fung/Still Moon Arts Society

Salmon Return to Still Creek
Credit: Still Moon Arts Society

TRANSBOUNDARY MUNICIPAL ECOSYSTEM GOVERNANCE IN STILL CREEK: SUCCESSES

Collaboration and Partnerships

Managing ecosystems that cross multiple jurisdictions requires horizontal (i.e., across internal municipal departments and neighbouring municipalities) and vertical (i.e., between different levels of government) communication. Collaboration between different government levels, and partnerships between public, private, not-for-profit, and academic institutions, is vital for the coordination of decision-making and provides opportunities to develop new policies focused on ecosystem health.

The joint development of strategies and actions raises awareness within government as well as in the public sphere, and has the potential to shift management towards interests that accommodate a wide variety of stakeholders, which in turn may influence the priorities of individual municipalities. Multiple entities can collaboratively address ecological enhancement through a variety of strategies, from stewardship and cost-sharing to education.[53]

Collaboration and partnerships provide opportunities for the incorporation of additional perspectives and innovative ideas, which can drive more diverse and holistic solutions than a lone entity might be able to generate. The ongoing restoration actions in the Still Creek watershed are the result of multiple agencies providing insights and catalyzing ongoing planning and policy development.[54]

For instance, in 2007, the Greater Vancouver Regional District (GVRD, now Metro Vancouver) mandated development of *Integrated Stormwater Management Plans (ISMPs)* for all its member municipalities under its *Integrated Liquid Waste and Resource Management Plan*, with the goal of integrating stormwater management practices within land-use planning and policy decisions at the watershed scale. The Still Creek *ISMP* was subsequently developed collaboratively between the GVRD, Vancouver, and Burnaby, and provided consensus and direction for future land use practices in Burnaby and Vancouver.[55]

The Still Creek *ISMP* devotes an entire chapter to the role of public art and festivals in raising awareness, largely due to the influence of diverse stakeholders and collaboration among several organizations. This contrasts significantly with *ISMPs* in other jurisdictions with open waterways, which tend to focus instead on the technical details of water drainage.

A coordinating entity or formalized partnership structure is vital for the long-term cooperation involved in managing ecosystems that cross government boundaries.[56] The GVRD played a coordinating role in its *ISMPs*, requiring progress reports to ensure that municipalities were implementing actions. In the case of Still Creek, the Brunette Basin Task Group, formalized as a result of the *LWMP*, provided a forum for the entities to convene and share information.[57]

Public Input

Municipal government is accountable to residents and responsible for transparency, meaningful engagement, public involvement, and support among stakeholders. Widespread public support for a plan can result in higher likelihood of its approval. Public engagement on policies and plans related to ecosystem health improves the potential for incorporation of local knowledge into the planning process, awareness raising within the community, and development of widespread support for policies and plans. Ensuring meaningful grassroots participation is present from the outset of planning processes and throughout implementation is therefore helpful to ensure the long-term feasibility of a plan.

There was extensive public consultation during the development of Burnaby's *Environmental Sustainability Strategy (ESS)*, and also during the development of the joint *ISMP*. Open houses for the *ISMP* raised community awareness about the existence of Still Creek, and made residents aware of their connections to the watershed. Throughout the process of developing the *ESS*, stewardship groups were consulted extensively, and their knowledge of the streams in Burnaby provided a basis for further planning and restoration work in the area.

The *ESS* process, which took place over four years, was as important to implementation as the final written report.[58] Though a strategy could have been developed without extensive public consultation, public acceptance provided an integral layer of legitimacy, which was helpful for council approval.

In addition, effective public input can ensure that the strategies and actions proposed by municipalities are likely to be realistic and feasible in the local context.[59]

> "Ensuring meaningful grassroots participation is present from the outset of planning processes and throughout implementation is therefore helpful to ensure the long-term feasibility of a plan.

Innovative Sources of Funding

Funding is necessary for the conservation and restoration of urban ecosystems, yet many municipalities face infrastructure funding deficits and also lack a steady funding stream dedicated to ecosystem health or adaptation to climate change. However, municipalities that are prepared with plans and objectives can be opportunistic with funding, and creative with existing policy tools. Ecosystems that cross jurisdictional boundaries may have more potential funding partners, particularly if the ES and values are acknowledged and accurately characterized. Municipalities can combine funding from various sources, including private property owners and developers, and grants from other levels of government or private agencies.

Both Vancouver and Burnaby found innovative ways of funding actions designed to improve ecosystem health in Still Creek. Municipalities typically obtain funding from private property owners through property taxes and development charges, however, private funding may be obtained through other means. In Vancouver, the revenue from the lease of land to major film studios adjacent to Still Creek was earmarked for support of right-of-way restoration along the adjacent industrial area of the stream corridor. These funds have allowed engineers and planners at the City of Vancouver to plan and implement multiple years of restoration and maintenance activities.[60]

Urban redevelopment also provides opportunities for rezoning and development requirements that can improve environmental conditions on privately owned property. Municipalities may require or incentivize developers to restore vegetation, increase setbacks, or protect environmental features during development, relying on various regulatory powers.[61]

Restoration activities can also be combined with routine infrastructure projects. Roads and transit infrastructure projects, as well as operations and maintenance activities for sewers and pipes, provide opportunities to use public funding to simultaneously achieve ecosystem restoration goals.[62] Any sewer or pipe replacement can be an opportunity for daylighting creek segments and restoring riparian areas. Ecological corridors can also qualify as active transit areas, and thus can become eligible for public amenity and transportation-based funding. For instance, a Highway 1 expansion project provided an opportunity to further a large portion of the restoration work in the riparian area;[63] Still Creek qualifies as active transit infrastructure as part of the Central Valley Greenway, which enabled the federal government and Translink, Metro Vancouver's regional transportation authority, to contribute financing towards re-vegetation initiatives along the creek corridor.

CONCLUSION

> “ the Still Creek case study highlights examples of successful ecosystem governance practices that led to positive changes in ecological integrity.

The conservation and restoration of urban ecosystems can provide valuable benefits and services and help communities to both mitigate and adapt to climate change. However, this value may be overlooked or discounted, and management for ecosystem health often falls through administrative cracks. Ecosystems that cross municipal boundaries present further challenges, as governance decisions are not made by one municipality alone, and capacity to collaborate may be limited.

Still Creek and its history of major policy change and municipal collaboration provides a useful case study with which to examine the complexities of transboundary municipal ecosystem management, and identify recommendations and conclusions that may be helpful for municipal decision-making in this context across the country.

Several challenges to transboundary ecosystem management in Still Creek were revealed as a result of this case study. The legacy of historical development results in limited developable space, and many competing land uses and municipal priorities. Neighbouring municipalities may have quite different land use priorities due to unique management histories and socio-economic contexts. In addition, government and public awareness of the value of ecosystems, as well as the complexities of ecological integrity, is still limited. Lastly, ecosystems often fall under the jurisdiction of multiple governments, and ecosystem health is unlikely to be the primary mandate of any one municipality.

Despite these political challenges, the Still Creek case study highlights examples of successful ecosystem governance practices that led to positive changes in ecological integrity. Collaborative planning enabled the vertical and horizontal transfer of information between government government and non-government entities. Establishment of partnerships contributed to coordinated decision-making and municipal prioritization of ecosystem health. In addition, ensuring public buy-in provided legitimacy to plans and policies; and in-depth community engagement helped to both incorporate local knowledge and raise widespread public awareness.

Finally, capacity issues and a lack of resources continue to be a burden for local governments. Innovative and creative ways of framing ecosystem benefits in Still Creek helped grant access to multiple, sometimes unforeseen, funding sources and opportunities.

POLICY RECOMMENDATIONS

The following recommendations are offered to municipalities considering transboundary ecosystem governance:

1. Reach out and form partnerships

- *In Still Creek, Metro Vancouver's actions drove collaboration under the ISMP*
- Connect with neighbouring local governments and other levels of government who have a connection to the ecosystem in question and whose actions influence local ecosystem health
- Support and help raise the profile of local environmental community groups and not-for-profit agencies that may be working towards preserving and enhancing local ecosystems
- Utilize the expertise of local academic institutions whose researchers can provide the latest social, economic and scientific research, and may be interested in applied local research

2. Establish a formal collaborative entity

- *Formation of the Brunette Basin Task Force enabled collaboration in Still Creek*
- Focus the mandate on ecological integrity, in order to emphasize ecosystem services (particularly those best suited to adapt to the impacts of climate change) and encourage participation from multiple municipalities, regional government, provincial government, academic institutions, and local organizations
- Meet regularly to discuss issues surrounding ecosystem management, and facilitate sharing of information
- If data is missing, jointly monitor ecosystems and ecological functioning

3. Access funding and resources from multiple sources

- *Still Creek received input from film studio revenues and transit funding*
- From the public through additional parcel taxes and utility user fees
- From developers at the time of redevelopment in urban areas
- Through grants for infrastructure projects, public health, and education
- Combine restoration and enhancement projects with other necessary infrastructure upgrades and developments

4. Engage the community

- *Still Creek public engagement included Burnaby's ESS and art-based events in Vancouver*
- Communicate information to the public
- Make data publicly available and easily accessible
- Facilitate meaningful public input, consultation, and engagement in planning and policy-making to incorporate local knowledge
- Engage the community through support for public art, celebratory festivals, youth educational institutions, and not-for-profit on-the-ground work

FURTHER RESEARCH RECOMMENDATIONS

1. Complete a comprehensive analysis of the values provided by Still Creek ecosystem services and benefits across the two municipalities (for instance, using the valuation methods described in **Table 1**).

2. Identify and analyze changes in other indicators of ecosystem health in Still Creek to provide a more complete assessment of factors contributing to vitality of the system over time (these could be selected from **Table 1**, in the list of "Related Indicators"); for example, measurement of indicators related to water quality, wildlife habitat and presence, and vegetation health.

3. This analysis of Still Creek featured two urban municipalities to provide an example of transboundary governance. The policy conclusions developed here could be tested for relevance among communities with unique governance and funding frameworks, such as First Nations communities, rural municipalities, and regional districts.

4. Since different jurisdictions within Canada operate under unique urban planning frameworks, the policy conclusions presented in this report could also be tested for relevance in other provinces and territories.

FIND OUT MORE

See **Table 1: Indicators, Ecosystem Services, and Values Relevant to Still Creek** on page 13.

For in-depth visuals and additional details about this report, see the **info-graphic** and **story map** online at **act-adapt.org/still-creek/**.

ENDNOTES

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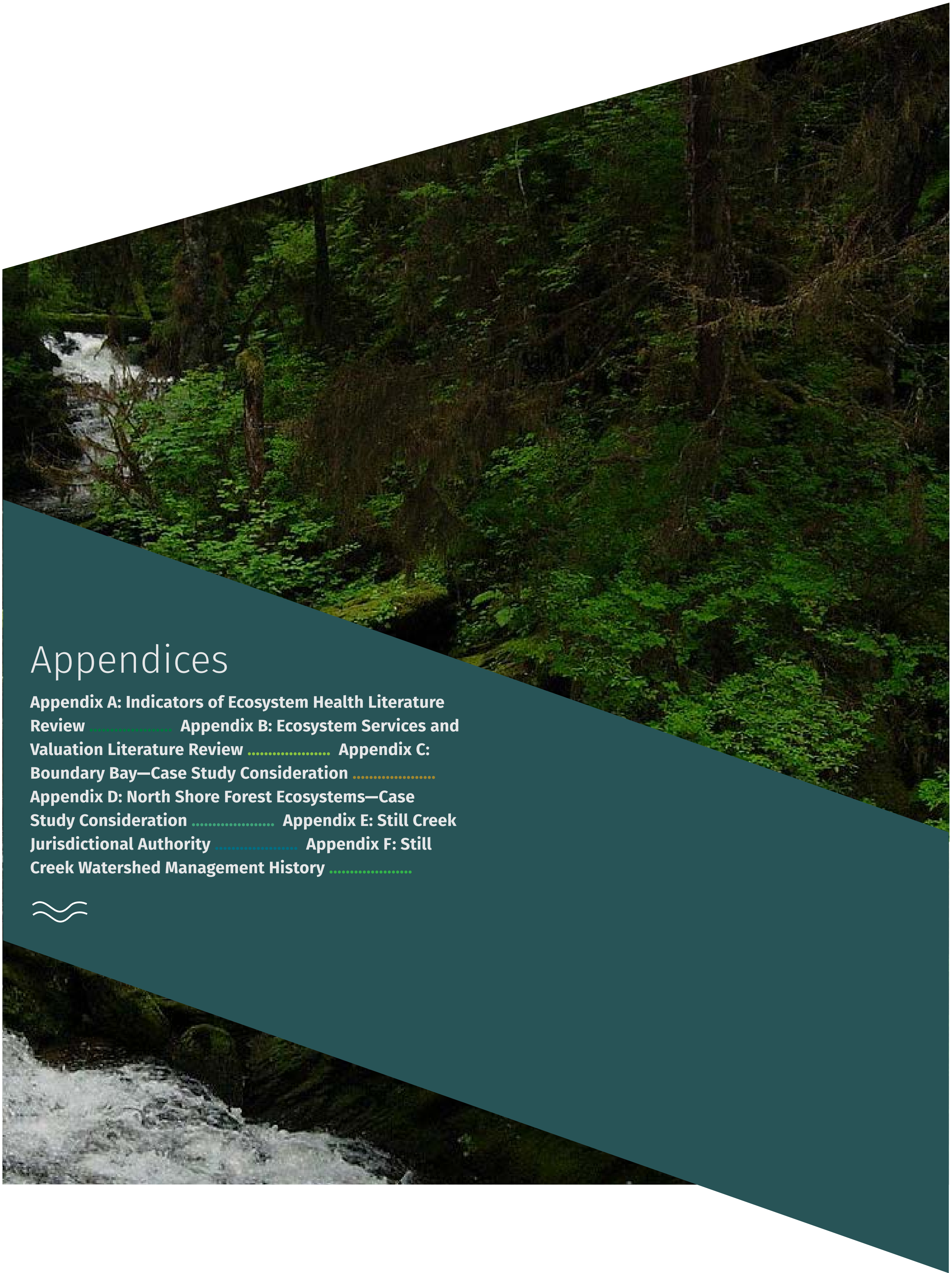

Appendices

APPENDIX A: **INDICATORS OF ECOSYSTEM HEALTH LITERATURE REVIEW**

Defining Ecosystem Health

Ecosystem health can be defined in a variety of ways, from a natural environment that is stable and sustainable while maintaining its organization, autonomy, and resilience to stress over time,[64] to an ecosystem that simply exhibits the absence of disease.[65] The measurement of ecosystem health is an important tool for understanding the state of environment for both humans and wildlife, and this has particular relevance in the context of current and future climate change.

Human Health and the Health of the Natural Environment: Drawing Connections

Human health and the health of the natural environment are inextricably linked, and the combination of human and environmental factors can help to define "the ecosystem health and quality of life for a place."[66] While ecosystem health can be impacted by human influences (e.g. pollution, deforestation, etc.), the affected ecosystems also have potential to provide significant benefits to human health, such as the filtering of air and water. The more degradation an ecosystem withstands, the less humans benefit from impacts to the services received from that ecosystem.[67] Ecosystem health has also been connected to consequences for economic opportunity, the survival of communities, and sustaining healthy people.[68]

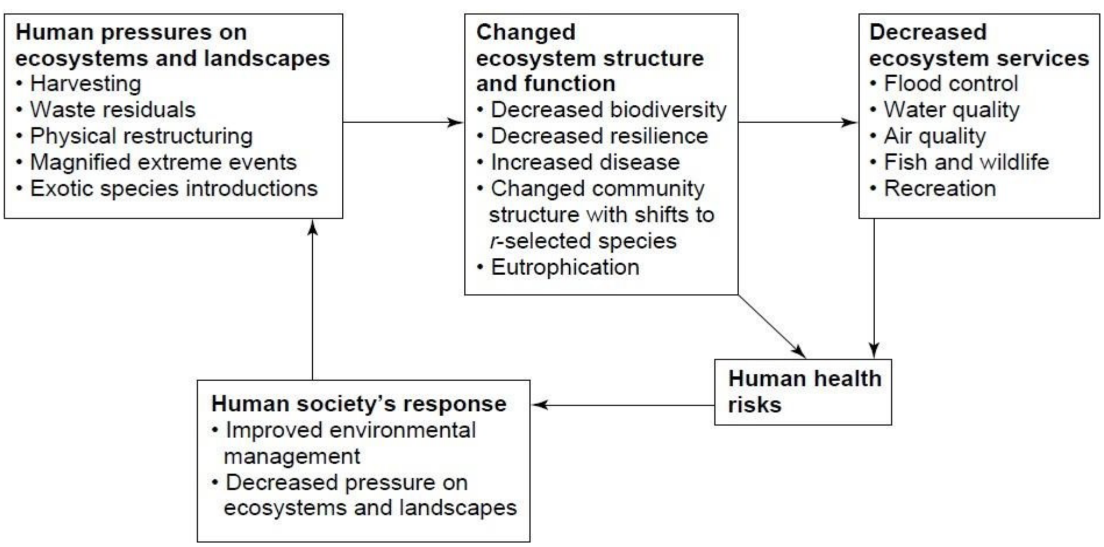

Figure 1: The Interconnections Between Human Activity, Ecosystem Change, and the Degradation of Ecosystem and Human Health[69]

Some elements of ecosystem health measurement can be compared to the practice of human medicine. For example, identifying characteristics that distinguish sick ecosystems from healthy ones, the ability to handle stress loadings, and the identification of risk factors are used in both disciplines.[70] In addition, healthy ecosystems are often defined, as in the case of healthy humans, as exhibiting the absence of disease.[71] However, there are several instances where these assessment frameworks do not align. In human health, for instance, it is possible to assess the standard parameters of a healthy person; however, in complex ecological systems, there may be an infinite number of parameters or interactions at play, and absence of disease may only be referenced to a poorly defined standard of an 'ideal' ecosystem.[72] Physicians in human medicine do not often infer a disease based on one parameter; however, this often occurs in environmental biology due to the limited number of diagnostic testing options for ecosystem health.[73]

Prospective analysis, an approach that monitors outcomes over time in relation to risk factors, can help protect ecosystems before it is too late to save them. Establishing prospective criteria involves acquiring a functional definition of disease with corresponding health factors, identifying the parameters of a healthy ecosystem, and responsible analysis and interpretation of information.[74] This criterion is often established through specific indicators of ecosystem health. Finding connections between human health and ecosystem health can be a necessary step in the development of ecological indicators.[75] Due to the uniqueness of local human and physical geography, a region's "climatic, geologic, hydrologic, biologic, and human factors" all combine to produce a set of functions that help to characterize a place and determine its complexity and interlinkages.[76] This complex array of natural and human factors in a region can be characterized by sets of indicators.[77]

Introducing and Defining Indicators of Ecosystem Health

Humans have been using indicators to help them understand the status of the environment for centuries. Traditionally, humans have used migration patterns of animals and studied spring flowering times to understand changing environmental conditions across landscapes.[78] In the 1920s, indicators were used to help determine water and air quality, as exemplified through examples such as the 'canary in the coal mine'.[79] In the past 50 years, scientific development and interest in ecosystem health indicators has risen, driven by the need for large-scale decision making based on regulation, stewardship, sustainability, and biodiversity. For example, the development of water quality acts within and between high-level governmental bodies was driven by the measurement of indicators for water quality health.[80] While measuring every environmental variable is likely impossible, carefully selected indicators can be used to assume changes in environmental conditions.

An indicator of ecosystem health can be defined as a "characteristic of the environment that, when measured, quantifies the magnitude of stress, habitat characteristics, degree of exposure to the stressor, or degree of ecological response to the exposure."[81]

The terms 'environmental indicators' and 'ecological indicators' are often used interchangeably; however, they have slightly different meanings. Environmental indicators tend to refer to elements that link human impacts with environmental conditions and the associated responses. Environmental indicators reduce 'information overload' by isolating key aspects of the environmental condition, and therefore these indicators are more understandable and translatable to non-biology based disciplines.[82] For instance, environmental indicators identified in the Environmental Sustainability Index (ESI) allow for comparisons of environmental conditions across international borders, and are more useful in a broad political context.[83]

Ecological indicators are a subset of environmental indicators that apply strictly to ecological processes, often influenced by chemical, physical, or biological changes to the environment.[84] Ecological indicators are defined by Niemi and McDonald (2004) as measurable characteristics of the **structure** (e.g., genetic, population, habitat, and landscape pattern), **composition** (e.g., genes, species, populations, communities, and landscape types), or **function** (e.g., genetic, demographic/life history, ecosystem, and landscape disturbance processes) of ecological systems.[85]

Despite a lack of consensus in the literature regarding what indicators of ecosystem health are or should be, there is consensus that a suite of indicators can differentiate ecosystems under severe stress from human activity from unstressed ones, and can reveal important information about structure, function, and composition.[86]

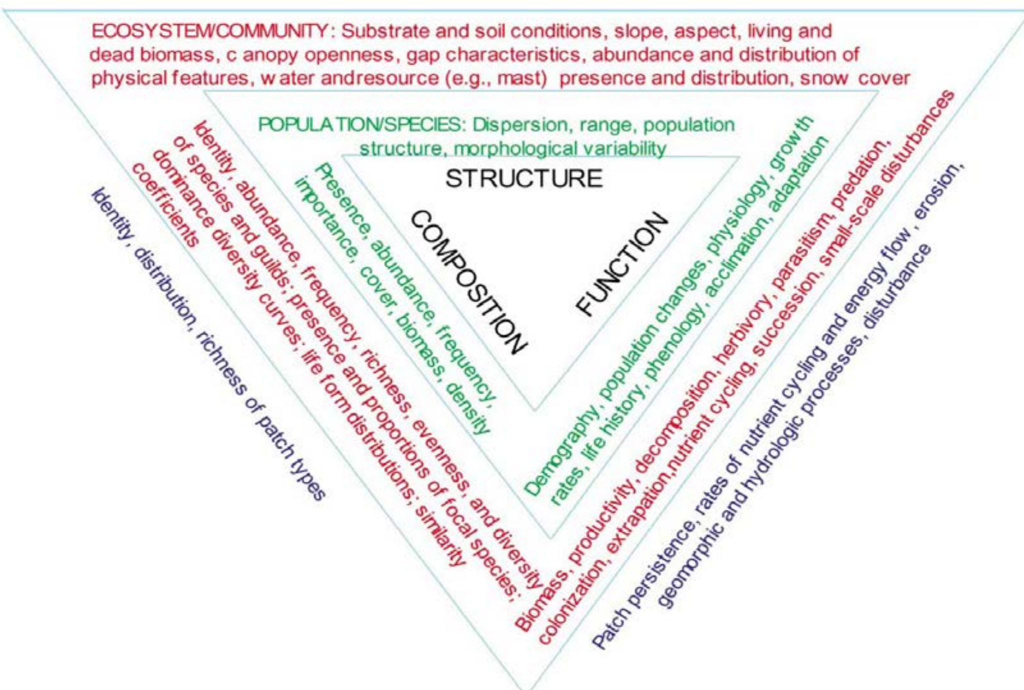

Figure 2: Structure, Function, and Composition at Different Scales[87]
In this figure, each triangle is representative of a different scale (population/species, ecosystem/community, and landscape/region). Each triangle outlines elements of an ecological indicator—structure, function, and composition—that may change with a shift in hierarchy or scale.

The Importance of Scale

Measurement of ecosystem health can occur at a variety of hierarchies and scales, from genes to species to entire regions.[88] The appropriate spatial and temporal scales and associated indicator choice should be dictated by the management goal or intended purpose of studying ecosystem health.[89] As the complexity of a system increases by moving to a larger geographic scale, the costs in applying ecosystem indicators also increases and the level of scientific understanding decreases, which can result in a loss of accuracy.[90] The following figure depicts indicators of ecosystem health for specific scales/hierarchies:

Example components and indicators for ecological integrity

Hierarchy	Processes	Suggested indicators
Organism	Environmental toxicity Mutagenesis	Physical deformation Lesions Parasite load
Species	Range expansion or contraction Extinction	Range size Number of populations
Population	Abundance fluctuation Colonization or extinction	Age or size structure Dispersal behavior
Ecosystem	Competitive exclusion Predation or parasitism Energy flow	Species richness Species evenness Number of tropic levels
Landscape	Disturbance Succession	Fragmentation Spatial distribution of communities Persistence of habitats

Figure 3: Indicators at Different Scales[91]

Establishing Indicators of Ecosystem Health

Indicators of ecosystem health are categorized by Cairns et al. (1993) broadly as **compliance indicators** (which are chosen to achieve ecosystem health objectives such as restoration), **diagnostic indicators** (which provide insight in to the cause of non-compliance), and **early warning indicators** (which allow for ecosystem management before environmental conditions have been depleted to a point where compliance indicators are affected).

Evaluation of indicators can be broken down from the compliance, diagnostic, or early-warning categories into subcategories, such as **physiochemical indicators** (related to water quality and ecological biologic conditions), **biological indicators** (which integrate the effects of several stressors), **measurements of individuals and populations** (such as indicator species), **measures of communities and ecosystems**, **community structure, community function**, and **landscape ecology** (such as relationships between ecosystem processes), **integrated measures of ecosystem health** and **socio-economic indicators** (such as those that link ecosystem health and human well-being.[92]

Data collection using indicators of ecosystem health is generally done for the following reasons:[93]

- To assess the current condition of an environment to judge its adequacy (e.g., through a compliance indicator)
- To document trends in ecological conditions over time (e.g., through a compliance or early warning indicator)

- To anticipate hazardous conditions before adverse impacts in order to prevent ecological damage (e.g., through an early warning indicator)
- To identify causative agents of change to determine a corresponding management action (e.g., through a diagnostic indicator)
- To demonstrate interdependence between indicators in order to make responsible management decisions (e.g., through identifying correlations between various indicators)

The criteria for selecting indicators of ecosystem health often includes options from the following list:[94]

- Maximizes unique information, minimizes redundant information
- Easily measurable and repeatable
- Interpretable and understandable by target audience
- Cost effective
- Integrative
- Anticipatory
- Non-destructive of the ecosystem
- Useful for measuring future change
- Appropriately scaled
- Time and space bound (i.e. comparable over time)
- Connects with management and societal values
- Sensitive to stressors without an 'all or none' response to extreme natural variability
- Applicable to many stressors
- Diagnostic of a particular stressor
- Low variability of results

Criticisms of ecological indicators are often made in response to a lack of well-articulated objectives, failure to acknowledge different sources of error, a lack of identification of appropriate context, a lack of a conceptual framework, a lack of integration of science and values, and a lack of validation of the indicator.[95] Ecological indicators can also be difficult to implement due to costs and feasibility.[96] Finding indicators that characterize the entire system (yet are simple and understandable to a broad audience) is an additional challenge.[97]

Species as Indicators of Ecosystem Health

Indicator species are commonly used to signify changes in ecosystem health in various fields such as ecology, environmental toxicology, pollution control, agriculture, forestry, and wildlife and range management.[98] They are often used "(a) to reflect the biotic or abiotic state of the environment; (b) to reveal evidence for the impacts of environmental change; or (c) to indicate the diversity of other species, taxa, or communities within an area."[99] Indicator species can be categorized under the broad term 'focal species', as shown in the table below:

Table 2: Categories of Focal Species[100]

Focal Species Category	Description	Example
Indicator species	Status is indicative of the status of a larger functional group of species. Reflects the status of key habitats, or acts as an early warning indicator to the action of an anticipated stressor	White tailed deer (*Odocoileus virginianus*): These populations signify the availability of forest-grassland margins
Keystone species	Have much greater effects on one or more ecological processes than would be predicted from their abundance or biomass alone	Red cockaded woodpecker (*Picoides borealis*): Creates cavities in living trees that provide shelter for 23 other species
Ecological engineers	Alter the habitat to their own needs and by doing so affect the fates and opportunities of other species	Beaver (*Castor canadensis*): Builds dams which create wetlands
Umbrella species	Have either large area requirements or use multiple habitats that encompass the habitats of many other species	Northern spotted owl (*Strix occidentalis caurina*): Occupy old growth forest in the Pacific Northwest
Link species	Play critical roles in the transfer of matter and energy across trophic levels or provide a critical link for energy transfer within complex food webs	Prairie dogs (*Cynomys spp.*): In grassland ecosystems, convert primary plant productivity in to animal biomass. The biomass of the prairie dog biomass, in turn, supports a diverse predator community
Special interest species	Include threatened and endangered species, game species, charismatic species, and those that are vulnerable due to their rarity.	

Consistent organization and hierarchy relating to indicator species and related terms in the table above is lacking across disciplines, though in general, the usage of species as indicators remains high in ecology-based fields.[101]

Developing a suite of indicator species can help to more accurately assess changing environmental conditions.[102] Indicator species may be limited to a smaller geographic scale, and developing community and ecosystem level indicators to complement indicator species approaches can be useful for understanding long term, cumulative environmental impacts.[103]

Broadening the Scope of Ecological Indicators: Assessing Social and Human Influence

There are a variety of quantitative ecological indicators that can be used for understanding ecosystem health, however, a more accurate depiction of ecosystem health can would incorporate qualitative, socio-economic and community-focused values.[104] According to Patil et al. (2002), "[i]mproved understanding of the relationships that exist between ecosystems and socioeconomic systems across time and space is essential to the design of economic, environmental, and natural resource policies that aspire to achieve sustainable outcomes with high levels of ecosystem health and quality of human life" (p.4). Thus, the most effective indicators of ecosystem heath "should systematically integrate indicators of the quality of human life and the functioning and structure of socioeconomic systems."[105]

Ecosystem health can also be judged by its resilience potential, or its ability to bounce back after a period of stress. Stress can be beneficial or even necessary for the health of perturbation-dependent ecosystems, such as forests that depend on fire for regeneration of nutrients.[106] However, stress fatigue can occur when ecosystems are repeatedly exposed to stress they have not evolved to handle.[107] While ecological indicators can be applied in the context of both natural and anthropogenic (human-caused) stresses, the primary aim of an ecological indicator is to measure the response of an ecosystem to human-based stresses, without necessarily identifying the stresses that caused the issue.[108]

Anthropogenic-induced stress factors, unlike natural stresses, are debilitating agents that differ from natural perturbation. Anthropogenic stresses can be classified into four main groups: physical restructuring (e.g., from land use changes); the introduction of exotic species; discharges of toxic substances to land, air, and water; and overharvesting.[109] Ecosystems may be unable to adapt to these stresses, and degradation can lead to a decrease in biodiversity, reduced primary and secondary production, and decreased resilience.[110]

Extreme events can also serve as stressors, particularly when they are combined with anthropogenic influences. For example, storm events can lead to increased runoff, which can increase nutrient loading from agricultural or urban sources.[111] In the context of human-induced climate change, a higher prevalence of extreme and variable climatic conditions will continue to have impacts on ecosystem health.

Indicators in Relation to Ecosystem Services

Indicators of ecosystem health can also be applied to measure the services that ecosystems provide. These services are often linked to specific ecosystems or land cover types. Using the ecosystem services categories provided by frameworks such as the Millennium Ecosystem Assessment (2005) or The Economics of Ecosystems and Biodiversity (2010) model, indicators can be chosen that identify the capacity of an ecosystem to provide a specific service.[112] This approach can also ascribe values to various land cover categories within Geographic Information Systems (GIS).[113]

We speculate on the connections between indicators of ecosystem health, ecosystem services, ecosystem valuation, and ecosystem type in **Table 1,** which includes the indicators chosen for Still Creek—open/closed stream and grey/green buffer. Ecosystem services and valuation methods are explained in more detail in **Appendix B**.

Indicators of Ecosystem Health Relevant to Urban Riparian Ecosystems

Stressors in urban riparian ecosystems can be physical, biological, or chemical, and they can also indicate urban stream syndrome—which occurs when catchment urbanization causes ecological degradation. Stressors or indicators of health degradation in urban creeks can include hydrological alteration (e.g., the addition of paved surfaces); altered geomorphology (e.g., through increased erosion or channel enlargement); piping and filling channels (e.g., through stream burial); increased temperature and light, increased toxicants, dissolved oxygen, increased ionic concentrations (e.g., through salt in storm runoff), increased available nutrients (e.g., through nitrogen or phosphorous released from fertilizers or other sources); altered terrestrial inputs (e.g., amounts of leaves or wood); and increased barriers to movement (e.g., due to manmade obstructions).[114]

Additional indicators used to assess the health of urban streams can include nutrient uptake, benthic microbial respiration, nitrification, fine particulate organic matter export, invertebrate production, and fish production.[115] Benthic invertebrates are useful indicators of stream condition, since they are key components of the aquatic foodweb, are sensitive to a variety of human stresses, have a long lifespan, and are not migratory or artificially stocked.[116] Rate of leaf litter decomposition and ecosystem metabolism can also be useful indicators, since riparian ecosystems benefit from land-based organic material, as well as algal material.[117]

Summary: Indicators of Ecosystem Health in the Context of Still Creek

Ecosystem health can be defined in a variety of ways, and its measurement is important for understanding the health of the ecosystem itself, but also the ramifications for human health—the two are inextricably linked, and affect the other. This symbiotic relationship is applicable in Still Creek, where the ecosystem has been affected by land use, development, pollution, and other human-related causes, yet a healthy creek system has the potential to benefit regional wildlife and the health of nearby community dwellers.

Using a prospective approach, indicators of ecosystem health can be measured over time to assess the rate of decline. Environmental indicators tend to be more broad and applicable across disciplines, whereas ecological indicators are rooted in biological sciences, often referring to the structure, composition and function of an ecosystem. When measuring using indicators, scale is an important factor, particularly at the landscape level. Indicator selection must match the scale of the environment, and should also be selected for the management purpose or goal.

For our case study of Still Creek, we selected indicators that were applicable and measurable at the broader landscape level, particularly since our interest is at the transboundary or regional scale. There are several rationales for selecting indicators of ecosystem health. From the list of rationales presented on pages 30–31, our aim was to understand historical and current conditions and trends, to anticipate hazardous conditions, to identify causative of change, and to identify correlations between indicators. From the list of criteria presented on page 31, we elected to choose indicators that were measurable and repeatable, comparable across time and space, connected to management and societal values, that maximized information and minimized redundancy, that were applicable to several stressors, and understandable by our target audience. Species can be used as indicators, but should not be solely relied upon to assess ecosystem health. While we did not measure the presence of salmon explicitly as an indicator of ecosystem health, we acknowledge the salmon return to Still Creek informally as an indicator of positive change.

Indicators of ecosystem health can be improved from the incorporation of social and human factors, particularly in the context of climate change. Indicators can be used to assess the effectiveness of ecosystem services for different ecosystem types. In our case study, we speculated on the ability of a healthy creek ecosystem to provide a myriad of ecosystem services. A literature review of ecosystem services and valuation techniques can be found in **Appendix B**.

Urban riparian ecosystems are often assessed using indicators such as urban stream syndrome, hydrological alteration, stream burial, temperature and light trends, nutrient trends, ionic concentrations, terrestrial inputs, urban development/barriers, benthic/invertebrate health, fish production, ecosystem metabolism, runoff, and flooding. As a proxy for several of these stressors, we selected open/closed stream and grey/green buffer as our measurable indicators (See **Table 1**).

ENDNOTES

64 Costanza, 1992

65 Schaeffer, Herricks, and Kerster, 1988

66 Patil, Brooks, Myers, Rapport, and Taillie, 2002, p.7

67 Burkhard, Kroll, Nedkov, and Muller, 2012

68 Rapport, Costanza, and McMichael, 1998

69 Rapport et al. 1998, p. 399

70 Rapport, 1989

71 Schaeffer, et al., 1988

72 Schaeffer et al., 1988

73 Schaeffer et al., 1988

74 Schaeffer et al., 1988

75 Niemi and McDonald, 2004

76 Niemi and McDonald, 2004

77 Patil et al., 2002, p. 6

78 Niemi and McDonald, 2004

79 Burrell and Siebert, 1916, as cited in Niemi and McDonald, 2004; Rapport, 1992

80 Niemi and McDonald, 2004

81 Hunsaker and Carpenter, 1990, as cited in Cairns et al., 1993, p.2

82 Niemi and McDonald, 2004

83 Niemi and McDonald, 2004

84 Niemi and McDonald, 2004

85 Niemi and McDonald, 2004, p.91

86 Dale and Beyeler, 2001; Rapport, 1989

87 Dale and Beyeler, 2001, p.5

88 Noon, Spies, and Raphael, 1999

89 Cairns et al., 1993, Niemi and McDonald, 2004

90 Niemi and McDonald, 2004

91 Dale and Beyeler, 2001, p. 4

92 Cairns et al., 1993

93 Cairns et al., 1993

94 Cairns et al, 1993; Dale and Beyeler, 2001; Niemeijer and de Groot, 2008; Schaeffer et al., 1998

95 Niemi and McDonald, 2004

96 Dale and Beyeler, 2001

97 Dale and Beyeler, 2001

98 Noss, 1990

99 Niemi and McDonald, 2004, p. 95–96

100 Modified from Dale and Beyeler, 2001, p.8

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102 Cairns et al., 1993; Schaeffer et al., 1988

103 Cairns et al., 1993

104 Patil et al., 2002; Rapport, 1999

105 Patil et al., 2002, p. 4

106 Rapport, 1989

107 Rapport, 1989

108 Niemi and McDonald, 2004

109 Rapport and Whitford, 1999

110 Rapport and Whitford, 1999

111 Rapport and Whitford, 1999

112 Burkhard et al., 2012, p. 20

113 Burkhard et al., 2012, p. 22

114 Wenger et al., 2009

115 New Zealand Ministry for the Environment, 2004

116 Morley and Karr, 2002; Salas et al., 2006

117 New Zealand Ministry for the Environment, 2004

APPENDIX B: ECOSYSTEM SERVICES AND VALUATION LITERATURE REVIEW

Definition of Ecosystem Goods and Services, Natural Capital

Natural capital consists of assets related to geology, soil, air, water, and living systems. From this capital, we draw a variety of ecosystem goods (such as timber or other marketable products) and services (such as the filtering of air and water).[118] These goods and services and the natural capital stocks that produce them are required to maintain the essential functions of life on earth, and they contribute to human welfare in both direct and indirect ways.[119]

These life-supporting systems and services could include marine or terrestrial food producing systems, wetlands that regulate water quality and levels, the buffering of natural disasters by coastal foreshores, or the filtration of air by forested regions. Large scale environmental changes such as climate change and biodiversity loss reduce the life-supporting capacity of the biosphere, expanding the geographical range of infectious disease, and threatening the productivity of agro-ecosystems.[120] Expert hypotheses on natural capital can be used effectively as a practical guide, and "even imperfect measures of their [ecosystem services] value, if understood as such, are better than simply ignoring ecosystem services altogether, as is generally done in decision making today."[121]

The International History of Natural Capital and Ecosystem Goods and Services

The Convention on Biological Diversity (CBD, 1992) adopted the 'Ecosystem Approach', which it describes as "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way."[122] The CBD also "cemented a view of 'nature' as a site for 'biological diversity', an idea that had been gathering momentum since the 1970s."[123]

The introduction of carbon trading also helped to bolster the movement that considered natural systems and processes in economic terms, including the Kyoto Protocol (which facilitated carbon markets for trading units of greenhouse gas equivalents).[124]

In 1999, a series of international committees passed a resolution calling for the creation of a Millennium Ecosystem Assessment (MA).[125] The MA focuses on ecosystem services and human well-being, and it contributed to a rapid policy shift from the ecosystem approach to the ecosystem services approach.[126] The MA was founded on the basis that in the past 50 years, humans have significantly altered Earth's ecosystem services through degradation of freshwater, air and water purification, as well as climate regulation.[127] The MA is considered a "critical landmark that firmly placed the ecosystem services concept in the policy agenda."[128] It describes four types of ecosystem services: Provisioning, regulating, cultural, and supporting. The following image depicts examples of the ecosystem services as outlined by the MA typology:

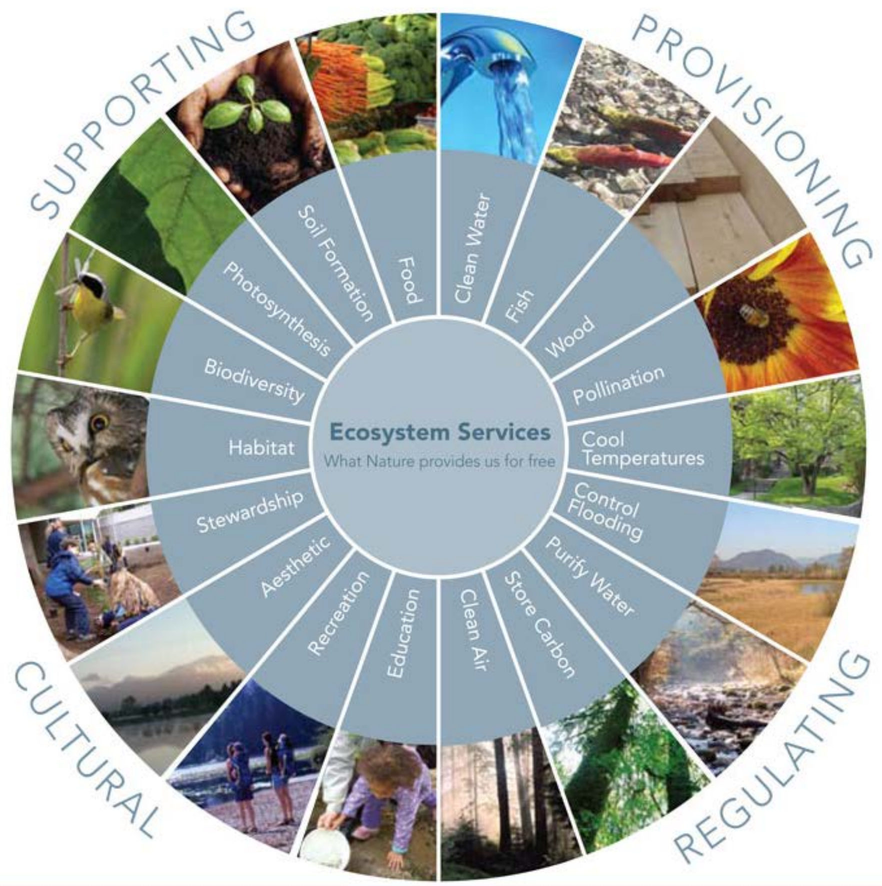


Figure 4: MA Ecosystem Services[129]

The Economics of Ecosystems and Biodiversity (TEEB) is an international initiative put forward by the G8+5 nations, the United Nations Environment Programme, and the European Union that recognizes the value of ecosystem goods and services (EGS) and aims to incorporate those values into public and/or private policy.[130] The TEEB approach picked up momentum from carbon pricing and the MA policy agenda, with a report that argued for the adequate reflection of the economic value of nature, and the effort to make nature visible to financial markets and policy makers.[131] This led to "a proliferation of initiatives by governments, UN agencies and finance and extractive industries all based on the assumption that if biodiversity was ascribed economic value, protection would follow suit."[132] Under this approach, EGS consist of the following groups: **Provisional** (refers to material or energy outputs such as food or fresh water), **regulatory** (services from ecosystems such as flood control or air quality), **habitat/supporting** (including habitat for species and the maintenance of genetic diversity), and **cultural** (which can derive value from tourism, spiritual beliefs, etc.).[133] The TEEB model replaced supporting services in the MA model with habitat services to avoid "double counting" of ecosystem services and benefits.[134] Despite this wariness of double counting, biodiversity often underpins several essential ecosystem services. For example, the biodiversity level of soil will help determine the production of a good, such as food.[135]

Provisioning services	Regulating services	Habitat services	Cultural services
Food Water Raw materials Genetic resources Medicinal resources Ornamental resources	Air quality regulation; climate regulation; moderation of extreme events Regulation of water flows Waste treatment Erosion prevention Maintenance of soil fertility Pollination Biological control	Maintenance of life cycles of migratory species Maintenance of genetic diversity	Aesthetic information Opportunities for recreation and tourism Inspiration for culture, art, and design Spiritual experience Information for cognitive development

Figure 5: TEEB Ecosystem Services Typology[136]

The 2012 Rio+20 summit also helped contribute momentum towards natural capital accounting through programs such as the World Bank Wealth Accounting and the Valuation of Ecosystem Services (WAVES) partnership and their corresponding natural capital accounting programs.[137] Thirty-two private banks have also launched a Natural Capital Declaration, with support from several national governments. The declaration represents a financial sector commitment to work towards integrating natural capital considerations into financial products and services.[138]

Follow up initiatives from the MA (2005) and International Mechanism of Scientific Expertise on Biodiversity (IMoSEB) eventually led to the creation of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, 2012/2014), which was formed to strengthen the links between science and policy related to biodiversity and ecosystem services.[139]

Ecosystem Services and Benefits in Practice

The valuation of ecosystem goods and services can also be applied in governmental, development, planning, and housing sectors to inform the location and type of urban development and alter taxpayer behaviour. For example, a municipality can raise taxes or implement fees and charges (to discourage environmental degradation), subsidize positive environmental action through grants, rebates, and financing (to encourage actions that have positive environmental effects), and incur development incentives (which promote environmental services from structures such as green roofs).[140]

On existing public or government-owned lands, an eco-asset/natural asset management strategy can be initiated by a municipality to identify existing natural capital, and the services gained from that capital. A municipality can make this information operational by including it within asset management practices.[141] Through natural asset management, the value of natural capital from green space, forests, soil, aquifers, foreshores, and creeks can be calculated or approximated in the same manner as traditional engineered assets, such as wastewater/stormwater treatment facilities. The town of Gibsons, BC has pioneered this strategy in practice by assessing ecosystems and the services they provide related to drinking water, stormwater management, and flood protection.[142]

The Formal Valuation of Ecosystems

Some environmental problems stem from market failures because EGS are not fully captured in markets or adequately quantified, and are often given little weight in policy decisions.[143] Valuing ecosystems in monetary terms attempts to capture some of the economic value of ecosystems lost in this cycle, and reduce the negative externalities of the business-as-usual approach. Market-based instruments can be useful for estimating the costs and benefits of specific projects; evaluating environmental damage claims; assessing the costs and benefits of policies on the environment; estimating the demand for environmental goods & services; estimating damage and abatement costs; and estimating social benefits and costs.[144]

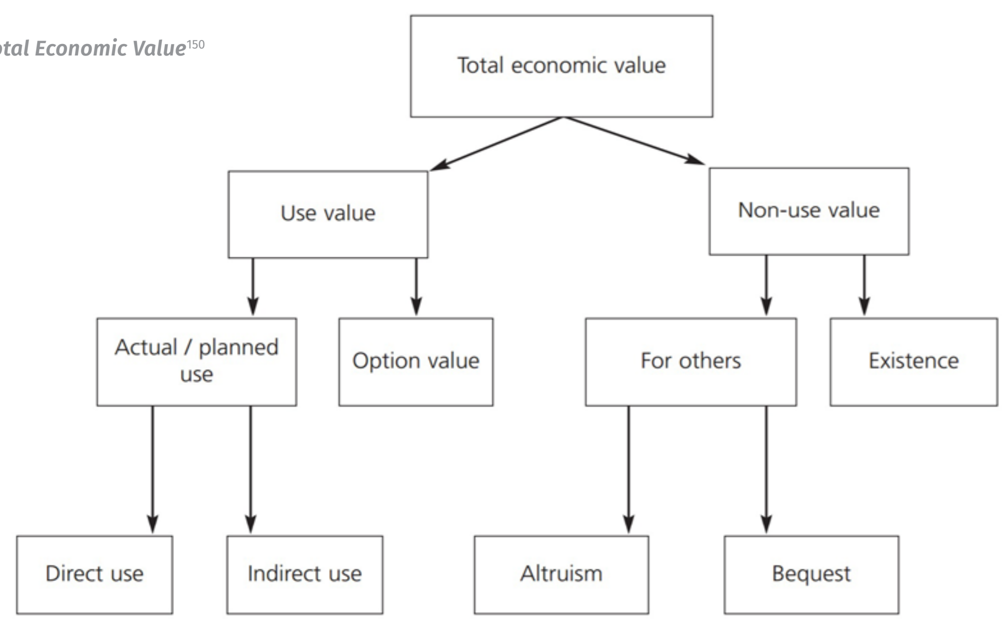
An economic value is often directly attributed to humans and their well-being, and this value helps identify tradeoffs of scarce or competing resources.[145] In terms of EGS, economic value can be categorized by either **use** or **non-use** values. Use values tend to be related to market values; non-market values are typically non-use values.

A use value can be categorized in one of four ways. An **actual use value** is the value obtained from the current use of the environment; an **option use value** is the value from having the ability to use the environment in the future; and a **direct use value** relates to the value from consumption of EGS based on current market processes, such as the market value of timber.[146] **Indirect use value** refers to the value from consumption of EGS with poorly defined market value, such as the value people ascribe to forests based on their being able to walk through them and enjoy their natural surroundings.[147]

A non-use value can be characterized in several different ways: **Existence value** is that which we ascribe to the environment based on knowing it exists, even if we never use it; **bequest value** is the value obtained by having the opportunity for future generations to gain value from EGS; and **altruism values** are values assigned to an ecosystem for use by others in the current generation.[148] Non-use values are difficult to measure and identify separately. For example, while it is well established within the literature that access to ecosystem services can reduce mortality and contribute to reductions in morbidity (including physical and mental health), a research gap exists in linking the value of ecosystem services to these benefits with statistical evidence.[149]

Total economic value can be obtained by adding use values together with non-use values. The following diagram depicts this process, in addition to the categorization of use and non-use values described above:

Figure 6: Total Economic Value[150]



Valuation Methods

When we cannot observe how consumers behave, conclusions can be drawn by asking how they would behave in a hypothetical market, using what is known as "stated preference methods."[151] Examples include contingent valuation (willingness to pay to preserve environmental services/willingness to accept funds for environmental degradation), and choice modelling (which ranks preferences of choices or attributes that people value for a certain environmental system).

Another approach known as "revealed preference methods" estimates original values by examining existing behaviour, and assessing the consumption of related market-priced private goods.[152] This approach includes a variety of methods, such as "hedonic pricing", which describes the contribution of an environmental asset to property price, and the "travel cost method", which examines how much people might be willing to pay to experience nature or environmental services.[153]

Value/benefit transfer models assess the environmental benefits from a site, and applies them to a different location. For example, "unit transfer" takes the value of a similar environmental site and uses that value as an estimate for an alternative site, and "function transfer" uses a similar method to determine willingness to pay values.[154,155]

To see how these valuation methods apply to the organizational system shown in Figure 6, refer to Figure 7 below:

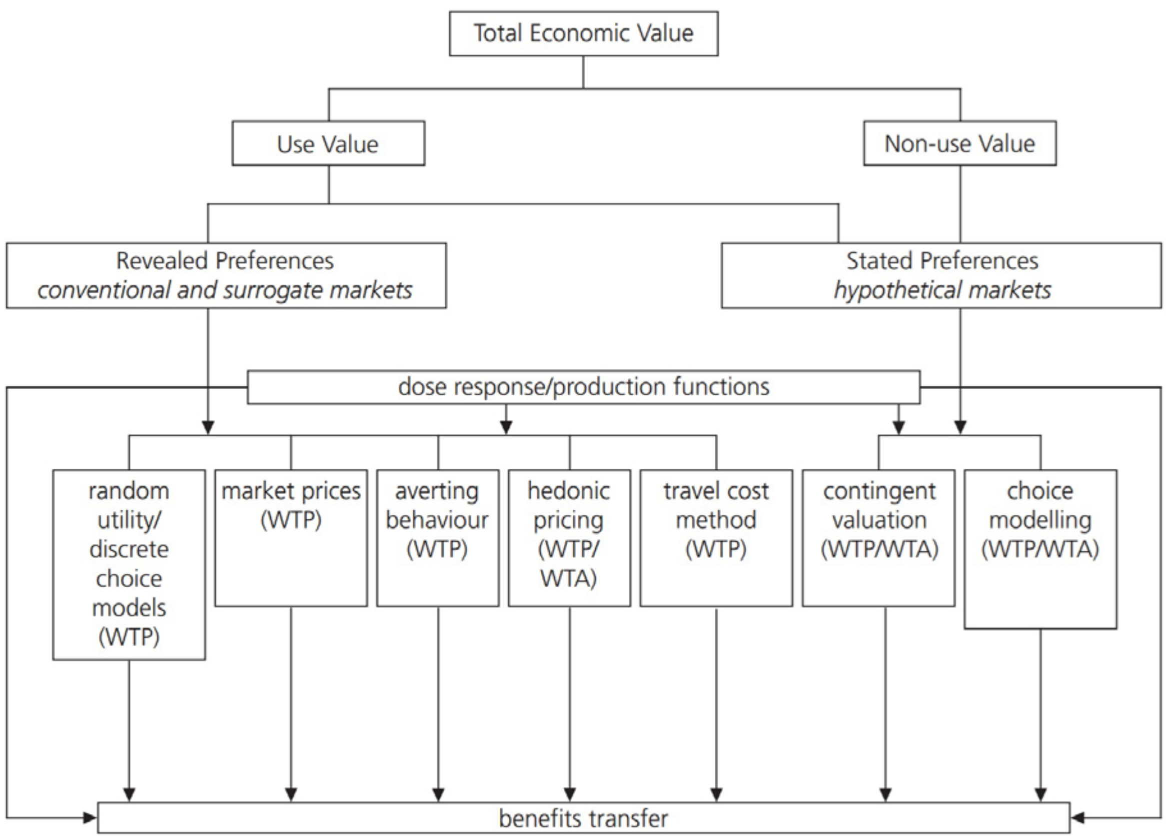


Figure 7: Total Economic Value with Valuation Methods[156]

Additional environmental valuation methodologies include "factor income" (services provided that provide or enhance incomes), and "avoided cost methodologies" (values based on avoided costs from lost or damaged ecosystems).[157]

Case Study: Ecosystem Valuation in BC's Lower Mainland

The David Suzuki Foundation undertook a case study in 2010 that used a variety of approaches for valuing ecosystem goods and services in BC's Lower Mainland. The study used the TEEB framework to categorize various ecosystem services, while primarily utilizing benefit transfer, avoided cost, travel cost, and replacement cost valuation methods. The study found that the most valuable ecosystem services in the Lower Mainland were climate regulation via carbon storage (in various land cover types, estimated at $1.7 billion per year), water supply due to filtration services (estimated at $1.6 billion per year), and food protection and water regulation from forest and other types of land cover (estimated $1.2 billion per year).[158] Most of these services would be classified as provisional and regulating services within the TEEB model. Additional benefits were accounted for from clean air, waste treatment, pollination, salmon habitat, recreation, and local food production services. Ecosystem type was connected to the associated ecosystem services and potential benefits for humans (Figure 8), and the valuation type was then ascribed to these benefits (Figure 9):

Figure 8: Services and Benefits by Ecosystem Type[159]

Ecosystem	Ecosystem services (Typology of ES from TEEB)	Potential benefits for human well-being
Wetlands	Storage of fresh water Regulation of water flows Waste treatment Carbon storage Cultural services	Food provision Climate regulation Flood control Waste processing Water supply Amenity/tourism/recreation Cultural/heritage conservation
Lakes and rivers	Waste treatment Maintenance of life cycles of migratory species Maintenance of genetic diversity Cultural services	Food provision Water supply Drainage and natural irrigation Transportation Erosion prevention Biological and genetic diversity Amenity/tourism/recreation Cultural/heritage conservation
Forests	Habitat services Pollination Air quality regulation Carbon storage Water filtration Erosion prevention Soil fertility Biological control Cultural services	Good air quality Water supply Climate regulation Pest control Biological and genetic diversity, Amenity/tourism/recreation Cultural/heritage conservation
Grassland and shrubland	Habitat services Pollination Air quality regulation Carbon storage Regulation of water flows Erosion prevention Soil fertility	Climate regulation Flood control Erosion control Air quality Biological and genetic diversity Amenity/tourism/recreation Cultural/heritage conservation
Well-managed cultivated areas	Pollination Carbon storage Erosion prevention Soil fertility	Provision of food Pollination of crops Amenity and recreation Cultural/heritage conservation

Benefits	Valuation method
Climate regulation	Avoided damages cost based on the value of the avoided costs of carbon emitted to the atmosphere. Forest age class was used to determine carbon storage for forests.
Clean air	Pollution removal rate for trees was based on research by USDA Forest Service based on average air pollution removal capacity for Seattle, Washington. Valuation is based on avoided costs.
Coastal protection	No valuation was undertaken
Flood protection/ water regulation	Replacement value costs for runoff control
Waste treatment	Replacement cost based on waste treatment plants in Metro Vancouver region. Based on original analysis of the wetland capacity to absorb excess nitrogen and phosphorus.
Water supply	Replacement costs of 10 per cent of current condition of the study area's forest cover in watersheds.
Pollination	Production function value: value and proportion of crops that depend on pollination in Lower Mainland.
Salmon habitat	Production function value: value of integral watershed/ forest cover for Coho salmon fishery
Recreation/tourism	Value of nature-based recreation and consumer surplus
	Travel cost (farm-based recreation)
Local food production	Travel cost

Figure 9: Valuation Methods Chosen by Benefit Type[160]

Limitations to Ecosystem Valuation

There are several limitations to ecosystem valuation methods that should be taken into consideration. Revealed preference valuations can be selective and subjective. For example, people may be willing to protect ecologically redundant species, and unwilling to protect critical ecosystems. Limitations such as this, among other biases and model conflicts, exist in willingness to pay and other contingent valuation approaches.[161] Economics pertain to human welfare, and each individual's assessment of their own well-being is unique—thus an absolute measure of a person's value for something is unachievable. This indicates the limitations to a variety of stated preference valuation methods.

It can be difficult to calculate value for services that are unique and have inherent value, and it is also difficult to analyze a full set of services, therefore it is common to focus on easily measurable ones (such as carbon fixation). A potential danger exists in compartmentalizing ecosystem services when they are inherently connected.[162] There also needs to be a clear distinction between price versus value. Caution should be taken when applying a monetary value to ecosystems, since comparisons emerge when there is a common value, and some ecosystem services can become incorrectly valued as higher than others.[163] Caution should also be taken when multiplying a physical quantity by unit value across different scales, such as through benefit transfer valuations.[164]

It is important to frame the scope of ecosystem valuation to avoid these criticisms. Bockstael et al. (2000) note that "correctly interpreting what economic value measures does not require exclusive reliance on the results from such calculations",[165] indicating that ecosystem valuation can be an effective tool to aid policy decisions and assess tradeoffs, but should not be depended on exclusively.

Riparian Ecosystem Services That Could Be Ascribed Value

Riparian corridors are used by approximately 70 percent of vertebrates during their life cycle, and they are important landscapes for supporting regional biodiversity.[166] Riparian vegetation is critical for downstream water quality, and riparian corridors play a significant role in maintaining water quality for fish such as salmon.[167] Temperature is critical to fish migration and survival, and the shading of streams by riparian vegetation reduces maximum temperatures—supporting fish, amphibians, and invertebrates.[168] Additional habitat services including primary productivity, preservation of soil, and nutrient cycling are particularly relevant in riparian corridors. Provisioning services such as food, raw materials, freshwater, medicinal resources, and ornamental plants are often enjoyed in riparian zones.[169] Regulating services such as carbon sequestration and storage, moderation of extreme weather events, pollution mitigation (air and water), pollination services, flood protection, erosion prevention, and disease and pest regulation are also valued in riparian corridors.[170] Cultural services such as sense of identity, mental and physical well-being, recreation, and aesthetic/spiritual/religious appreciation tend to be applicable in riparian corridors as well.[171] The benefits these ecosystem services provide are critical for maintaining resilience to climate change impacts.

Summary: Ecosystem Services and Valuation in the Context of Still Creek

Natural capital consists of assets related to geology, soil, air, water, and living systems. From this capital, we draw a variety of ecosystem goods and services. Momentum towards the valuation of these goods and services stemmed from the international level, most notably by the Millennium Ecosystem Assessment (MA) in 2005 and The Economics of Ecosystems and Biodiversity (TEEB) initiative put forward in 2010. Using the TEEB model, services can be categorized as provisioning, regulating, habitat/supporting, and cultural. Still Creek provides all four service category types.

As a part of British Columbia's Lower Mainland and a functional spawning corridor for fish, Still Creek provides several **provisioning benefits**, including food, water, and plants. **Regulation services** in the creek corridor could include air and water quality, climate regulation, flood retention benefits, etc. As a link to the Fraser River, Still Creek also provides significant **habitat value** to several types of wildlife, and the creek corridor has significant **cultural and spiritual value**. The applicable ecosystem services (and connections to valuation methods and indicators of ecosystem health) for our case study are identified in **Table 1**.

In professional practice, these types of values can be acknowledged and leveraged to spur the protection and restoration of ecosystems. A promising example is the concept of natural asset management, as pioneered by the municipality of Gibson's, BC. Formal evaluation of ecosystems can be categorized by use and non-use values into further subcategories. There are several methodologies for calculating the use and non-use values of ecosystems, as identified in **Figure 7**.

While we did not formally value the ecosystem goods and services provided by Still Creek in economic terms, exploring alternative valuation methods can challenge the current paradigm which undervalues the presence of nature in cities. Recognition of the diverse benefits ecosystems provide is a useful exercise to encourage ecosystem awareness, protection and restoration in the private and public realms.

ENDNOTES

118 World Forum on Natural Capital, 2015
119 Rapport, Costanza, and McMichael, 1998
120 Rapport, Costanza, and McMichael, 1998
121 Daily, 1997, p. 8
122 CBD, 2000
123 Kill, 2014, p.9
124 Kill, 2014
125 Kill, 2014
126 David Suzuki Foundation, 2010; Atkinson, Bateman, and Mourato, 2012
127 David Suzuki Foundation, 2010
128 Kill, 2014, p.9
129 MA, 2005
130 ACT, 2015; TEEB, 2010
131 Kill, 2014
132 Kill, 2014, p. 10
133 ACT, 2015; Atkinson et al., 2012; TEEB, 2010
134 David Suzuki Foundation, 2010; TEEB, 2010
135 Atkinson et al., 2012
136 David Suzuki Foundation, 2010, p.26
137 World Bank, 2015
138 UNEP, 2012
139 Kill, 2014
140 For a comprehensive analysis of these practices, see Metcalf Foundation, 2016, p 24–25.
141 Metcalf Foundation, 2016
142 Town of Gibsons, 2015
143 Rapport, 1989
144 Rapport, 1989
145 ACT, 2015
146 DEFRA, 2007
147 ACT, 2015; DEFRA, 2007
148 DEFRA, 2007
149 Atkinson et al., 2012
150 DEFRA, 2007, p.32
151 Atkinson et al., 2012
152 Atkinson et al., 2012
153 DEFRA, 2007
154 Mooney and Brown, 2013
155 For a full analysis of these valuation methods, see Mooney and Brown, 2013, p. 244.
156 DEFRA, 2007, p.34
157 ACT, 2015
158 David Suzuki Foundation, 2010
159 David Suzuki Foundation, 2010, p.27
160 David Suzuki Foundation, 2010, p. 29
161 Diamond and Housman, 1994; Hanemann, 1994; Portney, 1994
162 Kill, 2014
163 Kill, 2014
164 Bockstael et al., 2000
165 Bockstael et al., 2000, p.1389
166 Naiman et al., 1993; Olson et al., 2007
167 Parkyn et al., 2003
168 Bowler et al, 2012
169 Mooney and Brown, 2013
170 Mooney and Brown, 2013
171 Mooney and Brown, 2013

APPENDIX C: **BOUNDARY BAY— CASE STUDY CONSIDERATION**

The coastal areas of Boundary Bay were considered as a possible case study to explore ecosystem management across municipal boundaries, using the combined approach of mapped indicators and historical policy analysis as for the Still Creek study.

After investigation it was determined that Boundary Bay would not be a suitable case study, for the following reasons, listed here and described further below:

- Boundary Bay is entirely diked, and to date local governments in the region have been constrained in policy and management options for coastal areas by existing dikes as well as historical patterns of land use on adjacent lands since European settlement.
- Jurisdiction over shoreline areas is exercised by four levels of government—federal, First Nations, provincial and municipal—and while municipal regulation, policy and planning related to land use and infrastructure in nearshore and upland areas can have a significant impact on coastal ecosystems, it was not possible to isolate the effects of municipal regulation and policy from those of policy and decision makers at other levels of government. Furthermore the southern part of Boundary Bay is crossed by the international border with the United States.
- Existing data on ecosystem health is scattered and has been collected sporadically; in some cases data collection and management is being carried out primarily by non-governmental organizations.

Diking in Boundary Bay

After European settlement the entire coastline of Boundary Bay, as well as the lower extents of the Serpentine and Nicomekl Rivers, was diked (including an area along the eastern side where the railbed of the BNSF railway creates a *de facto* dike) to enable farming and commercial and residential development in the low lying areas adjacent to the shoreline. On the eastern side of the Bay, the armouring of the railbed effectively cut off the supply of sediment from feeder bluffs at Ocean Park to the beaches at White Rock and Crescent Beach, and to Blackie Spit.[172]

At present landward uses around the Bay include pockets of intensive residential development, Boundary Bay Regional Park, agricultural land, Boundary Bay airport, and the reserve lands of Semiahmoo First Nation. Currently the main human activity along the foreshore seaward of the dikes is recreational use, and much of this area is zoned as park land. Some ecological restoration activities have been undertaken in localized areas.[173]

Fragmented Legal Jurisdiction Over Shoreline Areas

Jurisdiction over coastal areas in Boundary Bay is exercised by four levels of government—federal, First Nations, provincial and local, with no formal (and little informal) integration.

Prior to European settlement, First Nations already inhabited coastal areas in BC, including Boundary Bay for many millennia, sustainably managing coastal and marine resources. For the purpose of this study we do not have access to information about Indigenous laws and practices specific to Boundary Bay, but examples from elsewhere in coastal BC where Indigenous laws and planning have been expressed in a contemporary context demonstrate a strong focus on environmental stewardship and an integrated perspective on coastal and marine ecosystems.[174] At present, First Nations may exercise jurisdiction through their own Indigenous laws, and also through Canadian law, as title and rights are recognized in s.35 of the Canadian Constitution.

Federal, provincial and local laws that have been adopted and modified over the period since colonization reflect a highly fragmented approach to management and policymaking in Boundary Bay and upland areas, for the most part without specific focus on coastal areas and ecosystems.

The foreshore (area between high and low water marks) in Boundary Bay is almost entirely provincial Crown land, and except for the dikes that border the foreshore and the pier at White Rock there has been little development in this area. The land under the waters of Boundary Bay was designated a UREP (Use, recreation and enjoyment of the public) reserve by the Province under the *Land Act* in 1958 and parts of the foreshore are also reserved for recreation.[175] In 2003, the entire area of Boundary Bay, seaward of the dikes and north of the international border, was further designated a Wildlife Management Area under the *Wildlife Act.* The Minister of Forests, Lands and Natural Resource Operations (FLNRO) is the lead provincial authority.[176] Individuals or organizations that wish to carry out activities in the foreshore areas must apply for a license or tenure, which is decided based on policies developed for specific activities, taking into account the WMA designation as well as other applicable Crown land policies.[177] As well, a 1977 Order-in-Council requires that environmental impact assessments are mandatory for all proposed developments along the shoreline in Boundary Bay.[178] However, there has been no integrated coastal environmental policy developed for Boundary Bay by the provincial government.[179]

The federal government exercises authority through the *Fisheries Act*, including the regulation of activities along the shoreline that may have a harmful impact on fish habitat. Federal jurisdiction may also be exercised through the *Navigation Protection Act* and the *Migratory Birds Convention Act*, as well as other federal statutes. The Vancouver Fraser Port Authority has also undertaken a restoration project along the shoreline in Boundary Bay, not without controversy.[180]

Metro Vancouver manages Boundary Bay Regional Park, which extends to the dikes from the landward side of the dikes along the extent of Boundary from Mud Bay in the east to Centennial Park on the western side. The areas adjacent to the shoreline are zoned for recreational use, although there are significant upland areas where public access is restricted. Metro Vancouver is also responsible for managing water quality in Boundary Bay as it relates to sewage and runoff from the land, and monitoring is coordinated with local governments.[181] However, water quality issues that led to the closure of oyster harvesting in 1962, and in particular a high fecal coliform count that is most likely attributed to agriculture operations on upland areas, have never been resolved, despite acknowledgment of the problem by provincial officials.[182]

Local governments can zone land out to the municipal boundary (which usually extends offshore), they can also designate shoreline development permit areas (DPAs) requiring nearshore buffers to protect foreshore land, and they can develop Official Community Plans and other policy tools such as Biodiversity Strategies to guide upland and shoreline uses and activities. For example, Surrey has designated coastal areas in Boundary Bay as Sensitive Ecosystems—Green Infrastructure Development Permit Areas.[183] Local governments also manage flood protection infrastructure such as dikes, although the design and maintenance of dikes is subject to provincial regulation that does not presently accommodate environmental restoration.[184] Both Delta and Surrey are now undertaking diking upgrades to respond to climate change and sea level rise, and it appears that this may be an opportunity to explore a more integrated approach to management of the coastal and marine parts of Boundary Bay.

For the purpose of this case study it was not possible to isolate the impacts of municipal policy and regulation on the coastal ecosystems of Boundary Bay from those of other levels of government.

Ecosystem Health Data

Despite having designated Boundary Bay a Wildlife Management Area, the province has not come forward with comprehensive environmental monitoring or management for the area. Most recently, inventories of forage fish habitat on the foreshore, and eelgrass offshore have been carried out by non-governmental organizations such as the Friends of Semiahmoo Bay.[185] The availability of historical data appears to be very limited.

ENDNOTES

172 Warren, 1978, p.11

173 For example, the City of Surrey has undertaken rehabilitation activities at Blackie Spit. See *Blackie Spit Park: Wildlife Enhancement Plan*, available online at: https://www.surrey.ca/files/lackieSpitParkWildlifeEnhancementPlan.pdf and Leean M. Graham (2010) *Savenye Environmentally Sensitive Area, Forage Fish Spawning Habitat Rehabilitation Project* for City of Surrey and Friends of Semiahmoo Bay Society. Available online at: http://urbanecology.ca/documents/Student%20Technical%20Series/Graham_ASER390.pdf

174 See, for example, outcomes from the Marine Planning Partnership (MaPP) on the north and central coast, and the *Assessment of the Trans Mountain Pipeline and Tanker Expansion Project* (2014) Treaty, Lands & Resources Department, Tsleil-Waututh Nation. Boundary Bay is within the traditional territories of Semiahmoo First Nation, and Tsawwassen First Nation.

175 Government of BC, Order-in-council 2185/58. 2630/53. (Crescent Beach) 1414/54 2114/59, 1460/38

176 Formerly the Minister of Environment was the lead authority under the *Wildlife Act*.

177 Government of British Columbia, Crown Land Policies, available online at: http://www2.gov.bc.ca/gov/content/industry/natural-resource-use/land-use/crown-land/crown-land-policies

178 Government of British Columbia, Strategic Policy, Crown Land Allocation Principles, available online at: http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/allocation_principles.pdf, and L-G of BC, Order-in-council 1977/908 under the *Environment and Land Use Act*.

179 A *Proposed Boundary Bay Wildlife Management Area Plan* was prepared for the BC Ministry of the Environment in 1993. This plan noted that upland planning and regulation by surrounding municipalities was directly relevant for management of Boundary Bay and proposed coordination.

180 Pynn, 2013

181 Metro Vancouver, 2010

182 Swain and Elder, 1981

183 City of Surrey, 2017

184 British Columbia Ministry of Environment, Lands and Parks and Department of Fisheries and Oceans Canada, 1999

185 See Ramona C. De Graaf, *Boundary Bay Intertidal Forage Fish Spawning Habitat Project, Summary of the Project and Findings July 2006—October 2007*, prepared for the Friends of Semiahmoo Bay Society, available online at: http://www.birdsonthebay.ca/reports/ff_final_report.pdf For activities related to eelgrass, see http://www.birdsonthebay.ca/eelgrass.html

APPENDIX D: **NORTH SHORE FOREST ECOSYSTEMS—CASE STUDY CONSIDERATION**

The forest ecosystems that span the North Shore of Burrard Inlet within four local government jurisdictions (District of West Vancouver, District of North Vancouver, Metro Vancouver and City of North Vancouver) were considered as a possible case study to explore ecosystem management across municipal boundaries, using the same combined approach of mapped indicators and historical policy analysis as for the Still Creek study.[186]

After investigation it was determined that the forest ecosystems of the North Shore would not be a suitable case study, for the following reasons, listed here and described further below:

- The largest intact areas of forest are within the protected watershed areas under the jurisdiction of Metro Vancouver. Activities within these areas are strictly restricted because these lands supply drinking water to a number of Metro Vancouver municipalities. Metro Vancouver also administers several large park and protected areas where recreation is allowed. It didn't appear helpful to compare the policies for these areas to other areas on the North Shore where land use is regulated for residential, commercial and industrial activities.
- Regarding urban trees, the policies in the three municipalities vary, but high level analysis of mapped data suggested that parcel size might correlate positively with more trees remaining on private property in the case of single family residential lots. It is possible that a more in-depth analysis would have been able to trace a more visible correlation between particular municipal policies and observable trees on private property generally, and the impacts of policies related to riparian buffers and municipal parks and other municipal land, but that was beyond the scope and resources of this report.
- Triggered by the Metro Vancouver Integrated Liquid Waste and Resource Management Plan, the City and District of North Vancouver are cooperating to develop an Integrated Stormwater Management Plan (ISMP) for the shared watersheds within their jurisdiction. The ISMP will focus on sustainable approaches that mimic the natural hydrologic cycle, reduce impermeable surfaces and protect and improve stream health. Maintaining and enhancing the urban tree canopy is a likely component. In future it would be interesting to monitor the impacts of the implementation of the ISMP.

Jurisdiction

More than 66,000 hectares of land is managed for drinking water supply by Metro Vancouver, including large areas on the North Shore that form the Capilano and Seymour watersheds (19,535 and 12,375 ha, respectively).[187] Metro Vancouver manages the land under a 999-year lease from the Province, granted in 1927. While much of the land is off limits to most human activities, lower areas of the watershed support non-motorized recreational uses on an extensive series of trails. By contrast, land within the North Shore municipalities is mainly zoned for uses (industrial, commercial and residential) that tend to significantly alter the natural forested landscape.

That said, somewhat below the public radar, given that there was no public access to the lands, Metro Vancouver amended its agreement with the Province and allowed logging of the lands from 1967 until the early 1990s. Not until a concerted public campaign beginning in the 1980s was the regional government forced to reconsider this decision. The Board revised its agreement with the Province in 1997 and formalized a ban on future logging because of public pressure and concerns about drinking water quality and supply.[188]

Urban Tree Policy

As elsewhere in the Lower Mainland, real estate property values on the North Shore have risen steeply in past years. The existing land base is constrained by the shoreline, the North Shore Mountains, and the protected areas managed by Metro Vancouver so that urban sprawl is limited. However, increased property values have translated into significant redevelopment activities in all three municipalities. While some densification is occurring, in many cases redevelopment has meant demolishing existing houses and constructing houses that have a much larger footprint on existing parcels. The impact is often the loss of existing trees, on a cumulative basis.

Each municipality has had a different approach to the regulation of tree cutting, as outlined below. Under the Community Charter,[189] municipalities have broad powers to regulate tree cutting on public and private lands, but generally (until recently) municipalities in BC have been reluctant to restrict tree cutting on private property. In contrast to the other two municipalities on the North Shore, and to many other municipalities in BC, the District of North Vancouver has been regulating tree cutting on private property since 1993.

District of West Vancouver (DWV)—until recently, DWV protected only trees on public lands or trees in watercourse areas, but in 2016 passed a bylaw (Interim Tree Bylaw) that restricts tree cutting on private property, where trees are of a certain size, except where trees are deemed to be hazardous. In the case of redevelopment this applies to trees outside the main building envelope.[190]

City of North Vancouver (CNV)—CNV does not regulate tree cutting on private property.[191] Regarding trees on municipal property, CNV's Tree Policy only allows trees to be cut down where they constitute hazards or interfere with other trees.[192] In 2007 the City also commissioned an Urban Forest Management Plan to support policy development and actions to maintain parks and natural areas "in as natural a state as possible."[193] Previously CNV commissioned a study that estimated that street trees in CNV (trees on road allowances) alone provided significant annual benefits, including energy savings, greenhouse gas reductions, air quality improvements, stormwater management, aesthetic values, and property value increases of $510,000.[194]

District of North Vancouver (DNV)—Distinct from its neighbours, DNV has been regulating tree cutting on private property since 1993, and does so currently through its Tree Protection Bylaw.[195] On private property, owners cannot cut down trees that are protected under the bylaw (because of size, species, location in an environmentally sensitive area or other characteristics) without a permit. Applicants are required to submit a report from a certified arborist. Where permits are granted to cut down protected trees, planting of replacement trees is required.

Replanting is required to maintain the District's forested character and to compensate for the loss of the significant ecological services provided to the community by the removal of a mature large diameter tree. Compensatory planting of new trees is an essential element in our tree permit process. Net benefits such as carbon sequestration, reducing water/air pollutants, storm water management, wildlife habitat, shade/shelter etc. are all detrimentally affected over time if we do not maintain a healthy level of tree canopy on private land within our community.[196]

Implementation of the Metro Vancouver Integrated Liquid Waste and Resource Management Plan (ILWRMP)—ISMP development on the North Shore

The Metro Vancouver ILWRMP was brought into force by the Minister of the Environment in 2011, and mandates member municipalities to develop integrated stormwater management plans (ISMPs) with the goal of protecting public health and the environment. Implementation of ISMPs is meant to reduce the impact of stormwater on streams and fish habitat, combining planning and policy at the watershed, neighbourhood and site scale.[197]

On the North Shore, the City of North Vancouver and the District of North Vancouver are cooperating to develop an ISMP for their shared watersheds. Future research and analysis might explore how this approach affected policies and implementation regarding urban trees and forest ecosystems on the North Shore.

ENDNOTES

186 It should be noted that these lands also fall within the traditional territories of Squamish Nation and Tsleil-Waututh Nation and are subject to their jurisdiction under Indigenous law and also to title and rights under s.35 of the Canadian Constitution.

187 Additional protected land is in the Coquitlam Watershed. See Metro Vancouver, Taking Care of the Watersheds, online at http://www.metrovancouver.org/services/water/sources-supply/watersheds/Pages/default.aspx See also BC Tap Water Alliance, About the Greater Vancouver Watersheds, online at: http://www.bctwa.org/AboutGreaterVanWatersheds.pdf

188 BC Tap Water Alliance, *op. cit.*

189 s.8(3)(c) and ss.50–52.

190 See District of West Vancouver, Protecting West Vancouver's Trees, A Balanced and Thoughtful Approach, online at: https://westvancouver.ca/home-building-property/major-projects/protecting-west-vancouvers-trees-balanced-and-thoughtful and District of West Vancouver, *Interim Tree Bylaw No. 4892*, 2016, online at: https://westvancouver.ca/sites/default/files/bylaws/4892%20INTERIM%20TREE%20BYLAW%204892%202016%20%28CONSOLIDATED%20UP%20TO%20AMENDMENT%20BYLAW%204913%202016%29-copy2.pdf

191 CNV has apparently considered regulating tree cutting on private property, without result to date. See http://www.nsnews.com/news/city-of-north-vancouver-to-consider-tree-cutting-bylaw-1.2248339

192 City of North Vancouver, 2003

193 City of North Vancouver, 2007

194 City of North Vancouver, 2014

195 District of North Vancouver, 2012

196 See District of North Vancouver, Trees—Frequently Asked Questions, online at: https://www.dnv.org/sites/default/files/edocs/tree-permit-faq.pdf

197 Metro Vancouver, 2010

APPENDIX E: **STILL CREEK JURISDICTIONAL AUTHORITY**

Federal Government Department of Fisheries and Oceans

The federal government legislates activities that impact fish bearing waterways through the *Fisheries Act* (1985). The *Fisheries Act* prohibits the destruction of habitat; any agency can be fined for polluting or physically damaging fish-bearing waterways. The Act is enforced by the Department of Fisheries and Oceans (DFO), which may also require permits, approvals, or notification for construction activities in fish bearing waterways, and provide a construction time window for activities to occur.[198]

The DFO, in conjunction with British Columbia and the Yukon, developed the Pacific Streamkeepers program in the early 1990s. The DFO created the Streamkeepers Handbook and associated modules, which aim to provide education and awareness surrounding fish bearing waterways in British Columbia and the Yukon.[199]

The federal government assists local governments in providing infrastructure. Through Infrastructure Canada and Transportation Canada, funding may be provided for wastewater and transportation infrastructure.[200] Infrastructure and large development projects may also trigger Canadian Environmental Assessment.[201]

Province of British Columbia

The Province of British Columbia delegates power to local government and regulates local government. The Province is involved in Still Creek primarily through the *Water Sustainability Act* (2016), the *Riparian Areas Protection Act* (1997), and the *Environmental Management Act* (2003). The Province may also provide funding for local wastewater and transportation infrastructure.[202]

Through the *Water Sustainability Act*, the Ministry of Environment (MoE) provides authority for the use of water in the Province. The MoE requires permits approvals, or notifications, for any construction near streams, including any work on riparian areas.[203]

Under the current *Riparian Areas Protection Act* the Province enforces the *Riparian Areas Regulation* (RAR). The RAR applies to any project within 30m of a watercourse, and requires assessment to determine width of streamside protection area. The regulation may impose restrictions or prescribe enhancement activities within this area. The RAR applies to all municipalities within the lower mainland except Vancouver.[204]

The *Environmental Management Act* (EMA) prohibits pollution and waste through solid and liquid waste regulations. The EMA requires Metro Vancouver to create Liquid Waste Management Plans (LWMP) identifying improvements in wastewater discharges. Municipal wastewater discharges must be authorized through the LWMP.[205]

Metro Vancouver

Metro Vancouver receives regional development and regional park planning authority through the *Local Government Act* (2015). Metro Vancouver outlines Regional Growth

Strategies, which municipalities agree to in their Regional Context Statements. The regional plans outline areas for urban development, in-fill redevelopment, areas protected for ecological reasons, and industrial areas.[206] Metro Vancouver manages land-use on regional parks which include park areas that cross municipal boundaries, such as greenways, larger parklands or purchased land for park owned by Metro Vancouver.[207]

Metro Vancouver has authority over liquid waste, including sanitary wastewater and stormwater, through *An Act to incorporate the Greater Vancouver Sewerage and Drainage District Act* (1956). Metro Vancouver maintains larger sewers within Metro Vancouver area, and manages water demand. The LWMP mandates that municipalities create ISMPs for open watercourses within municipal boundaries. The Still Creek ISMP was created jointly by the City of Vancouver, the City of Burnaby, and Metro Vancouver.[208] Catalyzed by the LWMP, municipalities in the lower mainland have begun a sewer separation program.[209]

Translink

Translink operates under the *South Coast British Columbia Transportation Authority Act* (1998), and develops and implements transportation strategies for the lower mainland. In 2011 Translink developed the regional cycling strategy for Metro Vancouver, including the Central Valley Greenway along Still Creek as an active transportation route. Translink also provides funding for active transportation infrastructure.[210]

City of Burnaby

The City of Burnaby receives authority from the Province through the *Community Charter* (2003). Burnaby influences development and land-use through its *Official Community Plan* (1998), zoning and regulatory bylaws. The city owns and has jurisdiction over land-use in parklands, roads, sidewalks, trails, and right-of-ways, over which the city has jurisdiction over land-use. Through Parks, Recreation, and Cultural Services, the city provides and maintains municipal-owned park spaces and programming of recreation facilities.

The City also operates and maintains the smaller sewer connections, and regulates new sewer connections on new developments or redevelopments. Through regulatory bylaws, the city maintains a development setback for riparian areas of open watercourses, and produces guidelines for development process within these areas. Development and redevelopment sites must meet the ISMP drainage policies and design criteria for the area, and all new developments must undergo an environmental review before approval.[211]

Burnaby council recently approved its *Environmental Sustainability Strategy* (2016), the first city-wide strategy aimed explicitly at conservation and enhancement. Through this strategy, the city aims to increase the ecological integrity of ecosystems within Burnaby, including parklands and open waterways.[212]

City of Vancouver

The City of Vancouver receives authority through the *Vancouver Charter*, and has the authority to manage local land use through their neighbourhood plans, zoning, and regulatory bylaws. Vancouver owns roads, streets, sidewalks, and right-of-ways, on which they have complete jurisdiction of the land-use. Vancouver also operates and maintains smaller sewer connections, and regulates new sewer connections.

Vancouver operates under the *Greenest City 2020 Action Plan* (2012), *Integrated Rainwater Management Plan* (2016), *Urban Forest Strategy* (2014), and *Vancouver Bird Strategy* (2015), which work together to enhance ecosystems that provide bird habitat, carbon sequestration, and rainwater management ecosystem services. Vancouver develops neighbourhood plans with community consultation. All development within Vancouver must conform to neighbourhood and city-wide plans.

The City uses funds from the Still Creek greenway enhancement fund to finance site riparian restoration on the right-of-ways adjacent to Still Creek.[213] The City currently has specific zoning in place for re-developments adjacent to Still Creek, and developments must conform to the 2002 Enhancement Study, Still Creek guidelines, and the ISMP.[214]

Vancouver Board of Parks and Recreation

Vancouver is the only municipality in Canada with an elected park board.[215] Vancouver Parks owns parklands within Vancouver area, and manages park land-use. Renfrew Ravine and Renfrew Community Park lands are owned by Parks Board, and Parks maintains vegetation and trails.[216] The Board operates under *Vancouver Board of Parks and Recreation Strategy Framework* (2012), and their *Rewilding* (2014) and *Biodiversity* (2016) *Strategies*.

ENDNOTES

198 British Columbia Ministry of Water, Land and Air Protection, 2004

199 Pacific Streamkeepers Federation, 2003

200 Infrastructure Canada, 2016

201 Canadian Environmental Assessment Agency, 2011

202 British Columbia Ministry of Transportation and Infrastructure, 2016

203 Government of British Columbia, 2016

204 Government of British Columbia, 2017

205 British Columbia Ministry of Environment [MoE], 2011

206 British Columbia Ministry of Community Services, 2006

207 Metro Vancouver, 2016

208 City of Burnaby et al., 2007

209 Metro Vancouver, 2014

210 Translink, 2011

211 City of Burnaby, 2017

212 City of Burnaby, 2016

213 City of Vancouver, 2017

214 City of Vancouver, 2005

215 Vancouver Board of Parks and Recreation, 2012

216 Vancouver Board of Parks and Recreation, 2013

APPENDIX F: STILL CREEK WATERSHED MANAGEMENT HISTORY

1900s–1950s

European immigrant settlers arrived in the Vancouver region from the 1860s–1900s, mainly engaging in logging and then agriculture as the land was cleared.[217] By the early 1900s, sewage pollution had become a serious problem, and the early municipalities in the Vancouver region formed the Burrard Peninsula Joint Sewerage Committee, hiring R. S. Lea in 1913 to create a sewage plan for the area.[218] The priority was drainage and waste management; ecosystem health was not a management consideration.[219]

The R. S. Lea report of 1913 recommended a joint sewerage board to administer the plan, which included plans for a sewer system where sanitary water and street runoff were conveyed in separate systems.[220] R.S. Lea found that Burnaby Lake, to which Still Creek flows into, would be unsuitable for sanitary sewage discharge, but could likely handle surface rainwater. Lea also stressed the importance of a healthy fish industry to Vancouver's economy, and its relationship to proper sewerage and drainage management.[221] In 1914, the Burrard Peninsula Joint Sewerage Committee became legally constituted as the Vancouver and Districts Joint Sewerage and Drainage Board, with the mandate to administer R. S. Lea's plan.[222]

Lea was believed by Vancouver engineers to have overestimated the pollution danger, and underestimated the case for a combined sewer system. Contrary to the Lea Plan, a combined sewer system was built, and all sewage flowed into Burrard Inlet and the Fraser River untreated.[223] The Caribou Dam was built on Burnaby Lake in 1914, and reconstructed in 1935, primarily to control lake levels and flooding in New Westminster.[224] During this time of residential development in Vancouver, Burnaby was primarily involved in agriculture and industrial land use, and was slower to implement sewer system infrastructure.[225] As the population in BC's lower mainland grew, Still Creek was envisioned as part of a "Parks and Pleasure Drive" connecting Vancouver and Burnaby.[226]

1950s–1970s

Post World War II, sewerage facilities proved inadequate to accommodate the increase in population growth, which peaked between 1950–1960.[227] Major floods and polluted beaches resulted in landowners demanding a change in municipal drainage and sewage treatment.[228] A committee was established under the leadership of A. M. Rawn to address these issues by updating the drainage master plan for the Vancouver area in what was known as the Rawn Report.[229] Provincial legislation was passed creating the Greater Vancouver Sewerage and Drainage District (GVSDD) in 1956, and the GVSDD gained jurisdiction over the Still Creek-Brunette River system due to its size and regional importance.[230] The Rawn Report included recommendations for removal of vegetation, channel straightening, and culverting of the remaining open creeks.[231] From

1960–1970, buildings were constructed directly on the creek's edge in anticipation of a completely enclosed system.[232]

By the 1960s and 1970s, salmon populations had been completely eliminated from the Brunette River system, and people became aware of the effect that the previous decade of rapid urban development was having on existing ecosystems.[233] In 1971, development restrictions were imposed around Burnaby Lake after 9000 local residents signed a petition.[234] Policies in both Burnaby (1973) and Vancouver (1976) called for existing open waterways to remain protected, and the Rawn Report was amended to reflect the new municipal policies.[235] In 1968, the GVRD acquired regional planning function, and from 1970–1975 began developing technical reports and engaging in public consultation. The *Livable Region Plan* was developed and released in 1976, which recognized open spaces as valuable for ecological and social purposes, and green belts as recreational opportunities.[236] At the provincial level, pollution control objectives and discharge permits were established in 1975 under the *Waste Management Act* (WMA).[237]

1980s–1990s

A shift in local government policies could not remedy a half-century of urban development, and by the 1980s the City of Vancouver's health department recommended that council erect signs to discourage human contact with Still Creek due to dangerously high coliform levels.[238] Throughout the 1980s, further regulatory attempts were made by multiple levels of government to remedy the damage that unrestricted development had caused to the existing ecosystem in Still Creek. Provincial amendments to the WMA in 1982 included allowing municipalities and regional districts the options of addressing waste management and related pollution issues by developing waste management plans to replace site-specific discharge permits issued by the province. The province established planning guidelines, which specified that urban stormwater be addressed in regional liquid waste management plans.[239]

Now legally mandated by the province, the GVRD developed the region's initial Liquid Waste Management Plan (LWMP), the first comprehensive report on drainage management in the Lower Mainland since the 1953 Rawn Report.[240] Stage 1 of the plan was completed in 1989. Through consultations during the 1990s, the public consistently expressed concern over the environmental quality of the region's receiving waters.[241] As a result, Stage 2 of the LWMP explicitly recognized the interrelationships between liquid waste management issues such as inflow and infiltration, stormwater, combined sewer overflows, source control, and wastewater treatment plants.[242] After almost 10 years of research and consultations, the LWMP was approved with conditions by the province.[243]

Concerns over depleted salmon stocks catalyzed the province to embark on studies and salmon enhancement programs in the Georgia Basin.[244] The province passed the *Fish Protection Act* in 1997 to provide greater protection to fish and fish habitat, and developed guidelines under which new streamside protection regulations were drafted.[245] The Riparian Areas regulation (RAR) was enacted in 2004, mandating development setbacks along open watercourses in urban areas.[246] However, this regulation did not apply to the City of Vancouver, which has its own Charter.

Around the same time, the Central Valley Greenway project was initiated, including a portion running along Still Creek. The project stemmed from proposals in Vancouver's *Greenways Plan* (1995), and the GVRD's *Livable Region Strategic Plan* (1996), both of which recognized greenways as important recreational opportunities. The project catalyzed the Greenway Enhancement Fund in Vancouver, utilizing earmarked funding generated through rental of a property on Grandview Highway towards activities related to the greenway.[247] In addition, the initiative received funding from the federal government and Translink as active transportation infrastructure.[248]

2000–2010

As part of the LWMP process, municipalities within the Brunette Basin, which includes Still Creek, agreed to undertake a pilot watershed-based planning project.[249] The pilot was an opportunity to share resources, and "work towards greater improvements in the environment than any one group could achieve alone."[250] The Brunette Basin Task Group (BBTG) was formed, and included representatives from the DFO, Province, Burnaby, Coquitlam, New Westminster, Vancouver, the GVRD, Sapperton Fish and Game Club, BCIT and UBC.[251] With input from relevant stakeholders, the pilot *Brunette Basin Watershed Plan* was released in 2001.[252]

Proposed actions by Burnaby, Vancouver, and the GVRD within the 2001 pilot plan included sub-watershed management plans, habitat enhancement and fish habitat improvements, greenways, flood management strategies, sewer repair and cross-connection elimination programs, and a Still Creek vision document with a specific riparian enhancement program targeting potential enhancement sites.[253] Following the release of the 2001 plan, the City of Vancouver developed the *Still Creek Rehabilitation and Enhancement Study* (2002), outlining specific actions for the daylighting and restoration of Still Creek. The City of Burnaby formally adopted a *'Total' Stormwater Approach* (2003) for the protection of open watercourses, including Still Creek. Following independent municipal policies, the joint *Integrated Stormwater Management Plan and Vision for Still Creek* (2007) was developed by Burnaby, Vancouver, and GVRD.

Current Context

As academic research and public concern focused on urban ecosystem health gain momentum, local governments have continued to create plans and policies that influence and attempt to restore Still Creek. In 2010, Metro Vancouver released its new *Integrated Liquid Waste and Resource Management Plan*, closely followed by its *Ecological Health Action Plan*, which outline steps for further eliminating water pollution and conserving green space respectively. The *Renfrew Ravine Master Plan* for the park at the head of Still Creek was released by Vancouver in 2013, recognizing the park area as an important cultural, recreational, and ecological asset for the surrounding community. Most recently, Burnaby has approved its *Ecosystem Sustainability Strategy* (2016), and Vancouver its *Rewilding* (2016), *Biodiversity* (2014), and *Urban Forest* (2014) strategies.

ENDNOTES

217 GVRD, 1996b

218 Cain, 1976; GVRD, City of Burnaby, and City of Vancouver, 2007

219 GVRD, 2001

220 Cain, 1976

221 Cain, 1976

222 Cain, 1976

223 Metro Vancouver, 2015

224 GVRD, 1996b

225 Green, 1952

226 GVRD et al., 2007

227 Cain, 1976; GVRD, 1996b; Metro Vancouver, 2015

228 GVRD et al., 2007

229 Cain, 1976

230 Hawkins, 1957

231 GVRD, 2001

232 GVRD et al., 2007

233 GVRD, 2001

234 GVRD, 1996b

235 GVRD et al., 2007

236 GVRD, 1976

237 GVRD, 1996b

238 GVRD et al., 2007

239 GVRD, 1996b

240 GVRD, 1996a

241 GVRD, 1996a

242 GVRD, 1996a

243 GVRD, 1996a

244 GVRD, 1996b

245 Burnaby, 2000

246 Curran & Krindle, 2016

247 City of Vancouver, 2000

248 Envirowest, 2005

249 GVRD, 2001

250 GVRD, 1996b

251 GVRD, 2001

252 GVRD, 2001

253 GVRD, 2001

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