Towards Regional Interdisciplinary Green Infrastructure in Metro Vancouver

by

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Declaration of Committee

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Abstract

Green infrastructure (GI) and nature-based solutions (NbS) have been identified as an important strategy to assist in delivering key infrastructure services in Metro Vancouver, particularly when considering predicted and observed climate change impacts such as increased extreme weather, flooding, sea level rise, and urban heat for the region. Municipalities within Metro Vancouver are increasingly planning and deploying GI, though efforts are largely disjointed and are primarily planned and executed at the local government scale. Recent global initiatives to address biodiversity loss and climate change are recommending more integrated governance that incorporate planning between jurisdictions and disciplines highlighting the potential to achieve greater collective benefits including ecosystem services, biodiversity protection, and human health and wellbeing. However, a transformation to more integrated work is challenged by a variety of complex structural, cultural, and conceptual barriers common of wicked social-ecological problems. This research deployed social innovation techniques to engage professionals and stakeholders within the Metro Vancouver area to identify these barriers and reflect on potential solutions to deploy GI more intentionally and effectively at a regional scale. The results of the research demonstrate a strong preference towards greater integration between professions as well as between municipalities and governmental jurisdictions.

Keywords: Green Infrastructure; Stormwater Management; Climate Change; Adaptation; Biodiversity; Ecosystem Services; Nature-based Solutions; Metro Vancouver; Lower Mainland; Social Innovation

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List of Acronyms

GI	Green Infrastructure
GSI	Green Stormwater Infrastructure
NbS	Nature-based Solutions
OECM	Other Effective Area-Based Conservation Measures
SFU	Simon Fraser University
SFU ACT	SFU Adaptation to Climate Change Team

Chapter 1. Introduction

While humans have tended to settle, develop, and urbanize areas of high biological diversity (Luck 2007), conservation methods have tended to focus on non-metropolitan protected areas ignoring biodiversity values in urban areas (Kennedy et al. 2019). Conservation of biodiversity in urban areas can be particularly complex with many overlapping interests, intensive land use, high costs of land, and increasing urban growth. This is further exacerbated by, and both directly and indirectly connected to, the current and projected effects of climate change. At the same time, there is an increasing call upon the deployment of green infrastructure and nature-based solutions (NbS) as a response to overlapping threats posed by climate change and biodiversity loss including increases in extreme weather, flooding and sea level rise, urban heat, loss of habitat, and species extinction (Diaz et al. 2019; Connop et al. 2015).

Metro Vancouver is no exception as an area that is quickly urbanizing, bringing with it land-use transformations to accommodate and service its quickly growing population. Projections estimate that the population in the region will grow from 2,600,000 in 2018 to 3,600,000 by 2050, an increase of 30% in 30 years (Metro Vancouver 2018). For these reasons, Green Infrastructure (GI) was selected as a focal point to research how it is already, and could be better, deployed as a response to biodiversity loss, climate change, and meet growing service delivery needs within the Metro Vancouver region. To investigate this, a mixture of workshops inspired by social innovation methods alongside literature reviews was used. The primary research questions were left open to allow for a broad understanding of the challenges and what shifts in policy, culture, institutions, and communities from an interdisciplinary perspective would help to support a transformation towards green infrastructure implementation.

1.1. What is Green Infrastructure?

Green infrastructure is a broad term that refers to the use of sustainable approaches to infrastructure, and as we learned is used by different disciplines in different ways. For the purposes of this research, the definition used here more closely relates to green stormwater infrastructure (GSI) relating to its purpose in managing

stormwater flows and treatment. The structures of GSI are inclusive of more ‘natural’ features like forests, wetlands, and riparian areas, as well as engineered features like rain gardens, bioswales, or porous pavement deployed by civil engineers to manage water and precipitation, aka stormwater, in developed areas. This definition also follows Metro Vancouver’s definition laid out in their 2015 Connecting the Dots Regional Green Infrastructure Network Resource Guide seen in Figure 1 (Metro Vancouver 2015). This definition does not include features that focus on materials or carbon reduction, or energy efficiency such as ‘green buildings’ or ‘green energy’ that do not contribute to stormwater management. While some natural features can be capable of reducing materials, carbon, or energy consumption, it is not the primary focus of their efficacy. For the sake of consistency, the rest of this paper will use the term GI in place of GSI.

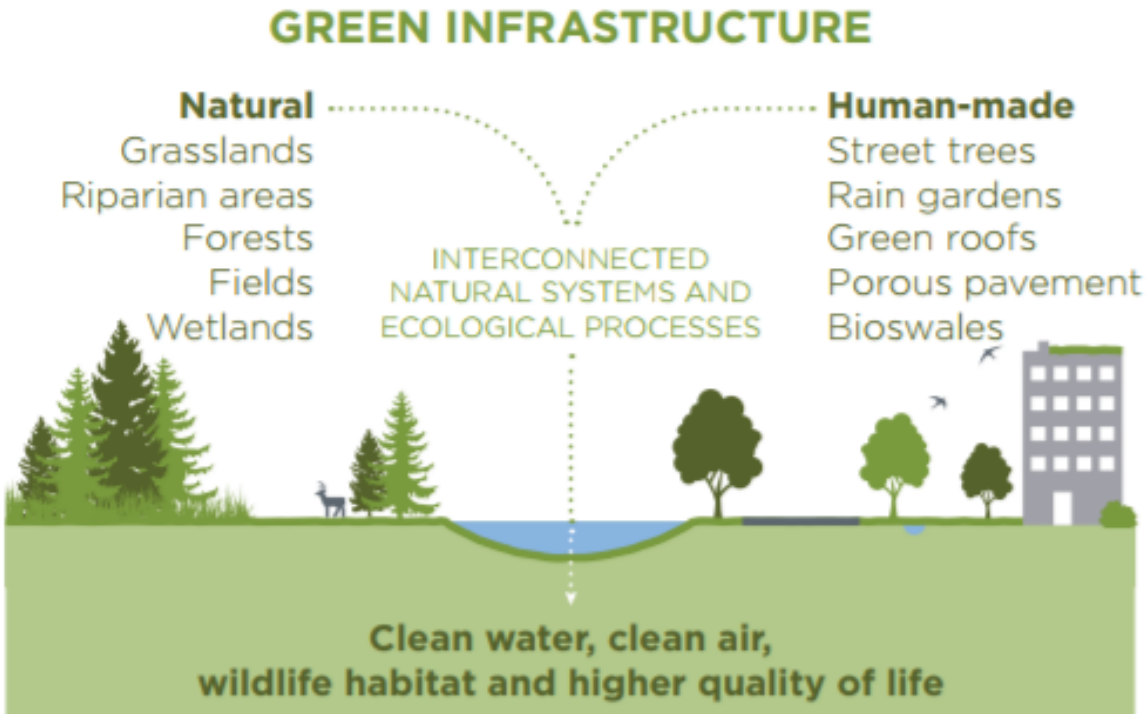

Figure 1: **Green Infrastructure as defined by Metro Vancouver**
(Metro Vancouver 2015)

1.2. Why does Green Infrastructure matter?

By 2050 the UN projects that 68% of people will be living in urban areas due to urbanization and population growth, today that number is 54% (United Nations 2018). Metro Vancouver is one of those quickly urbanizing regions, with its population predicted to grow by 35,000 residents per year (or roughly 2% per year on average) (Metro

Vancouver 2011). As a result, Metro Vancouver municipalities will see increasing demands on their infrastructure from urbanization, population growth, and projected climate change impacts.

Meanwhile, less and less funding from provincial and federal governments have been made available to municipalities to help pay for service delivery and infrastructure over the last 25 years (with some small exceptions. This reduction in spending includes a substantial area of infrastructure that includes sewage and stormwater service delivery. For example, federal and provincial transfers to BC local governments between 1996-2008 were $4 billion less than projected per capita transfers if 1995 levels were sustained (Figure 2), and currently, municipalities collect only 8 cents of every tax dollar (Duffy, Royer, and Beresford 2014). Reflecting this fact, between 2001 and 2010 local government spending on sewer services grew by 173% and water services by 130% in BC (Duffy, Royer, and Beresford 2014). At the same time, a large amount of municipal infrastructure is reaching the end of its service life and in need of replacement. Canada's 'golden age' of infrastructure followed World War II and into the '50s and '60s, then spending dropped off in the '70s and '80s (Federation of Canadian Municipalities 2016). The average service life of stormwater infrastructure is roughly 60-100 years which means that a large amount of reaching the end of service life and in need of replacement now or will be in the next 20-40 years (Federation of Canadian Municipalities 2016).

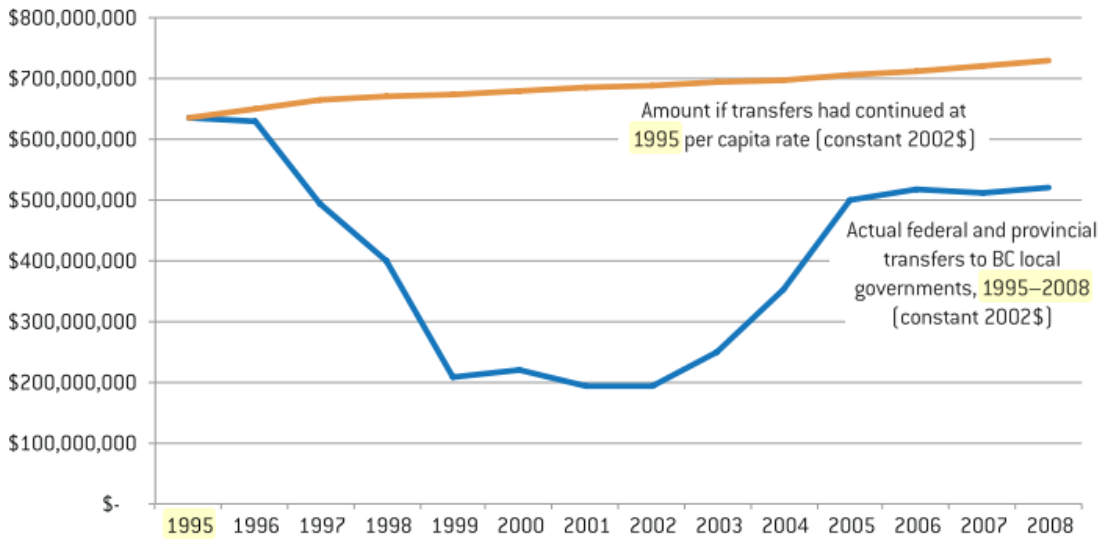

Figure 2: Federal and provincial transfers to BC local governments 1995-2008
(Duffy, Royer, and Beresford 2014)

Climate change will only exacerbate the pressure on infrastructure and service delivery for local governments in Metro Vancouver. Climate change projections for Metro Vancouver anticipate that by 2050 there will be twice as many days over 25 degrees C (from 22 days to 55 days), dryer summers (decrease in precipitation by 20%), more extreme precipitation in fall and winter (approximately 30% more on 95th percentile wettest days), and less snowpack accumulation in winter leading to increased flooding in winter and less available potable water in reservoirs in spring and summer (Metro Vancouver 2016). The current state of the urban built form, largely due to the amount of impervious 'grey' surfaces, will lead to an increased likelihood of natural disasters including landslides, more extreme urban heat island effect, and wildfire events in surrounding regions all impacting air and water quality among other human health and well-being indicators. On top of that, urban residents are dependent on essential life-giving services that municipalities provide like water, electricity, and transportation.

At the same time, biodiversity loss and its impacts are being recognized on a global scale, noted in detail with the release of the International Panel on Biodiversity and Ecosystem Services (IPBES) 2019 global assessment (Diaz et al. 2019). Nature-based solutions (NbS), which include the use of green infrastructure, are increasingly being recognized as a crucial response to both projected climate change and biodiversity loss impacts, in addition to a host of other co-benefits (Diaz et al. 2019). NbS are defined by the International Union for Conservation of Nature (IUCN) as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (IUCN 2016).

While GI has been identified as a primary NbS to address the above problems, these approaches are still relatively novel as a modern urban practice (Kuban et al. 2018). Grey infrastructure continues to be the default approach of cities for managing stormwater, however, increasingly policies and strategies are being deployed to incorporate green infrastructure in municipalities around the world including many Metro Vancouver municipalities. The City of Surrey's Biodiversity Strategy (Diamond Head Consulting 2014), and Vancouver's citywide Rainwater Management Strategy (City of Vancouver 2016) are two examples of many municipalities within the boundaries of Metro Vancouver looking to make GI a more mainstream and holistic approach to stormwater management and climate adaptation.

Building on this idea, and building on recent work of the Metro Vancouver regional government to connect green infrastructure on a regional scale (Metro Vancouver 2015), the aim of this research is to explore how might be more intentionally planned, integrated across jurisdictions, and accelerated at a regional scale. Research was conducted through literature reviews and a content analysis of two interdisciplinary workshops. Workshop participants included professionals (engineers, accountants, planners, landscape architects) primarily from local governments, as well as developers, stewardship groups, consultants, and First Nation's staff.

1.3. Green Infrastructure as a solution to ageing infrastructure assets and reduced funding for local governments

There is an increasing need and urgency for municipalities to acknowledge failing infrastructure, and increased deficits in the ongoing management of municipalities in Canadian cities. In Canada, most infrastructure was built between the 1950s to 1970s and much of it is coming to the end of its service life, and there is a huge deficit in infrastructure spending between $50 - $570 billion (Halseth, Ryser, and Markey 2015). As of 2009, the Public Sector Accounting Board determined municipalities must record asset depreciation in financial statements, which encourages an ongoing understanding of the value of their assets. Meanwhile, municipalities are only collecting eight cents of every tax dollar but build and maintain half of the country's core infrastructure (Federation of Canadian Municipalities 2006). According to the Organization for Economic Cooperation and Development under no scenario can developed countries meet future needs with traditional sources of public funding alone (OECD 2007). Moving forward will require long term planning, asset management with full cost accounting, as well as capacity building in human capital and keeping up with the most up to date technology when creating new or upgrading old infrastructure (OECD 2007; Halseth, Ryser, and Markey 2015).

Deployment of GI has already been proven to be helping cities to meet these challenges outside of Canada (Holland, Philadelphia). More recently, natural asset (or natural capital) management techniques are leveraging the responsibility to conduct provincially mandated asset management alongside a valuation of natural ecosystem services within a municipal asset infrastructure management context (Brooke, O'Neil,

and Cairns 2017). Where green infrastructure and engineered elements are created to mimic natural functions and processes in the service of human interests, “natural assets refers to the stock of natural resources and ecosystems that are relied upon, managed, or could be managed by a municipality, regional district, or other form of local government for the sustainable provision of one or more municipal services” (Brooke, O’Neil, and Cairns 2017). Unlike traditional infrastructure, such as roads, sewers, etc., natural assets can extend beyond the boundaries of municipal jurisdiction and can also be owned or “managed” by multiple entities (public and private). In this way, ecosystems can be acknowledged for the ecosystem services they provide as compared to typical engineered infrastructure.

With COVID-19, many have called for funding stimulus, commonly depolyed in times of economic downturn, to be directed towards efforts that address climate change and biodiversity loss, commonly referred to as ‘building back better’. As the OECD puts it, “Recovery policies need to trigger investment and behavioural changes that will reduce the likelihood of future shocks and increase society’s resilience to them when they do occur… including alignment with long-term emission reduction goals, factoring in resilience to climate impacts, slowing biodiversity loss and increasing circularity of supply chains” (OECD 2020). The way that infrastructure stimulus funding is deployed is both a big opportunity and a potential transformational turning point in responding to climate change and biodiversity loss.

Chapter 2. Literature Reviews

As this research focuses on how GI can act as a response to climate change and biodiversity loss in Metro Vancouver, literature reviews were conducted to help assess this inquiry. At first, it evaluates whether the scale of a region or a regional government is an appropriate scale to meet this issue. Therefore, a review of regional governance and authority in general, and specifically a deeper dive into the Metro Vancouver context, governance structure, and authority in executing something like this is necessary. In addition, as Metro Vancouver is a quickly urbanizing region, it is also important to better understand recent trends in GI as it relates to climate change adaptation and biodiversity in urban areas around the world.

2.1. Interaction of Biodiversity Loss, Climate Change, and Urbanization

The intersection of biodiversity loss, climate change, and land use are intricately connected. For the purposes of this research, the focus is restricted on how these rather macro-scale effects/impacts intersect at the urban / peri-urban / sub-urban setting of the Metro Vancouver region, and how GI might help to act as a multi-functional solution to all the above.

Loss of biodiversity has more recently garnered attention as a problem now on par with climate change in terms of its existential threat to humanity and the systems humans rely on. Urbanization has likely caused the local extinction of thousands of species throughout human history. In 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) released a global assessment report on the state of biodiversity globally (Diaz et al. 2019). More than 150 selected experts were involved in preparing this assessment and more than 15,000 scientific publications were analyzed making it the most substantial review of the state of biodiversity globally to date.

Of particular importance, IPBES identifies land-use change (primarily driven by urbanization, agriculture, and forestry) as the direct driver with the largest relative impact on terrestrial and freshwater ecosystems in the last 50 years, followed closely by climate change. Shifts in species distribution, changes in phenology, altered population

dynamics and changes in the composition of species assemblage, or structure and function of ecosystems, are all associated effects caused by land-use change.

Many species are unable to cope locally with the rapid pace of climate change. The continued existence of threatened wildlife species will depend on the extent to which they can move and track suitable climatic conditions. The effect of linear features associated with human land-use change (roads, pipelines) exacerbates the challenge of species' need to migrate due to climate change. Creating connectivity and migration corridors is already a well-established practice in ecosystem restoration and is even more important in the face of climate change for this reason (Diaz et al. 2019).

2.1.1. Nature-based Solutions as a response for urban areas

Nature-based solutions (NbS) are quickly gaining popularity as a response to the wicked problems of climate change and biodiversity loss. It is difficult to disentangle exactly how NbS might differ from something like GI, however, it is generally agreed that there is a great deal of overlap between the two with GI being at the least a substantial subset of NbS. As IPBES defines NbS, they “include combining grey and green infrastructure (such as wetland and watershed restoration and green roofs), enhancing green spaces through restoration and expansion, promoting urban gardens, maintaining and designing for ecological connectivity and promoting accessibility for all (with benefits for human health)” (Díaz et al. 2019). IPBES notes that NbS can be cost-effective for meeting the Sustainable Development Goals in cities, which are crucial for global sustainability. Increased use of green infrastructure and other ecosystem-based approaches can help to advance sustainable urban development while reinforcing climate mitigation and adaptation. GI in urban areas and their surrounding rural areas can complement large-scale “grey infrastructure” in areas such as flood protection, temperature regulation, cleaning of air and water, treating wastewater and the provision of energy, locally sourced food and the health benefits of interaction with nature. (Diaz et al. 2019). These complementary benefits, or co-benefits, of a GI approach are a value added service – and because climate change will only exacerbate the need for these services, GI is especially well suited for this challenge (Connop et al. 2015). Connop provides a helpful graphical summary of how GI can be deployed in urban settings, the services they provide, and common barriers to implementing GI in urban political contexts (Figure 3).

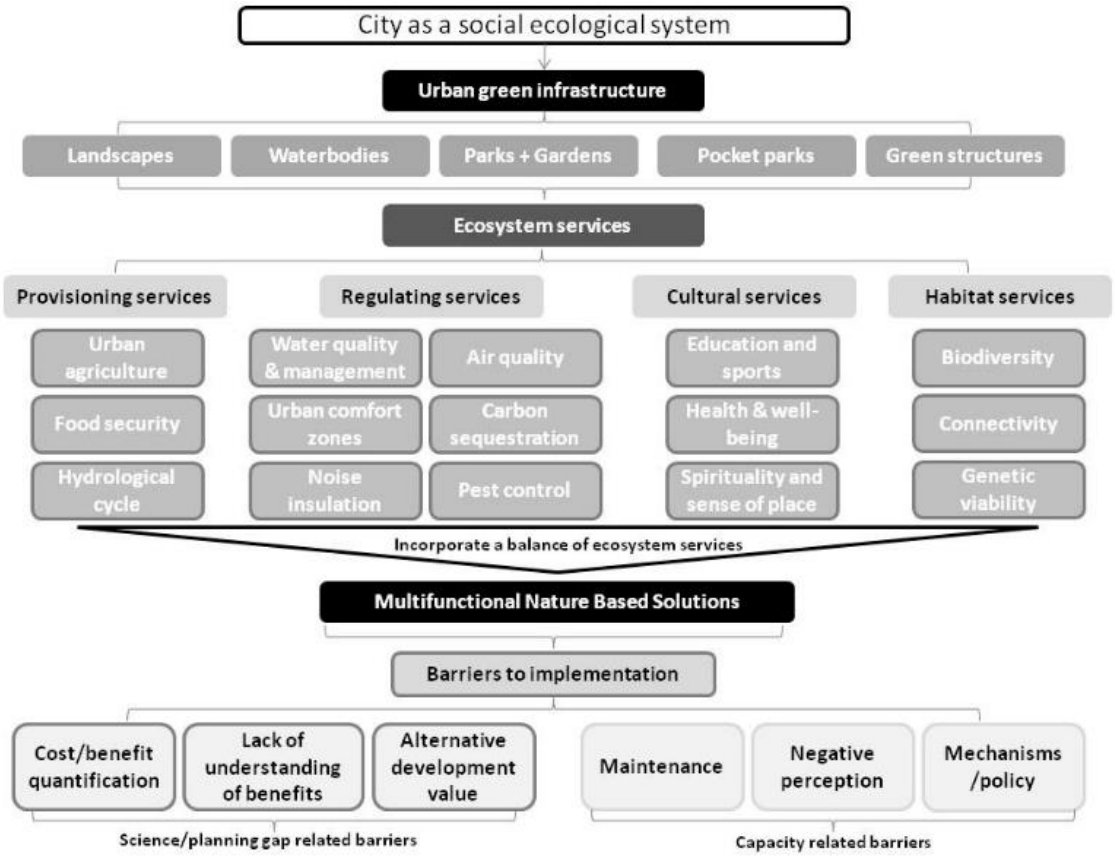

Figure 3: Flow chart outlining structures, services provided by, and barriers to achieving urban biodiversity-led green infrastructure in an urban setting
(Connop et al. 2015)

Planning for non-human species in urban areas largely remains in the realm of abstraction when compared to pragmatic day-to-day aspects of negotiating land uses and delivering services to human-oriented spaces. Planning theory generally privileges a human-centric view of the world, which accelerates these overlapping social-ecological crises (Parris et al. 2018).

2.1.2. Rethinking Urban Areas as Multi-functional Landscapes and Other Effective Area-Based Conservation Areas Measures

Two newly emerging conservation frameworks could aid in the type of innovative governance and transformation required for urban areas to retain biodiversity and adapt to climate change. These are ‘multi-functional landscapes’ and ‘Other Effective Area-Based Conservation Measures’ (OECM). As the IPBES lays out as a key action,

“managing landscapes sustainably can be better achieved through multifunctional, multi-use, multi-stakeholder and community-based approaches, using a combination of measures and practices, including well managed and connected protected areas and other effective area-based conservation measures” (Diaz et al. 2019). OECMs, as defined by the International Union for Conservation of Nature and the World Commission on Protected Areas, are “a geographically defined area other than a Protected Area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in situ conservation of biodiversity, with associated ecosystem functions and services and where applicable, cultural, spiritual, socio-economic, and other locally relevant values” (IUCN and WCPA 2019). OECMs were first enumerated in the Strategic Plan for Biodiversity 2011-2020 in Aichi target 11 which aims to improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity. Target 11 states:

> By 2020, at least 17 percent of terrestrial and inland water areas and 10 percent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes [underline added].

While protected areas have normatively provided the foundation of national biodiversity conservation strategies and delivery of Target 11 (Watson et al. 2014), the emergence of other effective area-based conservation measures (OECM) is a promising concept still in the process of being defined. Where the conception and functioning of protected areas are relatively well defined since the creation of parks and reserve systems in the late 19th century in colonial settings (such as Roosevelt in the USA), there is an urgent recognition that protected areas alone can no longer protect biodiversity effectively so more integrated approaches where other land uses can serve ecosystem function are necessary (Dudley et al. 2018).

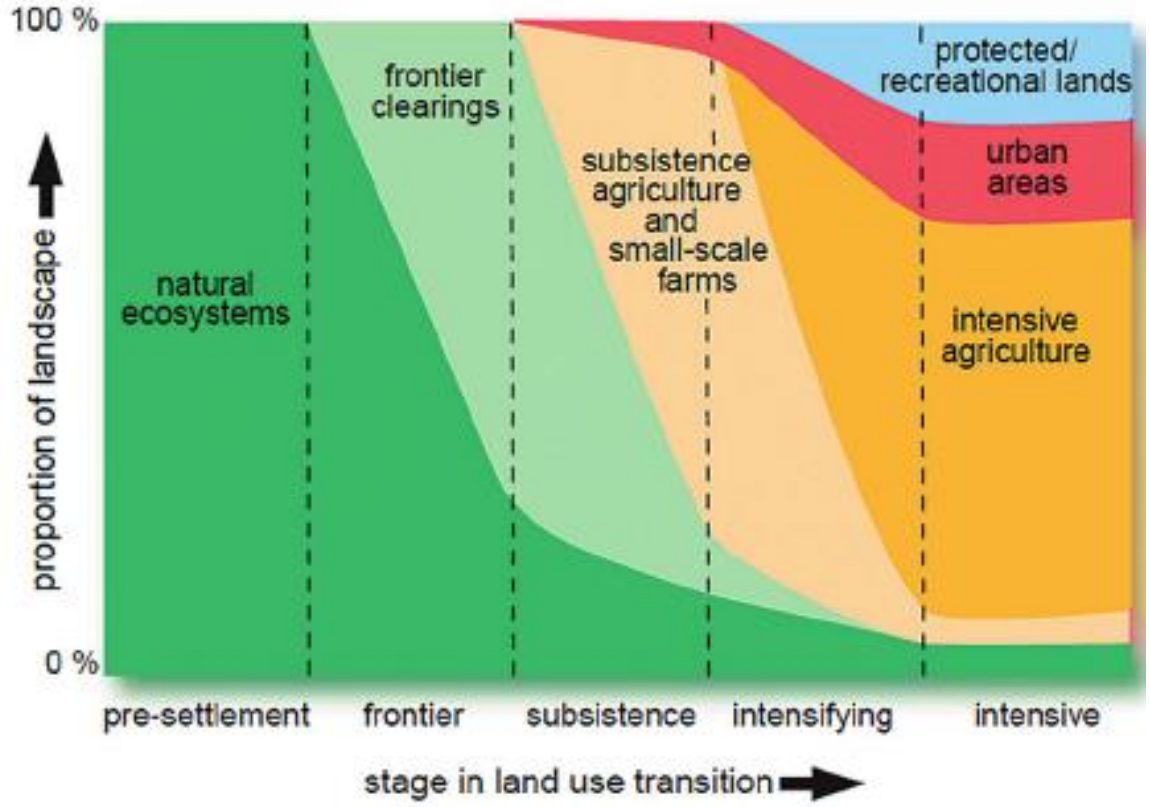

Figure 4: **Conceptualized understanding of the proportion of landscape serving particular land uses as a function of stages in land-use transitions**
From Foley, J. A. *et al.* Global consequences of land use. *Science (80-.).* **309**, 570–574 (2005). Reprinted with permission from AAAS

As Foley et al. conceptualizes (see Figure 4), societies follow a sequence of land-use regimes with 'developed' societies relying on intensive agriculture, urban areas for human uses, while a small proportion is set aside as protected recreational lands to protect species and ecosystems (Foley et al. 2005). As globalization continues to push societies towards 'intensive' land-use regimes, the prospect of protected areas alone serving biodiversity is becoming more and more tenuous, and at odds with human needs or exacerbating inequalities between nations (Dudley et al. 2018). It is increasingly essential to look towards OECMs to achieve biodiverse and resilient social-ecological systems which implies a fundamental change in how conservation works. While urban areas aren't often included in the conception of OECMs, it is becoming apparent that there is a role to be played by urban areas as some of the most historically biodiverse areas (Sanderson and Brown 2007) while many remain more highly biodiverse than non-urban areas despite their shift in land use (Luck 2007). Flourishing human settlements

have tended to settle in historically productive landscapes, with a range of natural resources available to support human population and high levels of biodiversity (Luck 2007; Ives and Kelly 2016).

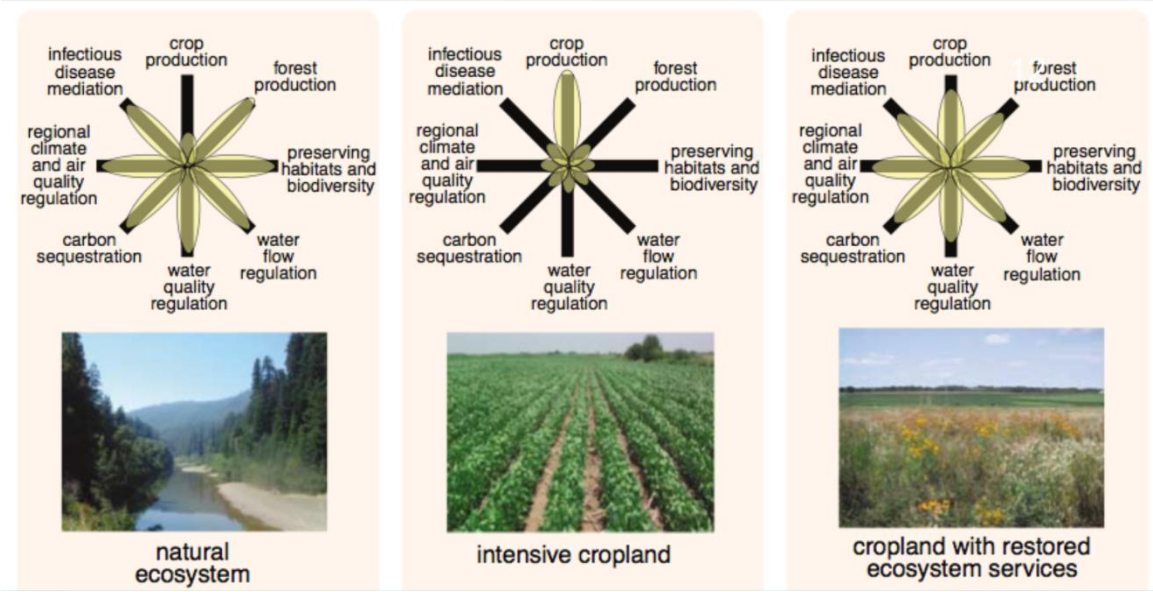

Figure 5: Conceptual framework for comparing land use and trade-offs of ecosystem services using 'flower diagrams' to convey a multi-functional landscape (right)
From Foley, J. A. *et al.* Global consequences of land use. *Science (80-.).* **309**, 570–574 (2005). Reprinted with permission from AAAS

As a response, it is becoming increasingly recognized that integrated city-specific and landscape-level planning, NbS and built infrastructure contribute to sustainable and equitable cities and make a significant contribution to the overall climate change adaptation and mitigation effort (Díaz et al. 2019). Foley proposes an alternative framework for land use that would illustrate conceptually how multiple benefits could be achieved alongside current ‘intensive’ or singularly focused land-uses dubbed ‘multi-functional landscapes’ (Foley et al. 2005). In Figure 5, Foley illustrates how an agricultural space with minor sacrifices to crop production (right) could provide a host of ecosystem related benefits that would also contribute to other human and ecosystem needs, in addition to long term sustainability of crop production. Multi-functional landscapes are a simple way to conceptualize how an OECM might function, and can also aid in imagining how a similar framework could be adapted to urban or suburban spaces. For instance, urban planning approaches such as designing compact communities with nature-sensitive road networks and low impact infrastructure and

transportation systems, including active, public and shared transport are all beneficial to meeting sustainability goals. These types of activities require a combination of bottom-up and city-level efforts, by public and private, community and Government partnerships the benefits of which are low-cost and locally-adapted solutions to maintaining and restoring biodiversity and ecosystem functions and services (Díaz et al. 2019). Integrating cross-sectoral planning at the local and landscape and regional levels is important, as is involving diverse stakeholders.

2.1.3. Regional Approaches to NbS and GI

Supporting non-human species has been an important component of modern regional planning principles and theory since its inception in the 20th century. The combination of ecology with early town planning by Patrick Geddes (1915) was key in the invention of regional planning (Parris et al. 2018). The lineage continued with concepts such as designing with nature from Ian McHarg (1969), Anne Whiston-Spirn's (1984) visionary demonstration of the role of biota in place-making, and Jack Ahern's ABC model linking the abiotic, biotic and cultural functions of cities (Ahern, 2007) (Parris et al. 2018). As humans increasingly live in cities and dominate Earth's natural processes through planetary urbanization, there is a need to inspire those who control and plan cities to consider more-than-human species within urban spaces (Parris et al. 2018). Particularly important at the regional scale are policies and programmes that promote sustainability-minded collective action, protect watersheds beyond city jurisdiction and ensure the connectivity of ecosystems and habitat (e.g., through green-belts) (Díaz et al. 2019). The case context for how NbS and GI could be deployed at a regional scale within specifically Metro Vancouver are investigated in more depth in section 3.1.

2.2. Social Innovation methods to solve Social-Ecological problems

It is well understood that the 21st century is rife with wicked, messy, or complex problems with an impossible to parse mix of personal and impersonal political, economic, and cultural forces acting at global scales with localized implications, where overlapping problems are both effects and causes.. Wicked problems were defined by C. West Churchman in 1967 as a ““class of social system problems which are ill-

formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing. . . [and] proposed ‘solutions’ often turn out to be worse than the symptoms” (Churchman 1967). Climate change and biodiversity loss fit neatly into this definition with a multitude of actors and decision makers, a lack of clear jurisdiction or information and rules, and conflicting values. . Scientists and practitioners have largely failed to recognize the close inter-connection between human and biophysical systems with potentially dire consequences, and innovation is crucial to avoid critical thresholds and achieve sustainability (Olsson and Galaz 2012). A large obstacle to addressing these types of sustainability problems is the lack of ontological frameworks that can hold the complexity of natural and human systems (Lawrence and Després 2004).

Given the lack of adequate or timely results given the scale of these crises demonstrates the failure of conventional responses, and creates opportunities to investigate novel and different ways to approach these problems. For wicked problems of this nature, new approaches need to address complex dynamics involved in social change processes, acknowledging roles and strategies that different actors hold in that problem area (Riddell, Tjörnbo, and Westley 2012). “To address joined-up problem contexts and break down silos, multi-paradigm and transdisciplinary knowledge development is a necessity” (Riddell 2015).

Social innovation is a set of decentralized methodologies emerging around the world that attempt to provide a framework and theories to ground innovative solutions to these problems. Westley and Antadze define social innovation as “a complex process of introducing new products, processes or programs that profoundly change the basic routines, resource and authority flows, or beliefs of the social system in which the innovation occurs” (2010). While this definition describes a quality of a result in terms of a process, it is well understood that it is the process, how it is enacted, that makes social innovation unique centering inclusion, improving social relations, and empowerment in its methods.

Given the complexity of stormwater management and watershed governance in urban areas, such as Metro Vancouver, this project deployed social innovation methods to help unpack the various overlapping issues in a group setting. Through gaining

shared understanding of the barriers, and working to dig deeper into structures that hold barriers in place, the aim is to uncover important levers of change that support a transition towards more holistic, collaborative, transdisciplinary, cross-scale, nature based or 'green' stormwater infrastructure across the Metro Vancouver region.

Following Francis Westley's guide to developing a social innovation lab (Westley 2012), a typical social innovation methodology can be broken down into four steps: 1) initiation, 2) research and preparation, 3) workshops and 4) field testing and refinement. Step 3, workshops, is in many ways what makes the work unique in that it brings together diverse stakeholders across a series of meetings to first 'see the problem', second to 'design solutions' and third, to 'prototype solutions'. This 'lab' format is laid out in order to deliver solutions that are capable of transforming the way a problem is approached by leveraging shared needs, knowledge, authority, and resources at multiple scales.

A key part of social innovation methodology is in first understanding a problem from a diversity of perspectives and at multiple scales. As Van de Ven and Poole put it, "It is the interplay between different perspectives that helps one gain a more comprehensive understanding of organizational life, because any one theoretical perspective invariably offers only a partial account of a complex phenomenon" (Van de Ven and Poole 1995). A transdisciplinary approach can help to deconstruct and transform bodies of knowledge through a multi-paradigm knowledge sharing and interaction (Lewis and Grimes 1999). Social innovation methods in this way put inclusive and integrative approaches at their centre.

Hernandez and Cormican compares the management of social innovation projects to that of typical industrial-oriented projects in Table 1 below. In so doing they outline key markers that make social innovation approaches unique from typical status quo approaches. In this assessment they note that social innovation projects are "complex, lengthy, and difficult to measure due to their intangible nature" (Hernandez and Cormican 2016). Kleverbeck and Terstreip affirm that innovation processes are complex and characterised by uncertainty that is difficult to grasp by research (Kleverbeck and Terstriep 2017). In typical or status quo project management, the metrics for value and success are largely quantitative making a traditional business-

oriented project easier to measure in comparison to social innovation projects, where metrics for success and value are more qualitative (Hernandez and Cormican 2016).

Table 1: Management of Typical Industrial-Oriented Projects and Management of Social Innovation Projects

Features	Project Management	Social Innovation Projects (SIP)
Objectives	To meet unique and specific goals; typically to bring about beneficial change or added value[25].	Associated with intended, planned, coordinated, goal-oriented, and legitimated actions undertaken by social agents aiming at social change that will emerge in the establishment of new social practices[32].
Key driver	Profitability and commercial success[26].	To meet social needs[5].
Bottom line	Money[5].	Political recognition/support; voluntary labour; philanthropic commitment[5].
Motivation	Extrinsic: Materialistic (profits, incentives; product creation).	Intrinsic: Non materialistic (e.g. inner moral passion/need; recognition; compassion; identity: autonomy; care) [5].
Goals	The temporary production, development, or improvement of a *physical* product, system or facility — and monitored and controlled against specification (quality), cost and time[29].	Blurred boundaries between production and consumption[9]. Non-material outcomes: changes of attitudes, behaviour, or perception resulting in new social practices [27].
Structures	There is a set structure and frameworks to manage projects[33].	There is an absence of an integrative framework for social innovation approaches[3].
Patterns of Growth	Faster growth; less resilient[5].	Slow, but tend to be more resilient[5].
Key agent of innovation	The firm[5].	Coalitions and network[9].
Metrics for success	Scale; market share; profit[34].	The very measures of success may be contested, as well as the tools for achieving results[9]. Improvements in the quality of life[5]; scale.
Metrics for value	Value is a function of benefit and cost[30]. Metrics for value are quantitative.	Value focusing on the improvement in quality and quantity of life[19]. Social innovation measurement is more qualitative[31].

However, thus far social innovation has focused primarily on addressing problems more squarely in the social realm, omitting the existential threats that ecological issues including climate change and other forms of degradation pose to social, economic, and political systems at all levels in the coming decades (Riddell 2015). Yet social innovation methods themselves draw heavily on ecological theory, the interaction of systems and adaptive responses, resilience theory and basins of attraction. For these reasons social innovation methods are arguably very well suited for holding the complexity of social-ecological systems, especially with practitioners that may already be trained in understanding at least ecological systems in this way. There is a significant opportunity and efficiency for deploying social innovation at problems of a social-ecological scale.

2.2.1. Interdisciplinarity and Innovative Governance as a Transformative Solution to Biodiversity Loss

Following suit with social innovation methodologies, the IPBES report echoes that “sustainability transformations call for cross-sectoral thinking and approaches. Sectoral policies and measures can be effective in particular contexts, but often fail to account for indirect, distant and cumulative impacts, which can have adverse effects, including exacerbating inequalities.” The IPBES assessment calls for increasing landscape approaches, integrated watershed and bioregional scale planning, and new urban planning paradigms (Diaz et al. 2019). These types of approaches are seen as offering important opportunities to reconcile multiple interests, values and forms of resource use when acknowledging uneven power relations between stakeholders.

Moreover, the IPBES recommends that “transformative change is facilitated by innovative governance approaches that incorporate existing approaches such as integrative, inclusive, informed and adaptive governance” (Díaz et al. 2019). Integrative approaches recognize relationships between sectors, disciplines, and policies help to ensure policy coherence and effectiveness. “Built-environment professionals such as planners, architects, landscape architects and urban designers have a central role to play in the persistence of urban biodiversity because of their direct influence on the evolving form and fabric of the urban environment… shared common language and world view are important first steps.” (Parris et al. 2018). Novel strategies for governance can also allow for knowledge co-production that are inclusive of diverse values and knowledge systems. (Diaz et al. 2019). Reflecting social innovation methods, the use of inclusive approaches are increasingly understood as helping to reflect a plurality of values, experiences, and create solutions that are better informed, improve equitable sharing of benefits, and deploy resources in new and transformative ways.

A rare and particularly relevant example of an outcome of social innovation methods is the Municipal Natural Assets Initiative (MNAI). MNAI was launched as a result of a social innovation lab called the Natural Capital Lab of Natural Step project which began in 2014. The idea was to bring together important actors from across disciplines to develop better systems to value ecosystem services. As a result, the MNAI was born and deployed first in the Town of Gibsons BC where they became the first municipality in North America to engage in an asset management policy that explicitly

defined and recognized natural features as having an actual and quantifiable value. This has proven an invaluable approach for Gibsons noting that the natural assets they assessed “provide services to the Town at a fraction of the cost of an engineered alternative, and with proper maintenance, they can do so in perpetuity” (Machado et al. 2014).

Before the Natural Capital Lab was underway, it was estimated in 2010 that nature in Metro Vancouver provides $5.4 billion of ecosystem services per year, or $2,462 per person per year through climate regulation, air quality, flood protection, water supply, pollination, tourism, and local food production services (Wilson 2010). Increasingly, more and more aspects of nature are being incorporated into these kinds of valuations as the connection between nature and the physical, mental, and spiritual health of people are better understood. MNAI has gone on to conduct 10 more pilot assessments as they did for Gibsons across Canada.

Chapter 3. Case Context and Methods

3.1. Metro Vancouver context for GI as a response to Climate Change and Biodiversity Loss

Metro Vancouver (formerly Greater Vancouver Regional District or GVRD) is a regional government comprised of 21 municipalities (including City of Vancouver), a treatied First Nation (Tsawwassen), and one electoral area. Metro Vancouver is home to approximately 2.5 million residents as of the 2016 census and is the third most populous metropolitan area in Canada. The Metro Vancouver government takes responsibility for delivering regional-scale services: drinking water, wastewater treatment and solid waste management. They also regulate air quality, urban growth, a parks system, and affordable housing. In addition to these core services, it also plays a role in planning and regulatory responsibilities and serves as a forum for discussion of significant regional issues. The regional district is governed by a board of directors made up of appointed elected officials from each local authority, and has a number of committees with specific mandates (eg. Parks and Climate Change) also made up of appointed elected officials.

Metro Vancouver was initially established as multiple authorities that managed sewage and water resources. The Greater Vancouver Sewerage and Drainage District (GVSDD) and Greater Vancouver Water District (GVWD) created in 1914 both predate the GVRD. In 1949 the Lower Mainland Regional Planning Board was created, and the GVRD formally established in 1967. In 1972 the GVSDD and GVWD were consolidated into the GVRD. Regional plans produced in 1966, 1976, 1986, and 1990 were based on extensive consultation and revolved around managing urban growth through the creation of distributed town centres, job creation, transit, and preserving farmland and parkland (Smith, Oberlander, and Hutton 1996). The vision statement from the 1990 Creating Our Future plan sets out a strong rationale for the inclusion of green infrastructure planning under their purview:

> Greater Vancouver can become the first urban region in the world to combine in one place the things to which humanity aspires on a global basis: a place where human activities enhance rather than degrade the natural environment, where the quality of the built environment approaches that of the natural setting, where the diversity of origins and religions is a source of social strength rather than strife, where people control the destiny of their community; and where the basics of food, clothing, shelter, security,

> and useful activity are accessible to all. (Greater Vancouver Regional District 1990)

In this way Metro Vancouver has both a long history of regional service delivery of water management, in addition to aspirational collaborative planning where human activities 'enhance rather than degrade the natural setting' and 'quality of the built environment approaches that of the natural setting.'

The province of British Columbia (BC) employs a regional district model of governance that helps in dealing with local issues that are beyond the scope of individual municipalities, and not quite at the scale of the province (Bish, Robert L; Clemens 2008). This has been made necessary as challenges and development patterns of the 20th and 21st century spill issues beyond the bounds of individual cities (Rosentraub and Al-habil 2008). Typically regional collaboration has been inspired as a response to economic stagnation, however, the concentration of a regional government can provide more effective responses to the management of growth-related land use planning and environmental issues as well (Rosentraub and Al-habil 2008). In faster growing areas, where vacant lands disappear and environmental threats arise more quickly, unified regional collaboration can be helpful in mitigating more narrow self-interests of individual cities, produce better long-term land use policies, in addition to taking advantage of efficiencies of scale for region wide services delivery (Rosentraub and Al-habil 2008), increasing advocacy and bargaining potential with higher level governments, and reduce the risk of being taken hostage by more powerful self-interested local authorities (Lefevre 1998).

Following this reasoning, it could be said that while adapting to climate change may seem unlike other types of service delivery, the efficiencies of scale achieved through adopting something that would support a regional green stormwater infrastructure approach could provide a collective ecosystem service benefits if approached at a regional level. "Local government officials – regardless of the level of fragmentation that exists – realize that cost-effective way to manage the financing of infrastructure and growth can lead to lower taxes and more competitive positions for their region" (Rosentraub and Al-habil 2008). There is also increasing justification for regional approaches due to a governance gap, or lack of governance capacity, for things like environmental protection and infrastructure services particularly in North America and Europe (Wallis 1998). As such, one of the five main goals of Metro Vancouver's

2010 Regional Growth Strategy is to ‘protect the environment and respond to climate change impacts.’

The fact that many aspects of water services are already managed at a regional scale in Metro Vancouver (drinking water reservoirs, water quality and treatment of both potable water and sewage) it is not a large leap to suggest that there are ways to apply regional concepts and efficiencies of scale to green stormwater infrastructure within cities, particularly for those natural features that span across cities’ boundaries.

Metro Vancouver is unique as a regional government in that it acts as a hybrid between a formal institution and one grounded in consensus and collaboration (Friesen 2014). As it operates, Metro Vancouver falls more squarely within the concept of ‘new regionalism’ referring to regional agreements or assemblies providing a forum for existing local governments to collaborate and cooperate with one another, as opposed to being strictly either an authoritarian regional government (progressive or metropolitan reform) or a dissociated informal regional collective with no mandate (polycentric or public choice) (Friesen 2014). In new regionalism, cooperation can be carried out on a fluid and voluntary basis among local governments that can regulate themselves through horizontally linked organizations (Savitch and Vogel 2000). In addition, new regionalism emphasizes the importance of collaboration between private industry, non-profits, and civil society in decision making, policy, and service delivery innovation and in this way a regional government’s role changes from a “…provider of solutions to enabler or partner in problem-solving” (Bradford and Bramwell 2014).

There is also the opinion that modern day regions, and Metro Vancouver specifically, may actually be suffering from a lack of authority in the face of an increasing number of problems that are regional in nature, what Oberlander and Smith (2006) call an “accountability crunch”. Regional authority needs to be ‘reconceptualized’ based on an assessment of what governance mechanisms have worked or failed to solve the problems of an increasingly urbanized world (Oberlander and Smith 2006). In creating new conceptions that include collaboration with other levels of government, non-profits, private industry, and civil society, the challenge will be to remain effective and efficient without losing democratic participation and autonomy of local governments in the process (Savitch and Vogel 2006).

Decision making is ultimately the responsibility of the board of elected officials representing the local authorities, though the process of arriving at these decisions involve engagement, consultations, and collaboration with various local actors. The balance of power in decision making between local authorities and the extent to which local actors and local authorities can influence decisions in Metro Vancouver is the subject of research by Mark Friesen (2014).

Notable moments in the history and evolution of Metro Vancouver's governance could serve as examples to moving towards regional green infrastructure coordination. For instance, in 2006, the provincial Minister of Transportation, Kevin Falcon, announced a panel to review Translink's (a regional transit authority) governance framework, noting there was "…too much focus on local backyard politics…" (CBC, March 2006). In 2007, the governance structure was altered so that an independent Board of Directors would be appointed for the Translink authority by the Mayor's council of Metro Vancouver, and there would no longer be direct involvement of Metro Vancouver board members (elected officials) in transportation discussions or decisions for the region.

The 2011 Regional Growth Strategy (RGS) carried on in the tradition of past regional plans from 1966-1996 with an emphasis on sustainability and urban growth management. However, the RGS has gone further than past regional plans to outline specific expectations and actions required for Metro Vancouver, municipalities, the provincial government, and Translink under each of five broad goals (Metro Vancouver 2011). The RGS outlines a "collaborative decision-making framework" designed such that "…the more regionally significant an issue, the higher the degree of Metro Vancouver involvement in decision-making" (Metro Vancouver 2011). Importantly though, the modifications to the local government act (1995) that allow for the creation of regional growth strategies result in a framework that cannot compel other entities or other levels of government to work towards the goals set out by a regional district (Friesen 2014). In an important example that relates to the management of green space, The Township of Langley won a supreme court case where they challenged Metro Vancouver's authority to enforce one particular aspect of the RGS. Namely the Township sought to develop within a "Green Zone" established by Metro Vancouver to protect those areas from development. Metro Vancouver declined the Township's application to exempt the area, the Township challenged this decision, and ultimately the supreme court of BC ruled in the Township's favour stating that "…a regional district's

planning and land use management powers do not apply to those parts of the regional district that are within a municipality" (BCSC 414 2014).

Ultimately Friesen (2014) concludes that Metro Vancouver may have over-reached in its more prescriptive approaches to the RGS and "doing so compromised the degree to which a forum of the type envisioned under new regionalism was realized." Further, the approach and outcome of the RGS restricted horizontal cooperation between local authorities, non-profits, private industry, and civil-society. The process also may have restricted vertical cooperation with senior levels of government, which Friesen notes "may be a critical dimension to deal effectively with regional issues, especially political issues such as land use planning" (2014). Metro Vancouver should then be cautious of prescriptive approaches to regional issues, and instead seek collaborative approaches to problem solving more consistent with new regionalism.

Using planning as an example of a discipline, Graham argues that current professional planning practice and legislation does not equip planners to effectively navigate the political context of climate change adaptation because they work between politicians and the public in the Metro Vancouver context (Graham 2016). Graham sees an important role for organizations outside of formal decision-making authority to play in adaptation planning to help address this mismatch between the best available knowledge and forward-looking practice (held by planners) and decision making power (held by politicians). For this reason, Graham also implores that planners revisit the role that a revitalized advocacy planning practice could play in climate change adaptation. As Davidoff (1965) writes, the planner should also be a proponent of substantive solutions aligned with the public good, and not just a provider of information to decision makers.

With all this being said, there is potential for many important opportunities within the realm of GI and natural asset management at the regional level that come in the form of substantive solutions providing collective and shared benefits without compelling local governments to adopt them. Finding the right opportunities is the challenge and core to the purpose of two workshops hosted by SFU's Adaptation to Climate Change Team that took place in late 2018 and early 2019.

3.2. Workshops' Methods

Two workshops hosted by Simon Fraser Universities' Adaptation to Climate Change Team (SFU ACT) in late 2018 and early 2019 form the primary research of this paper. The workshops invited professionals from across Metro Vancouver and asked how GI could be advanced as a response to climate change and biodiversity loss at a regional scale across Metro Vancouver.

The workshops are an example of social innovation and design thinking that orient research as an interdisciplinary, collaborative, problem solving exercise. A social innovation approach, outlined in section 2.1.3 provides an added value to participants making space for creative solutions to address wicked problems at the intersection of biodiversity loss, climate change, and urban land use. Rather than survey or interview based research, this approach seeks to provide an opportunity for shared learning and generative thinking about problems and solutions as it relates to the subject of this research.

The first workshop on November 23rd, 2018 included 47 participants largely environmental staff and planners from local governments in the Metro Vancouver region, as well as non-profits and academics involved in related work. The workshop consisted of three presentations and table discussions on how green infrastructure could be planned with the intent of reducing impacts on, or even enhancing, biodiversity health as climate change and land use alters the landscape of Metro Vancouver. The three presenters and their topics included:

- **Dr. Laura Coristine**, University of Calgary: Landscape Connectivity and Biodiversity Health in a Changing Climate
- **Pamela Zevit**, South Coast Conservation Program: Holistic Habitat Restoration for Species and Ecosystems at Risk
- **Mike Coulthard**, Diamondhead Consulting: The City of Surrey's Biodiversity Strategy and Adapting Municipalities for Biodiversity Health

Following the three presentations, participants were asked to imagine Metro Vancouver as a world leader of biodiversity focused green infrastructure, and to then name milestone achievements that would aid in reaching this vision. Participants

engaged in table-based discussions (roughly 6 persons per table with a notetaker at each) focused on answering the following questions in this order:

1. If Metro Vancouver were a global mecca (a world leader) of biodiversity-focused green infrastructure, what would it look and feel like?

2. What would be the major milestones on the path to achieving that vision?

3. How would governance, institutions, policies, politics, culture, education, your organization, and citizens have to adapt or transform to make that vision possible?

A second workshop hosted on February 22, 2019 sought to investigate how an interdisciplinary and intergovernmental (or regional) approach to green infrastructure might work and what challenges and benefits might arise. The workshop included 16 participants, primarily local government staff from municipalities within Metro Vancouver selectively chosen for a balance of disciplines including engineers, planners, accountants, and environment staff. Three main topics were discussed broadly: 1) collaborating across disciplines, 2) taking a regional approach, and 3) developing an interdisciplinary green infrastructure community of practice.

A summary of these workshops is prepared and summarized in reports published by SFU ACT and these summary reports form the basis of results for this paper. A content analysis of the workshops' results can be found in Chapter 4Chapter 4.

3.3. Assumptions, Limitations, and Scope

The workshops' results rely on relatively open-ended questions and open table discussion, rather than targeted specific questions that would result from a survey or interview style research, or purely literature reviews. This style of research sacrifices control and precision in preference of offering an opportunity to see other perspectives, shared learning, and generative brainstorming in real time. Discussions were captured by a group of volunteers, so there is certainly inconsistency in the style and way that discussions are reflected in the synthesized results. The open nature of the workshop style also allows for a large breadth and scope of results, some of which fall outside the scope of the primary goal of this research and some which necessarily also expand the breadth of this research since all systems for discussions are interconnected.

Chapter 4. Results

The following results provide a content analysis of proceedings from the two workshops described in section 3.2**Error! Reference source not found.**.

4.1. Workshop 1: Metro Vancouver 2050 - A Mecca of Biodiversity-Led Green Infrastructure

4.1.1. Envisioning a Biodiverse Metro Vancouver in 2050

Participants crafted a multi-faceted vision of Metro Vancouver's biodiverse future, captured in narrative format in the following paragraphs. The descriptions below are primarily qualitative in nature describing the physical state of how it looks and feels like, and how governance and institutions are structured.

Urban environment as nature experience

The urban environment becomes multi-functional and natural. Nature isn't something you 'get out' into on the weekends; it is something you experience every day because you are already in it as you move through the city. Bike and walk commuting are a nature experience in themselves.

Transforming the Physical Urban Environment

Participants noted many physical alterations to the way the physical environment would look and what kinds of services new structures would perform. Natural refuge from heat and sound for people and wildlife alike is spread all over the city. Roads and pavement become less common due to better investments in transit and more walkable and bikeable neighbourhoods, allowing the repurposing of roads into greenways. Roads that are left are permeable to water and reflect heat instead of absorbing it. Neighbourhoods employ fused grid systems decommissioning and greening inner streets to use as multi-functional natural areas, providing traffic calming and safer neighbourhoods. Underneath roads are natural wildlife passageways that allow species to travel throughout the city.

Rather than upgrading to larger culverts, creeks and streams are more routinely daylighted. Living dikes become common as coastal-edge habitats provide enhanced

ecosystems and connections between marine and terrestrial life while protecting against sea level rise. Neighbourhood spaces and yards are nature-scaped. Parks are reconfigured to maximize biodiversity health in concert with human use. The urban forest is home to a diversity of mostly native tree species adapted to local conditions, and canopy cover reaches 45%. Boulevards, gardens, public lands, and rights of way are intentionally designed to provide pollinator- and wildlife-friendly spaces. Riparian areas connect across landscapes irrespective of city boundaries.

Communal grey water in multi-family dwellings is treated on site and recycled for use in drier summer months to irrigate vegetation and provide water sources for wildlife. Green infrastructure manages on average 90% of the water, making the capacity to treat stormwater even better than present-day levels. Buildings are designed to provide shade for people and wildlife, and commonly employ living walls and green roofs, storing and treating runoff as well as providing habitat for birds and pollinators. The vertical landscape provided by the built environment supports a diversity of features that provide refuge for wildlife to thrive in.

Benefits of Regional Governance

Metro Vancouver's adaptive governance and regional planning approach attracts designers and practitioners from around the world to employ novel and innovative green infrastructure solutions. Cutting-edge technological advances (e.g., 3D design and printing) allow for the sharing and modifying of green infrastructure design, and eco-mimicry and bioengineering is cheaper and easier to employ. Accessible green infrastructure designs for private property (bioswales, green roofs, planting prescriptions, etc.) are readily available and ubiquitously offered by trained installation technicians—a burgeoning employment opportunity within Metro Vancouver that becomes a unique specialty and economic driver for ideas and services that are exported worldwide.

4.1.2. Milestones Required to Achieve the Vision

Building on the vision for what Metro Vancouver might look like if it were a world leader in biodiversity-led green infrastructure, participants identified major milestone achievements that would be required to achieve the necessary shifts in governance, politics, culture, education, policy, and institutions. Participants also considered what

transformations might be needed in their organizations and their own personal and professional practices.

The following themes emerged:

- more adaptive and integrated governance;
- regional green infrastructure planning process;
- collaboration across the Salish Sea;
- integration within and between institutions, teams, and organizations;
- a shift in the legal landscape;
- financing green infrastructure;
- leveraging the development community;
- more general shifts in society, education, and culture.

More Adaptive and Integrated Governance

The most commonly proposed solution was a move toward more adaptive governance at all levels that was more integrated, interdisciplinary, and interjurisdictional, and led by a more robust regional government mandate to connect green infrastructure. This would require Metro Vancouver to play a larger role in bringing municipalities together and facilitating development of an integrated green infrastructure planning process. This could be achieved through broadening the mandate of the regional growth strategy. This planning process should also complement and support First Nations' efforts in land-use planning. This presents an opportunity to recognize the authority, knowledge, and understanding that First Nations bring in this context, in order to further inform a green infrastructure approach focused on biodiversity and social-ecological systems planning.

Regional Green Infrastructure Collaborative Planning

With an enhanced mandate and clearer jurisdictional authority, Metro Vancouver—in coordination with, and support from, other levels of government—could lead development of a regional green infrastructure master plan and planning process that would empower communities, build capacity, and facilitate a more cost-effective approach to green infrastructure. This planning process would recognize the importance of prioritizing critical migratory corridors, refugia, and future habitats as part of climate change adaptation and mitigation, while supporting existing species and habitats.

Regional, cross-jurisdictional landscape-level green infrastructure pilot projects would increase cost effectiveness through shared investment, demonstrating additional benefits of a holistic approach to caring for natural assets. Components of the plan might include: targeted no net loss of greenspace or natural areas; development of a green infrastructure code, modeled after the BC Energy Step Code, geared toward promoting and incentivizing biodiversity-focused approaches; watershed-level planning and strengthening of the Water Sustainability Act, and; regional Integrated Stormwater and Watershed Management Plans.

Collaboration across the Salish Sea

To be truly effective, a regional planning process would make efforts to connect to transboundary interests on both sides of the Salish Sea, namely between Canada and the USA, as well as overlapping Coast Salish First Nations. This could be modelled after the transboundary working group, Shared Waters Alliance (Boundary Bay–Puget Sound), or larger landscape partnerships like the Yellowstone to Yukon Conservation Initiative and the North Pacific Landscape Conservation Cooperative. A transboundary coastal planning process would recognize the additional challenges and potential synergies that come with working to protect the ecologically-important biodiversity hotspots represented by the estuaries and upland ecosystems of the Salish Sea. This is especially important as these areas are currently facing historic levels of urbanization and habitat loss.

Integration within and between Institutions, Teams, and Organizations

Adaptive, collaborative, and integrated governance would be supported through embedding a transformative whole-systems approach in departments and organizations responsible for land-use decision-making. Sustainability would be positioned as a central, common goal in an organizational environment where it would be typical for diverse interests to work together and collaborate toward innovative solutions to complex problems. Departmental silos would be broken down through innovative information sharing and planning frameworks that incorporate an inter-disciplinary, interjurisdictional approach. This approach would expand to relationship building with post-secondary institutions that work to apply this transformative model in education and internal organizational training.

A Shift in the Legal Landscape

In this future vision, the rights of nature, and of people to have access to healthy ecosystems, are recognized and protected. This would be manifested through a restructuring of rights and constitutional reform, acknowledging the right to a healthy environment both equitably for all and temporally (for future generations). This would be accomplished through giving ecosystems better protection from harm (e.g., the Fraser River could be given personhood status, similar to the Whanganui River in New Zealand). The understanding that nature is inextricably intertwined with humanity's health and well-being would be normalized. Perceptions of public safety would shift from being short-term, reactive, and incident-driven to a long-term, proactive approach. The model of the Agricultural Land Reserve, which protects prime farmland across BC, could be used as an example of how to protect high-priority urban natural areas, as well as providing for a multi-functional landscape that supports people and wildlife alike. Policy would be evidence-based and founded on the precautionary principle, reducing the likelihood of support for unsustainable practices. These models and approaches are also integral to reconciliation with First Nations, shifting from colonial ways of thinking about land ownership toward a more balanced stewardship approach that reflects Indigenous knowledge and ways of being on the land and with each other.

Paying for a Greener Future

Money does grow on trees, in the form of the valuable ecosystem services they provide. Development of a robust natural asset management framework and valuation methodology for local governments would help to position green infrastructure as a critical priority. To be effective, this approach would need to be fully incorporated into asset management systems, beginning with alterations to Public Sector Accounting Board regulations to allow for inclusion of natural assets in annual reporting. A broader understanding of the risks of inaction would shed light on the harm of discounting the existing and future value of natural assets. A regional green fund would be established to ease the bur- den on municipalities to fundraise independently and bolster their capacity to find further funding for green infrastructure projects. Administered at the regional government level, the fund would incentivize collaboration between and across municipalities. Regional governments would carry the weight of acquiring funding from other levels of government (provincial, federal, international) so that municipal staff could spend less time in lengthy and complex fundraising processes. Municipalities would also

generate revenue from reimagined or redeployed mechanisms including: stormwater utility fees (e.g., the City of Surrey model); development cost charges and/or community amenity contributions; a green fund or green utility that would incentivize protection of natural areas and disincentivize damages to biodiversity in the same way as a carbon tax or pollution fine.

Connecting Development and Biodiversity Health

Property development processes also would acknowledge and mitigate damage to biodiversity. This could be realized through a green fund/utility. Salmon Safe certification is an example of a proactive process underway in urban and rural areas of BC and the Pacific Northwest that incentivizes green infrastructure practices through recognition and certification. This could be taken one step further by evolving such an approach into a green code incentive program for developers that employ best practices as simple as keeping trees or planting native species, to more robust features that manage stormwater like green roofs, living walls, and maintenance or enhancement of creek systems. Development that demonstrates best practices in this regard could also be prioritized by development permitting staff.

More detailed development and zoning bylaw requirements might include: tax or ban on turf lawns; requirement that 50% of undeveloped land meets topsoil specifications; brownfield development prioritized over greenfield; increased setbacks from ocean, stream sides, and wetlands; reduced footprint of construction, and more emphasis on higher-density, multi-family homes; industrial land that includes green infrastructure on site.

A regional government empowered with a stronger green infrastructure mandate could also pursue a more strategic, harmonized, regional development permitting process and/or zoning that focuses on maximizing ecosystem benefits. Scaling up urban agriculture could work to diminish some of the need for high-intensity farming methods on traditional agricultural land. Incentives to encourage biodiversity-friendly farming approaches (e.g., the Environmental Farm Plan program) can contribute to increasing economically-viable products while creating productive wildlife habitat.

Society, Education, and Culture

The natural setting of Metro Vancouver attracts many nature lovers, ideally positioning our region to encourage awareness of the value of the natural world. Health researchers have already acknowledged the inherent connection between nature, mental health, and well-being. A change in priorities would allow green infrastructure to provide solutions rather than barriers to pressing social issues like inequality by providing access to natural assets more broadly. In this vision, shared natural spaces facilitate unstructured play and neighbourliness, and a new cultural paradigm aligns people around shared socio-ecological interests and NbS. Education for all ages centres on a common goal of sustainability, with a core tenet of integrating the value of nature. Art-based green infrastructure projects are led by youth empowered by their communities. Innovative citizen engagement and festivals draw people together to participate in creative solutions thinking.

4.2. Workshop 2: An Interdisciplinary Approach to Green Infrastructure in Metro Vancouver

4.2.1. Collaborating across disciplines

Themes that emerged from discussions about integrating interdisciplinary perspectives included:

- starting with needs-based objectives;
- considering co-benefits;
- organizing teams to reflect desired results;
- fostering understanding and communication across disciplines;
- acknowledging risk, loss, and responsibility as part of the change process;
- proving the value of NbS.

Starting with needs-based objectives

One of the main ideas to come out of the focus group conversations was the benefit of starting any infrastructure planning project by first understanding the needs it must meet before considering grey and/or green solutions. Needs do not have to be new; they can be adopted from already established goals and objectives; however, there should be opportunities to better understand their importance and incorporate any

priorities that may be missing. Determination of a comprehensive set of needs requires convening a diversity of disciplines and expertise. Once needs are established, objectives can be created to meet them in an integrated way, using whatever combination of grey and green approaches is most effective in order to meet the highest proportion of needs. New information and priorities can be incorporated as appropriate as the process is carried through to development and implementation of solutions.

Several participants noted that the choice to use grey or green solutions has often already been determined at project outset, based on pre-existing positions and assumptions that one solution is better than the other. Making such assumptions, rather than considering a holistic set of perspectives, can lead to missed opportunities and ineffective use of either grey and green infrastructure. These assumptions also result in tension and lost trust between, and even within, disciplines and teams. By developing a needs-based objectives process, the positional, pervasive dichotomy of grey vs. green and either/or thinking can be broken down and both/and thinking can take its place, increasing the potential to innovate with more effective hybrid grey-green solutions, while building healthier teams and work cultures.

However, incorporating holistic needs-based objectives raises a complex set of challenges. Both interests and barriers may change during the life of any project, so service delivery and civic infrastructure must be as adaptable as possible while striving to maintain a consistent approach to addressing and prioritizing fundamental, comprehensive sets of needs. Without this internal pressure, the four-year political cycle tends to shift government focus to short-term needs and solutions that may run counter to the long-term needs of citizens without widespread public understanding that this is the case.

These challenges illustrate the importance of a comprehensive level of needs, or project requirements, being strategically developed and represented through intentionally diverse teams. Difficult decisions and trade-offs will always arise, but diverse teams can unite in taking ownership of plans and agreeing to the reasoning for and timing of the trade-offs being made. Ensuring that leaders and decision-makers are aware of the importance of integrating needs for the sake of long-term cost-effectiveness, and the benefits of doing so, is essential to building support for these processes.

Considering co-benefits

In order to achieve needs-based objectives, it is important to consider the wide range of co-benefits (ie. those other benefits that arise as a consequence and side effect of implementing better practices) that different grey-green solutions can achieve, such as:

- mental, spiritual, and physical health and well-being;
- reduced emissions;
- equity, inclusion, and livability;
- biodiversity and ecosystem health;
- stormwater management and quality of outflows;
- improved life cycle and maintenance costs;
- jobs and quality of jobs created; and
- adaptability and resilience to challenges resulting from changing conditions such as population growth and climate change impacts.

Understanding the potential for achievement of these co-benefits increases the likelihood that teams can consider more innovative and collaborative solutions to maximize low carbon resilience and adaptability as well as the sustainability of infrastructure projects.

Organizing teams to reflect desired results

As mentioned earlier, it is important to include a diversity of disciplines early in planning processes. However, many institutions organize their teams and departments by discipline, which tends to result in segregated needs, objectives, and solutions; for example, city engineering, planning, and finance departments tend to have limited interactions. This traditional institutional structuring is increasingly failing to adequately address the complex challenges of the 21st century.

Another example is the siloing of budgets and costs within departments, making it difficult for two or more departments to share the costs (and co-benefits) of creating or sharing infrastructure projects and solutions, and tending to discourage collaboration before it can begin. Flexible co-funding models and natural asset management practices can help overcome this, but require that accountants, engineers, planners, and environmental staff be given space and time to work together.

Further, disciplines tend not just to be grouped together in departments, but also physically, e.g., on the same floor or at adjacent desks. This structural siloing likewise discourages interaction and idea sharing across areas of expertise and can lead to lack of shared understanding and objectives across organizations, missed opportunities, and the emergence of unexpected problems. In the context of green infrastructure, such bureaucratic segregation is leading to increasingly inadequate results. As one participant noted, “In the end, we have grass.” Shuffling and reorganizing teams both physically and structurally—or even just raising awareness of the lack of diversity in teams—has the potential to improve the comprehensiveness and effectiveness of infrastructure planning.

Fostering understanding and communication across disciplines

In order to encourage interdisciplinary collaboration, efforts must be made to ensure teams are given space and time to develop common understanding. The ability to communicate across disciplines is key to building trust, shared language, and common understanding. Achieving this is a crucial skill set that can be learned and improved with practice, but often does not get much attention.

Participants shared a variety of insights into this process. One approach to fostering interdisciplinary discussion is to pose otherwise challenging ideas as hypothetical ‘what if…’ brainstorming exercises. This exercise activates the imagination and allows for sharing new ideas and generating innovative solutions in an open, creative, and supportive environment without the pressure of justification within existing contexts. Imagining new solutions together is enjoyable if the opportunity is framed the right way. Another tip is to share ideas with allies outside of one’s discipline and team, as this process can help unlock important perspectives that may otherwise be inaccessible. The creation of a regionally-based community of practice focused on employing NbS could aid in promoting such transdisciplinary understanding of planning and service delivery.

One suggestion shared by participants was to regularly incorporate collaboration skills training as part of both professional education and continuing professional development (CPD). Focusing more CPD opportunities on collaboration, and/or bringing leadership and collaboration experts in to work with interdisciplinary teams, could help organizations become more integrated. Professional programs or accreditation bodies

could also encourage or even mandate taking classes in other disciplines (e.g., planners taking engineering courses, accountants taking planning courses, etc.).

As noted above, starting with needs-based objectives is a great way to ensure that interdisciplinary collaboration happens in every process. The complexity of developing natural and hybrid grey-green solutions requires engaging across disciplines, combining expertise, and also working with the community. Adopting a needs-based approach to strategic grey/green infrastructure development would reinforce the benefits of non-siloed, interdisciplinary practice.

Acknowledging risk, loss, and responsibility in change processes

It is important to acknowledge, and where possible empathize with, the sometimes uncomfortable emotions and tension that individuals may experience as part of interdisciplinary work, as well as the fact that each individual's experience is different. Some level of risk, uncertainty, and loss will always be involved with change at a systems level. It is important to acknowledge who owns the responsibility for that risk and loss, and how that may affect their ability to meaningfully engage in change. Loss aversion is one of the main drivers of maintenance of the status quo, so if we want to overcome this mode of thinking, we need strategic ways to overcome this behaviour.

For example, engineers are responsible not only to their team but also to their profession; a failed solution can endanger an entire career. This responsibility can be exacerbated when a different department is in charge of designing a plan that is handed to engineers, putting them in the difficult position of explaining how or why it might not work or might infringe on their fiduciary duty. An environment in which unequal risk-taking puts only one discipline, team, or individual's livelihood or reputation in jeopardy has the potential to set up a process of conflict, fear, and adversity. At the same time, engineers hold a lot of power in decision-making, so their role and opinion are very important in working toward meaningful change. One potential solution could be to ensure that engineers are included throughout infrastructure planning and implementation processes from needs identification to completion, and that processes are made more iterative. Efforts to alleviate or distribute the responsibility and liability of engineers could pose challenges, but also potentially alter the level of risk aversion and open pathways to novel solutions.

Change is difficult and often perceived as risky; however, there are equal if not greater risks associated with continuing with the status quo that often go unacknowledged. The potential costs of inaction on climate change or other unsustainable practices are becoming increasingly significant, for instance, yet many people have difficulty acknowledging, assessing, and reacting to the likelihood of incurring risk and loss through maintaining the status quo. Proving the value of NbS

The combined challenges of climate change, biodiversity loss, and increasing urban growth require an integrated suite of strategic solutions, and a related shift in perception of the needs that infrastructure is fulfilling. Green infrastructure has the potential to deliver numerous co-benefits in addition to stormwater management. While in some extreme flooding cases, it may not deliver specific service needs as well as grey infrastructure, it is important to recognize that it may deliver solutions for other, less directly related needs, such as biodiversity health and improved property values. For many cities, objectives and regulations for infrastructure—related to stormwater management in particular—have historically been structured with grey infrastructure in mind, making it difficult to escape this pattern, since green infrastructure solutions are assessed by their ability to meet the same expectations as grey infrastructure. However, using a more sophisticated and forward-looking needs-based framework, many examples across the globe illustrate that green infrastructure can and does excel at meeting many of these challenges, and can be a useful complement to grey infrastructure that is increasingly overburdened by changing climate conditions, such as more intense rainstorms.

Another dimension to consider is the difference in lifecycle cost between green and grey solutions. Unlike grey infrastructure, most green infrastructure has the potential to increase in value over time with relatively little maintenance, and often has cheaper replacement costs than grey infrastructure. Traditional accounting systems have been designed to consider infrastructure as inevitably declining in value from the moment it is installed; however, natural asset management approaches (such as the Municipal Natural Assets Initiative) are working to value this unique aspect of green infrastructure as well as the benefits it provides.

Taking a systems-based approach to asset valuation contributes to improved understanding of the value of natural assets at the municipal level. For example, a forest

provides greater quality and quantity of benefits than individual trees, creating wildlife habitat, recreational space, flood absorption, air filtration, improved physical and mental health and well being, and more. Monitoring and evaluation methods that can capture these benefits are paramount to prioritization of green infrastructure and improved understanding of the value benefits NbS provide over time.

4.2.2. A Regional Approach to Green Infrastructure

Participants discussed the concept of a regional approach to green infrastructure in Metro Vancouver. Ecologically speaking, regional-scale approaches to ecosystem management, protection and restoration have been shown to benefit biodiversity through improved connectivity and availability of areas of refuge. Regional approaches also provide opportunities for other co-benefits by improving the ability to determine strategic needs at a larger scale. However, scaling up brings its own complex challenges. Themes that emerged from the discussion of a regional approach to green infrastructure included:

- overcoming jurisdictional and political boundaries, and
- understanding the benefits of a regional approach.

Overcoming jurisdictional and political boundaries

One advantage that a regional approach to green infrastructure might provide is in helping municipalities that are struggling to pay for infrastructure upgrades. At the jurisdictional level, responsibility from provincial and federal governments has been increasingly downloaded onto municipalities, and this is especially true in the context of both infrastructure and service delivery. Provincial and federal governments once provided more funding for infrastructure; however, up until 2015, an increasing proportion of costs had begun falling on municipalities with limited financial capacity. The federal Investing in Canada funding program, unveiled in 2016, allocated more substantial infrastructure funding to local governments, including funding specific to green infrastructure. However, participants noted a lack of capacity within municipal governments to apply for and secure this funding.

While Integrated Stormwater Management Plans (ISMPs), mandated through the provincial Liquid Waste Management Plan (LWMP), have set ambitious and helpful

objectives at a watershed and regional scale, they have ultimately proven to be relatively weak, with little accountability. More accountability, and stronger enforcement of water quality violations, would provide strong incentives to adopt green infrastructure, if higher levels of government step in to provide funding to avoid these violations. Unfortunately, water quality issues have not been prioritized, and in addition have been difficult for the provincial government to monitor, regulate, and enforce. Ensuring more stringent standards and requirements are in place could drive provincial and federal government resource provision designed to help address these issues for municipalities and First Nations.

One example of the need for more regulation and enforcement is in the case of three neighbouring Metro Vancouver municipalities, Vancouver, Burnaby, and New Westminster, which are dealing with a legacy of combined sewers, older sewage systems that do not separate sewage and stormwater drainage. High rainfall events can lead to combined sewer overflows (CSOs), in which untreated water and sewage flows into Burrard Inlet and the Fraser River. Conversely, during lighter rain events, a lot of relatively clean runoff water flows to water treatment plants, increasing the burden on these facilities. Replacing their combined sewer infrastructure is a high priority for these three municipalities; however, it is a costly and time-consuming process. Philadelphia and New York are demonstrating the important role green infrastructure can play in reducing overflows and unnecessary water treatment through absorbing and retaining stormwater before it enters the sewage system. However, without stronger regulation and enforcement, there is little incentive for these three Metro Vancouver municipalities to consider green infrastructure solutions, and the many co-benefits, to this situation.

Understanding the benefits of a regional approach

Participants shared a number of ideas regarding ways a regional approach to green infrastructure could benefit municipalities and citizens, including a coordinated regional vision with strategic objectives, and congruence through funding mechanisms, development schemes, and overall collaborative planning.

A regional approach could stimulate development of an already-burgeoning local green infrastructure industry that provides design, implementation, inspection, maintenance, monitoring, and evaluation of green infrastructure approaches, and allow for more standardization and consistency. Stratas, businesses, and property owners, for

example, are likely to increasingly require the use of these kinds of services, which could be funded or subsidized through tax incentives, such as the parcel tax used in the City of Colwood on Vancouver Island which allows for a more consistent and clear way to fund infrastructure and maintenance.

Participants also suggested that Metro Vancouver's regional growth strategy could be employed to freeze important pieces of land to secure natural assets. For this to be successful, the regional growth strategy would need the authority to demand growth in the areas where it is appropriate while preserving those natural areas required to serve residents in the future.

Increasing opportunities to pool resources and share data across municipalities could also help. Regional bodies like the Stormwater Interagency Liaison Group are a good start, but its objectives are not integrated with disciplines aside from engineering, e.g., it does not incorporate environmental objectives. The Stormwater Interagency Liaison Group could meet with the Regional Planning Advisory Committee and other regional bodies to identify opportunities to meet broader objectives collaboratively.

4.2.3. Developing An Interdisciplinary Community Of Practice

In advance of the focus group, participants completed a survey designed to provide insights into useful ideas and perspectives to explore in the context of green infrastructure and its co-benefits. Respondents were asked about their interest in participation in a green infrastructure interdisciplinary community of practice (CoP). Many responded that their participation would depend on what was involved, and we had a brief conversation about what this might look like. Participants expressed interest in a CoP that would:

- be led by someone external to government;
- help them with collaboration, integration, and sharing resources;
- create a safe space to share what is working and what is not;
- explore opportunities to partner with other cities; and
- involve disciplines from professionals to government staff, including developers and consultants.

Some participants are already involved in CoPs of their own, such as the Green Infrastructure Leadership Exchange which is made up of over 40 municipalities. The City of Vancouver has also been involved in a knowledge exchange with Seattle, Rotterdam, and Amsterdam.

Chapter 5. Discussion

The results of SFU ACT's two workshops reveal a variety of challenges and opportunities associated with GI that a more integrated regional and interdisciplinary approach may help to address. There are some tangible and innovative ideas generated by the very practitioners that would see them implemented. With that said, there still remains a large gap between the ideas generated and the methods and conditions to execute these at a structural or governance level. Within a social innovation framework, these two workshops have begun to surface step 1, seeing the system, that includes brainstorming potential solutions and ideal scenarios without getting to real design or prototyping more robust solution sets (steps 2 and 3) (Westley 2012). Ideas emerged from all sectors and scales including financial instruments, legal and constitutional fixes, reconfiguring organizational structures and work flows, specific land-use planning and cultural / ideological. Arguably all are reasonable pathways to explore given that many are rooted in solutions found to be already at work elsewhere in the world, though further work could be done to further design, prototype, and if deemed reasonable test the success and validity of these in the Metro Vancouver context.

For the purposes of discussion and attempting to further a set of solutions for future workshops, this section will focus on two key themes that emerged from the workshops, a regional approach, and a collaborative interdisciplinary approach. The below sections assess feasibility and potential outcomes that a regional and interdisciplinary approach to green infrastructure might offer to address climate change impacts, biodiversity loss, and stormwater service delivery based on what has been gathered through the workshops, literature reviews, and social innovation context in chapters 2, 3, and 4.

5.1. Regional Biodiversity Planning in Metro Vancouver

The desire from participants for an enhanced mandate for the regional government poses a central idea to allow more consistent deployment and collective benefits that regional governments are well positioned to advance as discussed in section 3.1. The suggestion to include the enhanced mandate in the Regional Growth Strategy update for 2021 could be an important move, however, it remains to be seen

how this would best be framed so that it manifested meaningfully, and to what extent member municipalities of Metro Vancouver would react to an enhanced mandate and authority.

There is a lot of alignment between the results of the workshops and broader research that regional and integrated approaches to GI provide for greater collective benefits if alignment can be achieved between their representative municipalities. Policies, financial mechanisms, funding, and bylaws enacted at a regional scale alongside research and data sharing that would identify regional priorities would most certainly come with collective benefits, especially in an area like environment protection where there is a significant governance and capacity gap for municipalities alone. Under current practices, Metro Vancouver has not typically taken an authoritative position to mandate any of these, and arguably would be quickly checked by its own governance structure as in the example of the green zone and the supreme court decision in 2014 siding with Township of Langley laid out in section 3.1. The challenge is that a more authoritative change cannot come from within the regional government, it must be called for by municipally elected officials themselves which is where external organizations and the provincial government can support these efforts.

The example of the BC government stepping in to form an independent board to manage public transit (aka Translink) at a regional level could serve as an example of how green infrastructure and NbS could be managed and mandated at a regional scale, through an arms length body appointed by something like a mayors task force. This sort of step would have to be considered carefully due to the specifics of how land use legislation is laid out in the local government act, and may be better suited to aligning itself to provide collective shared benefits such as working with provincial and federal governments to form a regional GI fund, and/or working with developers to provide incentives for GI practices at scale, rather than punitive or exclusionary measures such as containment zoning or additional taxation of an already overburdened municipal system.

Financial and legal instruments were also discussed which would definitely require more work to understand how each would be deployed in a locality or at a regional level. Natural asset management practices are gaining traction, and have been deployed at site scale, municipal scale, and more recently at watershed scale in the

case of Comox Valley. Natural asset management deployed at a regional scale for assets shared between municipalities could be an intriguing opportunity though exactly how best to do this remains to be seen. Differences in resources, capacity, political alignment, and needs between municipalities adds a level of complexity that may often be challenging to overcome – though there may be opportunities like the case of Still Creek between Vancouver and Burnaby (Boyle and Nichol 2017). Proving that natural assets are capable of cost-effective service delivery will continue to be a key to the deployment of NbS and supporting natural asset management practices at a regional scale is a compelling collective benefit, even if just for regionally owned natural assets.

Other financial tools relating to land development such as development cost charges, community amenity contributions, fines, or utility fees, are all possibilities to boost GI at a local scale. All of these are deployable at a municipal scale, and can be adopted if it suits the locality. The idea of collecting these at a regional scale for a regional fund may be challenging since municipalities are short of funds as it is and will be eager to hold these for themselves, though perhaps additional funds could be sought through the provincial and federal governments from available infrastructure funds.

One key governance consideration is that Metro Vancouver does not represent, let alone have a mandate or any official framework for how it engages with First Nation's communities, except for Tsawwassen First Nation who signed a tri-partite treaty in 2009 with federal and provincial governments. Because Metro Vancouver is beholden to their member municipalities through their boards made up of municipally elected officials, there would first have to be more robust mandates agreed upon by municipalities that First Nations and Indigenous rights should be respected through an enhanced mandate of engagement.

As the province of BC have jurisdiction over municipalities through the Local Government Act and have more considerable and legislated responsibility to First Nations, particularly since the recent Declaration on the Rights of Indigenous People's Act (Government of British Columbia 2020), perhaps there is potential here to enact policies or legislation that would give Metro Vancouver a more meaningful mandate in how it engages and liaises between municipalities, First Nations, and the province. If left to municipalities, it seems unlikely that they would arrive at some unilateral approach to engaging First Nations in land use and decision making which excludes a significant

recommendation laid out by the IPBES. Indigenous groups are often more aligned with NbS, and are one of the strongest strategic levers for a more holistic and integrated approach to GI (Diaz et al. 2019). A further exploration of how all levels of government and non-government organizations might contribute to being more inclusive of First Nations at a regional scale might surface other pathways towards more holistic use of GI and NbS.

While an integration of GI could have collective and shared benefits at a regional scale, its unclear exactly what role Metro Vancouver regional government is best positioned to play and how well it can play it. What is clear is that Metro Vancouver is not in a position to do it alone – it requires external actors to assist and apply pressure if they desire a more substantive change. A more in-depth investigation of how external organizations and the province could help to unlock collective benefits of GI could unveil some important opportunities at the regional scale.

5.2. Integration of disciplines, institutions, teams, and organizations

Another prominent theme emerging from the workshops was a strong call from participants for more integrated governance, disciplines, and institutions. This call aligns closely with recommendations featured prominently in IPBES summary for policy makers (Diaz et al. 2019).

In terms of improving interdisciplinary work, a few ideas from the workshops align closely to concepts found in the research laid out in Chapters 2 and 3. There is a well recognized gap in shared understanding between disciplines that needs to be met. Beginning with leadership rooted in a place of mutual understanding can lead to more balanced and innovative outcomes with multiple co-benefits. The example of starting an infrastructure planning process with an interdisciplinary cross-departmental team, and discussing needs-based objectives could help some institutions to undo routinized procedures and seek more innovative pathways. As every department and institution has its own power struggles and authority flows, using a more comprehensive needs-based objectives rather than value-based or status quo decision making is one pathway that could often lead to more GI, since in many cases it is proven to deliver more benefits and address multiple needs. This does require having a comprehensive

understanding of needs, how they interrelate, and knowledge of possible solutions that meet those needs ready at the outset of a planning process, since the life of infrastructure is long and difficult to change once put in place. All of this speaks to the need for more capacity and skill building for interdisciplinary styles of work that foster better understanding across disciplines and innovative solutions.

For existing staff, a typical pathway would be to incentivize professional development training programs, though establishing a community of practice where municipal staff from across the region could share knowledge and solutions may also aid in this, and provide other unknown and emergent collective benefits. For students who will be the future of GI, revising post-secondary curriculums would be helpful, but another more integrated pathway could be to make informal partnerships between various disciplines and municipal governments. For example, City Studio connects students of many major post-secondary institutions with City of Vancouver staff on projects. A similar partnership could be coordinated at a regional level which would bring with it integration and the potential for shared projects between municipalities.

A regional interdisciplinary community of practice centred on advancing GI and NbS facilitated by a University or other type of non-governmental organization if done well could help to fill capacity gaps, increase cross-jurisdictional and interdisciplinary collaboration. This organization should bring with it capacity to lead inclusively by calling actors in including First Nations, other levels of government, and non-governmental orgs. Deploying a social innovation style lab with this in mind could serve as a good road map for how to go about forming this kind of a community of practice.

One of the most unique and specific themes of the workshops is in understanding the practical aspects of deploying GI through the eyes of an engineer. There appears a vast inequality and consequence of risk being shouldered by professional engineers due to the uncertainty in deploying GI and the responsibility they hold to their profession. This unequal element of isolated risk, whether perceived or real, has very real implications for a city in its ability to deploy GI at scale to meet the demands of 21st century challenges. This challenge is a fundamental mismatch of shared understanding, power structures between departments and disciplines, decision making, and ultimately demonstrates perfectly how a system and work flow that is not integrated, not adaptive, not inclusive, not addressing power differences, and not

innovating can actually create vastly more risk for the future of biodiversity, urban areas, and humans ability to adapt to and mitigate these challenges.

There are many ways to think about addressing this challenge including changing how risk is distributed, how other disciplines are involved in design and decision making, how engineering is taught at educational institutions, and changes to liability laws and regulations that effectively handcuff engineers and municipalities to status quo solutions. In the example of City of Philadelphia, they have had a long and successful integration of GI as a method to address combined sewer overflows and integrated watershed management dating back to the late 1990s largely inspired by a need to meet regulations laid out by the EPA in a very cost effective way (pers comm. Noon 2019)

Employing adaptive leadership techniques can help challenge risk aversion at the institutional level and help overcome expectations that things must stay the same:

...leadership is not about meeting expectations; it's about challenging them. It's about telling people what they need to hear—especially when what they need to hear differs from what they want to hear. Challenging people's expectations generates resistance and pushback… Adaptive leadership is uncomfortable because it involves helping people through loss (Bernstein and Linsky 2016).

Adaptive leadership identifies and acknowledges with empathy the potential loss in a process of change, while providing new ideas to help confront major systemic issues such as climate change. For an institution, team, or individual, growing accustomed to change and risk is a process in itself and requires trust, leadership, and relational approaches to allow room for that process.

Chapter 6. Conclusion and Recommendations

Overall, there appear to be important ways that a more intentional regional and collaborative approach to GI could be advanced in the Metro Vancouver context, with an eye to address climate change and biodiversity loss. As the scope of research is broad and open-ended, the conclusions and recommendations are also broad touching on ways to approach interdisciplinarity, regional collaboration, and shifts in policy that could encourage a novel and effective approach to GI. Each of the recommendations below require more investigation to understand exactly if they would be effective and how they would best be executed. This falls in line with social innovation process and these results could inform step 2, designing and prototyping solutions. These preliminary recommendations are provided here as a rudimentary menu of options that can be pursued collaboratively by various organizations.

6.1. A Regional approach to GI

Non-governmental organizations (NGOs) could seek meaningful pathways to support Metro Vancouver to work with municipalities, First Nations, and the provincial and federal government to collaborate on a regional approach. There are many pathways mentioned above, most importantly is to begin with a regionally scaled and interdisciplinary social innovation lab or community of practice to further design and prototype these solutions. The ideas provided below can act as a starting place for designing, prototyping, and testing context specific solutions in more detail.

NGOs could advocate to provincial and federal governments to support regional governments to deploy larger scale green infrastructure, since they are uniquely positioned to do this. As part of provincial and federal infrastructure stimulus funding, a ‘regional green fund’ could be pursued to be managed at a regional level. Other funds could support this through the use of a utility service fee or development charge. A formation of a new regional organization, similar to Translink, would give more authority and could be tasked with the protection of natural areas and disincentivize damages to biodiversity at a regional scale.

Metro Vancouver in collaboration with an external agency could prepare an economic business case for using natural asset management principles for an ‘efficiency

of scale' for regionally integrated green infrastructure program to help make the case, integrating local government needs as well. Local governments could simultaneously play their part by assessing feasibility, potential effectiveness, and long-term cost savings and risk reduction by deploying natural asset management practices. Programs like Municipal Natural Assets Initiative offer expertise in this area.

On the regulatory side, BC Government could work in concert with Metro Vancouver and municipalities to establish consistent and enforceable standards and associated requirements for stormwater management, water quality, biodiversity, development, and zoning through the Local Government Act, Water Sustainability Act, Clean BC, that are supported by related infrastructure funds that would incentivize these changes.

As the Declaration on the Rights of Indigenous People's Act unfolds, First Nation's rights and perspectives will only grow in power, though it is uncertain how that will land at municipal and regional levels of government. More work should be done to investigate how First Nations can and should be involved in decision making with local and regional governments around ways to deploy service delivery infrastructure in concert with local governments on their territories.

Non-governmental organizations should work more closely with municipalities and First Nations to build a regional community of practice focused on GI that encourages information sharing and collaboration within and across disciplines, sectors, and municipalities.

6.1.1. Interdisciplinary approach to GI

The following are some ideas to work specifically on more interdisciplinary approach to GI.

1. Start all infrastructure planning processes with needs-based objectives co-created across disciplines. Involve all disciplines throughout infrastructure planning process, revisiting and evaluating objectives, and ensuring solutions are meeting objectives regularly helps various disciplines work together and feel comfortable in pursuing collaborative projects.
2. Shift the structure and makeup of teams, workspace, institutions, and processes to increase interaction between disciplines.

3. Break down budgetary boundaries between departments to allow for creative cost sharing opportunities
4. Encourage investment in professional development that provide relational leadership training for all disciplines; Post-secondary institutions should consider curriculums that incorporate interdisciplinary components
5. Find meaningful ways to illustrate the risks and costs associated with maintaining status quo as opposed to tackling what may at first glance be ‘risky’ solutions.

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