Exploring the Amplification of Nature-Based Climate Solutions in Urban Canada: A Comparative Case Study

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored; see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

This thesis follows the manuscript option for master's students in the Department of Geography and Environmental Management at the University of Waterloo. This thesis is comprised of 5 chapters, I am the principal author of all chapters, and the sole author of Chapters 1, 2, and 5. Chapters 3 and 4 are distinct manuscripts written for publication, to which Dr. Sarah Burch made contributions to both manuscripts, and Dr. Marta Berbés-Blázquez to one.

The first manuscript, *Mapping Amplification Pathways of Urban Nature-Based Climate Solutions: Insights from Canadian Case Studies*, is co-authored with Dr. Sarah Burch (10%) and Dr. Marta Berbés-Blázquez (10%). Both co-authors provided conceptual feedback, structural suggestions, and editorial support. This manuscript has been submitted to Npj Urban Sustainability.

The second manuscript, *A Swale of Two Cities: Governing the Amplification of Nature-Based Climate Solutions in Urban Canada*, is co-authored with Dr. Sarah Burch (10%), who contributed to concept refinement, structural suggestions, and editorial support. Dr. Marta Berbés-Blázquez contributed to editorial support as a committee member to this thesis but is not a co-author to this chapter. This manuscript is intended for submission to Earth System Governance.

Abstract

As cities navigate increasingly severe impacts from interrelated climate, biodiversity and socioeconomic crises, nature-based climate solutions (NBCS) are increasingly promoted across research, policy and practice as compelling multi-solving approaches that conserve, restore, and steward natural places and processes for social-ecological benefit. Yet their implementation is often limited to small-scale pilots and short-lived programs. While scholarship has examined how to accelerate and scale urban NBCS, less is known about the conditions through which their impacts are amplified within and across urban contexts, particularly in Canada. This thesis investigates the pathways and governance conditions of urban NBCS amplification through a comparative case study of Vancouver and Halifax. Through abductive thematic analysis of 20 key informant interviews alongside policy and planning documents, I developed two manuscripts which: 1) map the pathways of how NBCS initiatives are amplified beyond their initial scope; and 2) identify what are the structural governance conditions that determine if and how these initiatives are amplified. The first manuscript shows that amplification follows non-linear, multidimensional, and recursive pathways involving multiple actors over time. It also introduces enriching as a new type of amplification to capture how initiatives increase their impact through a broader diversity of co-benefits. The second manuscript highlights that the context sensitivity of NBCS includes where in the organizational structure they are operated from. Structural barriers are identified as products of how complexes of governance conditions interact, as well as strategies that can catalyze how these complexes are reconfigured for advancing amplification. By empirically analyzing how urban NBCS are governed and amplified across scales and contexts, this study advances theoretical and practical understanding of how NBCS can shape and are shaped by urban regimes, and how they can contribute to transforming urban Canada towards positive futures.

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This research is built on the experiences of and aims to empower local practitioners and professionals in climate, conservation and sustainability. Thank you to all those who participated in my research as interviewees, and those who promoted it within their professional circles, including those from the City of Vancouver, Metro Vancouver Regional District, Halifax Regional Municipality, Kerr Wood Leidal Associates Ltd., Helping Nature Heal, Green Communities Canada, and Federation of Canadian Municipalities' Green Municipal Fund. Your insights have been central to this research, and your tenacity in championing new ways of growing urban nature

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Table of Contents

Author's Declaration ii
Statement of Contributions iii
Abstract iv
Acknowledgements v
List of Figures x
List of Tables xii
Quote xiii
Chapter 1 – Introduction 1
1.1. Urban nature-based climate solutions 2
1.2. Governing NBCS beyond the pilot 7
1.3. Research objectives and questions 11
1.4. Thesis organization 12
Chapter 2 – Methodology 13
2.1. Study Design 13
2.1.1. Vancouver as a case city 14
2.1.2. Halifax as a case city 16
2.1.3. Case comparison 18
2.2. Data Collection 19
2.4. Data Analysis 22
2.5. Limitations 24
2.6. Positionality 25
Chapter 3 – Mapping Amplification Pathways of Urban Nature-Based Climate Solutions: Insights from Canadian Case Studies 28
3.1. Introduction 28
3.1.1. Urban nature-based climate solutions 30
3.1.2. Urban transitions and transformations 32
3.1.3. Understanding and employing an amplification framework 33
3.2. Methods 35
3.2.1. Case contexts 36

3.2.2. Data collection 38
3.2.3. Data analysis 39
3.2.4. Limitations 40
3.3. Results: mapping amplification pathways of NBCS initiatives 41
3.3.1. Green Infrastructure in Vancouver 42
3.3.2. Naturalization in Halifax 46
3.3.3. Shoreline Restoration through Green Shores 49
3.3.4. Urban community gardening (Halifax) 53
3.3.5. Urban Forestry 57
3.4. Discussion 61
3.4.1. Enriching as a type of amplification 61
3.4.2. Amplification pathway dynamics 64
3.5. Conclusion 67
References 69
Chapter 4 – A Swale of Two Cities: Governing the Amplification of Nature-Based Climate Solutions in Urban Canada 90
4.1. Introduction 90
4.2. Background 92
4.2.1. Urban NBCS governance 92
4.2.2. Challenges to NBCS uptake in urban systems 94
4.2.3. Amplifying NBCS beyond the pilot 96
4.3. Methods 99
4.3.1. Case context: Vancouver 100
4.3.2. Case context: Halifax 102
4.3.3. Data collection 104
4.3.4. Data analysis 105
4.3.5. Limitations 106
4.4. Results: Prominent conditions of NBCS governance 107
4.4.1. Environmental 108
4.4.2. Financial 110
4.4.3. Operational 111

4.4.4. Institutional 114
4.4.5. Political 116
4.4.6. Cognitive 119
4.4.7. Systemic 121
4.5. Discussion 123
4.5.1. Comparing Vancouver's and Halifax's NBCS governance systems 123
4.5.2. Interacting conditions and structural barriers 127
4.5.3. Catalysts for Amplification 136
4.6. Conclusion 139
References 141
Chapter 5 – Conclusion 161
5.1. A synthesis of study findings 161
5.2. Contributions and recommendations 166
References 169
Appendix A – Ethics Documents 194
Appendix B – Interview Guide 208
Appendix C – Sample Codebook 211

List of Figures

Figure 2.1: Map of Vancouver, situated in Metro Vancouver Region of British Columbia, Canada. ……14

Figure 2.2: Map of settlement distribution across the Halifax Regional Municipality in Nova Scotia, Canada..... 17

Figure 2.3: Process chart of document selection, screening and analysis.. 22

Figure 3.1a: Process map of amplification of green infrastructure in Vancouver. 45

Figure 3.1b: Matrix diagram of green infrastructure amplification.. 45

Figure 3.2a: Process map of amplification of naturalization in Halifax. 48

Figure 3.2b: Matrix diagram of naturalization amplification.. 48

Figure 3.3a: Process map of amplification of shoreline restoration. 52

Figure 3.3b: Matrix diagram of shoreline restoration amplification..... 52

Figure 3.4a: Process map of amplification of urban community gardening..... 56

Figure 3.4b: Matrix diagram of urban community gardening amplification.. 56

Figure 3.5a: Process map of amplification of urban forestry..... 60

Figure 3.5b: Matrix diagram of urban forestry amplification..... 60

Figure 3.6: Illustration of the eight original amplification processes grouped into three categories, along with enrich as a new type and revised category definitions..... 61

Figure 4.1: Illustration of the eight original amplification processes grouped into three categories, along with enrich as a new type and revised category definitions..... 97

Figure 4.2: Map of Vancouver, situated in Metro Vancouver Region of British Columbia, Canada. 99

Figure 4.3. Map of settlement distribution across the Halifax Regional Municipality in Nova Scotia, Canada..... 101

Figure 4.4. Conditions of urban NBCS governance. 107

Figure 5.1. Research questions of study addressed by constituent manuscripts..... 16262

List of Tables

Table 2.1. Interview sample composition by case and participant affiliation. 20

Table 3.1. Interview sample strata by case and participant affiliation..... 38

Table 4.1. Interview sample strata by case and participant affiliation..... 104

Table 4.2. Interaction patterns among governance conditions by category..... 127

Table 4.3. Synthesis of the predominant governance conditions, their produced barriers and types of NBCS amplification they impede..... 127

Table 4.4. Interaction patterns among governance conditions by category..... 136

Quote

"…In order to create beautiful minds, you have to create beautiful places."

(P16-0722)

Chapter 1 – Introduction

The changing climate is a complex and rapidly escalating crisis, but not the only one cities face. Intensifying extreme weather events, shifting temperature and precipitation patterns, and sea level rise already impact communities in Canada and worldwide, and will continue to intensify as we accelerate to climatic and social tipping points (Armstrong McKay et al., 2022; Intergovernmental Panel on Climate Change [IPCC], 2023; Otto et al., 2020). As continued urbanization concentrates people, infrastructure, and economic activity in cities, they are increasingly placed at the front lines of experiencing and responding to these impacts (Dodman et al., 2022; Hölscher & Frantzeskaki, 2020). Simultaneous crises arising from biodiversity loss, food insecurity, growing political tensions and socioeconomic divides overlap and complexify in what is increasingly described as a "global polycrisis" (Lawrence et al., 2024). To meet this demands integrative solutions that address multiple challenges simultaneously by transforming the biophysical and socio-institutional structures of the urban (Hölscher & Frantzeskaki, 2021; Romero-Lankao et al., 2018; Sawin, 2024). As researchers and decision-makers at all scales seek more integrated responses to these intersecting crises, the interpretations, valuation and benefits of nature are increasingly understood as integral to determining how and for whom this urban transformation occurs (Maller, 2021; Pascual et al., 2023; Tozer et al., 2020; Welden et al., 2021).

Canadian cities are not exempt from these crises. Urbanization is set to add to the already three quarters of Canadians living in urban centres (Statistics Canada, 2025), whose needs are already failed by neoliberal urban development policies and aging infrastructure (Mirza & Ali, 2017; Tretter & Heyman, 2022). As Canada continues to warm at twice the global average (Bush & Lemmen, 2019) which has already experienced its first year with average temperatures more than 1.5 °C above pre-industrial levels (Bevacqua et al., 2025), the increasing severity of climate

change compounds intersecting stressors and existing socioeconomic vulnerabilities to impact urban social-ecological health and wellbeing (Environment and Climate Change Canada [ECCC], 2024; IPCC, 2023; Radatus-Smith et al., 2025; Viseh & Bristow, 2023).

While significant commitment and capacity to meet the intersecting crises of climate change, biodiversity, and affordability are established and negotiated at the federal level (ECCC, 2022a; 2022b; 2024; 2026; Department of Finance Canada, 2025), much of the development and deployment of these occurs at the local level (Dale et al., 2018). As municipal governments and local actors navigate shifting institutions and growing sociopolitical and environmental pressures to deliver on multiple mandates, there has been a growing exploration into experimenting with transformative sustainability innovations in, of and by local governance systems (Bulkeley et al., 2014; Burch, 2017; Burch et al., 2018; Hölscher & Frantzeskaki, 2021). Amidst these sustainability experiments and urban living labs, nature-based climate solutions have gained prominence across research, policy and practice domains as a promising approach that delivers on multiple social-ecological sustainability outcomes simultaneously (Adams et al., 2024; Buma et al., 2024; Frantzeskaki & McPhearson, 2022; Seddon et al., 2020).

1.1. Urban nature-based climate solutions

Nature in cities is by no means new. Cities have long shaped and been shaped by internal and surrounding ecosystems. Further, they are viewed as ecosystems themselves, characterized by flows of social-physical resources and outputs mediated through prisms of economic and political power (Benton-Short & Short, 2013; Heynen et al., 2006). While conventional understandings of the urban situate "nature" (encapsulated by pristine and unoccupied wilderness) as antithetical, scholarship across landscape architecture, urban planning, geography, and political ecology have instead advocated understanding cities as "imbrications of the physical and the social, the

ecological and the political […] The city is an integral part of nature and nature is intimately interwoven into the social life of cities." (2013, p. 4). Accordingly, green commons, foresting, horticulture and conservation have established histories in urban development that still persist today, such as the Halifax Common, Toronto's High Park, Montreal's Mount Royal Park and Vancouver's Stanley Park as sites of public health and leisure and products of the 'city beautiful movement' (Reece, 2018; von Baeyer, 2015). The ways in which nature has been understood, valued, and governed in cities have shifted alongside changing sociopolitical, and environmental paradigms (McPhearson et al., 2016; Wilson, 2023).

Developing from environmental sciences and nature conservation contexts within the last two decades, nature-based (climate) solutions (NBCS) has emerged as a captivating umbrella concept for actions that "protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016, p. xii). Primarily focused on the twin crises of biodiversity loss and climate change at first, NBCS have since expanded in the scope across social, ecological, and economic objectives for addressing urban challenges (Kabisch et al., 2016, 2022). This has both facilitated and required the bridging of otherwise disparate governance scales, disciplines and communities of practice under the logic of 'working with and enhancing nature to help address societal challenges' (Frantzeskaki et al., 2023, 2025; Hanson et al., 2020; Seddon et al., 2020).

Much of this research was first developed, and still largely stems from, urban European contexts (Frantzeskaki et al., 2023; Goodwin et al., 2023; Hölscher et al., 2023; van der Jagt et al., 2023), and with it, the narratives through which it is framed, operated and measured. While largely celebrated, it is also cautioned from being a panacea, with growing discourse that highlights its

limitations, and interrogate and expand the constituent definitions of "nature" and "solution", as well as for whom and by whom these are governed (Melanidis & Hagerman, 2022; Tallent & Zabala, 2024; Tozer et al., 2020). Critical analysis of the assumptions and power structures that surround NBCS research and praxis highlight its deeply political nature: both in its adaptability as a boundary concept that can bridge epistemologies and radically re-orient values and agency in urban regimes (Hanson et al., 2020; Mguni et al., 2025; Pascual et al., 2023; Tallent & Zabala, 2024; Tozer, Bulkeley, & Xie, 2022), as well as in its potential to be coopted by incumbent regimes that reproduce extractive and colonial violence through exclusion, tokenization, gentrification and greenwashing (Reed et al., 2024; Townsend et al., 2020). Further, academics caution that the effectiveness and accounting of NBCS, particularly in urban contexts, remains uncertain and should not placate the urgency for rapid decarbonization (Buma et al., 2024; Seddon et al., 2020, 2021). Urban NBCS, then, are not neutral technical interventions but contested socio-political projects whose outcomes shape and are shaped by the underlying value systems and power structures in which they operate (van der Jagt et al., 2021). In recognizing the plurality of terms surrounding these solutions across scholarship and policymaking and the politics they are watermarked with, my use of nature-based climate solutions in this thesis over other terms is done in the interest of aligning to the current language used in Canadian policy contexts.

Urban NBCS include a variety of site types and practices, such as green roofs and walls, bioswales and rain gardens as urban drainage systems, urban forests, grasslands and wetlands, and communal gardens (Kabisch et al., 2016; Pauleit et al., 2017; Raymond et al., 2017). Increasingly, however, the literature emphasizes that the transformative potential of NBCS depends not only on the interventions themselves, but also on the governance (re-)arrangements through which they are planned, implemented, and maintained (Adams et al., 2024; Frantzeskaki et al., 2023; Kabisch et

al., 2022). Governance of and with urban NBCS requires moving beyond conventional, sectoral approaches towards collaborative, adaptive, and place-based forms of governance that recognize cities as complex social-ecological-technological systems (Frantzeskaki, 2019; Frantzeskaki et al., 2023; McPhearson et al., 2022). Because urban landscapes exhibit distinct biophysical, institutional, and socio-cultural conditions, effective NBCS must be tailored to local contexts while integrating diverse forms of knowledge, including scientific, Indigenous, practitioner, and community expertise (Bina et al., 2024; Damon, 2024; Mercado et al., 2024; Reed et al., 2022). Consequently, the planning and implementation of urban NBCS are inherently inter- and transdisciplinary processes that require trust and collaboration across governmental departments and scales, civil society organizations, private actors, researchers, and local communities (Kabisch et al., 2022; Kauark-Fontes et al., 2023; Kiss et al., 2022; Raymond et al., 2023; Tozer et al., 2020).

NBCS are increasingly understood as governance focal points and processes that reshape relationships between people, nature, and institutions (Bremer et al., 2021; Bush & Doyon, 2023; Frantzeskaki, 2019; Mercado et al., 2024). Inclusive participation and co-production are therefore critical for ensuring interventions are contextually compatible and capable of advancing social and environmental justice outcomes (Cousins, 2021; Frantzeskaki et al., 2025; Pineda-Pinto et al., 2022; Raymond et al., 2023). Such approaches orient NBCS towards local stewardship, plural place-making and ecocultural practices embedded in community rules and values that enhance both the quality and durability of NBCS as well as the deeper relational impact (Battisti et al., 2025; Mguni et al., 2025; Raymond et al., 2023; Tallent & Zabala, 2024). Contemporary literature has grown to stress that successful urban NBCS are characterized by integrated governance, cross-sectoral collaboration, and context-sensitive planning that enables multiple co-benefits while

supporting broader urban sustainability and transformation agendas (Frantzeskaki, 2019; Kabisch et al., 2022).

In Canada, federal NBCS policy has been focused around projects in rural contexts for the primary purpose of meeting greenhouse gas emissions reduction and biodiversity protection targets through conservation and restoration programs (ECCC 2021; 2022b; 2026). Although this is understandable given the extent of Canada's abundance of complex terrestrial, riparian and marine ecosystems in these regions and the impact potential these initiatives can have in meeting emissions reduction and biodiversity commitments (Ashton & Bradshaw, 2023; Council of Canadian Academies, 2022; Drever et al., 2021), it has also ostensibly maintained formally structured NBCS initiatives and the prioritized as disparate from the urban contexts where the majority of Canadian people, infrastructure and development structures are situated. While federally-operated urban NBCS programming and funding is growing (ECCC 2021; Housing, Infrastructure and Communities Canada, 2024; Parks Canada, 2024), the majority of Canada's urban NBCS landscape has developed through local initiatives from municipal government, nonprofits and civil stewardship groups (Alejo et al., 2026; Doucet et al., 2024) often supported through federal investment streams such as the Green Municipal Fund and Tree Canada (Natural Resources Canada, 2024a). Extant literature of this predominantly pertains to NBCS for sustainable service delivery, such as green infrastructure for stormwater management (Jang & Doyon, 2024; Johns, 2019), urban forestry and greenspaces for improved environmental comfort and resilience (Cheng et al., 2021; Devisscher et al., 2023; Lu et al., 2023), as well as shoreline restoration for coastal resilience (Jones et al., 2025; Rahman et al., 2021). While this research has begun to explore the socio-institutional dimensions of NBCS uptake and impact in urban governance structures (Cheng et al., 2021; Jang & Doyon, 2024; Jones et al., 2025), and the critical

relationships between urban and colonial geographies in how urban NBCS are representative of, governed and constructive towards Indigenous communities and their priorities (Moola et al., 2024; Reed et al., 2022), this research has yet to substantively translate into policy and practice.

Despite the promise and ambition with which NBCS are promoted in policy and practice, there is demonstrable persistent implementation gap within and across urban contexts identified in research (Dorst et al., 2022; Hölscher et al., 2023; Martin et al., 2025; Sarabi et al., 2020). Specifically, this means urban NBCS are unevenly implemented across cities, and are often limited to isolated pilot projects, small-scale and isolated demonstration sites, and ephemeral programs. While investigating how to better institutionalize, scale, accelerate and deepen urban NBCS uptake and impact is a growing focus in social-ecological systems and urban sustainability transitions governance research, both the impact potential of urban NBCS and the structural conditions by which the scaling of these solutions is enabled or impeded remains underexplored in Canada (Goodwin et al., 2023; Jang & Doyon, 2024; Jones et al., 2025; Rahman et al., 2021; Schröter et al., 2022; Skoyles et al., 2025; Tozer, Bulkeley, van der Jagt, et al., 2022). Given the fervor with which it is promoted in policy and practice, along with the shifting nature-climate policy portfolio of the federal government from which much of multi-level mandate and capacity is derived (ECCC, 2026; Department of Finance Canada, 2025), it stands as an opportune time to explore how to increase the impact of nature-based climate solutions in urban Canadian contexts.

1.2. Governing NBCS beyond the pilot

Emerging out of seminal sociotechnical transition research (Geels & Schot, 2007; Meadows, 2008), the past two decades have seen sustainability governance scholarship expand significantly in its understanding of how niche innovations emerge, evolve, and interact with established urban regimes. Increasingly, research has focused on how such innovations are deployed across diverse

spatial, institutional, socioecological, and socioeconomic dimensions of urban systems through experimental formats such as urban living labs and sustainability experiments (Bulkeley, 2023; Bulkeley et al., 2014; Evans et al., 2021). These approaches have provided important insights into how urban sustainability transitions are initiated and tested in real-world contexts.

However, as experimentation has become a dominant mode of sustainability governance, scholars have raised concerns about its unintended limitations. In particular, there is growing attention to the indeterminacy and "projectification" of urban experimentation, whereby initiatives become locked into short-term, isolated pilot projects that fail to scale or meaningfully transform underlying systems (Bulkeley, 2023; Torrens & von Wirth, 2021). Rather than serving as steppingstones toward transformation, experiments risk becoming an end in themselves, reinforcing fragmentation and stagnation. As a result, scholars increasingly call for attention to pathways that move beyond experimentation toward deeper systemic change (Evans et al., 2021; Schröter et al., 2022; Sengers et al., 2021). This shift has directed analytical focus toward understanding how transformative initiatives evolve beyond pilot phases and how they navigate the deeper structural conditions of urban governance that shape their trajectories.

In response, several complementary concepts have emerged to describe how sustainability initiatives transition from experimentation to leverage deeper system change, including scaling, mainstreaming, and accelerating sustainability transitions (Adams et al., 2023, 2024; Bruley et al., 2025; Hölscher et al., 2023; Tozer, Bulkeley, van der Jagt, et al., 2022; van der Jagt et al., 2023). Collectively, these perspectives emphasize that transformation depends not simply on increasing the number of projects, but on embedding innovations within governance systems, institutions, and societal practices. Among these, the concept of amplification offers a particularly integrative perspective. Viewing system change as a non-linear process, amplification describes the process

of increasing of a sustainability initiative's impact by strengthening existing interventions, expanding across contexts, and reshaping the policies, institutions, norms, and values that govern urban systems along multiple pathways (Lam et al., 2020). This facilitates an analysis of the ways in which the potential impact of an NBCS initiative lies not only in its physical outcomes, but also in its capacity to shape discourse, governance practices, and relations. This positions amplification as an integrative framework along with others used in contemporary urban transformations governance research of NBCS, and as a conceptual bridge between experimentation and transformation, drawing attention to the pathways through which otherwise discrete, niche interventions can influence the urban at scale.

Despite this growing recognition, the amplification of NBCS remains constrained by persistent governance barriers embedded within urban systems. While practical challenges such as limited funding, fragmented institutional responsibilities, and insufficient technical capacity are frequently identified, recent scholarship emphasizes that these issues are symptoms of deeper structural conditions rather than isolated constraints (Dorst et al., 2022; Sarabi et al., 2020). Existing research highlights how incumbent governance regimes, regulatory frameworks, organizational cultures, and dominant urban development paradigms often privilege conventional grey infrastructure, siloed decision-making, and short-term planning horizons. These conditions collectively limit the ability of multifunctional, nature-based approaches to become embedded within mainstream urban governance systems (Dorst et al., 2022; van der Jagt et al., 2023). Consequently, advancing NBCS beyond experimentation requires not only implementing more demonstration projects, but also changing the institutions that structure urban decision-making (Bremer et al., 2021; King et al., 2023; Schröter et al., 2022). Understanding these structural

conditions and their combined role in enabling or constraining amplification, is therefore necessary for better understanding and realizing the transformative potential of NBCS in cities.

International research provides further insight into these dynamics, although similar structural questions remain underexplored in the Canadian context. Major European research initiatives such as NATURVATION (van der Jagt et al., 2020), BiodiverCities (Maes et al., 2021), and NATURGO (Jamšek et al., 2025) collectively represent institutional investment in understanding how urban NBCS can be amplified by addressing the socioeconomic and institutional conditions required to translate projects outward across cities and upward into policy. Similarly, the SUNCASA initiative (Scaling Urban Nature-based Solutions for Climate Adaptation in Southern Africa) contributes to advancing governance, community capacity, and gender-responsive approaches for scaling urban nature-based solutions that strengthen climate resilience and biodiversity in rapidly urbanizing African cities. (Gcanga et al., 2024; International Institute for Sustainable Development, 2024). In Canada, efforts to strengthen NBCS governance, capacity, and knowledge-sharing are beginning to emerge but remain fragmented and underdeveloped. Transdisciplinary and inter-governmental initiatives such as Living Cities (Tozer et al., 2022; Devisscher et al., 2025), the Natural Solutions Initiative (ACT, 2023), Greening Canada's Community Canopies (Natural Resources Canada, 2024b), the NATURA Roadmap for the United States and Canada (Bisht et al., 2026), and the expansion of Canada's Urban National Parks through the recent Federal strategy on nature conservation (ECCC, 2026) signals budding interest and recognition of the significance of urban nature and indicates a growing foundation for Canada's nature-climate governance landscape, yet still remains underexplored.

1.3. Research objectives and questions

This study aims to address a critical knowledge gap by examining the pathways through which NBCS are amplified within and across urban Canadian contexts, and the structural conditions that determine if and how this amplification occurs. Specifically, it provides the first qualitative empirical application of the amplification framework to urban NBCS initiatives in Canada, integrating it with contemporary frameworks of urban regimes, sustainability transitions and local governance. In doing so, the study extends existing scholarship within an underexplored context while advancing understanding of how amplifying sustainability initiatives both shapes and is shaped by urban governance processes. Findings will contribute to better understanding of how these initiatives interface with local urban governance complexes, and identify how to more effectively and equitably advance NBCS uptake and impact for a low carbon, just and resilient climate future.

To achieve this, this study aims to address the following descriptive, diagnostic and prescriptive research questions:

RQ1: What are the governance conditions of NBCS in Canadian cities, and how do these conditions interact to impede to enable NBCS amplification?

RQ2: How are NBCS initiatives amplified over time, and how do these pathways interact with one another?

RQ3: What strategies, policy mechanisms and practices should actors utilize to better amplify NBCS within and across urban contexts?

1.4. Thesis organization

This thesis is organized according to the requirements for the manuscript option for master's students in the Department of Geography and Environmental Management. It is comprised of two independent manuscripts that together represent the findings of one, cohesive research project on the how nature-based climate solutions are amplified within and across urban Canadian contexts. The first manuscript (Chapter 3), *Mapping Amplification Pathways of Urban Nature-Based Climate Solutions: Insights from Canadian Case Studies*, has been submitted to Npj Urban Sustainability and appears as such in this thesis with only minor editorial changes. The second manuscript (Chapter 4), *A Swale of Two Cities: Governing the Amplification of Nature-Based Climate Solutions in Urban Canada*, is intended for submission to Earth System Governance and will be adapted in response to peer review. Both are formatted according to University of Waterloo standards and will be adjusted when submitted for publication based on journal requirements. Chapter 2 outlines the methodology employed in this study, and Chapter 5 summarizes findings from both manuscripts and outlines future research and practical recommendations.

Chapter 2 – Methodology

While Chapters 3 and 4 of this thesis are both self-contained manuscripts that each offer explanations of the methods used, this chapter presents more breadth and depth into the design, data collection, and analysis employed in this study, and the position from which it was conducted.

2.1. Study Design

This research study is comprised of a mixed methods comparative case study of two Canadian cities: Vancouver, British Columbia and Halifax, Nova Scotia. A comparative case study approach is particularly well-suited for this research as it facilitates an in-depth, context-sensitive investigation of how NBCS are governed across diverse urban environments (Goodrick, 2014; Simons, 2020). Critical comparison between these cities can offer increased generalizability across urban Canada by being able to identify common patterns while also accounting for the distinct governance structures, institutional arrangements, and socioecological conditions shape implementation across different scales. Since NBCS are inherently place-based and embedded within political, ecological, and socio-economic contexts, comparison helps identify both shared patterns and context-specific dynamics. This design is well established in climate governance, sustainability and urban transformations research. Comparative case methods have been used to trace how climate change policy is mainstreamed and mobilized across different municipalities, offering valuable insight into institutional enablers and barriers (Burch, 2010; Pasquini et al., 2015; Wamsler & Pauleit, 2016). More recent research has explored the strategies and policy suites involved in mainstreaming NBCS across diverse European urban contexts, revealing heterogeneity and inertias in governance systems, as well as catalysts that can overcome these (Dorst et al., 2022; Hölscher et al., 2023; van der Jagt et al., 2023). Adjacent research into the mechanisms and impacts of scaling NBCS up into more formal policies and out to new contexts has yielded insight into the

context sensitivity of these approaches, and the need to account for different combinations of co-benefits, scales of NBCS types and the systemic structures embedded in urban planning (Cilliers et al., 2022; Cortinovis et al., 2022).

The selection of the two cities for this study, Vancouver and Halifax, was done based on governance and socioecological context criteria. Vancouver and Halifax are both Canadian cities, are widely recognized as leaders in climate policy and sustainability innovation, and, critically, have existing initiatives for implementing NBCS. Beyond both being the largest metro areas and economic keystones on Canada's Pacific and Atlantic coasts, respectively, the similarities and complementary differences between these cities make them well suited for a comparative case study.

2.1.1. Vancouver as a case city



Figure 2.1. Map of Vancouver, situated in Metro Vancouver Region of British Columbia, Canada. Adapted from Awmcphee (2019), Hayden120 (2009), and Hitoubashira (2023).

Home to over 660,000 people (Statistics Canada, 2026), the City of Vancouver is the largest local municipality in British Columbia and is the principal economic cultural centre of Canada's West Coast. The City of Vancouver is situated within the Metro Vancouver Regional District, a federation of 21 municipalities, one Electoral Area, and one Treaty First Nation that is collectively home to 3 million people and responsible for regional services and infrastructure including waste management, environmental quality, and regional parks (Metro Vancouver, 2026; Statistics Canada, 2026). While most municipal and regional jurisdiction is established through the provincial legislation of the Community Charter (2003) and Local Government Act (2015), the Vancouver Charter (1953) grants the city a distinct legal status and broader authority in areas including finance, land-use planning, and the regulation of public services. Despite this distinction, Vancouver continues to face similar challenges in local governance, socioeconomic pressures and climate impacts as other Canadian municipalities (Burch, 2017; City of Vancouver, 2024; Viseh & Bristow, 2023). The City of Vancouver is a densely built urban centre situated in a temperate oceanic climate zone (Köppen Cfb) and continues to grow through intensification (City of Vancouver, 2026; Natural Resources Canada, 2022). The City is organized around 19 urban watersheds that drain into the surrounding 5 receiving basins in the Salish Sea bioregion, which has increasingly foregrounded inter-jurisdictional watershed management and green infrastructure in urban planning (City of Vancouver, 2025; Tolsma & Hunter, 2020). The City lies on the unceded traditional territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) Nations, who have lived on these lands as sovereign stewards since time immemorial.

Vancouver faces multiple interrelated climate risks, including intensifying heat events, reduced air and water quality, increased flooding from shifting rainfall patterns, and sea-level rise

(City of Vancouver, 2024). These risks are compounded by interconnected social vulnerabilities, including unequal access to green space, food and housing insecurity, persistent affordability challenges, and the continuing tensions from historical and ongoing marginalization. (City of Vancouver, 2019; Devisscher et al., 2023; Tolfo & Doucet, 2022). Vancouver is recognized nationally and globally as a leader in urban sustainability and environmental planning. As the first Canadian city to adopt a Climate Emergency Action Plan (CEAP) (City of Vancouver, 2020), and has developed a suite of plans and policies targeting climate resilience, biodiversity and ecosystem conservation, water quality, community and cultural resilience, waste and energy management. Prominent plans such as the Greenest City Action Plan (2011), Vancouver Board of Parks and Recreation's master plan (VanPlay) (2020), the Rain City Strategy (Conger et al., 2019), and the recently revised Urban Forest Strategy (2025) have all contributed to Vancouver's identity as "The Greenest City". How Vancouver continues to uphold and advance its standing in urban sustainability alongside socioeconomic challenges has become central to its social and political discourse.

2.1.2. Halifax as a case city

Halifax is the capital region of Nova Scotia, the most populous region in Atlantic provinces (516,000 as of Statistics Canada, 2026). Following municipal amalgamation in 1996, Halifax is governed as Halifax Regional Municipality (HRM), the largest municipality in Atlantic Canada. HRM is governed primarily under its charter (2008) in addition to the provincial Municipal Government Act (1998), granting additional authority and flexibility to local decision-making power in legislation, development and planning. HRM encompasses urban, suburban, and rural communities, with jurisdiction over the region's most densely built metropolitan areas to its most rural and largely unserviced communities. The region is located in Kjipuktuk of the

Sipekne'katik district of Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq who are the original caretakers of the land and whose rights are ratified through the Peace and Friendship Treaty of 1752. HRM is situated in a humid continental climate (Köppen Dfb) (Natural Resources Canada, 2022).

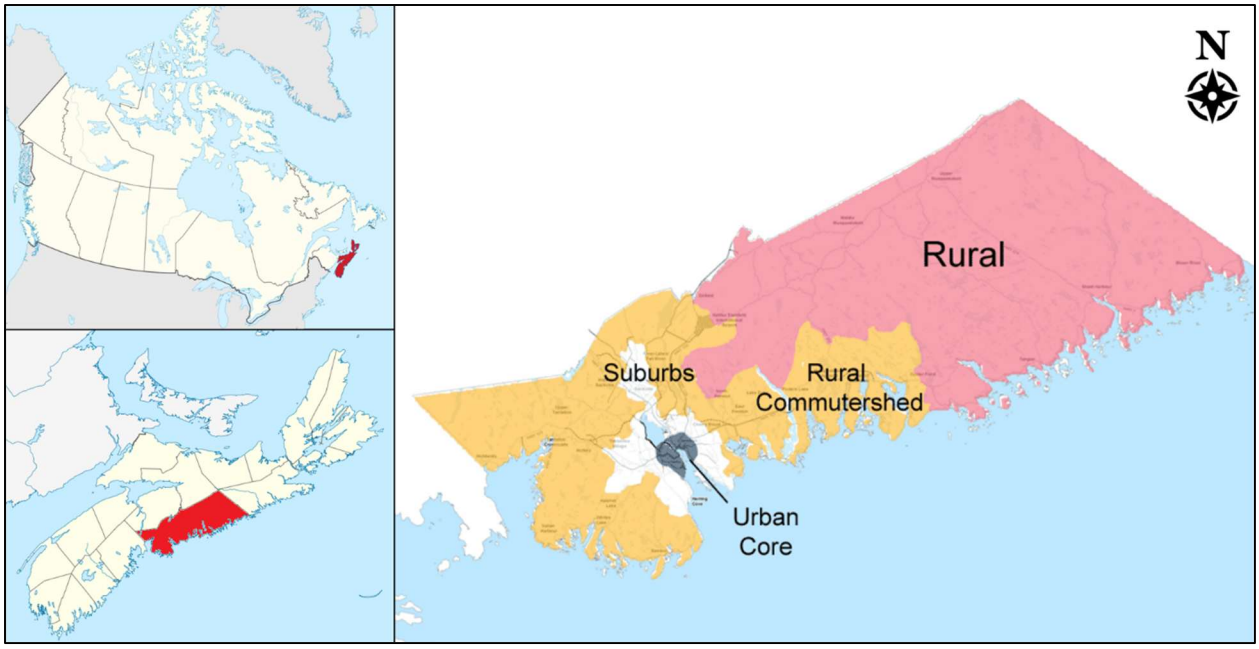


Figure 2.2. Map of settlement distribution across the Halifax Regional Municipality in Nova Scotia, Canada. Adapted from CanadaOlympics989 (2014), MapGrid (2020), WayeMason (2015).

As one of Canada's fastest growing cities. Halifax's growth has been characterized by inter-provincial and international immigration alongside persistent low-density suburban expansion, shaped by long-standing path dependencies in land use planning that have limited sustained suburban densification (Grant et al., 2019). Recent pressure to expand housing development to service this population growth against an ongoing housing crisis has led to renewed prioritizing of urban core densification (Exon Smith & Smith, 2025; Nicol & Biggar, 2025).

Alongside its increasing population and urbanization, Halifax is projected to experience increased temperatures, sea level rise, shifting precipitation patterns and intensifying extreme weather events, resulting in increased risks of flooding, storm surges, wildfire and heat stress

impacting residents and infrastructure (HRM, 2023; Nova Scotia Department of Environment and Climate Change, 2022). These climate impacts compound existing socioeconomic stressors and systemically marginalized communities in 'inequality hotspots' where spatial concentrations of income disparity, housing insecurity, and uneven access to services shape differential vulnerability and adaptive capacity (HRM, 2022; Ramos & MacNabb, 2018).

Halifax is a growing leader in climate and sustainability. 2020 saw the launch of HalifACT: Acting on Climate Together, a comprehensive climate strategy that commits the city to become a carbon neutral and climate resilient municipality by 2050. HalifACT centres equity and community resilience integrates adaptation and mitigation across sectors, with nature-based climate solutions (NBCS) playing a key role in flood protection, carbon sequestration, and resilience. In parallel, successive and parallel priority plans like the Halifax Green Network Plan (HRM, 2018) and the Naturalization Strategy (Halifax Regional Council, 2022), HRM is also home to several Wilderness Areas: provincially-managed conservation areas that provide habitat and ecological connectivity for biodiversity, access to outdoor recreation, and ecosystem services to surrounding communities. Notably, the Blue Mountain-Birch Cove Lakes Wilderness Area is under review as a candidate for Parks Canada's National Urban Park program (Parks Canada, 2022).

2.1.3. Case comparison

While located in different bioregions, both cities face similar climate hazards (Viseh & Bristow, 2023) and socioeconomic stressors, derive their local decision-making power through both provincial legislation and bespoke charters, and have demonstrable NBCS implementation. A primary comparator between these cities is that Vancouver's jurisdiction is nested within a larger urban region that is governed as a federated regional district, while Halifax is within the sole

municipal jurisdiction of HRM, which extends well beyond the urban service boundary. Additionally, different public services are built within or adjacent to each city's municipal corporation. Notably, Vancouver Board of Parks and Recreation is a separate body (governed by a separately elected board of commissioners) to the city's organizational units but operates on shared funding and zoning. Conversely, Halifax's Parks and Recreation department is housed inside of the municipality's corporation, but Halifax Water is a separate utility company that is owned by HRM and reports to the provincial Utilities and Review Board. Together, they provide rich ground for comparative insights in the governance of NBCS implementation and amplification for Canadian urban contexts.

2.2. Data Collection

The majority of data collected for this study was obtained through semi-structured interviews of key informants on NBCS governance and practice. For the purposes of this study, this was defined as individuals who are:

i. employed or affiliated with a municipal government in Halifax or Vancouver, a non-governmental organization, a local business, or an inter-municipality federation; and
ii. involved in the decision-making, management, funding, implementation, communication, coordination and/or maintenance of NBCS initiatives within an associated case study city.

While this study is designed as a comparative case study between two cities, organizations that facilitate local NBCS programs across Canada were also included. I followed a stratified sampling approach to ensure a balance of perspectives across case cities and informants' roles, experiences and expertise (Brinkmann, 2020; Tongco, 2007). A total of 20 interviews were conducted between June and October of 2025, through a combination of in-person interviews in Halifax and Vancouver, as well as remotely via Zoom (www.zoom.com). Online interviews can

offer flexibility and accessibility for both participants and researchers, albeit remaining attentive to technological limitations and potential impacts on comfortability, connection and data richness (Oliffe et al., 2021). This has proved a useful and sufficiently effective medium for interviewing in recent research with similar participants (Jones et al., 2025).

Table 2.1. Interview sample composition by case and participant affiliation.

Case	Municipality	NGO	Business	Academic research hub	TOTAL
Vancouver	6	1	1	1	9
Halifax	4	2	1	1	8
Pan-Canadian	1	2	0	0	3
TOTAL	10	6	2	2	20

Participants were identified through a purposive sampling approach, making combined use of existing professional contacts, publicly available documents that connect key informants to NBCS projects and programs, and snowball sampling. Purposive sampling allows for the strategic selection of individuals with expertise or decision-making power related to NBCS planning and implementation (Tongco, 2007). Snowball sampling enables the identification of additional relevant actors through existing networks, particularly in fields where relational ties and informal knowledge are influential (Parker et al., 2019). Participants were contacted individually by email and invited to participate with appropriate information and consent. Communication with and interviews of participants were done after receiving approval from the Waterloo Research Ethics Board (REB #47371). Recruitment and consent materials are available in Appendices A and B.

Interviews were semi-structured, which allowed for flexible conversations while covering core themes consistently with pre-determined questions and prompts[1] (Ahlin, 2019). Interviewing was also reflexive and responsive, where sections of the interview guide were continually (de-)emphasized based on available information on the expertise and organization affiliation of a particular participant, and based on previous interviews. This helped to support analytic rigor and saturation in line with Guest et al. (2006) and LaDonna et al. (2021), who argue to move beyond the simplistic notion of saturation as a numeric threshold and instead as a marker of conceptual richness and reflexive adequacy compatible with the study's design and analysis objectives. Interviews were audio recorded and participants were given the opportunity to review their transcript before proceeding with analysis.

These semi-structured interviews were supported by qualitative document analysis. Pairing key-informant interviews with document analysis is a well-established form of triangulation (Natow, 2020). The collection and review of documents began prior to participant sampling and ran concurrent with interviewing. This helped to: support purposive sampling; cumulatively familiarize with specific NBCS initiatives and the policy and their planning and policy contexts; and establish a broad reference base for iterative review, refinement and triangulation during transcription and interview analysis. This was particularly useful in comparing information in public-facing documents (e.g. reviewing the published plans and strategies by a municipality) with sentiment and experiences from key informants on the same projects, deepening analysis through corroboration, contradiction and nuance (Bowen, 2009; Morgan, 2022). Document selection was continuous throughout data collection and analysis, informed by Morgan's recommendations, as

[1] Refer to Appendix C for a sample interview guide.

well as contextual relevance, where documents were obtained from website searches and/or from direct or inferred references in interviews (2022). To review the collection and screening process, refer to figure 3 below.

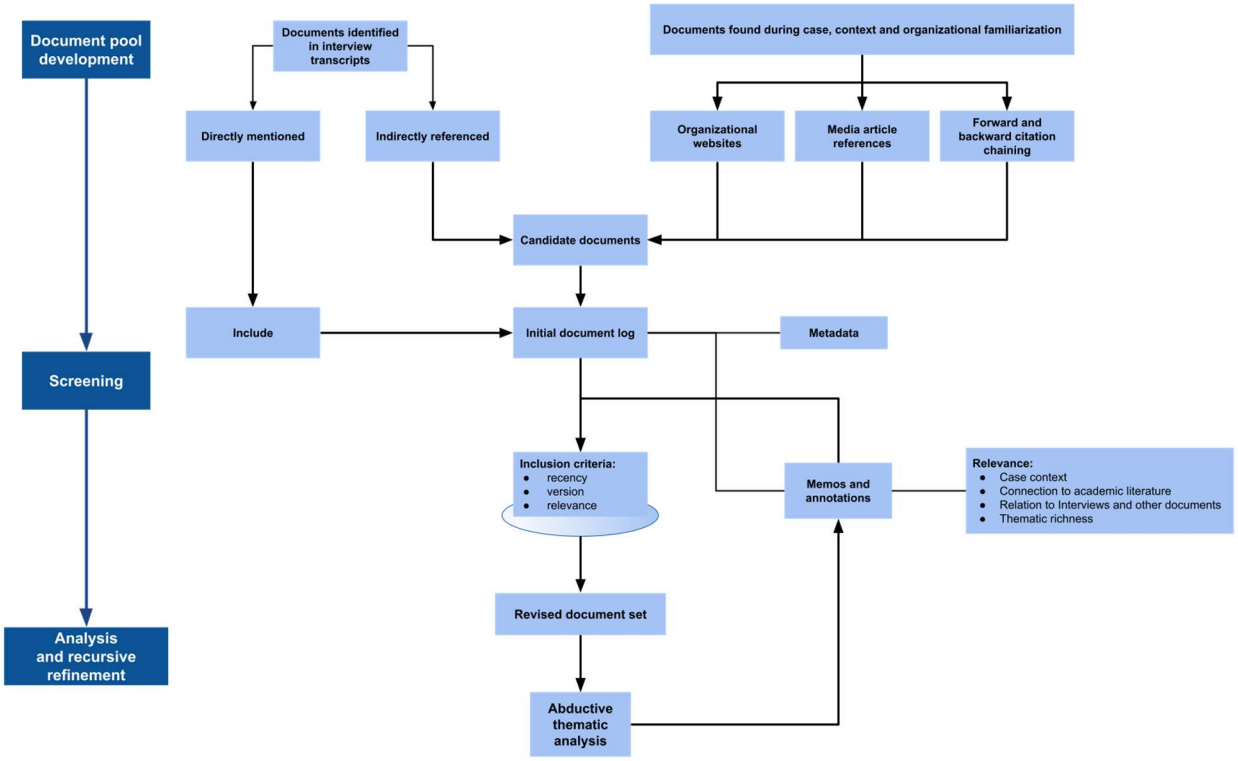


Figure 2.3. Process chart of document selection, screening and analysis. Adapted from recommendations by Morgan (2022).

2.4. Data Analysis

Data for this study was analyzed qualitatively. While formally starting after completing interview transcription, analysis began at the outset of interviewing. This included travelling to Vancouver and Halifax in June and July of 2025 to familiarize myself with the urban milieu and specific NBCS sites discussed in interviews; continually taking field notes after each interview and site visits; and attending a conference for climate and sustainability professionals held in Halifax (Phillippi & Lauderdale, 2018).

Interview recordings were transcribed and cleaned on Microsoft Word and ATrain to further familiarize myself with the data (Braun & Clarke, 2006; Haberl et al., 2024; Thompson, 2022). Interview transcripts were coded and reviewed using NVivo 15 through an abductive thematic analysis approach (www.lumivero.com/products/nvivo/). Abductive analysis is well-suited for creatively engaging with empirical data and extant literature through a pragmatic and reflexive movement between inductive and deductive modes of inquiry throughout the analytical process (Khurshid et al., 2026; Thompson, 2022). Maintaining this exchange between data-driven and theory-driven interpretations of findings allowed for multiple interpretations of the anomalies and pattens in data, which iteratively adjusted themes and frameworks through the process for deeper proposed scholarly and practice advancements (2022).

The first pass of coding was the first analytical link between raw data and my interpretation of it. As such, this was done with a deductive-dominant codebook that aimed to capture and structure as much from the dataset with existing conceptual frameworks. The second cycle of coding was more selective and inductive-dominant, which consolidated existing codes and developed new codes from emergent and unexpected themes that weren't yet fully captured (2022). After each coding cycle, codes were reviewed to develop more complex synthesis through analysing relationships between codes, triangulation with evidence from document analysis, and ongoing engagement with related literature (Khurshid et al., 2026; Lochmiller, 2021). Consistent with an abductive approach, the codebook was treated as a provisional analytical tool and was iteratively revised as new insights emerged from the interaction between data and theory.

Continual memo writing helped to reflexively adjust the codebook (see Appendix C), as well as equally engage with both empirical data and extant theoretical understanding to ground thematic emergence (Braun & Clarke, 2006; Khurshid et al., 2026). Temporal and methodological

separation of passes and their analyses also helped to defamiliarize myself with newly-coded excerpts, allowing for renewed perspective that can better interrogate for unexpected insights and latent themes beyond the semantic (Thompson, 2022). Additional comparative analysis of code prevalence and relationships was done between the two case cities, with specific memos developed for notable projects or initiatives (Khurshid et al., 2026; Thompson, 2022). While I conducted all coding, summaries of coding passes and outputs were reviewed with the manuscript co-authors (Burch and Berbés-Blázquez).

These methods, supplemented by a review of scholarly literature, formed the basis of this thesis. The qualitative data provided by the semi-structured interviews and document analysis enabled the mapping of distinct, but interrelated pathways of how NBCS initiatives have been amplified, as well as the catalysts, conditions and actor roles that shape them. These findings are discussed in Chapters 3 and 4, and synthesized in Chapter 5.

2.5. Limitations

Firstly, we received modest informal, and no formal, input from Indigenous participants, communities or organizations. While relevant staff at Indigenous-led or focused organizations were contacted to discuss their involvement and perspectives on NBCS initiatives through publicly available means, no one from this was available to be interviewed. Partnerships with First Nations and Indigenous organizations are increasingly centered in climate action and NBCS governance in both Halifax and Vancouver. However, we did not have existing relationships with any of the First Nations bands, and not enough capacity to build the necessary reciprocal relationship with the three First Nation governments in Vancouver and the Mi'kmaw Confederacy in Halifax in line with preventing extractive research practices (Government of Canada, 2023). To attenuate this, interview participants were asked about how they and their team partnered with First Nations and

Indigenous organizations on NBCS, which helped to connect literature on Indigenous-led and co-produced NBCS and sustainable self-determination to emergent themes in the data. We stress that those individuals and organizations did not speak on behalf of any First Nation(s) or urban Indigenous communities.

Secondly, although we reached saturation with the existing set of interviews and we have reasonable confidence that essential perspectives were captured, a small number of staff from notable organizations in each case weren't available to be interviewed. While exhaustive interviewing is not necessary to reach saturation and rich contextual understanding, the gaps in certain organizations' presence in the interview process does allow for potential blind spots or omissions in the interplay between organizations, actor groups and specific NBCS initiatives within each case city. Thirdly, while continuity in the research process from interview guide design, through interviews, transcription, and analysis has its merits, all transcription and coding being done by a single researcher also limits the study's reliability by preventing inter-coder checks. Multiple coding passes and reviews between the authors helped to ameliorate this.

2.6. Positionality

Positionality reflects what brings me to this research, what I bring with me, and how these influence my research priorities, processes, and outcomes. Recognizing that this is neither exhaustive nor fixed, I approach this as an ongoing and reflexive practice: an "interpretation of an interpretation" (Gabriel, 2018). Making these declarations enhances the clarity and credibility of this study by situating me as an active instrument in its production, interpretation and dissemination, as well as contextualizing it within the dialogue among scholarly and non-scholarly audiences.

I am a white, English-speaking male immigrant from South Africa and a Canadian permanent resident studying at a public institution in southwestern Ontario. I live, learn and work as an uninvited guest in what is now known as Waterloo Region, which is on the traditional territory of the Attawandaron (Neutral), Anishinaabe, and Haudenosaunee peoples in the Haldimand Tract, lands promised to the Six Nations which include six miles on each side of the Grand River. The case study cities involved in this research, Halifax and Vancouver, are on traditional and unceded territories of distinct First Nations, each with unique cosmologies, land relationships, and colonial histories. As a researcher who does not reside in either case study city, I recognize my position as an outsider to the everyday social, political, and relational dynamics that shape these contexts and that the ways in which I choose to and get to move through these spaces is always political. I have committed to approaching research across these spaces in a way that respects the unique histories, cultures and lived realities of their Indigenous communities and local residents.

Both my birth and adopted countries have histories marked by institutionalized racial, colonial violence that has contributed to the cultural hegemony, extirpation, and invisibility experienced by marginalized peoples. The privileged experiences I carry from and in these contexts have, to varying degrees, informed my understanding of the challenges, solutions and values of the people and places represented in this research. I approach these power structures through critical justice-oriented perspectives, recognizing that I often benefit from and act within the very systems I critique.

Epistemologically, this research is grounded in critical realism built on undergraduate training in environmental science and economics that is largely rooted in positivist paradigms (Fletcher, 2017). Critically examining how my background, context, and privilege shape the

research process is a necessary but non-sufficient criterion for conducting reflexive, responsible, and rigorous geographic research. This positionality should not be understood as a checkbox that prefaces the manuscript chapters, but rather a lens through which the methodological decisions and interpretations presented throughout this thesis should be contextualized. While my perspectives inevitably shape this research, I have sought to engage reflexively and transparently with participants, data, literature, co-authors and place in ways that support a rigorous and credible examination of urban NBCS in Canada.

Chapter 3 – Mapping Amplification Pathways of Urban Nature-Based Climate Solutions: Insights from Canadian Case Studies

3.1. Introduction

As cities are increasingly at the forefront of experiencing and responding to the intensifying impacts of climate change in a 1.5°C world (Kirchengast & Pichler, 2025; Romero-Lankao et al., 2018), its impacts are compounded by stressors of biodiversity loss, political tensions and widening social vulnerabilities in what is increasingly described as a polycrisis (Lawrence et al., 2024). As global systems continue towards social and ecological tipping points (Kirchengast & Pichler, 2025; Otto et al., 2020; Rockström et al., 2023), it is clear that the question of whether social-ecological-technological systems will fundamentally change has been replaced with how willing and able communities are to steer transformations towards just, resilient futures (Díaz et al., 2019; Rusca et al., 2024). Yet efforts for these transformations are increasingly constrained by path dependency, indeterminacy, and a growing "projectification" of sustainability experiments (Bulkeley, 2023; Evans et al., 2021; Torrens & von Wirth, 2021). Local governments and actors must navigate shifting institutions to deliver on multiple mandates under growing pressures and populations, highlighting the need to leverage existing, multidimensional solutions (McPhearson et al., 2025).

Nature-based climate solutions (NBCS) have gained prominence as one such solution in their ability to multi-solve: mitigating greenhouse gas emissions and adaptation gaps, conserving biodiversity, and creating urban green commons to deliver multiple social–ecological co-benefits (Kabisch et al., 2016; Raymond et al., 2017; Sawin, 2024). Across communities of research, policy and practice, NBCS have been implemented to protect, restore, enhance and manage natural systems for social and environmental benefit (Adams et al., 2023; Frantzeskaki et al., 2023;

Goodwin et al., 2023). Despite the exponential growth in NBCS research over the last two decades (Dunlop et al., 2024; Zyoud & Zyoud, 2025), urban NBCS often remain confined to isolated pilots and demonstration sites, making for unequal access, inconsistent implementation and unrealized potential impact (Dorst et al., 2022; Martin et al., 2025; Schröter et al., 2022).

Emergent research across sustainability disciplines has begun to investigate how initiatives such as NBCS are advanced beyond their experimental stage for increased impact within and across urban contexts for positive transformative change (Adams et al., 2023; Bina et al., 2024; Frantzeskaki et al., 2025; Hölscher et al., 2023). However, reviewing this literature highlights both geographic and analytical gaps in need of addressing.

Firstly, Canada remains underexplored in urban sustainability transitions and NBCS scholarship despite its globally significant role in climate and biodiversity governance, rapid climate warming, and continuing biodiversity decline (Coristine & Kerr, 2011; Council of Canadian Academies, 2022; Drever et al., 2021; ECCC, 2019; Goodwin et al., 2023; Lemieux et al., 2023; McPhearson et al., 2025; Ray et al., 2021; Richman, 2022). With approximately threequarters of Canadians living in urban areas and municipalities responsible for most public infrastructure and service delivery, Canadian cities are central to climate adaptation, mitigation, and ecological stewardship (Mirza & Ali, 2017; Statistics Canada, 2025). Coupled with Canada's evolving nature-climate governance landscape—including distinctive settler-Indigenous relations and institutional change—this positions urban Canada as a valuable context for understanding how NBCS are amplified and contribute to sustainability transformation (Department of Finance Canada, 2025; ECCC, 2026; Reed et al., 2022). Secondly, qualitative research has increasingly examined how urban NBCS are scaled, mainstreamed, and accelerated, particularly through the conditions and strategies shaping their uptake (Bruley et al., 2025; Dorst et al., 2022; Tozer et al.,

2022), yet comparatively little attention has been paid to how their impacts are amplified across different dimensions or how amplification contributes to transformation across NBCS types and governance contexts.

To this end, we employ an amplification framework with the aim of: 1) empirically analyzing how urban NBCS have been and can be amplified in Canadian governance contexts, and 2) examining how these amplification dynamics contribute to urban transformation. In the remainder of this paper, we contextualize our study within contemporary literature on NBCS, urban sustainability transitions and transformations, and present a consolidated analytical framework for conceptualizing and employing amplification. We then map and synthesize how prominent NBCS initiatives have amplified within and across contexts, and how these amplification pathways interact with one another and their governance conditions.

3.1.1. Urban nature-based climate solutions

The dominant definitions of nature-based (climate) solutions have emerged from various nature-positive agendas of multinational organizations. For instance, the International Union for Conservation of Nature (IUCN) defined the term nature-based solutions (NBS) 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" (Cohen-Shacham et al. 2016, p.xii). Urban NBCS are often regarded as a bridging or collating concept bringing together adjacent ecosystem-based approaches in urban settings, such as 'urban ecosystem services', 'blue-green infrastructure', 'urban ecological infrastructure', 'ecosystem services', or 'natural assets' (Childers et al., 2019; Frantzeskaki et al., 2019; McPhearson et al., 2022; Pauleit et al., 2017). Across these, the potential of natural elements in urban areas is highlighted with a particular aim to deliver multiple beneficial services over the

use of artificial solutions (Kabisch et al., 2022). The adaptability and multifunctionality of NBCS make them uniquely appealing to urban planners and policymakers facing complex, interdependent social-ecological urban challenges. Moreover, NBCS are recognized as bridges that connect across governance and disciplinary boundaries of climate action, including public health, biodiversity conservation, civil infrastructure, sustainability innovation and social equity (Frantzeskaki et al., 2025; Hanson et al., 2020).

Over the past decade, contemporary urban NB(C)S research has predominantly explored these interventions through case-based methods in urban policy, planning, and practice (Frantzeskaki, 2019; Kabisch et al., 2016; McPhearson et al., 2025). As recognition has grown of their limited implementation within and between cities, investigations into how NBCS can be amplified beyond pilots and demonstrations for transformative impact have become increasingly common (Dorst et al., 2022; Schröter et al., 2022; Tozer et al., 2022; van der Jagt et al., 2023).

While urban NBCS include urban forests, green roofs and walls, restored wetlands and coastlines, community gardens, and permeable green infrastructure such as bioswales and rain gardens (Frantzeskaki et al., 2019; Nesshöver et al., 2017), these are not solely technical or ecological interventions. They are deeply political, shaped by competing narratives, values, and power relations. Policy actors may appropriate the term to align with existing planning paradigms, potentially enabling implementation while constraining more transformative or community-led approaches (Hanson et al., 2020; King et al., 2023; Nesshöver et al., 2017). The concept's flexibility can therefore advance urban greening agendas, but also risks oversimplifying complex socio-ecological relations. Accordingly, scholars emphasize the need for conceptual clarity and caution against reductive framings that obscure ecological and governance complexity (Melanidis & Hagerman, 2022; Seddon et al., 2021).

At the same time, Indigenous and political ecological perspectives challenge isolated notions of "nature," highlighting relational ontologies in which people and ecosystems are not separate (Reed et al., 2024; Townsend et al., 2020). The ambiguity of NBCS definitions, rooted in contested narratives of "urban," "nature," and solutionism, has become a key site of debate regarding their role in just sustainability transformations (Frantzeskaki et al., 2020; Kabisch et al., 2022; Melanidis & Hagerman, 2022). This has strengthened critical discourse on governance, including questions of for whom, by whom, and under what conditions NBCS are implemented (Cousins, 2024; Lemes de Oliveira, 2025; Tozer et al., 2020). While NBCS are increasingly promoted in urban sustainability agendas, they are not a panacea and must complement, not replace, rapid decarbonization efforts (Buma et al., 2024; Drever et al., 2021; Seddon et al., 2021). As policy momentum continues, the debate has shifted from whether NBCS should be implemented to how they can be implemented more justly and effectively (Reed et al., 2022, 2024; Seddon et al., 2021; Tallent & Zabala, 2024).

3.1.2. Urban transitions and transformations

The past two decades has seen the establishment of distinct but overlapping frameworks to investigate the transformation in, of, and by urban systems (Hölscher & Frantzeskaki, 2021; Torrens et al., 2021). Built on seminal perspectives and understandings of sociotechnical regimes, sustainability management, niche innovations, urban climate experimentation and resilience (Bulkeley et al., 2014; Geels & Schot, 2007; Olsson et al., 2014), a corpus of research has emerged that theoretically and empirically examines socio-technical, socio-institutional and socio-ecological dimensions of urban change (Loorbach et al., 2017; Torrens et al., 2021). While the concepts of transitions and transformations are coupled, compared and emphasized variously across research foci, they can largely be understood to both describe desirable radical and non-

linear societal change that include innovative practices and processes interacting with the regimes they operate in (Hölscher et al., 2018). Recent scholarship has expanded this conceptual terrain further, articulating the power, politics and agency that structure by whom and for whom these transitions occur (Avelino, 2017; Avelino et al., 2024), and the varied processes by which sustainability initiatives can be catalyzed (Adams et al., 2023; Bruley et al., 2025; Lam et al., 2020; Nerland et al., 2025; Sengers et al., 2021; Tozer et al., 2022).

To understand how these processes unfold in cities, scholars have identified several mechanisms through which sustainability interventions such as NBCS can move from isolated actions to systemic impact. Several extant theoretical and conceptual frameworks that aim to describe and analyze how sustainability initiatives grow beyond experiments, all with varying scope, disciplinary focus, overlap and similarity (Hölscher et al., 2018; Hurlimann et al., 2021; Lam et al., 2020). Prominent neologisms and frameworks include mainstreaming (Hölscher et al., 2023; McPhearson et al., 2025; Tozer et al., 2022b), accelerating (Frantzeskaki et al., 2017; van der Jagt et al., 2020), scaling (Bruley et al., 2025; Cortinovis et al., 2022; Moore et al., 2015) and amplifying (Lam et al., 2020). Amplification, described as increasing the impact of a sustainability initiative to foster transformative change, is adept in consolidating and translating across much of this, and as such, is employed in this paper (Lam et al., 2020).

3.1.3. Understanding and employing an amplification framework

Lam et al.'s integrated typology describes 8 distinct modes of amplification aggregated into three primary categories: amplifying within, which involves improving the speed and duration of an initiative; amplifying out, referring to how an initiative is expanded or adapted across (dis)similar contexts; and amplifying beyond, which is changing how we interact with the solution and its impact through policies, institutions, norms, and values (2020: pp. 10-17).

This is constructive to analyzing how the potential impact of an NBCS initiative lies not only in its physical outcomes, but also in its capacity to shape discourse, governance practices, and relations (Barth et al., 2023). This positions amplification as connective tissue between constituent frameworks and a critical conceptual bridge between experimentation and transformation, drawing attention to the pathways through which otherwise discrete, niche interventions can influence the urban at scale.

Recent amplification research has been applied across several fields and scales in broader sustainability transformations. Small and medium-sized enterprises (SMEs), and the business ecosystems they operate in, have been recognized for their capacity for sustainability innovation through experimentation, with recent research calling for and exploring SMEs as amplifiers for increasing community resilience (Burch et al., 2022, 2026). Perspective on amplifying NBCS emphasize that realizing their transformative potential requires fundamental changes to the institutional, financial, and governance structures that shape decision-making, alongside greater collaboration across sectors, actors, and scales (Schröter et al., 2022). Further, case-based studies have begun to operationalize amplification as an analytical lens to social-ecological initiatives. Reinforcing their framework with empirical application, Lam et al. examined the amplification of food initiatives through specific actions within the agri-food system of Stockholm, Sweden, showing differential outcomes from amplification types with regard to the transformation of the incumbent agri-food system, as well as the need for continuity from local governance actors (2022). Biocultural initiatives from Indigenous and Local Communities' have been recognized for their transformative potential, particularly in scaling deep through intercultural and ancestral education, empowering communities' agency, and revitalizing the connections between people and nature for deeper values (Jiménez-Aceituno et al., 2025). Similarly, co-produced NBCS in global South

contexts emphasizes the sociopolitical dimensions of amplification, where scaling deep can cultivate resistance and desire for change that interrogates and reworks power geometries in post-colonial systems through a contested, emergent and continual praxis of sustainability transition (Mguni et al., 2025). Amplification as an analytical lens has also highlighted the active role of national beyond-GDP indicator initiatives beyond metrics through legal mandates, institutional integration, and collaboration in transforming socio-institutional governance (Dethier & Roman, 2026).

This study contributes to this nascent development by empirically analyzing the amplification pathways of NBCS initiatives in urban Canadian contexts to highlight the modes by which this amplification takes place, the actors involved in these amplification 'steps' or 'moments', and how they assemble together to realize greater impact. This is done through a process mapping method, combined with an interpretation of amplification as a change in vector space, both of which are described in the following section.

3.2. Methods

This study examines how NBCS initiatives are implemented and amplified in Canadian urban contexts through a comparative case study across two cities: Vancouver, British Columbia and Halifax, Nova Scotia. Beyond both cities being the largest metro areas on Canada's Pacific and Atlantic coasts, respectively, both cities are recognized as leaders in climate action, environmental planning and sustainability innovation. Critically, both cities have a suite of existing NBCS initiatives, which are described further in the sections that follow. A prominent comparison between these two cities rests in their local government structure: Vancouver as a local municipality to a federated regional district (of which it is the urban center), and Halifax as an amalgamated singular regional municipality that stretches from the urban core to the rural

periphery. Although the study conducted was designed as a comparative case study primarily between two cities, urban NBCS initiatives are implemented and supported by a myriad of actors across local to (inter)national scales. As such, initiatives that exist between and beyond these cities' contexts were also included.

3.2.1. Case contexts

Located in the lower mainland of British Columbia, the City of Vancouver is the cultural and commercial epicenter of Canada's West Coast. The city lies on the unceded traditional territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) Nations, who have lived on these lands as sovereign stewards for millennia. While viewed as the preeminent municipality, The City is situated within Metro Vancouver Regional District, a federation of 21 municipalities, one Electoral Area, and one Treaty First Nation that jointly manages region-wide policy domains such as land use planning infrastructure, regional parks, service delivery and regional policy. While the Vancouver Charter supersedes the Vancouver Incorporation Act and grants the City augmented power over municipal organization, administration, regulation and economy, such as an elected Vancouver Parks Board separate and additional to City Council, Vancouver still experiences similar challenges in local governance, NBCS implementation, and climate risks (Burch, 2017; Viseh & Bristow, 2023). As Canada's first municipality to adopt a Climate Change Adaptation Strategy (which has since been succeeded by the Climate Change Adaptation and Climate Emergency Action Plans) (City of Vancouver, 2012; 2020) alongside its Greenest City Action Plan (2011), Vancouver's longstanding commitments to sustainability, equity, reconciliation, and a growing green economy have established the city as a leader in urban environmental sustainability.

Halifax is the capital region of Nova Scotia, the most populous region in the Atlantic provinces, and one of the fastest growing municipalities in Canada. The region is located in Kjipuktuk, in the Sɨpekne'katik district of Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq who are the original caretakers of the land and whose rights are ratified through the Peace and Friendship Treaty of 1752. Following municipal amalgamation in 1996, Halifax is governed as Halifax Regional Municipality (HRM) and is the largest municipality in Atlantic Canada. HRM's jurisdiction encompasses urban, suburban, and rural communities, extending from the region's most densely built metropolitan center to its most rural, unserviced periphery. HRM is governed primarily under its charter in addition to the provincial Municipal Government Act, granting additional authority and flexibility to local decision-making power in legislation, development and planning. As one of Canada's fastest growing cities, Halifax's growth has been characterized by inter-provincial and international immigration alongside persistent low-density suburban expansion, shaped by long-standing path dependencies in land use planning that have limited sustained suburban densification (Grant et al., 2019).

Amidst this, Halifax continues to be a growing leader in climate and sustainability. In 2020, HRM launched HalifACT, a comprehensive climate strategy that commits to a carbon neutral and climate resilient municipality by 2050 (HRM, 2020a). HalifACT centres equity and community resilience integrates adaptation and mitigation across sectors, with nature-based climate solutions (NBCS) playing a key role in mitigation, adaptation and resilient development. Successive and parallel priority plans like the Halifax Green Network Plan (HRM, 2018) and the Naturalization Strategy (Halifax Regional Council, 2022), which expand and protect ecological networks and urban green spaces aim to support biodiversity, cultural connections, and recreation access through the region's growth and land use changes.

3.2.2. Data collection

Following a qualitative mixed methods approach, a combination of semi-structured interviews with key informants and document analysis were employed. Key informants were selected through stratified purposive sampling to best allow for balanced, in-depth understanding of specific NBCS initiatives from practitioners and subject experts within and between cases. NBCS practitioners and experts were considered as individuals who are 1) employed or affiliated with a municipal government in Halifax or Vancouver, a non-governmental organization, a local business, or an inter-municipality federation; and 2) involved in the decision-making, management, funding, implementation, communication, coordination and/or maintenance of NBCS initiatives within an associated case study city. Participants were identified through a combination of existing professional contacts, key staff associated with NBCS initiatives from publicly available documents, and snowball sampling. A total of 20 interviews were conducted between June and October 2025, in-person or virtually via Zoom.

Interviews followed a semi-structured approach, which allowed for baseline questions and core themes to be consistently covered with pre-determined questions and prompts, while flexible enough for conversations to develop (Ahlin, 2019). Interviewing was also reflexive and responsive, where sections of the interview guide were continually (de-)emphasized based on available information on the expertise and organization affiliation of a particular participant, and based on previous interviews. Interviews were transcribed and cleaned using Microsoft Word and ATrain (Haberl et al., 2024), whereafter participants were given the opportunity to review their transcripts. Interviews and participant communications were conducted with the approval of the University of Waterloo Research Ethics Board (REB #47371).

Table 3.1. Interview sample strata by case and participant affiliation.

Case	Municipality	NGO	Business	Academic research hub	TOTAL
Vancouver	6	1	1	1	9
Halifax	4	2	1	1	8
Trans-municipal	1	2	0	0	3
TOTAL	10	6	2	2	20

Interview data were complemented with relevant documents surrounding NBCS initiatives. This includes municipal plans, policies and strategies; academic reports; legislation and bylaws; as well as grey literature and public media (Morgan, 2022). Documents were collected and reviewed before, during and after the interview period to support 1) purposive sampling; 2) cumulative familiarization with specific NBCS initiatives and the policy and planning landscape they operate in; and 3) establish a wide base of reference to iteratively review, revise and analyze for triangulation during transcription and interview analysis. This occurred over three recursive stages: document pool development, screening and refinement.

3.2.3. Data analysis

Both interview and document data were analyzed qualitatively, through an abductive thematic analysis. Abductive thematic analysis involves pragmatic, iterative alternating between theory-driven and data-driven analysis, allowing for emergent themes from the corpus to interface with extant literature. Additionally, abductive approaches are well-suited for otherwise unexpected findings through creative interpretation (Gabriel, 2018; Thompson, 2022)

Adapting Thompson's (2022) and Khurshid et al.'s (2026) approaches, after interviews were transcribed, cleaned and member-checked, a first pass of coding was completed with a deductive-

dominant codebook (see Appendix C) developed from extant frameworks and typologies in literature. This helped to structure interview data in line with extant theory, whereafter a second inductive-dominant pass was completed to further refine, extend and condense themes. Throughout the data collection and analysis process, field notes and memos were continually taken and reviewed, which helped to further deepen analysis and reflexivity (Phillippi & Lauderdale, 2018).

The process maps developed from this analysis describe the pathways of NBCS initiatives, including the actors' organizations, constituent and related programs, and amplification type. We then synthesize these maps by interpreting Lam et al.'s amplification typology in three-dimensional vector space, where amplify within, out and beyond are orthogonal directions that the impact of a sustainability initiative can increase along. This allows for a systems mapping approach that illustrates how NBCS and their impact have grown over time, and a condensed representation of the aggregate impact growth for comparison within and between initiatives.

3.2.4. Limitations

We recognize three significant limitations in our data collection and analysis. Firstly, we had modest informal and no formal input from Indigenous participants, communities or organizations. While relevant staff at Indigenous-led or focused organizations were contacted to discuss their involvement and perspectives on NBCS initiatives through publicly available means, no one from this was available to be interviewed. Partnerships with First Nations and Indigenous organizations are increasingly centered in climate action and NBCS governance in both Halifax and Vancouver. However, we did not have enough capacity to build the necessary reciprocal relationship with the three First Nations in Vancouver and the Mi'kmaw Confederacy in Halifax in line with preventing extractive research practices (Government of Canada, 2023). We recognize that this capacity for

reciprocal research partnership is in itself is a finding and return to it in the discussion section. To attenuate this, interview participants were asked about how they and their team partnered with First Nations and Indigenous organizations on NBCS, which helped to connect literature on Indigenous-led and co-produced NBCS and sustainable self-determination to emergent themes in the data. We stress that those individuals and organizations did not speak on behalf of any First Nation(s) or urban Indigenous communities. Secondly, although we reached saturation with the existing set of interviews and we have reasonable confidence that essential perspectives were captured, staff from notable organizations in each case weren't available to be interviewed. While exhaustive interviewing is not necessary to reach saturation and rich contextual understanding (Guest et al. 2006; LaDonna et al., 2021), the gaps in certain organizations' presence in interview does allow for potential blind spots or omissions in the interplay between organizations, actor groups and specific NBCS initiatives within each case city. Thirdly, while continuity in the research process from interview guide design, through interviews, transcription, and analysis has its merits, all transcription and coding being done by a single researcher also limits the study's reliability by preventing inter-coder checks. Multiple coding passes and reviews between the authors helped to perturbate this.

3.3. Results: mapping amplification pathways of NBCS initiatives

Five prominent NBCS initiatives arose from interview and document analysis: green infrastructure (Vancouver), naturalization (Halifax), urban community gardening (Halifax), shoreline restoration (Transmunicipal), and urban forestry (Transmunicipal). It should be noted that this is not an exhaustive list of urban NBCS in these cases, nor are these initiatives wholly exclusive to one another. Additionally, while these initiatives describe different types of urban NBCS, their amplification pathways (presented in the process maps below) are heavily context-

sensitive and are not designed for a generalizable typology. In the interest of conciseness, enrich is included as a type of amplification in the narrative and diagrammatic mapping below. This new type of amplification is further explained and substantiated in the discussion.

3.3.1. Green Infrastructure in Vancouver

Vancouver's implementation of green infrastructure is long-standing and widely prevalent. The City currently operates through its strategic GI document, Rain City Strategy, which defines green rainwater infrastructure as, "an emerging field and approach to rainwater management that uses both engineered and ecosystem-based practices to protect, restore and mimic the natural water cycle." (Conger et al., 2019: p. 4). This followed the adoption of the Integrated Rainwater Management Plan (IRMP) in 2016, which helped to establish a dedicated Green Infrastructure Implementation Branch with the mandate to capture and clean 90% of rainwater in the city by 2050 (City of Vancouver, 2016). While the Rain City Strategy and the IRMP are primarily to help Vancouver fulfil Metro Vancouver's requirement to eliminate all combined sewer overflows (CSOs) by 2050 through the separation of their remaining combined sewers (Metro Vancouver, 2010), their development and adoption was a watershed moment for expanding GI practice across the city. Chiefly, 250 managed GI assets that were previously managed across 9 different departments such as Transportation's Green Streets program, were transitioned to the GI branch in Engineering Services (P04-0620). This transfer and consolidation allowed for continued maintenance of these assets and the provision of benefits they provide (P21-1009) (amplify within, stabilize).

As private property takes up 57% of the City's land base (City of Vancouver and Vancouver Parks Board, 2018), several interviewees stressed the City's shifted focus in recent years to GI development on private property (P02-0617; P06-0627; P09-0704; P21-1009). The Rain City

Strategy also prompted the inclusion of GI requirements in the building code and zoning by-law for private property development to achieve on-site rainwater management targets (P02-0617; P06-0627; City of Vancouver, 2023; 2025a) (amplify beyond, scale up). Initially, these required a tiered approach that prioritized vegetative GI types such as rain gardens, swales, and blue-green roofs, followed by infiltration types like permeable pavements, followed by detention methods like storage tanks if all else was not feasible. Several participants described that over time, property developers were opting for detention-based methods to meet these requirements in the majority of proposals, rationalizing this through the permitting process to difficulties in insuring certain GI types, increased capital and maintenance costs, constraints in land availability, preferences towards other land use options, and lacking design standards (P02-0617; P06-0627). As political priorities have concentrated around accelerating housing development to address the housing crisis, these building code and zoning by-laws changes were recently amended to set the detention tank as the default, with the option for infiltration or retention-based methods to at the developer's discretion (de-amplify out, de-enrich). This was done to apply the on-site rainwater management requirements to more building types (amplify out, grow, transfer) and expedite the permitting process (amplify within, speed up) (P02-0617; P06-0627; P21-1009).

Since being transitioned to engineering services, Vancouver has increased the existing 250 managed GI assets to over 400 through an expanded typology including bioretention practices, tree trenches, blue-green roofs, permeable pavements, and stream daylighting (City of Vancouver, 2025b; Conger et al., 2019) (amplify out, grow, spread). Many of these projects were done through inter-departmental partnerships (prominently with Transportation, Real Estate and Facilities Management's Ecological Services team, and the Vancouver Board of Parks & Recreation), and through inter-organizational partnerships with local non-profits, community coalitions and

stewardship groups. Participants described these partnerships as central to these GI projects becoming embedded in the community, not just implemented in their space. The St. George Rainway project was prompted from a community-led coalition who, through partnering with the GI branch and other municipal departments, co-designed and established a multi-block system of blue-green bioretention and right-of-way changes to include triple-A bike routes and car-free spaces (City of Vancouver, 2022). By opening these spaces for community gatherings, workshops and markets, and improved recreation and safety, the Rainway became a participatory space for residents beyond the ambient ecosystem services it provides (amplify beyond, scale deep; amplify within, enrich). The Reconciled Futures project, in partnership with the Museum of Vancouver, hosted local Indigenous youth in museum tours and mentored workshops where they designed sculptures that were installed as public Indigenous art displays at the 63rd and Yukon rain garden plaza (City of Vancouver, 2021). Through this, the youth group were led through museum tours, on-site educational programs on how GRI function and green employment opportunities. This helped to form a sociocultural connection to the rain garden, skills building in local Indigenous youth, and make salient the relationship between the land and the Indigenous communities who have called them home since time immemorial, influencing residents' sense of place and human-nature relationship (amplify beyond, scale deep). Figures 3.1a and b illustrate how this amplification developed over time.

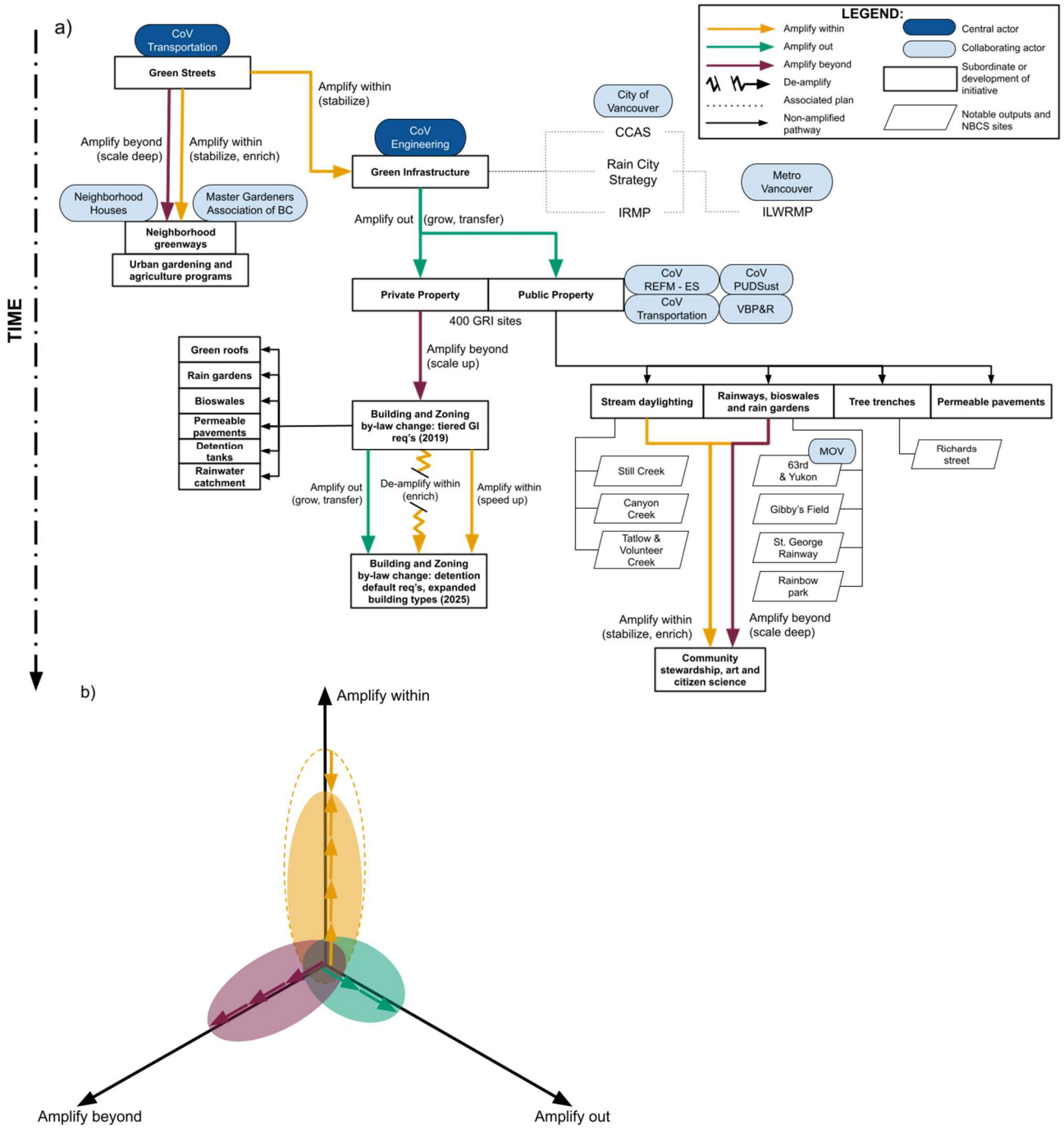


Figure 3.1a. Process map of amplification of green infrastructure in Vancouver. CoV: City of Vancouver. REFM – ES: Real Estate and Facilities Management, Ecological Services Team. PUDSust: Planning, Urban Design & Sustainability. VBP&R: Vancouver Board of Parks & Recreation. MOV: Museum of Vancouver. CCAS: Climate Change Adaptation Strategy. IRMP: Integrated Rainwater Management Plan. ILWRMP: Integrated Liquid Waste and Rainwater Management Plan.

Figure 3.1b. Matrix diagram of green infrastructure amplification. Amplify within, out and beyond are positioned as orthogonal axes, where each instance of amplification along each direction in figure 1a is mapped as a conceptual unit vector.

3.3.2. Naturalization in Halifax

After a 3-year pilot project, Halifax approved the Naturalization Strategy in 2022, which expanded efforts in parks and right of ways to 32 sites across the municipality (Halifax Regional Council, 2022). Halifax defines their naturalization as "an ecologically based approach to landscape management that seeks to enhance biodiversity and ecological resilience in the urban landscape through the use of native or non-invasive-adapted plant species." (Halifax Regional Council, 2019: p. 2). The Naturalization Strategy was borne from calls for naturalization in existing priority plans, such as the Urban Forestry Master Plan (which was later updated to the Urban Forestry Management Plan, UMFP), the Halifax Green Network Plan (HGNP), and HalifACT (Halifax's climate action plan) (2022). This helped to establish a dedicated naturalization team within the HRM parks and recreation department, funded by the climate capital fund. Both the pilot and expanded naturalization initiative involved partnership with the environment and climate change team in the property, fleet and environment unit.

At the time of this writing, Halifax has completed an additional 6 of their 32 planned sites for naturalization, many of which were prioritized to improve environmental quality and recreation use in underserved and equity-seeking communities (P14-0716) (amplify out, grow, spread). In terrestrial park naturalization, access to high-quality greenspaces that included physical amenities, shaded areas, and naturalized sections to facilitate quality recreation were discussed as priorities in selecting parks. Many of the terrestrial naturalization projects have or are set to be done in partnership with Tree Canada, a transmunicipal environmental non-profit organization specializing in tree planting, stewardship and education. Shoreline (also described as riparian) naturalization sites have prioritized lakes that are highly sought recreation spaces and that experience frequent beach closures due to water contamination (P14-0716; P17-0724). This runs

in parallel to Halifax's collaborative initiative, Living Lakeshores, which specifically focuses on shoreline naturalization (further discussed in shoreline restoration).

As HRM's Naturalization initiative is housed in its parks and recreation department, naturalizing private property is out of their jurisdiction. Given this, and an understanding of the contention regarding how much coastal access is privately owned in Nova Scotia (P17-0724), engaging community members and homeowners to naturalize and steward their own properties is a significant component of their naturalization practice. In 2020, HRM passed an administrative order respecting boulevard gardening that widens constraints and grants residents greater control over what they can plant in the abutting boulevard strip between the street and their property (amplify beyond, scale up) (HRM, 2020b; P17-0724; P18-0801). As the naturalization strategy emphasizes improving native plant biodiversity, this enabling legislation change is coupled with public stewardship and education programs to increase residents' native biodiversity awareness, access to beneficial management practices and to native plant stock (amplify within, stabilize). Additionally, one participant described how engaging with community groups and elementary-school youth through showcases and a pollinator card program cultivated improved sense of agency and excitement in students experiencing eco-anxiety, and a renewed understanding of how nature can exist and benefit them in their urban milieu (P17-0724) (amplify beyond, scale deep). Figures 3.2a and b illustrate how this amplification developed over time.

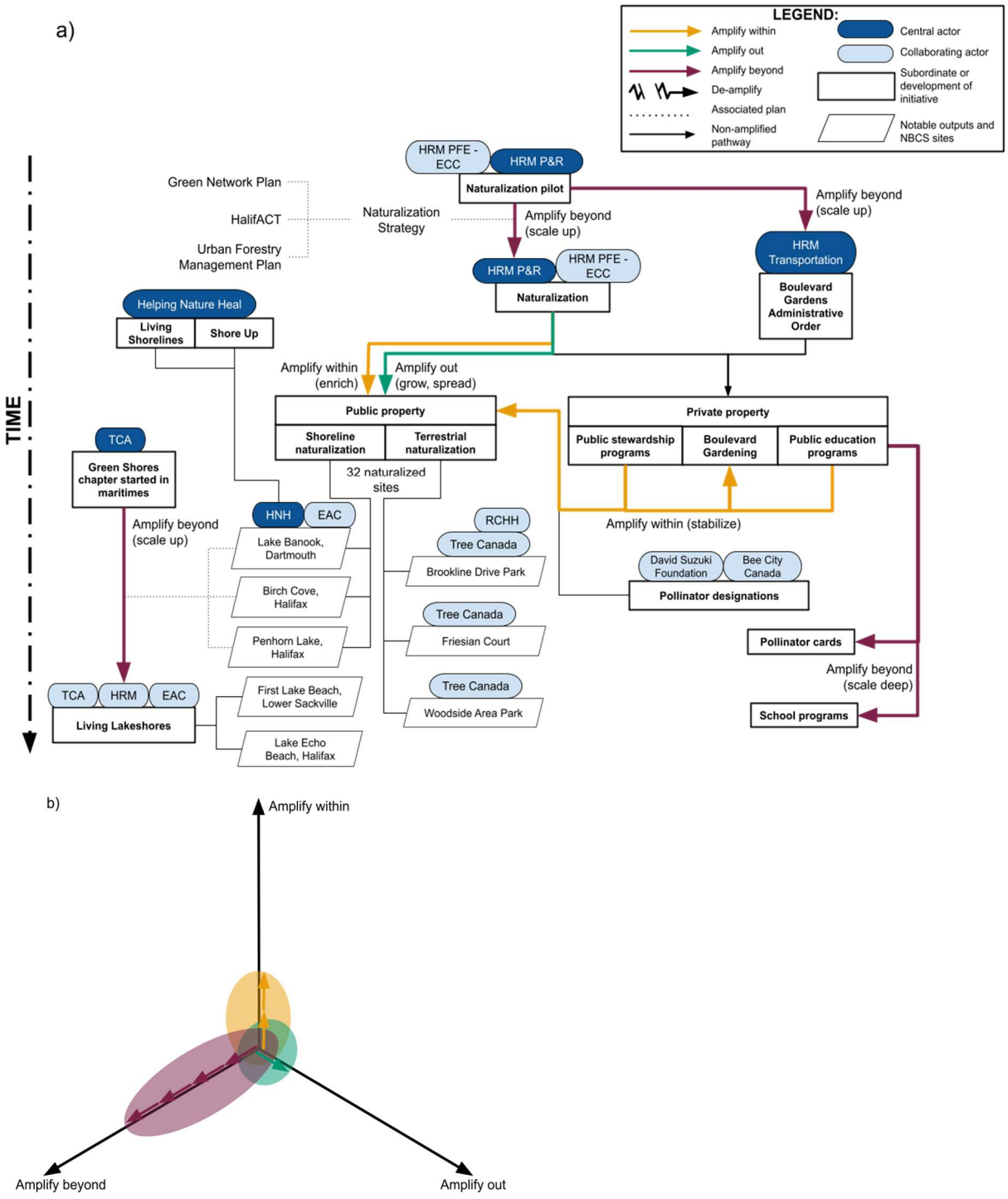


Figure 3.2a. Process map of amplification of naturalization in Halifax. HRM: Halifax Regional Municipality. PFE: Property, Fleet and Environment. ECCC: Environment and Climate Change. P&R: Parks and Recreation. EAC: Ecology Action Centre. TCA: TransCoastal Adaptations Centre for Nature-Based Solutions.

Figure 3.2b. Matrix diagram of naturalization amplification. Amplify within, out and beyond are positioned as orthogonal axes, where each instance of amplification along each direction in figure 2a is mapped as a conceptual unit vector.

3.3.3. Shoreline Restoration through Green Shores

The Green Shores program of the Stewardship Centre for British Columbia (SCBC) aims to "minimize the impacts of new developments; and restore shoreline ecosystem function of previously developed sites… [to promote] healthy shore environments that provide significant environmental, economic, and social values to coastal communities" (SCBC, 2023: p. 1). It quickly expanded to provide training in tandem to shoreline restoration through site visits, workshops, online courses and webinars provided in partnership with the University of Victoria and the British Columbia Institute of Technology. This provides three levels of training that educate participants on the program, its benefits, implementation, shoreline ecology, governance and management practices. Participants range from general public, homeowners, local and regional government staff, and environmental professionals, who can progress to a professional accreditation through the program. A participant described how "nature-based projects are weakest the first day that they're put in and strongest many years down the road, whereas built infrastructure [is] going to be strongest the first day you put it in and the weakest in 20 to 30 years from now" (P01-0616). Given this, the Green Shores training is critical to not only informing property owners' decision-making towards a nature-based approach to shoreline restoration over a rock wall, but also to stewarding newly-restored sites during their first few years until sufficiently matured for homeostatic resilience (P01-0616). Through Green Shores for Local Government (GSLG), SCBC operates as an intermediary and capacity builder to local governments, providing support in planning, technical expertise, community engagement and education, site management and access to a forum of other local governments involved in the process, supporting further training and site restoration. Additionally, the province of BC partnered with SCBC to develop an Expedited Permit Guide and a Nature-based Shoreline Projects Checklist for homeowners,

property managers and Crown Lease holders (amplify within, speed up). Over the last two decades, there have been over 20 projects enrolled and certified throughout lower mainland BC. Notably, New Brighton and Jericho Beach Parks, both located on the City of Vancouver's north shore (Burrard Inlet and English Bay respectively), are both gold-rated shoreline restoration projects (SCBC, 2024) (amplify out, grow, replicate).

These demonstration sites were instrumental in providing the legitimacy and operational expertise to start a Green Shores chapter in the Maritimes (Atlantic provinces of Canada) (amplify out, replicate). While the TransCoastal Adaptations Centre for Nature-Based Solutions (based at St. Mary's University in Halifax) had been an existing partner with the Green Shores program while still in lower mainland BC, establishing this chapter in 2021 transitioned them to the central organization in translating and replicating the Green Shores program into new physical and institutional contexts. In this capacity, they are building a similar program model to the BC chapter, providing green shores training and capacity building alongside shoreline restoration demonstration sites (P13-0715). A prominent project in this is Shore Road: Building with Nature, where HRM partnered with TCA and Helping Nature Heal (a local SME specialized in ecosystem restoration) to restore and robustify a 480-meter stretch of Shore Road, a key transportation corridor in Halifax's Eastern Passage, against erosion from extreme weather events. This project is not only being used to develop capacity and expertise to grow shoreline restoration within HRM, but also as a legitimizing case study for other Nova Scotian municipalities with less capacity and risk tolerance (amplify out, grow, transfer) (P14-0716; King, 2026).

In 2025, HRM partnered with TCA alongside Ecology Action Centre (a regional environmental non-profit) to launch their Living Lakeshores program, aiming to "increase the resilience of freshwater shorelines in the Halifax region and build community understanding of

natural restoration approaches in sensitive ecosystems" (Living Lakeshores: Enhancing Shorelines and Building Community, 2025) (amplify beyond, scale deep). This uptake into HRM's Living Lakeshores situates Green Shores practices adjacent to HRM's existing Naturalization program (P14-0716). These initiatives have (at the time of writing) a combined five shoreline restoration sites completed, consolidating and institutionalizing practices and resources into staff operations. Further, this combining mutually augments the public education and stewardship programs from Naturalization and the free Green Shores training offered to HRM residents (P14-0716) (amplify within, stabilize, speed up). Figures 3.3a and b illustrate how this amplification developed over time.

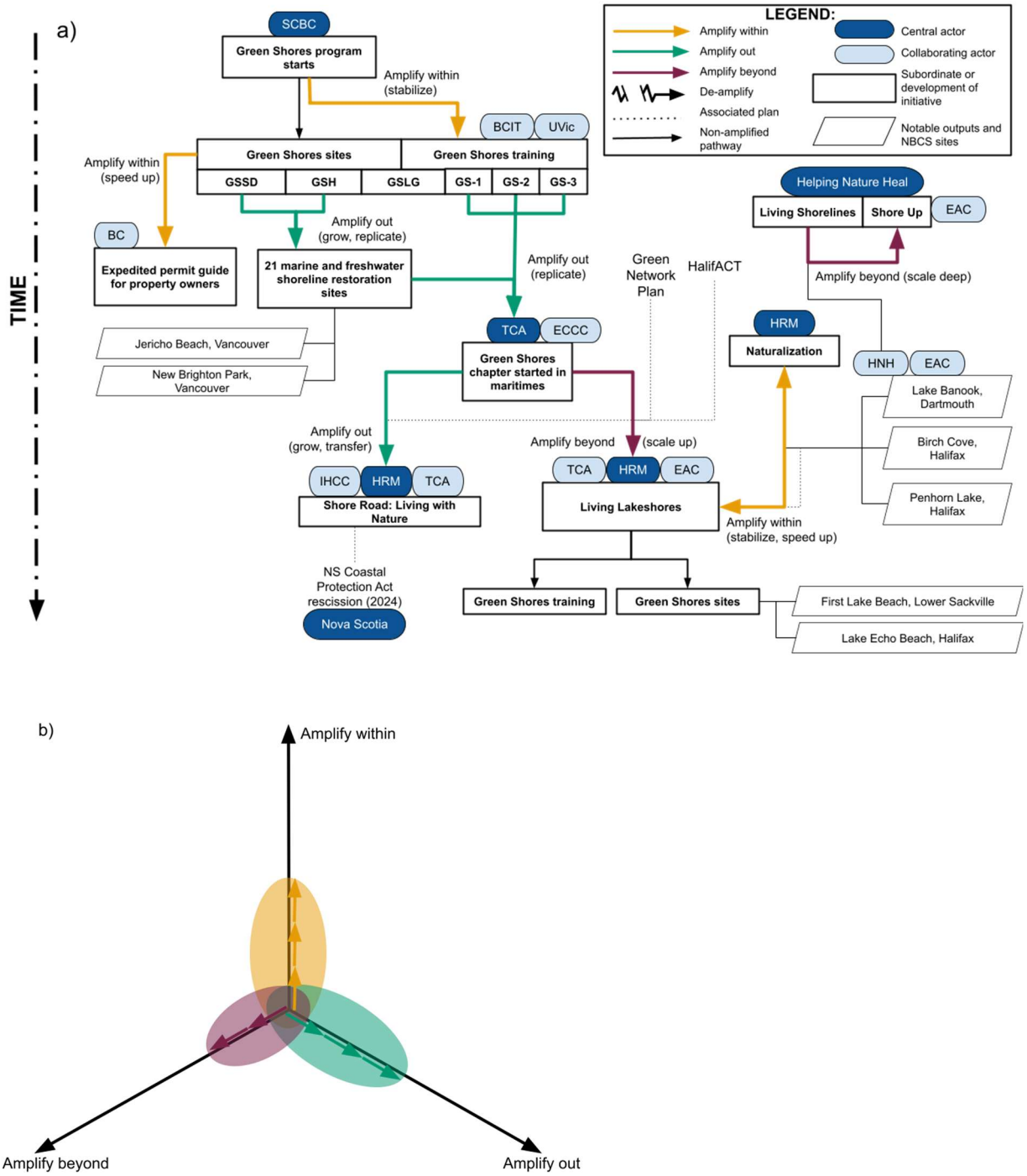


Figure 3.3a. Process map of amplification of Green Shores for shoreline restoration. SCBC: Stewardship Centre for British Columbia. BCIT: British Columbia Institute of Technology. UVic: University of Victoria. TCA: TransCoastal Adaptations Centre for Nature-Based Solutions. IHCC: Infrastructure, Housing and Communities Canada. EAC: Ecology Action Centre.

Figure 3.3b. Matrix diagram of shoreline restoration amplification. Amplify within, out and beyond are positioned as orthogonal axes, where each instance of amplification along each direction in figure 3a is mapped as a conceptual unit vector.

3.3.4. Urban community gardening (Halifax)

Amplifying NBCS is not the exclusive practice of governments and regional-scale non-profits. Hope Blooms is a community-driven non-profit social enterprise that engages youth in Halifax's North End neighborhoods through agri-environmental, sociocultural and enterprise programs centered around an urban community garden. The African-Canadian settlement of Africville that began in the northern end of the Halifax peninsula in the 19th century was destroyed and extirpated by the then City of Halifax in the mid-20th century (McRae, 2023; Prouse et al., 2014). These roots still hold in Halifax's North End today, which is home to strong African Nova Scotian (ANS) communities and is central to ANS identity. Historically ANS communities like Uniacke Square still experience systemic marginalization, with many still living in a food desert amidst untenably rising costs of living, up-zoning and affluent-serving development gentrifying and displacing ANS residents and businesses (Canadian Centre for Policy Alternatives, 2023; Ramos & MacNabb, 2018).

Hope Blooms began as an underutilized plot-turned-community-garden involving neighborhood youth in growing, harvesting and selling produce. This matured over time to implementing and facilitating multifarious youth-centered programs that have made it a keystone to community gatherings, food security, safety and place-making. From the success of the urban garden and farmer's market, a cohort of Hope Blooms pitched and acquired funding from Dragon's Den for an investment in developing a greenhouse (Lummis, 2018). This helped to not only publicize the social enterprise but create a consistent supply of produce and available space for expanded education programming and youth-led enterprises (P16-0722) (amplify within, stabilize, enrich). The greenhouse operates as a net-positive facility (powered by solar energy through a partnership with Build Right Nova Scotia) with organic farming practices, integrated rainwater

catchment and compost-driven heating. It has become a catalyst in Hope Blooms changing youths' perceptions and understanding of social-environmental sustainability and their place in it. Not only are climate, sustainable agriculture and community-centered resilience embedded in curricula, one participant described how: "the kids are very aware [of climate change and sustainability challenges] and that's exactly why we started the green labs program […]. [W]e want to see more of them going into maybe green careers because there is a huge […] lack of people of color in green careers and I think we're going to see that changing, not only from Hope Blooms, but other organizations that are also doing the work." (amplify beyond, scale deep) (P16-0722). Green Labs is a STEM education program that offers workshops focusing on experiential science, environmental stewardship, renewable energies, and health. This program has since been embedded in school curricula, allowing students in the community to receive credits through their work in the Green Labs program (P16-0722) (amplify beyond, scale up).

Focused on long-term impact, community youth are involved in Hope Blooms programs across their childhood and adolescence in a reinforcing feedback structure. Joining at a young age, youth are empowered through multi-year education programs on environmental science, urban agriculture, music and culinary arts. Through this, they become in-program leaders for younger cohorts, as well as bringing new understanding and perspective to their homes and peers: "anything that we include in Hope Blooms, it's taught to the community by the kids." (P16-0722). As students graduate, revenue from youth-led enterprises help fund scholarships for Hope Blooms alumni to pursue post-secondary education, who often return to facilitate new cohorts of youth-led enterprises and education (amplify within, stabilize).

In partnership with Green Communities Canada and Tree Canada, Hope Blooms became a site for a Living Cities project, involving community youth in planting trees and their ongoing

stewardship (amplify out, replicate) (Hasan, 2025; P10-0709). In addition to the greenhouse, Hope Blooms partnered with a family-owned farm in Broad Cove, increasing growing capacity and supply for produce sales at the Farmer's market and for their culinary programs (amplify out, grow).

The North End is also home to the Mi'kmaw Native Friendship Centre (MNFC), who closely partners with Hope Blooms. A participant described a sense of kinship between ANS and urban Indigenous youth and their caregivers, which fosters a mutual celebration of cultures, customs and cuisines at the community garden, kitchen and events (P16-0722). Hope Blooms is also a frequent site for the MNFC childcare program to plant medicinal and culturally significant plants to be used at smudging ceremonies and Mi'kmaw events. Furthermore, Hope Blooms was host and partner to a cross-cultural event, We All Meet At Food, alongside MNFC and their Everyone Every Day initiative to cross-pollinate experiences and perspectives on land stewardship, community, coloniality and food justice (amplify beyond, scale deep) (Nocturne Halifax, 2025; P16-0722). Figures 3.4a and b illustrate how this amplification developed over time.

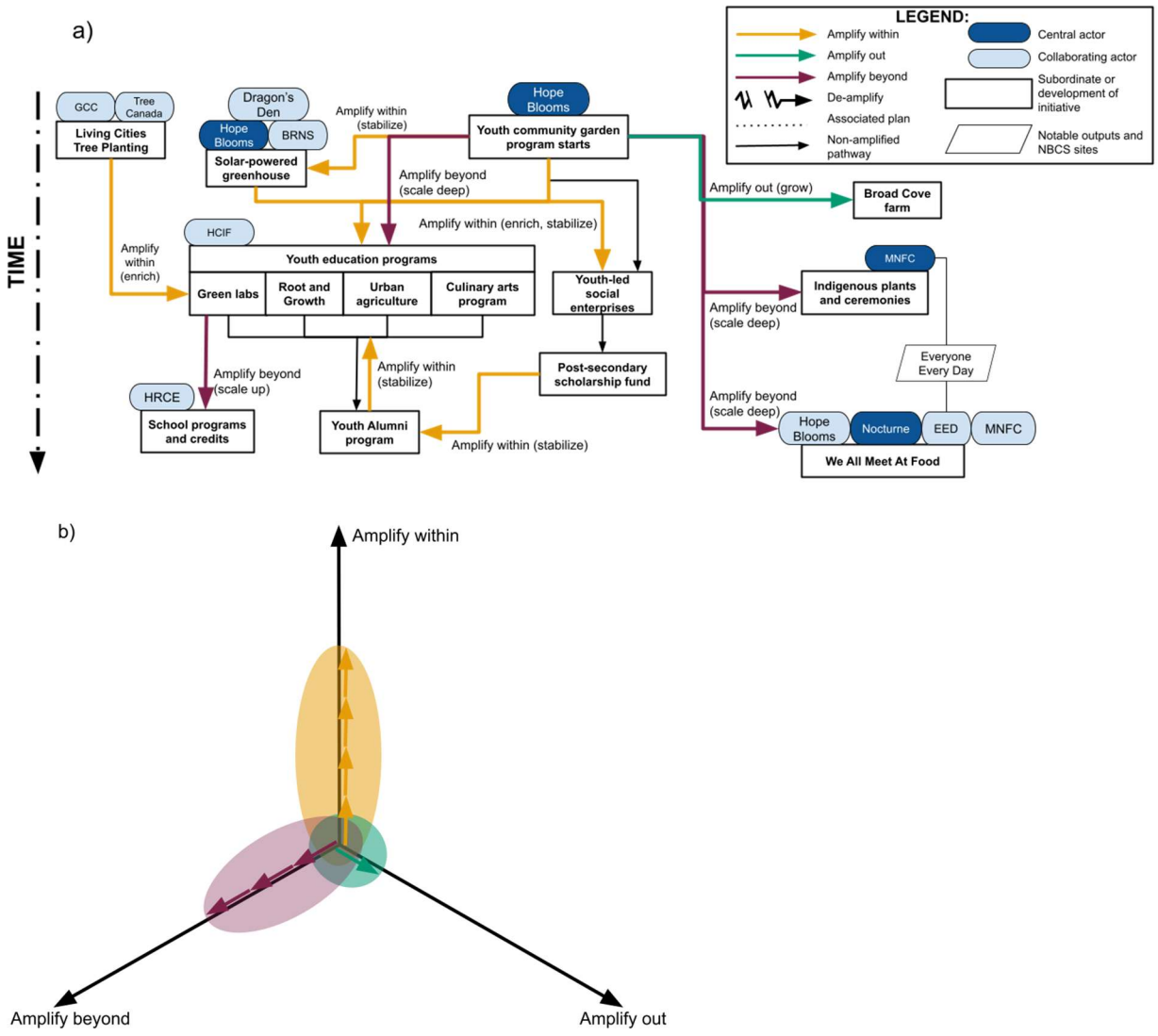


Figure 3.4a. Process map of amplification of urban community gardening in Halifax. BRNS: Build Right Nova Scotia. GCC: Green Communities Canada. HCIF: Halifax Community Investment Fund. HCRE: Halifax Regional Centre for Education. MNFC: Mi'kmaw Native Friendship Centre.

Figure 3.4b. Matrix diagram of urban community gardening amplification. Amplify within, out and beyond are positioned as orthogonal axes, where each instance of amplification along each direction in figure 4a is mapped as a conceptual unit vector.

3.3.5. Urban Forestry

A significant amount of climate action at the federal level in Canada has been centered on increasing carbon sequestration to meet mitigation targets, with a significant amount of this being focused on large-scale forestation and agricultural projects (Drever et al., 2021; Environment and Climate Change, 2020). In 2020, the Natural Climate Solutions Fund (NCSF) horizontal initiative was announced, which included 3 separate but related programs to fund natural climate solutions across different sectors and jurisdictions: the Agricultural Climate Solutions program (administered by Agriculture and Agri-Food Canada [AAFC]); the Nature Smart Climate Solutions Fund (administered by Environment and Climate Change Canada [ECCC]); and the 2 Billion Trees (2BT) program (administered by Natural Resources Canada [NRCan]). As the name suggests, the 2BT program was established to provide financial support to organizations to plant 2 billion trees by 2031 for an expected 12 megatonnes of CO2e mitigated annually by 2050 (Natural Resources Canada, 2025). In 2024, the Canadian federal government partnered with the Federation of Canadian Municipalities' Green Municipal Fund (GMF) to establish the Growing Canada's Community Canopies (GCCC) program, to further enable urban forestry projects in small- and medium-sized municipalities across Canada in contribution to the 2 billion tree goal. When asked about this program's inception, a participant described a mutual benefit in partnering between NRCan and FCM's GMF. NRCan received limited applications due to small municipalities not having the available land (10,000 trees per year per project) or the financial capacity (50% cost share) to participate in the 2BT program, as well as a staff sentiment on the program's underutilized potential to deliver on adaptation targets alongside sequestration: "[we got a] really strong reaction from our members that like how the federal program was designed isn't really meeting the needs of smaller communities. So, we made a pitch of like, 'If you give us

a substantial portion of the municipal stream of funding, we will help broaden the target audience'" (P20-0819) (amplify out, replicate, spread). Furthermore, despite the core reporting requirements of the GCCC program aligning with the mitigation focus of the federal 2BT program, GCCC projects allow for more prevalent urban reforesting, and as such, included additional evaluation criteria such as the proportion of planting occurring in low canopy neighborhoods, near equity-deserving communities or in flood-prone areas.

Announced in the Federal Fall Budget of 2025, the 2 Billion Trees program was discontinued, with existing agreements still being honored (Natural Resources Canada, 2025). Not only did the launch of GCCC help to expand increase the number of projects funded towards 2BT's sequestration targets by improving local government eligibility, it increased the program's benefits to include adaptation and social well-being in addition to mitigation (amplify within, enrich), and doing so beyond the lifespan of the original 2BT program (amplify within, stabilize).

Adjacently, Green Communities Canada (GCC, a trans-municipal nonprofit that supports grassroots-led climate action) acts to enable and implement local urban forestry projects across Canada. GCC's Living Cities Canada Fund provides financial and operational capacity support to local partner organizations through four streams. The 'mobilize' stream provides training and network resources in partnership with FCM. The 'demonstrate' and 'transform' streams help to fund new and equity-improving green infrastructure projects, respectively. The 'thriving microgrants' stream provides funding to support volunteer-based monitoring and maintenance of existing green infrastructure sites to conserve the site's quality and continued maturation. This is often done with partnering local organizations that had previously established their green infrastructure project through the 'demonstrate' or 'transform' streams (amplify within, stabilize) (P10-0709). Since beginning its national pilot launched in 2022, GCC's Mini Forests program has

directly supported 45 mini forest projects across Canada (amplify out, grow, replicate), with a notable example being the Hope Blooms tree planting project in 2024 (funded through the transform stream). The mini forest program follows a Miyawaki method, making use of a tight multi-layered planting design of locally native species that mimics native forest complexity and promotes taller plants in a shorter growing period (Devisscher et al., 2025). Building off these mini forest projects, GCC partnered with the Forestry Department of the University of British Columbia to publish a synthesis report, Seeds of Change (2025). This report collates lessons learned and recommendations stemming from these pilot projects for local governments and nonprofits to diversify their forestry strategies, transform spaces for community and ecological resilience by meaningful public engagement, and expand and expedite tree planting programs across Canada. Figures 3.5a and b illustrate how this amplification developed over time.

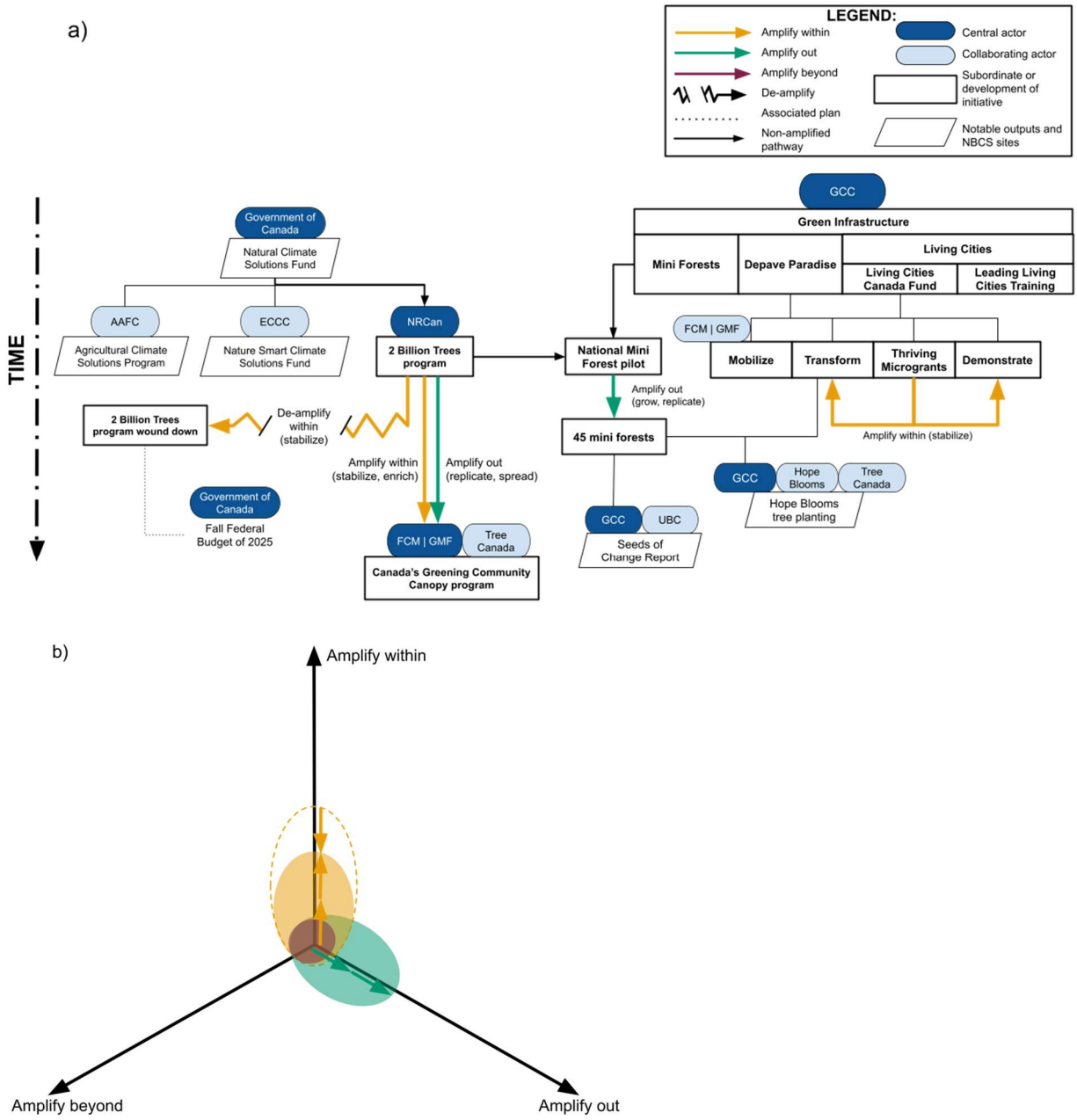


Figure 3.5a. Process map of amplification of urban forestry. AAFC: Agriculture and Agri-food Canada. ECCC: Environment and Climate Change Canada. NRCan: Natural Resources Canada. FCM | GMF: Federation of Canadian Municipalities | Green Municipal Fund.

Figure 3.5b. Matrix diagram of urban forestry amplification. Amplify within, out and beyond are positioned as orthogonal axes, where each instance of amplification along each direction in figure 5a is mapped as a conceptual unit vector.

3.4. Discussion

3.4.1. Enriching as a type of amplification

In abductively analyzing the amplification pathways of NBCS initiatives, it became clear that how the diversity and quality of an initiative's co-benefits change through its amplification could not be adequality captured with the existing 8 types. This prompted the conceptualization, parameterizing, and use of "*enriching*" as a new type of amplification. *Enriching* describes increasing the impact of a sustainability initiative through increasing the diversity and/or quality of co-benefits received. In this, we interpret urban NBCS co-benefits through the framework proposed by Raymond et al. (2017). As this does not necessarily change the initiative's impact along spatial (i.e. the number of people and places impacted), or institutional dimensions (i.e. scaling into policy and values), but rather changing the density of impact from a given initiative, enriching is most suitably situated in the *amplifying within* category (shown in Figure 3.6).

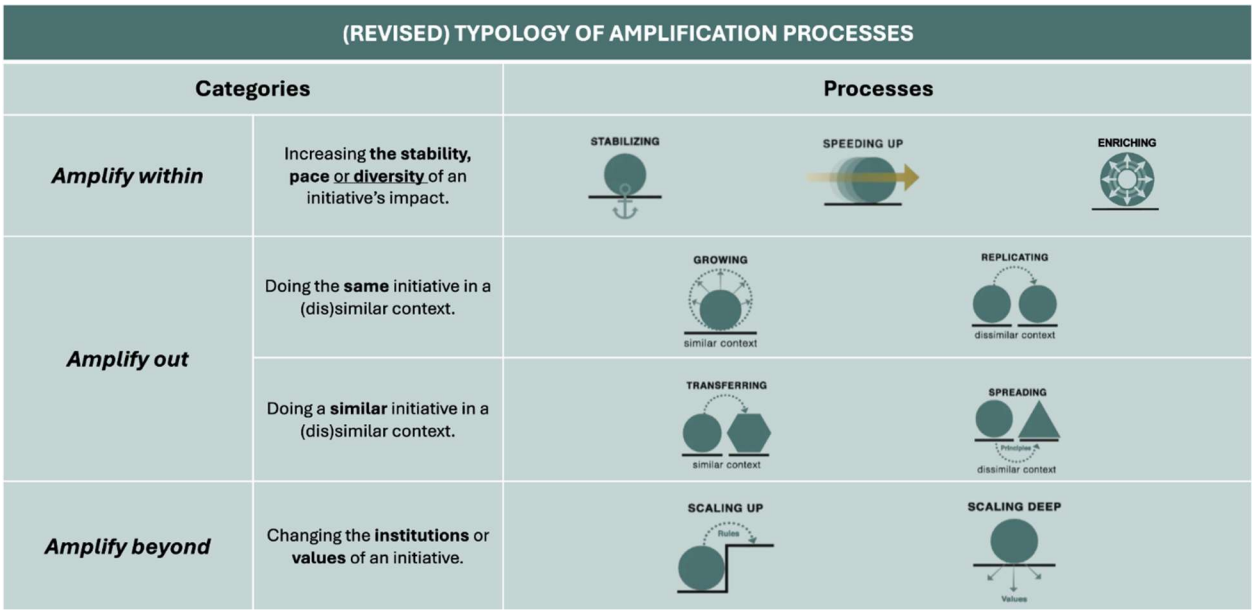


Figure 3.4. Illustration of the eight original amplification processes grouped into three categories, along with enrich as a new type and revised category definitions (adapted from Lam et al., 2020).

Amplifying urban NBCS through enriching was observed in several initiatives. In urban forestry, the injection of 2BT funding to launch the GCCC program not only stabilized, replicated and spread the impact by expanding and outlasting the original federal program, the GCCC initiative enabled urban forest canopy expansion through funding that would have otherwise been largely allocated to sequestration projects in rural contexts. This still contributed to the central mandate of 2BT of mitigation, but critically increased the program's impact through providing co-benefits associated with urban forestry: improved air quality, climate adaptation (such as microclimate regulation and flood risk management), biodiversity habitat, social commons and cohesion.

Enriching an initiative can also occur without changing the context in which its impact is experienced. The iterative growth of infrastructure and programming in Halifax's urban community garden has helped to stabilize and enrich the impact it has on the community. In particular, the sustainable infrastructure amenities of Hope Blooms' greenhouse (solar power, rainwater catchment, has allowed sustainable enterprise programs to produce and sell stock for their youth-led social enterprises year-round (stabilize), as well as allowed Green Labs STEM education program to offer expanded curricula and workshops, including off-grid organic farming, aquaponics, and renewable energy, increasing the experiential education gained by participating youth and surrounding community members (enrich). Similarly, Halifax's naturalization of parks and shorelines enriched the sociocultural co-benefits from ecosystem services and biodiversity. This naturalization allowed for continued recreation uses, while creating opportunities for civic education and involvement in stewardship and monitoring, such as outdoor youth education, community-based stewardship, and citizen science initiatives.

Interestingly, a *de-enriching* (explained further in following section) of Vancouver's Green Infrastructure implementation on private property also occurred in the amendment to the Building By-law (City of Vancouver, 2025a). In the City's aim to increase both housing development and on-site rainwater management across the city's footprint, by-law requirements changed from a three-tiered system that favored vegetation-based infiltration and retention methods to a default detention tank system (that could be optionally supplemented or substituted by more vegetative types). While this helped to speed up the growth and transfer of the policy's central aim for on-site stormwater volume reduction and treatment (expanded the building typology subject to these requirements and faster permit approvals), the diminished obligation to include bioretention, green roof, tree trenches, permeable pavements and other GI methods reduced the co-benefits that would be associated with subsequent implementation. Notably, the differences in co-benefits between GI and detention-based methods were highlighted in a report recently published by the City's Sustainability Group (Lotus Water, 2024: pp. 25-27). It should be recognized that GI already implemented prior to and despite this amendment will still provide their respective co-benefits. This de-enriching describes the decreased density of co-benefits institutionalized into policy for the City's Green Infrastructure initiative, which will shape what and where co-benefits will precipitate in the city through these requirements going forward.

In proposing this new type of amplification, we do so with some recommended criteria and considerations. Firstly, is the criterion of additionality: enriching should describe an increase in the quality and diversity of co-benefits to the initiative, not simply the presence of multiple benefits at its initial state. Secondly is that it often occurs coincidentally with other amplification processes, but should be recognized as a distinct way impact is increased. In particular, changing the density of co-benefits can influence how people interact with and relate to the space (particularly in

restorative, co-produced or community-led initiatives). However, the increase of co-benefits can be coincidental or contributional to but not equal to the changing of values and norms seen in scaling deep. Furthermore, just as Lam et al. (2020) highlight the need to leave the growth-centered paradigm that assumes more initiatives will foster more transformation associated with amplifying out, so too do we caution against unilaterally assuming that denser automatically means better. Instead, we hope for this extension to the amplification framework to better capture how the co-benefits change as an initiative is amplified, and how these impacts are experienced differently within and between initiatives and their contexts.

As NB(C)S are promoted in research, policy and practice for their ability to provide multiple benefits in addressing interrelated socio-ecological crises, it stands necessary to critically capture what co-benefits are experienced, for who, and what urban futures these are transformative towards (Bina et al., 2024; Mahajan, 2025; Rusca et al., 2024).

3.4.2. Amplification pathway dynamics

Mapping NBCS amplification also allows for a more salient representation and analysis of the non-linear, plural and interrelated characteristics of these pathways. These maps suggest that NBCS amplification rarely occurs in isolation; both with respect to the types of amplification occurring, as well as the actors involved.

Across the five NBCS pathways mapped, amplification often occurred through new or existing partnerships between actor groups. Within the organization, amplification could occur across jurisdictions and disciplines, such as the shift of GI from the City of Vancouver's Streets and Transportation department to its Engineering department, which allowed for further collaboration with Ecological Services, Planning, Urban Design & Sustainability, and the Vancouver Parks Board to amplify GI out. Between organizations, partnership helped to expand

the initiative beyond its original context. Notably, after the Green Shores program was replicated in the Maritime context through the partnership between SCBC and TCA, a collaborative governance process was evident among local government, business, non-profit and private actors in the program's scaling up into HRM's Living Lakeshores program in line with its existing Naturalization, scaling deep through community-based stewardship and education, and growing shoreline restoration practices across Atlantic Canada. This corroborates current research underscoring the need for inter- and transdisciplinary knowledge in realizing the transformative potential of urban NBS (Frantzeskaki et al., 2025), and how partnerships and experience-based collaboration themselves can be transformative (Barth et al., 2023; Burch et al., 2026; Riedy et al., 2025).

In analyzing the multidimensional, recursive and non-linear amplification pathways of NBCS, we found that multiple types of amplification occurred in relation to one another. Most notably, this occurred through moments of simultaneous (amplifying an initiative along multiple directions at the same time) and sequential (amplifying along one direction facilitates successive amplification along a new direction) amplification. Simultaneous amplification can be seen in Vancouver's public GI projects. By engaging neighborhood residents and associations in the design, development and stewardship of like St. George Rainway stabilized the project through integrating more continuous maintenance and citizen science monitoring, enriched the project through the inclusion of community arts- and recreation-based events and spaces for improved social cohesion, which cumulatively scaled deep into community members' place-making and human-nature relations. Sequential amplification can be seen in how the Green Shores program was replicated in the Maritimes, which allowed for the program to be successively scaled up into HRM's municipal shoreline restoration programs.

Further, we identified instances where the impact of an NBCS initiative decreased, implying the possibility of *de-amplification*. This was seen in two notable cases: firstly, the amendment in Vancouver's on-site rainwater management requirements to detention tank methods de-enriching of private GI in reducing the co-benefits associated with vegetative-based methods on private property; and secondly, the destabilizing of the federal urban forestry initiative through the dissolution of the 2BT program. We represent this as a broken arrow in pathway maps, and as a similar conceptual unit vector with inverse direction in the accompanying matrix diagrams (figures 1-5b). In presenting de-amplification, we aim to highlight and interrogate the implicit assumption of sustainability initiatives only increasing their impact. This can better capture regressions in policy and practice, such as the recission of governmental legislation, austerity-driven reductions in capacity, or the erasure of collaborative practices within and between contexts.

These dynamics (simultaneous, sequential and de-amplification) help to better capture and describe the non-linear and multidimensional nature how NBCS are amplified, and how the impact compounds across scale and scope. By interpreting this amplification in 3-dimensional vector space, we are able to better represent how an initiative's impact changes along the 3 different categories as orthogonal directions (within, out, and beyond). This synthesis can describe the changes in an initiative's impact over time (longitudinal comparison) or the differential impact between initiatives (cross-sectional comparison). Capturing the dynamics of how NBCS initiatives are amplified and their resulting transformative impact, this research complements the continuum of systemic, selective and constrained amplification profiles proposed by Dethier and Roman (2026). We further speculate that as these amplification dynamics compound and complexify, they change the social, ecological and technological conditions for further amplification. This could contribute a more mechanistic understanding among nascent research on contextual

reconfiguration, which highlights the multidimensional, recursive and hybrid nature of transformative change through experiments changing the physical, social and institutional landscapes of the urban regime (Ehnert, 2025; Tozer et al., 2022; Welden et al., 2021).

3.5. Conclusion

In this paper, we leverage the amplification typology as a qualitative analytical framework to map how urban NBCS initiatives are amplified beyond their inception for increased impact. Building on existing interdisciplinary literatures surrounding urban transformation, sustainability governance, and nature-based (climate) solutions, our comparative case study maps the amplification pathways of five prominent NBCS initiatives across urban Canadian contexts as non-linear, multidimensional and collaborative.

Our systems mapping approach contributes a more detailed approach of demonstrating and analyzing how the impact of NBCS evolve over time, highlighting the contextual interactions among actors and the differential outputs, developments and subordinates that shape the NBCS system. This, coupled with our proposed addition of enriching to account for the diversity and quality of co-benefits constituting the initiatives developed impact, could provide deeper insight into the differential impact of NBCS initiatives, and the kind of transformation they contribute to. Further, this empirically corroborates that amplification is a non-unitary, non-linear, interrelated process, particularly for urban NBCS which are inter-disciplinary and inter-jurisdictional. In particular, our analysis suggests that amplification pathways occur along partnerships, both within and among organizations, supporting that inter- and transdisciplinary praxis of NBCS is critical to achieving positive urban transformation outcomes.

While interrogating when or under what conditions amplification “achieve transformation” (and the assumptions in determining that) was outside of the capacity of this paper, we encourage

further research using and refining our findings to explore a more mechanistic understanding of when the impact from amplifying these initiatives realizes transformative change, whether by our speculation to contextual reconfiguration or otherwise. Future research could further refine the concept of "enriching" to better understand how different co-benefits interact with and reshape urban systems, particularly in respect to the role of NBCS multidimensionality in the polycrisis.

While we suggest that further research explore complementary quantitative approaches to quantify the magnitude of how these impacts have changed (advancing the conceptual framework of amplification as the increase along a vector in 3-dimensional space), we also caution the reduction of NBCS amplification and transformation to a purely positivist or metric-based representations, as this risks excluding pluralistic, Indigenous, and locally situated knowledge systems that are essential to just urban transformation research. Relatedly, we highlight the need for further research on NBCS in Canadian contexts. The amplification pathways described in this study do not represent an exhaustive account of NBCS initiatives across urban Canada. Given the diversity in institutional structures, social and ecological landscapes, and distinct relationships between settler governments and Indigenous Peoples from coast to coast to coast, Canada offers rich potential for examining how NBCS initiatives precipitate just transformation, and the political, relational, and more-than-human dimensions of its praxis. As mentioned in this study's limitations, we were unable to substantively investigate Indigenous-led and co-produced NBCS initiatives sufficiently and reciprocally. This is partly due to the combined structurally limited capacities of Indigenous community representatives, settler NBCS practitioners and (early career) researchers to partner in this research praxis. We stress that formalized financial and informational resources are necessary for the capacity to sufficient and co-creative collaboration for the implementation and amplification, and research of NBCS called for in existing literature to be realized in Canada.

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Chapter 4 – A Swale of Two Cities:

Governing the Amplification of Nature-Based Climate Solutions in Urban Canada

4.1. Introduction

Cities are home to more than half of the global population and three quarters of Canadians (Statistics Canada, 2025; World Bank Group, 2026). As urbanization further concentrates people and infrastructure in urban centres, cities are recognized as key arenas of experiencing, mitigating and adapting to the climate crisis (Dodman et al., 2022). Amidst this, interrelated social-ecological and socioeconomic crises like biodiversity loss, unaffordability, and aging infrastructure compound these already intensifying impacts (Lawrence et al., 2024). The need to deploy integrative and multidimensional solutions to these crises at scale and speed has become increasingly urgent.

Nature-based climate solutions (NBCS) have emerged across research, policy and practice domains as one such approach for their ability to multisolve across multiple social-ecological challenges through the provision of co-benefits (Cohen-Shacham et al., 2019; Raymond et al., 2017; Sawin, 2024). Despite the extent of literature and advocacy for NBCS, their implementation often remains limited to pilot projects, fragmented demonstration sites, and ephemeral programs (Dorst et al., 2022; Kabisch et al., 2016; Martin et al., 2025; Schröter et al., 2022). As urban NBCS research has matured, investigating how to scale these solutions across spatial, institutional and normative dimensions has become an emerging focus of urban sustainability governance research (Adams et al., 2023; Bruley et al., 2025; Hölscher et al., 2023; Tozer et al., 2022a; van der Jagt et al., 2020). Contemporary case-based research has yielded promising insights into the contextual and structural conditions that impede or enable NBCS to grow beyond the pilot stage for longer and stronger impact (Adams et al., 2023; Dorst et al., 2022; Tozer et al. 2022b;

van der Jagt et al., 2020). This empirical research has engaged with various theoretical and conceptual frameworks from political ecology, urban transformations and sustainability governance (Bina et al., 2024; Carmen et al., 2024; Frantzeskaki & Bush, 2021; Hölscher et al., 2024; Krueger et al., 2022; Tozer et al., 2022b).

Much of the conceptual development of NBCS and research on their implementation and scaling has been done in urban European contexts (Hölscher et al., 2023; Tozer et al., 2022b). While recent translation and application into different socioenvironmental contexts have yielded promising insights into the institutional, context-sensitive and transformative dimensions of NBCS (Gcanga et al., 2024; McPhearson et al., 2025), urban Canadian contexts remain comparatively underexplored (Goodwin et al., 2023; Jang & Doyon, 2024; Skoyles et al., 2025). In parallel, the conditions that determine how the transformative impact of NBCS initiatives are increased (i.e. amplified) across spatial, procedural, institutional, and relational dimensions is only just growing out from conceptual to empirical application (Dethier & Roman, 2026; Lam et al., 2020; Mguni et al., 2025; Schröter et al., 2022). Beyond addressing these geographic and application research gaps, recent attrition in Canada's climate policy, shifts in in economic, public housing and infrastructure development policies (Department of Finance Canada, 2025), as well as growing governmental investment in restoring and protecting nature (Environment and Climate Change Canada [ECCC], 2026) present a critical opportunity to explore the processes by which NBCS initiatives and their impact are advanced within and across urban contexts and scales towards just, low-carbon and resilient futures.

In this paper, we investigate the conditions and processes of how NBCS are governed and amplified in a Canadian context through a comparative case study of Vancouver and Halifax. To do achieve this, we position three successive questions:

i. What are the governance conditions for NBCS in urban Canadian contexts?

ii. How do these conditions interact to impede or enable NBCS amplification?

iii. What strategies can catalyse these conditions to further enable NBCS amplification?

4.2. Background

4.2.1. Urban NBCS governance

Emerging from the ecosystem approach outlined by the Convention on Biological Diversity, NBCS as a concept has largely been shaped by nature-positive agendas of multinational organizations (Cohen-Shacham et al., 2019). Defined by the International Union for the Conservation of Nature, NB[C]S are actions that "protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016, p. xii). While global discourse of NBCS has largely been centered on addressing the climate and biodiversity crises through inter-governmental scientific bodies (IPBES, 2019; IPCC, 2022), the multidimensional benefits of NBCS have expanded appeal in potentially spanning across and outside disciplinary boundaries of conservation, public health, ecocultural practices, infrastructure and community resilience, and economic development (Frantzeskaki et al., 2025; Hanson et al., 2020; Raymond et al., 2017). Beyond changes to the biophysical and infrastructural urbanscapes, NBCS are also promoted as vehicles through which deeper institutional and cultural paradigms of urban regimes can be challenged (Bush & Doyon, 2023; Maller, 2021; Mguni et al., 2025; Raymond et al., 2023). These, combined with their local or regional level of implementation, have expanded NBCS discourse in policy and practice across scales and contexts (Adams et al., 2024; Bush & Doyon, 2019; Nesshöver et al., 2017; Raymond et al., 2017).

In Canada, significant discussion of NBCS has been concentrated around large-scale projects in rural contexts for the primary purpose of meeting greenhouse gas emissions reduction targets through "the protection, restoration, or expansion of ecosystems that sequester carbon, or reduce emissions to the atmosphere" (CCA, 2022, p. x). Understandably, much of how Canada's nature is governed has been focused on the conservation and sustainable management of its complex terrestrial, riparian and marine ecosystems in its rural regions (CCA, 2022; Drever et al., 2021; Reed et al., 2022). Further, critical scholarship on NBCS in Canada (among other settler colonial contexts) rightly interrogates Western ontologies of human-nature relations that underpin dominant conceptualizations of NBCS, and the how NBCS praxis can challenge or reproduce colonial structures that have and continue to dispossess Indigenous Peoples from their lands and Knowledge systems (Reed et al., 2022, 2024; Townsend et al., 2020). The federal government's launching of their new conservation strategy frames nature protection as a means of advancing interconnected biodiversity, climate, and reconciliation objectives through initiatives such as Indigenous-led conservation, protected and conserved areas, and the expansion of the National Urban Parks program (ECCC, 2026).

As stated, Canada's urban centres are already home to three quarters of its population, and are expected to see further concentration of people and infrastructural demand (Statistics Canada, 2025). A growing recognition to plan for this urbanization amidst aging infrastructure, intensifying climate impacts and socioeconomic stressors (primarily housing unaffordability and precarity) (Merwe & Doucet, 2021) has made for a groundswell in implementing and scaling of NBCS across scholarly, sustainability professional, and local governments spaces (Jang & Doyon, 2024; Jones et al., 2025; Skoyles et al., 2025). Extant literature of urban NBCS predominantly pertains to sustainable service delivery, such as green infrastructure for stormwater management

(Jang & Doyon, 2024; Johns, 2019) or urban forestry for improved air quality and greenspace access (Devisscher et al., 2023), as well as shoreline restoration for coastal resilience (Jones et al., 2025; Sutton et al., 2023). Given the same persistent lag in uptake of urban NBCS in Canada as other contexts, these studies have largely focused on examining the barriers and enablers to implementation of their various types of NBCS.

4.2.2. Challenges to NBCS uptake in urban systems

Recent governance scholarship on urban NBCS conceptualizes barriers and enablers not as isolated factors, but as emergent properties that reflect the social, ecological and technological conditions of urban regimes (Dorst et al., 2021; Kim et al., 2021; Sarabi et al., 2020). Resilience and climate governance research has demonstrated that barriers and enablers shaping municipal climate action are produced through the alignment and interplay of institutional, political, financial, and social conditions, including organizational structures and cultures, interdepartmental coordination, polycentric governance arrangements, and political leadership (Bremer et al., 2021; Burch, 2010).

Reflecting this systems perspective, scholarship has increasingly moved beyond interpreting barriers as discrete deficits in institutional or technical domains and instead toward understanding them as relational and structurally embedded within broader governance complexes. These complexes, composed of actor networks, regulatory arrangements, knowledge systems, financial structures, and cultural norms, configure the possibilities for NBCS uptake and transformation (Dorst et al., 2021; Sarabi et al., 2020; Simmons et al., 2018). Rather than operating independently, conditions are often mutually reinforcing: fragmented governance, limited knowledge and capacity, institutional inertia, and constrained financial resources interact across scales to produce implementation challenges. Raška et al. (2022) demonstrate that barriers to NBCS emerge through

the interaction of governance, social, economic, technical, and institutional conditions across multiple domains and scales, while Frantzeskaki et al. (2025) emphasize that addressing these relational and systemic challenges requires inter- and transdisciplinary approaches capable of bridging jurisdictions, disciplines, actors, and epistemologies to transform urban contexts towards more just futures. Similarly, Simmons et al. (2018) conceptualize urban governance as an innovation process embedded within broader socio-economic regime transitions, highlighting how governance arrangements both shape and are reshaped by institutional change.

Building on this, barriers to NBCS uptake are increasingly understood as the active products of structural conditions interacting within urban governance regimes, characterized by misaligned and entrenched policy mixes, context sensitivity, and dominant growth-centered development paradigms (Dorst et al., 2021, 2022; Martin et al., 2025; Sarabi et al., 2020). Transformative governance of urban NBCS, then, is less about removing or overcoming singular barriers than strategically reconfiguring conditions within and of the governance system itself. Similarly, sustainability transitions and systems thinking research have conceptualized enabling factors as leverage points (Abson et al., 2017; Meadows, 2015) or, more recently, catalytic stepping stones (Tozer et al., 2022b; Xie et al., 2022) that can destabilize and reconfigure the complex of governance conditions towards more sustainable processes and outcomes.

Recent case-based studies in the lower mainland of British Columbia, Canada reinforce this dynamic and interdependent understanding of NBCS governance conditions, exploring the trust, collaboration and knowledge systems among actors and their underlying institutions to increase coordination and capacity for mainstreaming NBCS (Jang & Doyon, 2024; Jones et al., 2025). Similar case-based research in Canada's Atlantic coast demonstrates institutionally- and cognitively-driven path dependence impeding nature-based coastal adaptation, closely interfacing

historical infrastructure planning and current community perspectives (Rahman et al., 2021; Sutton et al., 2023).

We build on these recent empirical and conceptual advances to examine the factors that determine urban NBCS governance and the barriers and enablers as outcomes of these structural configurations (Dorst et al., 2021, 2022). In addition to this framework of structural conditions applied to urban NBCS governance in Canadian settings being relatively novel, our employment of an amplification framework (the increasing of a sustainability initiative's impact for transformation) in these structural conditions helps to examine the dynamics of how the advancing of NBCS beyond the pilot is changed by and changes the conditions of the urban regime (Bulkeley, 2023; Lam et al., 2020).

4.2.3. Amplifying NBCS beyond the pilot

Current discourses diagnose the inertia of NBCS uptake as stagnating in a liminal and indeterminant state of "projectified" urban experiments (Bulkeley, 2023; Torrens & von Wirth, 2021), or "being proposed and implemented within […] structures that were not designed to accommodate them" (Jones et al., 2025, p. 59). As such, examining how niche and discrete practices and sites can and have advanced beyond their initial state for more systemic transformation has become a central focus of contemporary sustainability transitions governance research. While there are several areas and approaches explored across research fields of sustainability transitions governance, urban transformations, resilience and social innovation (among others), the concepts of scaling, mainstreaming, and accelerating have been most prevalently applied in investigating how NBCS can and have been advanced past their pilot stage.

Scaling describes the expansion of initiatives across actors, sectors, and geographies. Maturing beyond growth-centered and unidirectional thinking, contemporary scholarship

differentiates relational, socio-spatial, and institutional dynamics between scaling up, out and deep (Bögel et al., 2022; Bruley et al., 2025; Moore et al., 2015). Mainstreaming describes the normalization and institutional integration of novel sustainability initiatives into governance complexes to achieve a 'new normal' (Adams et al., 2023; Frantzeskaki & McPhearson, 2022). This includes a reconfiguring of policy windows, governance capacities and structures, and organizational processes and culture, with particular focus on specialized role archetypes and catalytic actions that can incrementally or stochastically reshape and calibrate governance structures (Adams et al., 2024a; Adams et al., 2024b; Tozer et al., 2022). Accelerating describes the pace and momentum-building of niche initiatives towards transformative outcomes. This looks at the reinforcing dynamics that emerge from mutual exchange of sustainability innovations and experiments that can overcome barriers and constraints to broader and deeper uptake (Gorissen et al., 2018; van der Jagt et al., 2020). Collectively, these frameworks reflect a broader shift away from linear models of transition toward more systemic understandings of transformation as recursive, political, relational, and multi-scalar. While these terms and others approach sustainability transitions of and by urban governance differently, their overlap, emphasis and distinctions inform an interdisciplinary dialogue of empirical and theoretical research.

In this paper, we employ a framework of amplification, which integrates prominent transformation conceptualizations and frameworks to describe the increasing of a sustainability initiative's impact to foster transformative change (Lam et al., 2020). This increased impact is differentiated across 8 types of amplification and aggregated into 3 categories: amplify within, amplify out, and amplify beyond (2020, pp. 10–17).

Amplifying within describes increasing the impact of an initiative by changing the procedural and structural dimensions of an initiative to provide beneficial impact to the same context faster or longer. Amplifying out describes increasing the number of people impacted by the initiative by expanding or adapting across (dis)similar contexts. Amplifying beyond describes changing how we interact with the initiative and its impact, by embedding it into policies, institutions, norms and values. We also build off adjacent research that expands this framework to include enriching as a type of amplifying within, which describes increasing the diversity or quality of co-benefits of an initiative, as shown in figure 4.1 (Boyall et al., forthcoming)[2]. Our use of amplification not only serves as a conceptual bridge for how otherwise discrete, niche initiatives can increase along distinct lines that interact and compound towards transformative impact, but also as an interstitial framework for exchange among other sustainability transition concepts and the insights from their empirical application.

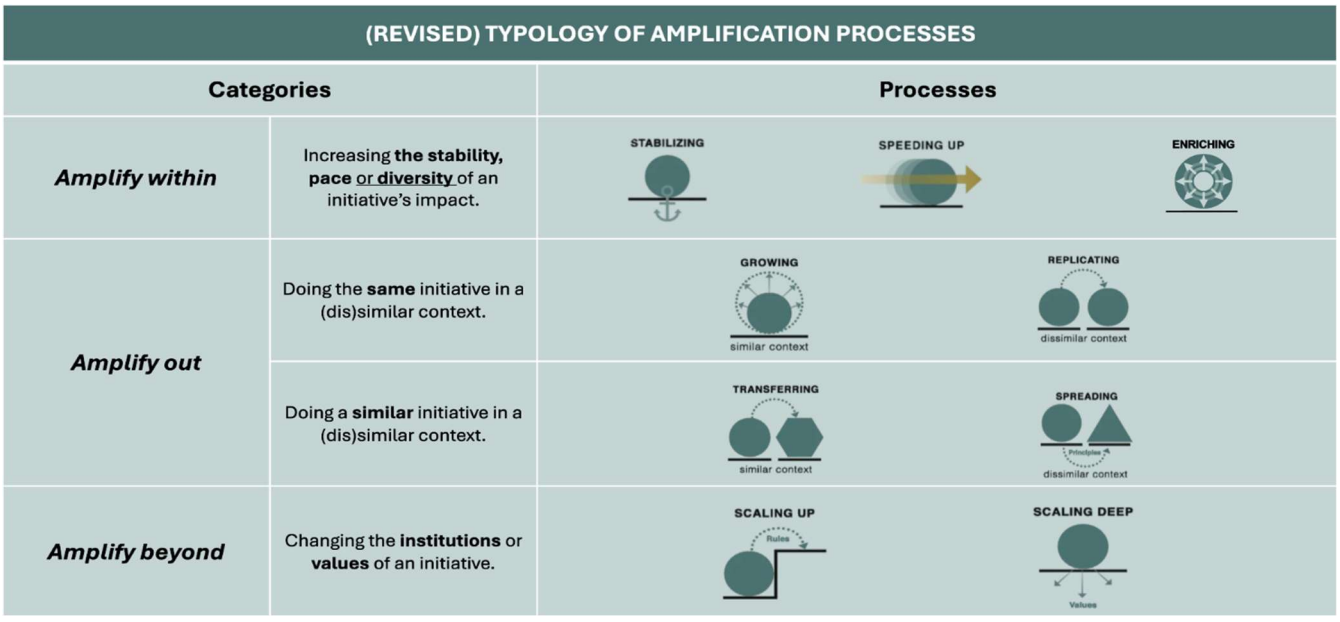


Figure 4.1. Illustration of the eight original amplification processes grouped into three categories, along with enrich as a new type and revised category definitions (Boyall et al., forthcoming; adapted from Lam et al., 2020).

[2] For further description and context of enriching, refer to section 3.5. (Discussion of Chapter 3).

In the sections that follow, we outline the study design, case context and methods by which we collected and analyzed our data. Empirical results of governance conditions of urban NBCS are presented and analyzed, along with how they compare between the piloting and amplifying stages. Analysing these conditions, we discuss how they interact to produce barriers and enablers to NBCS amplification. We conclude with describing current and recommended policies and practices to enabling further amplification through the lens of leverage points (Meadows, 2015) and steppingstones (Tozer et al., 2022a).

4.3. Methods

To analyze the structural conditions that influence NBCS governance in urban Canadian contexts and how those conditions enable or hinder broader amplification, a mixed methods comparative case study approach was employed. The two cities chosen for this case comparison were Vancouver, British Columbia and Halifax, Nova Scotia. Both cities are the largest metro areas on Canada's Pacific and Atlantic coasts, respectively. Beyond this, both cities are also recognized as regional and national leaders in climate action, environmental planning and sustainability innovation. Critically, both cities have a suite of existing NBCS initiatives, which are described further in their respective case study contexts and Results. While this paper describes a comparative case study that was primarily designed and conducted between two cities, it is also with recognition that governance complexes exist outside the municipal boundary, often with higher levels of government (provincial and federal) as well as intermediary organizations operating at higher governmental levels and across municipalities. As such, organizations, policies and conditions that exist between and beyond these cities' contexts were also included.

4.3.1. Case context: Vancouver



Figure 4.2. Map of Vancouver, situated in Metro Vancouver Region of British Columbia, Canada. Adapted from Awmcphee (2019), Hayden120 (2009), and Hitoubashira (2023).

The city of Vancouver is the largest municipality in British Columbia, home to over 660,000 people (Statistics Canada, 2026), and is the cultural and economic epicentre of Canada's West Coast. The city lies on the unceded traditional territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) Nations, who have lived on these lands as sovereign stewards for millennia. The City is situated within Metro Vancouver Region, a federation of 21 municipalities, one Electoral Area, and one Treaty First Nation that is collectively home to over 3 million people (Statistics Canada, 2026). Most of the municipal planning, policy, and service delivery responsibilities are divided uniformly between constituent municipalities and the region, enabled by provincial legislation including the Community Charter (2003) and Local Government Act (2015). Vancouver, however, is also governed by a bespoke charter that grants it augmented power over municipal organization, administration,

regulation and development. While this charter creates comparatively unique components within Vancouver's policy and administration, such as an elected Board for parks and recreation separate and additional to City Council, the City still experiences similar challenges in local governance as other Canadian municipalities, NBCS implementation and climate risks (Burch, 2017; Viseh & Bristow, 2023; White et al., 2023; Zoghi et al., 2025). As city operations and priorities concentrate around addressing housing unaffordability through aggressive development and re-zoning, Vancouver's densely built urban core continues to grow through intensification (City of Vancouver, 2021).

Vancouver has a long history as a leader in social and environmental planning and policies. In 2012, Vancouver became the first Canadian municipality to adopt a Climate Change Adaptation Strategy (which has since been succeeded by the Climate Change Adaptation and Climate Emergency Action Plans) (City of Vancouver, 2012; 2020) which was preceded and followed by a suite of vanguard plans, strategies and actions towards issues of climate change, biodiversity, water quality, social cohesiveness and equity, waste management and energy use. This includes prominent plans such as the Greenest City Action Plan (2011), Vancouver Board of Parks and Recreation's master plan (VanPlay) (2020), the Rain City Strategy (Conger et al., 2019), and most recently, the Urban Forest Strategy (2025). Over the last two decades, Vancouver's efforts to integrate social, environmental and economic priorities through these plans and actions have precipitated advancements in equity, reconciliation and a prominent green economy and labor force that has helped to earn Vancouver's self-branding of "The Greenest City". Despite its sustainable and livable reputation, however, Vancouver embodies persistent inequalities across greenspace access and socioeconomic vulnerability that often correlate and (Devisscher et al., 2023; Tolfo & Doucet, 2022), backdropped by a

longstanding affordability crisis (City of Vancouver, 2024c). This was evidenced by the unprecedented heat dome of 2021, the deadliest single weather event in Canadian history. The 6-day event impacted the lower mainland of BC and pacific northwestern Unities states, resulting in over 600 deaths, many of which concentrated in communities with low green canopy coverage and preexisting vulnerabilities (City of Vancouver, 2023a; White et al., 2023).

4.3.2. Case context: Halifax

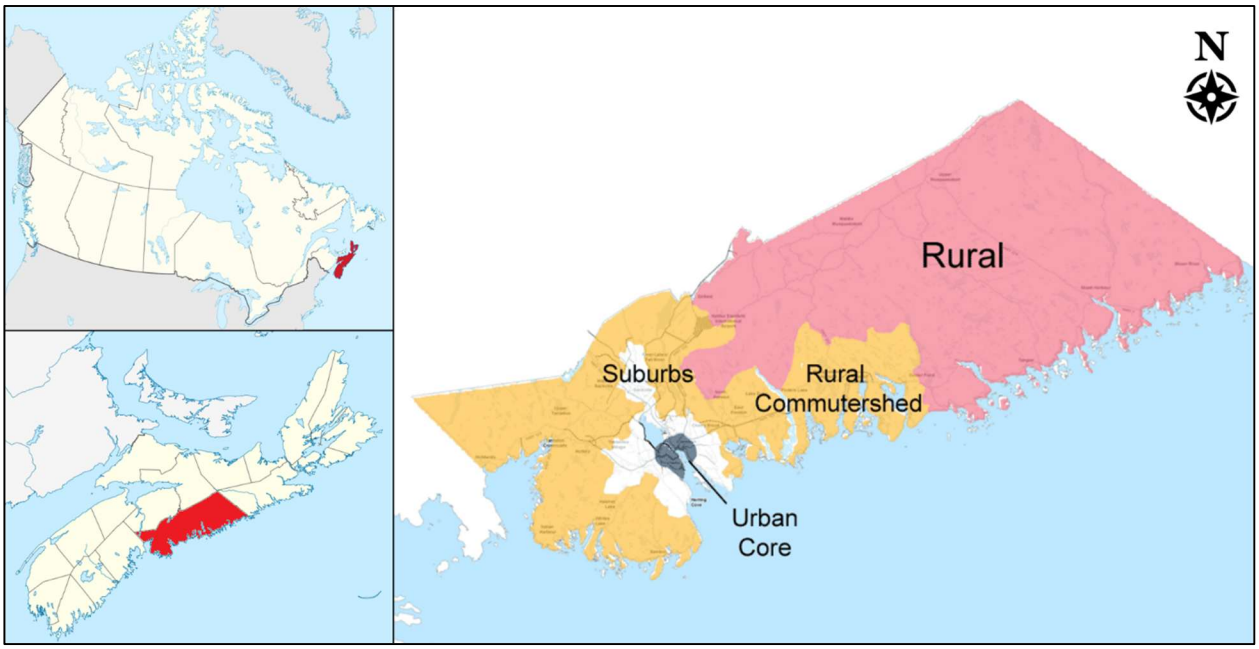


Figure 4.3. Map of settlement distribution across the Halifax Regional Municipality in Nova Scotia, Canada. Adapted from CanadaOlympics989 (2014), MapGrid (2020), WayeMason (2015).

Halifax is the capital region of Nova Scotia, the most populous region in Atlantic provinces (516,000 as of Statistics Canada, 2026), and one of the fastest growing municipalities in Canada. The region is located in Kjipuktuk of the Sɨpekne'katik district of Mi'kma'ki, the ancestral and unceded territory of the Mi’kmaq who are the original caretakers of the land and whose rights are ratified through the Peace and Friendship Treaty of 1752. Following municipal amalgamation in 1996, Halifax is governed as Halifax Regional Municipality (HRM) and is the largest in Atlantic Canada. HRM's jurisdiction encompasses urban, suburban, and rural communities, extending

from the region's most densely built downtown core to its rural, unserviced boundaries. HRM is governed primarily under its charter (2008) in addition to the provincial Municipal Government Act (1998), granting additional authority and flexibility to local decision-making power in legislation, development and planning.

Intensifying climate impacts compound existing socioeconomic stressors and systemically marginalized communities across Halifax's 'inequality hotspots' where spatial concentrations of income disparity, housing insecurity, and uneven access to services shape differential vulnerability and adaptive capacity (Ramos & MacNabb, 2018). As one of Canada's fastest growing cities, Halifax's growth been characterized by inter-provincial and international immigration alongside persistent low-density suburban and rural expansion. This has been shaped by long-standing path dependencies in land use planning that have sustained limited urban densification (Grant et al., 2019). Recent pressure to expand housing development to service this population growth against an ongoing housing crisis has led to renewed prioritizing of urban core densification (Exon Smith & Smith, 2025; Nicol & Biggar, 2025). Additionally, recent provincial policy developments, such as the recission of the Coastal Protection Act (2019) and the creation of Special Planning Areas (SPAs) for expanded and expedited development into rural regions and wilderness areas has shifted expectation and jurisdiction in urban sustainability governance in HRM's landscape.

Amidst this, Halifax continues to be a growing leader in climate and sustainability. In 2020, HRM launched HalifACT, a comprehensive climate strategy that commits to a carbon neutral and climate resilient municipality by 2050 (HRM, 2020b). HalifACT centres equity and community resilience integrates adaptation and mitigation across sectors, with nature-based climate solutions (NBCS) playing a key role in mitigation, adaptation and resilient development. Successive and

parallel priority plans like the Halifax Green Network Plan (HRM, 2018) and the Naturalization Strategy (Halifax Regional Council, 2022), which expand and protect ecological networks and urban green spaces aim to support biodiversity, cultural connections, and recreation access through the region's growth and land use changes.

4.3.3. Data collection

Following a qualitative mixed methods approach, a combination of semi-structured interviews with key informants and document analysis were employed. Key informants were selected through stratified purposive sampling to best allow for balanced, in-depth understanding of specific NBCS initiatives from practitioners and subject experts within and between cases. NBCS practitioners and experts were considered as individuals who are 1) employed or affiliated with a municipal government in Halifax or Vancouver, a non-governmental organization (NGO), a local business, or an inter-municipality federation; and 2) involved in the decision-making, management, funding, implementation, communication, coordination and/or maintenance of NBCS initiatives within an associated case study city. Participants were identified through a combination of existing professional contacts, key staff associated with NBCS initiatives from publicly available documents, and snowball sampling. A total of 20 interviews were conducted between June and October 2025, conducted either in-person or virtually via Zoom. Interviews followed a semi-structured approach, which allowed for baseline questions and core themes to be consistently covered with pre-determined questions and prompts, while flexible enough for conversations to develop based on the direction of conversation (Ahlin, 2019). Interviewing was also reflexive and responsive, where sections of the interview guide were continually (de-)emphasized based on available information on the expertise and organization affiliation of a particular participant, and based on previous interviews. Interviews were

transcribed and cleaned using Microsoft Word and ATrain (Haberl et al., 2024), whereafter participants were given the opportunity to review their transcripts. Interviews and participant communications were conducted with the approval of the University of Waterloo Research Ethics Board (REB #47371).

Table 4.1. Interview sample strata by case and participant affiliation.

Case	Municipality	NGO	Business	Academic research hub	TOTAL
Vancouver	6	1	1	1	9
Halifax	4	2	1	1	8
Inter-municipal	1	2	0	0	3
TOTAL	10	6	2	2	20

Interview data were complemented with relevant documents surrounding NBCS initiatives. This includes municipal plans, policies and strategies; academic reports; legislation and bylaws; as well as grey literature and public media (Morgan, 2022). Documents were collected and reviewed before, during and after the interview period to support 1) purposive sampling; 2) cumulative familiarization with specific NBCS initiatives and the policy and planning landscape they operate in; and 3) establish a wide base of reference to iteratively review, revise and analyze for triangulation during transcription and interview analysis. This occurred over three recursive stages: pool development, screening, and refinement.

4.3.4. Data analysis

Both interview and document data were analyzed qualitatively, through an abductive thematic analysis. Abductive thematic analysis involves pragmatic, iterative alternating between theory-driven and data-driven analysis, allowing for emergent themes from the corpus to interface with extant literature. Additionally, abductive approaches are well-suited for otherwise unexpected

findings through creative interpretation (Gabriel, 2018; Thompson, 2022). Adapting Thompson's (2022) and Khurshid et al.'s (2026) approaches, after interviews were transcribed, cleaned and member-checked, a first pass of coding using a deductive-dominant codebook developed from extant frameworks and typologies in literature (see Appendix C). This helped to structure interview data in line with extant theory, whereafter a second inductive-dominant pass was completed to further refine, extend and condense themes. Both passes of coding were done using NVivo 15 (www.lumivero.com/products/nvivo/). Throughout the data collection and analysis process, field notes and memos were continually taken and reviewed, which helped to further deepen analysis and reflexivity (Phillippi & Lauderdale, 2018).

4.3.5. Limitations

We recognize three significant limitations in our data collection and analysis. Firstly, we had modest informal, and no formal, input from Indigenous participants, communities or organizations. While relevant staff at Indigenous-led or focused organizations were contacted to discuss their involvement and perspectives on NBCS initiatives through publicly available means, no one from this was available to be interviewed. Partnerships with First Nations and Indigenous organizations are increasingly centered in climate action and NBCS governance in both Halifax and Vancouver. However, we did not have existing relationships with any of the First Nations bands, and not enough capacity to build the necessary reciprocal relationship with the three First Nation bands in Vancouver and the Mi'kmaw Confederacy in Halifax in line with preventing extractive research practices (Government of Canada, 2023). We recognize that this capacity constraint for reciprocal research partnership is in itself is a finding, and return to it in the results and discussions sections. To attenuate this, interview participants were asked about how they and their team partnered with First Nations and Indigenous organizations on NBCS, which helped to connect literature on

Indigenous-led and co-produced NBCS and sustainable self-determination to emergent themes in the data. We stress that those individuals and organizations did not speak on behalf of any First Nation(s) or urban Indigenous communities.

Secondly, although we reached saturation with the existing set of interviews and we have reasonable confidence that essential perspectives were captured, a small number of staff from notable organizations in each case weren't available to be interviewed. While exhaustive interviewing is not necessary to reach saturation and rich contextual understanding (Guest et al. 2006; LaDonna et al.; 2021), the gaps in certain organizations' presence in the interview process does allow for potential blind spots or omissions in the interplay between organizations, actor groups and specific NBCS initiatives within each case city. Thirdly, while continuity in the research process from interview guide design, through interviews, transcription, and analysis has its merits, all transcription and coding being done by a single researcher also limits the study's reliability by preventing inter-coder checks. Multiple coding passes and reviews between the authors helped to ameliorate this.

4.4. Results: Prominent conditions of NBCS governance

Analysis of participant interview and document data revealed 24 interrelated conditions, which can be aggregated into 7 categories: cognitive, environmental, financial, institutional, operational, political, and systemic (see figure 3). While these categories were informed by other categorizations of similar contemporary research (Dorst et al., 2022; Jang & Doyon, 2024; Jones et al., 2025), their framing and relationships were developed abductively to better describe differences between conditions influencing the piloting and amplification of urban NBCS. We preface the following results by noting that the categories used to group these conditions were chosen to support analysis and to align with existing categories from literature. These are not

intended to be restrictive or isolated. Rather, these are shown to be interrelated, as some conditions span multiple categories or exist in close relation to other conditions. In this section, we describe and analyze the prominent conditions across these categories emergent from empirical analysis. Following this, we interpret urban NBCS amplification as impeded or enabled at the interface of these conditions.

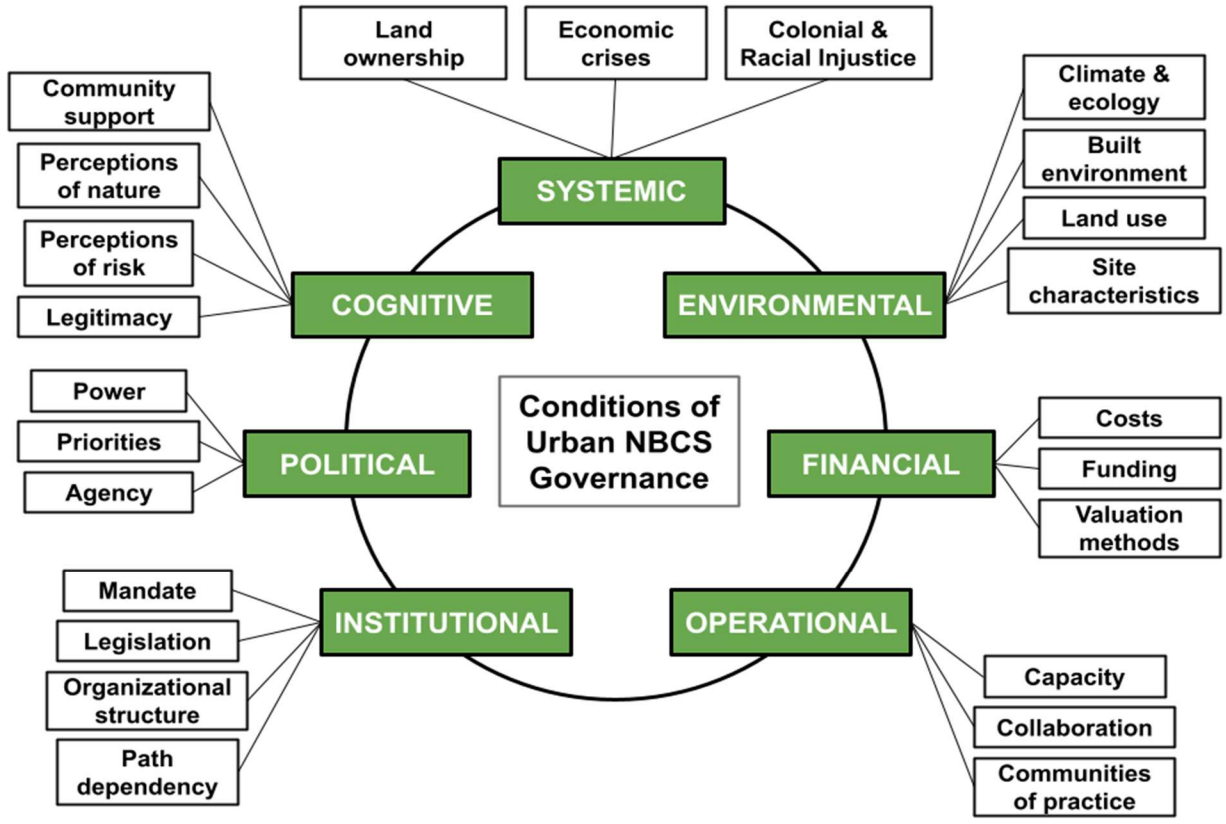


Figure 4.4. Conditions of urban NBCS governance. Categories are situated in an interrelated circle, with conditions as offshoots to this. Orange-blue gradient describes the categories having the potential to enable or impede NBCS initiatives and their amplification.

4.4.1. Environmental

Environmental conditions describe the factors that make a site (un)conducive for the implementation and maintenance of NBCS initiatives, both in the present and in the future. Given

the inherent scale dimension of NBCS and the ecological determinants of the living systems they are made of, these environmental conditions can range from the individual parcel, neighborhood, community, watershed or regional scales. Prominent themes that emerged as environmental conditions include the region's climate and ecology, the characteristics of the site and broader built environment, and the land use type and availability.

The climate and ecology of the region influence the specific ecological function and composition of different NBCS types, and as such, how suitable they are to that context. Participants involved in the Green Shores program, a riparian and marine restoration implementation and training program, described the differences in climate, geomorphology and native species requiring re-designing practices and establishing a local case studies portfolio in replicating and spreading the program from the Salish Sea bioregion[3] to the eastern Atlantic Maritime ecoregions[4] (P01-0616; P13-0715). Participants also described built environment and site characteristics, such as the composition of the surrounding urban morphology, public infrastructure and material requirements, affecting how NBCS initiatives can grow from parcel to larger scales, or transfer to additional sites within the same context (P02-0617; P09-0704; P10-0709; P18-0801). Further, scarcity of available land for NBCS was described as a significant factor for if and where NBCS sites would be implemented. This was prominent in the specific zoning of parcels, as well as in alternative current or potential land uses such as public recreation or residential amenities (P01-0616; P02-0617; P06-0627; P10-0709; P11-0709; P17-0724; P20-0819).

[3] The Salish Sea bioregion encompasses estuarine ecosystem composed of a network of inland marine waterways in Washington and British Columbia in which the City of Vancouver is located (Flower, 2021).
[4] The eastern Atlantic Maritime ecoregions make up most of New Brunswick, Prince Edward Island and Nova Scotia, forming part of the larger Atlantic Maritime Ecozone (McAlpine & Smith, 2010).

4.4.2. Financial

The financial conditions that influence the means and methods of planning, implementing and maintaining NBCS were discussed around 3 themes: costs, funding, and valuation methods. Costs were frequently cited as a limiting factor across participant strata in both capital and operating expenses. The costs of installing additional NBCS sites, as well as the ability to insure them (particularly green roofs and walls), were described as a limitation to NBCS projects both as pilots and their successive expansions (P02-0617; P06-0627). By contrast, operating costs for maintenance, monitoring and restoration were described as constraints within existing NBCS sites, potentially compromising their maturation and quality (P06-0627; P08-0703; P10-0709; P14-0716; P17-24).

Given these cost constraints, external funding was described as a critical condition for NBCS projects, particularly among participants from smaller municipal teams and non-profits. In local governments, participants attributed this to project scales (and budgets) exceeding internal capital funding capacity and/or the legitimacy gained from securing external funding to further attract financial support (P03-0618; P04-0620; P11-0709; P19-0807). In non-profits, payroll and project costs were often supported mostly, if not entirely, through grant-based funding (P01-0616; P10-0709; P16-0722). As such, funding in general was discussed positively regarding both singular projects and larger initiatives. However, it was often clarified that the consistency and structure of funding determined how reliable it was to their initiative's continuity and growth. Short-term, irregular and restrictive funding was recognized as constraining the scale and time horizon of planning and resourcing initiatives (i.e. constraining how they are stabilized and sped up), often resulting in staff and collaborating partners implementing smaller, ad hoc projects and stochastically running or pausing community-centered programs (P01-0616; P05-0623; P16-0722).

Further, participants from inter-municipal organizations that support urban forestry growth and stewardship across Canada described eligibility criteria (such as cost-shares, minimum planting requirements, and eligible expenses) associated with incoming funding as determining how many local partners could receive outgoing funding to implement projects (P10-0709; P20-0819). As such, these criteria were directly effectual to where and how far these urban forestry initiatives are grown, replicated and spread.

When NBCS projects were presented to decision-makers, their perceived financial gain was only as strong as the method used to evaluate them. These methods often focused on capital installation costs and single service delivery (e.g. stormwater management), which participants described as structurally disadvantaging NBCS. Specifically, in not adequately capturing the increasing resilience of NBCS over time compared to declining resilience in artificial infrastructure alternatives, nor the multiple co-benefits through ecosystem services valuation approaches (P01-0616; P05-0623; P08-0703; P12-0715; P17-0724).

4.4.3. Operational

Operational conditions describe the resourcing, capacity and coordination of actors that plan, deploy and sustain NBCS initiatives. These were the most widely discussed across interviews (129 mentions) and are the most related to conditions discussed in related literature. Operational conditions arose around 3 major themes: capacity, communities of practice, and collaboration.

Specific themes surrounding capacity involved material, informational, labor and expertise resources, all of which were confounded by the novelty of NBCS practices. Participants involved in Halifax's park and shoreline naturalization initiatives noted limited access to seasonal on-site labor and native plant stock from in-province suppliers who lacked familiarity with continuous native planting programs. This attenuated the pace and total size of planting during the planting

season (Halifax Regional Council, 2019; 2022; P12-0715; P14-0716; P17-0724). Participants drew clear connections between the continuation or erosion of NBCS programs to the presence of technical, experiential, and organizational expertise among key staff. The retention of staff (and positions as a whole) was effectual to how organizational, technical and relational experience accrued into expertise that stabilized and sped up initiatives beyond the trial processes of pilot stages. This was apparent in practitioners involved in NBCS planning, who credited one or a few key staff with the championing of plans through the early stages of plan development (P04-0620; P11-0709; P05-0623; P19-0807), and among on-site practitioners, who described how seasonal and inconsistent contract labor in environmental management led to repetitive training cycles and limited opportunities for expertise development in restoration and stewardship activities (P12-0715; P17-0724). Informational resources were spoken to in concert with staff expertise. Vancouver participants described that accessible, consistent and reliable data sets allow intermediary actors to translate GI projects across different departments' operations and mandates (P04-0620; P05-0623; P06-0627; P09-0704). Similarly, regional-scale ecosystem mapping, planning and data sets were identified as critical to translating NBCS projects to surrounding municipalities of different sizes and capacities (P05-0623). In Halifax, participants described the lack of design guides and standards for naturalization sites as impeding both the growth of naturalization across HRM, but also the maintenance and restoration of existing sites when adjacent construction or maintenance occurs (P18-0801):

> "I don't think you're going to find that many municipalities have bioswales in [their design guide], right? It's not part of the standard. And if it's not part of the standard, then it's not being built on the new stuff. It's only being built [as a] pilot experiment, you know, one-off here and there." (P18-0801).

A prominent vehicle through which these informational resources were amplified out was communities of practice. Participants' affiliations with professional associations and forums were a common tool for troubleshooting, best practices and sharing resources among peers (P04-0620; P11-0709; P17-0724; P21-1009). Further, professional conferences were described as sites of 'cross-pollination', where counterparts from different contexts exchanged case studies, technical resources and further expanded professional networks (P03-0618; P08-0703). Metro Vancouver's Regional Advisory Committees were also described as an increasingly utilized medium for disseminating case studies and resources across the different local municipalities, as well as improving ecological connectivity and conservation at the regional scale (P05-0623).

Across interviews, it was apparent that NBCS praxis and amplification are deeply collaborative. This collaboration existed within organizations, as well as between organizations along both vertical and horizontal scales. Specific configurations of actor collaboration varied by context and NBCS initiative, but often were often polycentric among multiple governments and departments, local businesses, university research units, nonprofits, and civic organizations. Additionally, these collaborations ranged in formality, contracted contribution agreements and through to informal mutualistic exchange in troubleshooting or expanding public engagement. Several municipal participants noted the compartmentalization of departments into specific units, such as planning and implementation (P11-0709; P17-0724) or land use type (P02-0617; P06-0627; P19-0807). As participants described navigating the constituent mandates and coordinating different resources and timelines within and between departments, both intra-departmental and intra-organizational collaboration were effectual to the pace and stability of these initiatives the co-benefits they provide. Given the distinct jurisdictions and specialized roles among different municipal departments as well as between organizations, both inter-departmental and inter-

organizational collaboration was often the medium through which participants described the growth of projects within a particular urban context. Relatedly, several instances of translating and replicating NBCS initiatives to external contexts required collaboration between organizations, often with an intermediary organization that bridges the exporting of the initiative (P04-0620; P05-0623; P08-0703; P10-0709; P13-0715; P20-0819). When NBCS initiatives were enriched with more diverse co-benefits, renewed community and cultural dimensions and deeper value setting of residents, participants often attributed these to partnerships with Indigenous communities (either as urban Indigenous nonprofits or with First Nation governments) and civic organizations (P01-0616; P04-0620; P09-0704; P11-0709; P12-0715; P13-0715; P16-0722; P21-1009).

4.4.4. Institutional

Institutional conditions encompass the laws, policies and structures that shape an initiative, along with the (explicit or implicit) rules and assumptions that frame the problem it addresses and acceptable means of action. These were discussed across themes of legislation, mandate, jurisdiction, organizational structure, and path dependence.

Legislation included municipal by-laws and charters, permits to non-state actors, and provincial and federal acts. Legislation was often discussed as constituting the rule-sets that determine which practitioners were involved in NBCS initiatives, as well as their selection of decisions and behaviors. As charter cities, Halifax and Vancouver were described with having unique opportunities and constraints in local NBCS relative to other municipalities. In Vancouver, participants recognized it enabling higher agency in urban greenspace protection and cultivating a nature positive culture through the creation of Parks and Recreation board, but also excluding Vancouver from legislative requirements as other BC municipalities such as riparian setbacks or zoning mechanisms for environmentally sensitive areas (P04-0620; P11-0709; P21-1009).

Similarly, Halifax's charter was described by one participant that while enabling more bespoke by-laws and planning for the Halifax region, it also builds a unique relationship to provincial oversight in requiring all planning to be tied to economic development, constraining which priorities could be foregrounded, and their tools for conservation through land acquisition (P19-0807).

As several municipal practitioners derived their authority from or contributed to the creation and enforcement of bylaws, plans and strategies, they were frequently described as key mechanisms through which NBCS are institutionalized and operationalized. In Halifax, the Boulevard Gardens Administrative Order, developed through collaboration between HRM's Transportation and Public Works and Parks and Recreation departments, institutionalized better staff direction and homeowner agency in naturalistic gardening (HRM, 2020a; P17-0724; P18-0801). In Vancouver, building and zoning by-laws have been the primary regulatory mechanism through which green infrastructure on private property development is outlined and enforced (City of Vancouver, 2023b; 2025; P02-0617; P06-0627). Legislation was repeatedly emphasized as only being as effective as its provisions and enforcement. While plans can guide direction and institutional intent, they do not necessarily carry the same authority or accountability as policy instruments (P15-0721; P19-0807). Practitioners involved in shoreline restoration and in Vancouver's private green infrastructure described the permitting process, both receiving and issuing, as inadequately distinguishing, requiring and incentivizing NBCS from other land development or artificial infrastructure alternatives (P01-0616; P02-0617; P06-0627; P13-0715):

> "I think a big lesson learned from our [general experience is] […] don't be surprised if you don't get uptake of green infrastructure, at least on private property, if it isn't mandated and required." (P06-0627).

Largely, participants credited their mandate as the institutional floor from which they operated: where the quality and multidimensionality of NBCS initiatives were expanded upon or reduced down to according to political and financial conditions. Further, mandate affected the jurisdiction of central actors responsible for NBCS implementation, influencing where these initiatives were grown and transferred across the urban landscape. The growth of GI across Vancouver's public and private land is owed considerably to its mandate from Metro Vancouver's Integrated Liquid Waste and Resource Management Plan (2011), which was itself mandated by the provincial government. As private property takes up over half of Vancouver's land base (City of Vancouver and Vancouver Parks Board, 2018), participants described the focus on private property on-site rainwater management leading to the formalizing of the Green Infrastructure branch in Engineering Services and the institutionalizing of requirements for private on-site rainwater management as critical to meeting the objectives of Vancouver's Rain City Strategy and Liquid Waste Management Plan (City of Vancouver, 2016; P02-0617; P06-0627; P09-0704; P21-1009).

Institutional factors also included the organizational structure, hierarchies and labor and distribution. The different proximities of departments (and their mandates) and organizations to each other was a prominent difference between Vancouver and Halifax NBCS governance. This was mostly discussed regarding Vancouver's Board of Parks and Recreation and Halifax Water as separate entities from their respective municipal corporations, and the focal NBCS initiatives being implemented in Vancouver's Engineering Services and Halifax's Parks and Recreation department.

4.4.5. Political

Political conditions represent the interactions of decision-makers' priorities, and the power and agency they have to act on them. While community support is discussed further in cognitive

conditions, the close relationship between public support and political priorities was evident in interviews. Vancouver's longstanding valuing of nature and sustainability, encapsulated in the "Greenest City" branding (2011), was described as embedded across the city's social culture, external reputation, and within municipal officials and staff. Several participants described positive feedback between public and political sentiment that has helped stabilize NBCS initiatives such as creek daylighting to be a considerably non-partisan issue (P09-0704; P11-0709; P21-1009).

Adjacently, the housing and affordability crisis was discussed as a central political concern in nearly every interview. As a focal point of discourse in Canada's most recent federal election, this has cascaded similar prioritizing across provincial and local governments. This was salient in municipal budget hearings, with scrutiny over municipal jurisdiction, "essential services", and what expenditures can be reduced or removed (P04-0620, P05-0623; P08-0703; P11-0709; P15-0721; P19-0807; P20-0819). This narrowing of political focus was described as crowding out priorities such as fulfilling climate action plans through maintaining or passing legislation (P11-0709; P14-0716; P15-0721; P19-0807).

As the housing crisis has taken centre stage in Canadian politics, it has also further empowered the private development community. Participants described this housing crisis lens as compounding existing tensions of institutionalizing improved legislation for ecological restoration and conservation against development priorities in local policy. This was reflected in proposed amendments to the Vancouver Charter that would improve urban environmental planning being quickly dissolved (P11-0709), as well as recent amendments to Vancouver's by-law requirements for on-site GI implementation for rainwater management primarily to expediting permit approvals. While this did expedite permitting and expand the types of buildings subject to on-site rainwater management, speeding up and growing private GI across Vancouver's footprint, participants also

noted it as a regression to the development industry's current standard practices and preference for detention approaches and away from more co-beneficial bioinfiltration types (City of Vancouver, 2023b; 2025; P02-0617; P06-0627).

Tensions in different governing authority over NBCS and the land they occupy was also prevalent across jurisdictions. Notably, this discourse existed horizontally in Vancouver between its City Council and Board of Parks and Recreation, with Council's recent contentious rejection of the Imagine West End Waterfront project (City of Vancouver, 2024b; P03-0618; Vancouver Board of Parks and Recreation, 2025) foregrounding ongoing tensions in dissolving the independent parks board (City of Vancouver, 2024a). Conversely, Halifax's interrelated negotiations and tensions with the Nova Scotian provincial government in superseding HRM charter authority over development planning in the establishment of Special Planning Areas (SPAs), confounding the implementation of the (priority but non-binding) Green Network Plan (HRM, 2018; P15-0721; P19-0807).

Furthermore, the ongoing process to designate the Blue Mountain Birch Coves Lake Wilderness Area as an Urban National Park is interrupted and confounded by the development of adjacent SPAs and an ongoing legal dispute with a private development company (Annapolis Group Inc. v. Halifax Regional Municipality, 2022; HRM, 2025; P15-0721; P19-0807). In both cases, tensions between governmental authorities can obstruct the advocacy and procedural involvement of community priorities by civil society and stewardship organizations:

> "…[O]ur kind of point that we're trying to make is the province is trying to build cities we don't want to live in. And so that if I could change anything, it would just be for the province to actually hear what the public has to say and take it into accurate advisement." (P15-0721).

4.4.6. Cognitive

Cognitive conditions describe how values and understanding influence the implementation and impact of NBCS initiatives. These conditions were evident in interviewees' perceptions of risk and nature, the involvement and support from the communities these solutions are situated in, and the legitimacy afforded to NBCS.

Perceptions of risk from NBCS included increased risk of property damage from wildfire in foresting and shoreline restoration (P01-0616), flood damage from green roofs (P02-0617, P06-0627, P08-0703, P21-1009), and intrusion of invasive species and pests in park naturalization (P13-0715, P17-0724). Participants largely attributed the difference between these perceived risks and actual risk posed by NBCS to a lack of understanding among developers, residents and private property owners, seeing these perceptions as further lengthening the planning and implementation timelines of NBCS projects (P01-0616; P08-0703; P13-0715; P17-0724). Conversely, the impacts of natural disasters and extreme weather events, most notably hurricane impacts in Halifax (P12-0715, P13-0715, P20-0819) and the 2021 heat dome in lower mainland BC (P01-0616; P04-0620; P11-0709), were described as (unfortunate) catalysts for NBCS support.

Participants frequently connected (lack of) public understanding with public education and community engagement practices in their NBCS initiatives. "Community engagement" in this sense ranged from specific neighborhoods (such as rainways and community gardens), to entire regions (such as civic stewardship and advocacy groups for Wilderness Areas) in concert with the scale of the NBCS initiative. Across both cities, participatory NBCS initiatives were described as catalysts for shifting perceptions of urban nature and human-nature relations. Specifically, involving community members in the design, implementation, and stewardship of projects fosters deeper engagement and community-centered practices, embedding the site within community

identity and reflecting local priorities (P01-0616; P04-0620; P12-0715; P15-0721; P16-0722; P17-0724; P21-1009). How NBCS was valued and understood was also in conversation with their practitioners perceived and framed them. Participants were asked how they define NBCS and its success. While responses often aligned closely to their disciplinary background, their organization's definition, and the underlying priorities that the NBCS initiative addresses, more plural understandings also emerged. Participants generally regarded ambiguity and overlap in NBCS terminology as inconsequential for collaboration within and between their communities of practice. Instead, they emphasized that clear and consistent definitions were critical when communicating with external audiences, such as decision-makers, community, and professionals outside their fields (P04-0620; P05-0623; P11-0709).

Interviewees indicated that pilots and demonstration sites improve the perceived legitimacy of NBCS. Several participants described the benefit of pilots and demonstration sites in breaking through inertia and hesitancy from the novelty of nature-based practices both within and outside of the initiative. Externally, these increasing public and political confidence build legitimacy, familiarity and positive sentiment in public consultation and decision-making (P01-0616; P04-0620; P10-0709; P14-0716; P17-0724). Within the initiative, these pilots were helpful in establishing and developing partnerships and capacity among partners, as well as developing confidence and repeatable operational standards:

> "So that was a major first project. And again, another big learning experience, even in working on the designs for the team, working with the construction crews […] All of those things were 'pilot-feeling' but led to a really successful project and gave everybody more confidence to kind of keep going and learn from what we've done." (P04-0620).

Participants also described improved legitimacy through aligning NBCS initiatives to the goals of and partnering with Indigenous communities. Participants suggested that contributing to the values of Indigenous sovereignty and decolonization was affirming to themselves, their organization, and to Indigenous and settler partners and communities (P01-0616; P04-0620; P09-0704; P11-0709; P16-0722). Beyond legitimizing the initiative, participants described partnering with Indigenous communities as a watershed moment in how they perceived and practiced these initiatives. This included suspending typical project timelines for more substantive values-based and reciprocal consultation, embedding ceremony and cultural practices into site implementation, and exchanging Western and Traditional Ecological Knowledge about the ecology, significance and stewardship of sites (P03-0618; P11-0709; P12-0715; P16-0722).

4.4.7. Systemic

Systemic conditions extend beyond individual projects, actors and contexts to reflect structural dynamics of the urban regime at a given place and time. This was discussed in relation to land ownership, colonial and racial injustice, and economic crises.

Several participants pointed to the need to purchase and own land to conserve or restore it can limit the growth of NBCS initiatives, particularly given urban land is costly and predominantly privately owned. As a result, initiatives are often confined to publicly owned or lower-cost parcels, rather than areas of highest ecological or social value. Fragmented ownership further complicates efforts to conserve connected and mature ecosystems, limiting opportunities for regional or watershed-scale planning (P01-0616; P05-0623; P11-0709; P19-0807). Several participants also described tensions between private property regimes and efforts toward decolonization, noting the

contradiction of needing to own land in order to practice "land back"[5] within treaty and unceded contexts (P01-0616; P11-0709).

The larger relationship between the built environment, urban nature and (de)colonization was also prominent. Participants emphasized navigating historical and current conflicts in relationships between marginalized communities and local government, as well as legacy effects of urban planning, such as the buried streams and unequal greenspace access (P11-0709; P17-0724). Simultaneously, urban NBCS were described as fertile ground for new co-creative and reciprocal relationships between equity-deserving communities and colonial organizations, particularly surrounding ecosystem restoration for cultural practices, food sovereignty, wildlife habitat restoration, and creek daylighting (P01-0616; P09-0704; P11-0709; P16-0722). This was evident in partnerships to daylight streams and restore harvesting practices in Burrard Inlet, BC (Tsleil-Waututh Nation, 2017) and in urban community gardening becoming critical to food security and socioeconomic agency to African Nova Scotian neighborhoods impacted by racial violence, displacement and gentrification (P16-0722).

Participants also discussed the impacts of broader socio-economic disruptions on NBCS implementation. Some noted that while the adaptive reframing of NBCS for economic efficiency has helped to meet priorities around affordability and housing crises, they expressed concern that increasing austerity and regulatory backsliding justified by urgency across levels of government can undermine long-term NBCS implementation and is rooted in the same economic-political paradigms that have given rise to these crises (P06-0627; P08-0703; P15-0721; P19-0807).

[5] Land Back is an Indigenous-led movement to reclaim decision-making power, stewardship, and governance over traditional territories. It is a core part of Indigenous self-determination and reconciliation that challenges colonial power structures, environmental exploitation, and promotes social-ecological sustainability (King & Pasternak, 2019).

4.5. Discussion

While these conditions (systemic, cognitive, political, institutional, environmental, financial, and operational) were presented separately in the results for analytical clarity, participants rarely experienced or discussed them in isolation. The interaction of these conditions across these 7 categories helped to reinforce and precipitate structural challenges to the governance of and with NBCS, and how these initiatives are amplified along specific pathways within and across urban regimes. While comparative synthesis of Vancouver and Halifax demonstrates processes and challenges that are comparable across Canadian cities, they also present distinct configurations of institutional arrangements, political and informational structures, and actor relations that corroborates regime heterogeneity and context sensitivity in contemporary transitions governance literature (Dorst et al., 2021, 2022).

4.5.1. Comparing Vancouver's and Halifax's NBCS governance systems

A comparison of Vancouver and Halifax NBCS initiatives supports NBCS implementation and amplification not only being sensitive to the biophysical, infrastructural, sociopolitical, and legislative context, but also by where in the broader polycentric governance systems these initiatives are situated. While previous work has demonstrated the context sensitivity of NBCS and the importance of aligning interventions with local ecological and institutional landscapes (Dorst et al., 2021, 2022; Tozer et al., 2022), and further that limited collaborative governance among departments impedes uptake (Dorst et al., 2022; Jang & Doyon, 2024), we suggest from this comparison that the organizational configuration of local governmental structures, and the location of NBCS within them, is a critical precondition shaping the potential for and pathways of amplification through this collaboration. The materiality of the mandates, jurisdictions, operational

capacities, and proximity to different actors shape not only how NBCS are implemented, but also the pathways through which they can be amplified.

Although both Halifax and Vancouver are charter cities, their charter arrangements produce distinct governance dynamics. As stated, the independent Parks and Recreation Board enabled by the Vancouver Charter improves the proximity of urban greenspace governance between the city's residents and policy processes on nature and conservation. This, combined with the rolling mandate from Metro Vancouver's Integrated Liquid Waste and Resource Management Plan (Metro Vancouver, 2011) have situated Vancouver's GI in its Engineering Services department. Conversely, Halifax's stormwater management is a mandate for Halifax Water, a separate entity regulated by the Nova Scotia Utility and Review Board, while its naturalization initiative is housed within the municipal corporation in the Parks and Recreation department to deliver on mandates primarily from HalifACT and the Urban Forestry Management Plan within their land use jurisdiction. These placements form the basis of how NBCS are amplified through the configuration of actors within these respective governance structures.

While in each case, a dedicated team was created in the focal department to lead the NBCS initiative, the specific mandate and jurisdiction differences between and within departments contribute to these programs being persistent siloing and misalignment to other departmental operations. As Vancouver's GI branch has both private and public property components, there are different propensities for collaboration with other municipal teams and extra-municipal partners (such as community organizations). While its placement in Engineering allows for direct exchange with and regulation of implementation in private development to meet rainwater management requirements, it also distances the implementation of these systems from the surrounding physical and social context of that site. Despite participants involved in public GI projects describing

meaningful collaboration with other departments, organizations, local residents and First Nations that led to deeper relationships to the cultural and non-human relations of restored and naturalized greenspaces, this was arguably in spite of green infrastructures' organizational location, and instead attributable to partnering departments higher collaborative potential and jurisdiction over public land and infrastructure. This influences how green infrastructure development amplifies out across the City, as well as how the processes and interactions of developing these sites embeds within the values and placemaking of residents (i.e. scaling deep) (Jang & Doyon, 2024). Halifax's naturalization team, ostensibly less institutionalized than Vancouver's green infrastructure, relies comparatively more on partnerships with Public Works and Environment and Climate Change departments, as well as partnering with local non-governmental organizations and community stewardship and voluntary participation. However, its relatively small size and specialized mandate within the larger Parks department can limit how naturalization is made routine across broader municipal operations for speeding and scaling up, and confines the growth of naturalization to public parks and right of ways.

These differences suggest that amplification is not simply a matter of replicating successful projects, but of translating practices across distinct organizational and governance contexts. If NBCS amplification involves growing, scaling, spreading, and translating innovations, these cases suggest that translation is required not only across urban contexts but also within them. While NBCS being able to move between departments, jurisdictions, and governance networks with different mandates and operational logics is a strength relied on by practitioners, they are often shaped to reflect these mandates and logics in the types of sites, land uses, spatial distribution, and benefits that are prioritized. An NBCS site developed within an engineering context may prioritize hydrological performance and regulatory compliance, while the same intervention situated within

parks or civic society context may be reshaped around recreation, stewardship practices, or biodiversity enhancement. Consequently, amplifying urban NBCS needs to account for the institutional fabric through which it occurs: the rules, organizational structures, cultures and relationships of actors in the governance complex. In this, institutional configuration foregrounds which co-benefits and types of NBCS are possible, prioritized and permissible within the existing mandate of actors reflective of the larger urban infrastructure regime, and thus, how NBCS initiatives are (de)enriched with multidimensional impact as they develop:

> "I think there are many co-benefits provided by green infrastructure; the ones that initially resonate in a city are probably the ones that are already being addressed by departments in another form." (P06-0620)

The comparison also reinforces the concept of regime heterogeneity in urban governance (Dorst et al., 2022). Both cities had strong focus of stabilizing initiatives, with both experiencing intensified housing and affordability pressures that have strengthened the influence of private development interests and extirpated much of climate and sustainability priorities from political agendas. However, these broader political-economic dynamics interact with local governance structures in different ways. Vancouver's charter is demonstrably a repeat arena for horizontal governance tensions of NBCS: as the legislative authority through which its building code requirements for GI-based private rainwater management were amended for expedited development approvals, as well as being the central statute in City council's aim to dissolve the independent Parks Board (and for which an additional Ecological Services team was established). In Halifax, provincial intervention through Special Planning Areas and the rescission of the Coastal Protection Act have redistributed responsibility toward municipal actors while simultaneously constraining local planning autonomy. The semi-coherence, proximities and

niches of the (sub-)organizational actors within these configurations, and how central collaboration within and between organizations, contexts and scales illustrates a fundamentally polycentric structure, supporting contemporary empirical and conceptual understandings of NBCS governance (Tzoulas et al., 2021; Zingraff-Hamed et al., 2021).

Finally, both cities occupy the role of "NBCS incubators" that surrounding municipalities look to for trialing and operationalizing NBCS projects they themselves don't have the risk tolerance or capacity to pilot. Metro Vancouver functions as an intermediary that facilitates the coordination and translation of NBCS practices across municipalities, while, in Halifax, collaborative networks approaches with non-governmental organizations such as the Ecology Action Centre, TransCoastal Adaptations Centre, and Helping Nature Heal are involved in replicating and spreading shoreline restoration projects and training to surrounding regions. This aligns with literature on sustainability transitions and NBCS that identifies intermediaries as key actors in brokering relationships, translating knowledge, and enabling coordination across governance contexts and scales (Ehnert et al., 2022; Frantzeskaki & Bush, 2021; Kivimaa et al., 2019). These findings suggest that efforts to amplify NBCS should attend not only to the information and operational practices that are being transferred, but also to the governance settings from which they emerge and into which they are translated. The mandates, capacities, jurisdictional relationships and knowledge systems embedded within those settings shape how NBCS are amplified out and how they ultimately precipitate impact to new contexts.

4.5.2. Interacting conditions and structural barriers

Across both these case contexts, the interaction and interdependency of conditions was apparent. Table 4.2. illustrates the overlap in condition categories from participants and documents describing barriers and enablers of NBCS praxis. By interpreting the empirical data within

frameworks for structural barriers and amplification (Dorst et al., 2022; Lam et al., 2020), we present the prominent barriers to NBCS amplification in urban Canadian contexts in Table 4.3.

Table 4.2. Interaction patterns among governance conditions by category. Shades of green stratified to 0-9, 10-19, and 20-29 mentions. Leading diagonal shaded in grey, as this denotes the same condition mentioned. Created through matrix query on NVivo 15.

	Environmental	Financial	Operational	Institutional	Political	Cognitive	Systemic
Environmental	50	3	13	13	6	4	4
Financial	3	68	13	8	10	6	1
Operational	13	13	129	26	16	28	3
Institutional	13	8	26	95	19	12	7
Political	6	10	16	19	89	23	9
Cognitive	4	6	28	12	23	97	7
Systemic	4	1	3	7	9	7	21

Table 4.3. Synthesis of the predominant governance conditions, their produced barriers and types of NBCS amplification they impede.

Barrier	**Prominent conditions categories**	**Affected amplification type(s)**
Competition in land use	Environmental Financial Institutional Political Systemic	Amplifying within: *stabilizing*. *speeding up, enriching* Amplifying out: *growing, transferring*
Insufficient valuation of (urban) nature	Financial Cognitive	Amplifying within: *speeding up, enriching* Amplifying out: *growing; spreading* Amplifying beyond: *scaling deep*
Limited trust and understanding of urban nature	Operational Cognitive	Amplifying within: *stabilizing, speeding up*

		Amplifying out: *growing, spreading, replicating* Amplifying beyond: *scaling up; scaling deep*
Precarious capacity	Financial Operational Political Institutional	Amplifying within: *stabilizing, speeding up* Amplifying out: *growing, spreading, replicating*
Limited internal collaborative governance	Operational Institutional Political	Amplifying within: *stabilizing, speeding up* Amplifying out: *growing, transferring*
Limited external collaborative governance	Operational Institutional Political Cognitive Systemic	Amplifying within: *stabilizing* Amplifying out: *transferring, replicating, spreading* Amplifying beyond: *scaling deep*
Limited mandate of central actors	Operational Institutional Political Systemic	Amplifying within: *enriching* Amplifying out: *growing, transferring, replicating* Amplifying beyond: *scaling up, scaling deep*

Competition in land use

Across both cases, participants described NBCS as competing against more politically and socioeconomically favoured land uses, including housing, transportation infrastructure, parking, and recreational amenities. Similar to Dorst et al. (2022), practitioners described tension in scarce available land to deliver on multiple services. This was also stratified and complexified by the land tenure of different actors, and whether the land was privately or publicly owned, and how much existing infrastructure or use existed in the site. While NBCS can be integrated into other land uses to attenuate this, and is often done so opportunistically, it is often at an additional cost and/or prohibitively difficult to fund and insure. This competition impaired amplifying within for both

conservation (stabilizing) and restoration (stabilizing, speeding up, enriching) NBCS practices, the need to negotiate between different priorities can slow implementation and reduce opportunities to enrich projects with social-ecological co-benefits. Amplifying out (growing, transferring) is limited in the land uses type(s) and spatial distributions of NBCS sites being constrained to low-value parcels, rather than where those benefits have the highest impact potential:

> "They described it in the naturalization strategy as being 'underutilized places', and I can tell you in our parks, you'd be hard pressed to find a spot that isn't used for something." (P17-0724).

This was especially evident where conservation or restoration required the acquisition of private land, and where naturalization competed with public infrastructure and recreation.

Insufficient valuation of (urban) nature

How nature is valued was present across condition categories and participant strata, but most salient in financial and cognitive dimensions. The structural disadvantages of current valuation methods were evident in how NBCS compete against other land use types and grey infrastructure alternatives in capital projects. Participants shared pragmatic aspirations for more appropriate and expansive valuation approaches that would allow the multidimensional and longitudinal benefits of NBCS to be better recognized, which would cultivate political appeal in financially austere decision-making priorities, with multiple specifically referencing calls for a formalization of natural asset accounting disclosures and standards (Eyquem, 2025).

Insufficient valuation and overemphasis of capital cost burden within political decision-making exposes NBCS projects to funding cuts from shifting political priorities and fiscal austerity, resulting in a contraction of project size, maintenance, complexity and quality that impedes the

stabilizing and enriching of NBCS. Similarly, the financial valuation means for NBCS frame these projects as high risk and outside of essential services, potentially dissuading smaller organizations and municipalities from adopting or spreading NBCS initiatives from "incubator" projects, even after demonstrated success in pilots. This constrains opportunities for growth and diffusion across contexts.

Just as participants recognized the need for better financial valuation of NBCS, they contended with the financialization of nature as reductive and diametric to more intrinsic and ecocultural valuation of nature and more-than-human thinking. Particularly, participants described difficulty in adaptively framing NBCS to meet the more infrastructural and economic development priorities that help NBCS to amplify within and out, while also maintaining the deeper ecocultural and ecocentric perspectives that allow it to scale deep.

Limited trust and understanding of urban nature

Trust and understanding underpinned much of how NBCS were valued cognitively and financially, as well as their uptake into operational norms. Participants described persistent uncertainty among developers, decision-makers, and residents regarding the performance, maintenance requirements, and potential risks associated with nature-based approaches. This lack of confidence and familiarity makes for longer approval timelines, greater scrutiny, or reduced political support, limiting both speeding up and long-term stabilization. While this uncertainty was attributable to knowledge gaps and general novelty, there was also a larger skepticism and in moving away from established practices and financing of artificial infrastructure. Across both case cities and among practitioners experiences in supporting NBCS in inter-municipal contexts, particularly under limited capacity and political capital, trust is both constrained by and constrains the willingness of actors to experiment with nature-based approaches even with demonstrable

success in other contexts, reducing opportunities for growing, spreading, and replicating. Demonstration projects and pilot initiatives helped to remediate this by providing visible proof-of-concept and building operational experience, but the political trust to institutionalize often also required the legitimizing of these initiatives in financial valuation and from other institutional authorities (i.e. provincial or federal government, health authorities, multinational organizations or post-secondary research groups). Understanding this in the context of contemporary literature (Jang & Doyon, 2024; Muñoz-Erickson et al., 2017) suggests a co-production of knowledge(s) and of legitimacy is required for both the initial uptake of NBCS praxis as experimental and their institutionalizing toward standard practice.

Precarious capacity

Across both municipalities, participants emphasized that having dedicated staff positions, teams, funding streams, consistent informational resources and expertise were critical for initiating and maintaining projects. Restrictive funding structures, time-sensitive material and labor resources, shifting political priorities and informational misalignments produced a precarity in the central and partnering actors operating NBCS initiatives. This impaired how NBCS was stabilized, with participants often describing precarious funding and staff to continue both the design and implementation of sites, as well as their continued stewardship (particularly during primary succession of ecological development). The turnover in staff and lack of informational and expertise retention also slowed down NBCS operations, as new practitioners needed to redevelop relationships, local practices, site familiarity and informational resources.

> "Like every year you have to apply for funding and then you cannot apply for the same project so like how do I make this project grow and be better and like tell people that this is here for them, if it might not be next year because I cannot even apply for the

same thing? So, we're piloting every year like it's always going to be in pilots and like it's never going to develop and be better if we don't have that sustainability." (P16-0722)

Precarity in operational capacity also constrained how practitioners collaborated across various horizontal governance structures. Multiple instances of working groups, peer exchanges and roundtables were described for navigating large-scale, inter-jurisdictional and inter-disciplinary NBCS projects, but the ability of the same practitioners to engage with these mediums affected how much these collaborations sped up NBCS, or amplified it out to contexts:

"In those meetings, lots of good ideas come up […] I find there's definitely a willingness to cooperate—in fact, a need to cooperate—it's finding the time […] There's also can be turnover in government […] people have to learn again and reach out and make those connections and networks and do that networking, right? […] I find that's what it's particularly useful for: making those connections and sharing that knowledge, and then you're better able to problem-solve and advance ideas."
(P19-0807)

These constraints to collaboration constrict the communication and operational channels through which NBCS practices and their requisite resources are amplified out to new contexts. Moreover, participants described this as 'a catch 22', where collaboration can help pool capacity to collectively execute and expand NBCS projects, but also required sufficient capacity to do so. Participants involved in translating NBCS projects and disseminating funding streams across municipal and nonprofit actors across Canada described the differential capacity between the contexts exporting NBCS case studies to those who are importing them as requiring additional support to account for differences in capacities, particularly for smaller and non-

specialized teams. Further, participants described chronically constrained capacity to collaborate and consult on NBCS projects among Indigenous partners, primarily attributed to limited staff and funding that is frequently inundated with multiple requests from multiple departments across governmental levels. This limited the consistency and quality of collaboration on NBCS projects, and the potential for scaling these projects deeper to reflect multiple priorities, practices, Knowledges and ecocultural values.

Limited collaborative governance

Consistent with previous research on NBCS and urban transitions, limited collaboration within organizations presented as a significant barrier to NBCS amplification (Bush, 2020; Hölscher et al., 2023; Jang & Doyon, 2024; Kabisch et al., 2016, 2022; Schröter et al., 2022). Participants described how differing mandates, jurisdictions, team cultures and operational logics between departments created siloed decision-making, redundancies and discordant implementation practices. While this misalignment is not new to literature, limited collaboration within and between organizations appeared to constrain NBCS amplification differently.

Internal collaborative governance is particularly important for amplifying within initiatives, as enmeshing these initiatives across multiple departmental operations and personnel helps to both speed up the initiative as well as stabilize the initiative through specific capacity changes and distinct mandates among individual departments. This also constrains amplifying out, as initiatives confined to a single department (and the mandate, jurisdiction, and knowledges within which they operate) are less likely to become embedded across multiple plans, strategies and land use types within the same urban boundary (growing, transferring).

As discussed in the previous barrier, the greater collective capacity reaped from collaboration, and the required capacity to do so were often a self-reinforcing and stagnating

feedback loop. While this constrained both internal and external collaboration for amplifying within initiatives, external collaboration was effectual to how they stabilized and enriched. The constrained stability from limited collaboration came to bear in both the transience of initiatives, as funding, legitimacy, and expertise that enable particular actors' implementation waxed and waned, as well as in the ecological resilience of existing sites from inconsistent stewardship. Limited collaboration with local communities, civic organizations and regional non-profits often severed central actors access to a base of nature-positive volunteers and coordinators who championed the initiative within their circles, assisted and delivered grassroots public education and on-site implementation, as well as internalize the stewardship of these sites within community norms. When these relationships were absent or neglected, community sentiment sometimes became apprehensive of these initiatives. Limited collaboration with local communities and Indigenous partners also eroded the potential of these initiatives to be more than technical interventions, as participants stressed these partnerships as the means through which placemaking, values and relationships were reoriented. External collaboration was also the vehicle through which these initiatives were replicated, spread and transferred into new urban contexts. While the willingness for 'importer' and 'exporter' actors to collaborate was itself a factor, participants frequently identified the absence of intermediaries, such as inter-municipal organizations, regional districts and non-profits, and post-secondary knowledge-to-action teams, as critical. Without these actors to coordinate collaborative spaces, provide informational resources, and translate practices across institutional and environmental contexts, any willingness for amplifying out was often eroded.

Limited mandate of central actors

The mandates assigned to central actors determined what types of NBCS were institutionally permissible, which co-benefits were emphasized, and how their success was measured. Participants often described how although retrofitting NBCS to otherwise unchanged mandates helped to institutionalize NBCS within municipal operations and scale up into legislation, it also meant that misalignments between departments and organizations persisted. Thus, when political priorities shifted, the multidimensionality of NBCS initiatives narrowed to the service delivery required of the actor. This was also reflected in the lack of mandate, specifically in that for the maintenance and management of existing greenspaces or established NBCS sites, weakening conservation and ecosystem resilience. Mandates also shaped the spatial pathways through which NBCS could be amplified. By defining the land uses and jurisdictions over which actors had authority, they determined where initiatives could grow within the urban footprint. The rigidity of these mandates reflects and reproduces a reluctance in these governance structures to internalize more intrinsic and plural valuations of nature beyond its ability to fulfil existing service demands.

4.5.3. Catalysts for Amplification

Not only did structural barriers emerge from analyzing the governance conditions of urban NBCS across these contexts, but also key strategies and practices that can restructure these conditions for further amplification. Combining existing or petitioned strategies, policies and practices from participants with existing recommendations in literature (Bruley et al., 2025; Hölscher et al., 2023; Schröter et al., 2022; Tozer, Bulkeley, van der Jagt, et al., 2022), Table 4.4 outlines a set of catalysts that can challenge and restructure these persistent condition configurations to advance NBCS amplification, graduated along an axis informed by leverage points (Abson et al., 2017; Meadows, 2015). Parameters describe the components and numerical artefacts of the system. The catalysts listed here can be understood as ‘low-hanging fruit’ in that

the structural change is shallow but can be a readily accessible entry point of intervention for incumbent actors. Feedbacks describe the relationships and internal informational dynamics, where the catalysts described here can have deeper influence on how information is used, translated and legitimized. Design describes the architecture of the governance complex, where the catalysts have as high amount of leverage through changing the purposive behaviors and interactions of actors within the system. Intent describes the underlying goals and paradigms that (re)produce the system. Catalysts to this depth have the deepest potential leverage through resetting the rules and worldviews of the system.

Table 4.4. Catalysts to NBCS amplification through the lens of leverage points. Strategies, policies and practices are organized according to the depth they intervene at. Based on empirical analysis and strategies adapted from Hölscher et al. (2023), Meadows (2015), Reed et al., (2022), Tozer et al. (2022b), and Schröter et al. (2022).

Catalyst	Amplification type(s)	Description
Parameters		
More flexible and consistent funding structures	Stabilizing Speeding up Replicating Transferring	Supports the capacity required for existing initiatives and expertise to persist, as well as allowing for wider eligibility in applicants and cost types.
Incentivize urban nature and certification in private development permitting	Speeding up Enriching Growing Transferring	Provide higher cost-share and priority review incentives in permitting, funding, and regulatory review processes for faster and more attractive NBCS adoption within existing development systems.
Plan for site stewardship in budget and continued responsibilities	Stabilizing Speeding up Transferring	Embeds long-term maintenance into operational planning and costs, improving site expertise retention and early-stage site resilience.
Strategically reframing and relocating NBCS to align political priorities	Stabilizing Growing Transferring	Reframing NBCS benefits towards priorities such as resilient infrastructure, public health benefits, stormwater management, etc., or translating the initiative to a different actor with alignment can fortify NBCS to political

		priority changes and expand to new jurisdictions.
Feedbacks		
Expand valuation methods for NBCS to better reflect advantages	Speeding up Enriching Replicating Scaling up	Expand financial analysis methods to include lifecycle assessment, repair and replacement costs, co-beneficial services, as well as develop standards for natural asset disclosures.
Institutionalize NBCS training and experience retention protocols	Stabilizing Growing Transferring Scaling up	Creates organizational learning loops and builds internal procedures that introduce new knowledge for NBCS implementation and retain existing expertise through turnover.
Supporting intermediaries to translate NBCS across contexts	Speeding up Replicating Spreading	Improves information exchange and learning between governance actors and contexts, translating successful practices.
Design		
Improved legislative regulation and alignment	Stabilizing Scaling up	Restructuring bylaws, administrative orders, charters, and regulatory codes to better reflect biophysical and social dimensions of NBCS and differentiate from artificial infrastructure.
Provide capacity for collaboration	Stabilizing Enriching Speeding up Growing Transferring Replicating Spreading Scaling deep	Create responsibilities in existing roles dedicated to collaborative practices, create new roles to liaise and coordinate between internal and external partners, and create resourcing structures to collaborate for Indigenous and local community partners.
Youth education and engagement in urban nature	Stabilizing Enriching Scaling deep	Embeds long-term social and experiential learning, translates stewardship practices, and improves ecological literacy in households and community norms.
Community-led NBCS initiatives	Stabilizing Enriching Scaling deep	Design NBCS sites and initiatives to be operationally transferred to or co-managed with the local communities they are situated in.
Intent		

Public mandate for urban nature	Stabilizing Scaling up	Establishing a mandated obligation to conserve, restore and steward ecological spaces within the respective jurisdiction.
Support for Indigenous-led and partnered NBCS projects	Enriching Replicating Spreading Scaling up Scaling deep	Expand financial, legal and operational resource streams to establish and support Indigenous-led and collaborative NBCS initiatives, to support Indigenous sustainable self-determination and reorient human-nature and Indigenous-settler norms.
Establishing legal precedence for rights of nature and of peoples' access to natural spaces	Stabilizing Scaling up Scaling deep Spreading	Decoupling the value of land and nature from growth-centered financial paradigms and instrumental ecosystem services toward more intrinsic value, autonomy and recognized rights, aligned with Traditional Territorial land claims and multi-epistemological legal structures.

4.6. Conclusion

In this paper, we investigate the conditions of governing urban NBCS, the persistent barriers produced within these governance structures, and how these NBCS are amplified within and across contexts. Through a qualitative mixed methods comparative case study of two Canadian cities, 24 interrelated conditions were identified across 7 categories, which interact and assemble as context-specific configurations within semi-coherent, complex urban regimes. In comparing these condition structures between urban contexts, several key findings emerge. Firstly, the potential pathways for how NBCS initiatives can be amplified is dependent on where in the organizational structure (and larger governance complex) it is situated. The legislation, mandates, jurisdictions, expertise, operational capacity, and institutional proximity of departments and surrounding actors determined which NBCS and land-use types, forms of collaboration, financial and informational resources, and knowledge systems could be mobilized. As a result, NBCS governance processes and amplification varied not only between urban contexts, but also within them. Collaboration

within and between organizations emerged as a critical medium for amplification, with the required operational capacity and intermediary actors as decisive factors to this. This corroborates contemporary urban transformations and sustainability transitions literature that highlights the polycentric, inter- and transdisciplinary characteristics central to NBCS governance. Several structural challenges are also identified as the product of these conditions: competition in land use; insufficient valuation of (urban) nature; precarious capacity; limited trust and understanding of urban nature; limited internal and external collaborative governance; and limited mandates of central actors. Additionally, a set of catalytic strategies are abductively developed and described which can reorient and reconfigure persistent conditions and their interactions for advancing how urban NBCS are amplified for longer, broader and deeper impact. As cities across Canada and worldwide face the increasingly severe impacts of interrelated climate, biodiversity and socioeconomic crises, nature-based climate solutions are increasingly promoted as powerful approaches to addressing these challenges. Realizing their transformative potential requires amplifying their impacts beyond the experimental stage within and across contexts. This amplification, in turn, requires transforming the social, institutional, technical and ecological systems which govern them.

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Chapter 5 – Conclusion

5.1. A synthesis of study findings

This thesis has examined the amplification pathways of urban NBCS in Canadian contexts, and the structural conditions of urban governance systems that shape them. Based on a review of contemporary literature, as well as of how NBCS are currently implemented in Canadian policy and practice and international initiatives, a research gap was identified that prompted the development of the following research questions:

RQ1: What are the governance conditions of NBCS in these cities, and how do these conditions impede or enable NBCS amplification?

RQ2: How are NBCS initiatives amplified over time, and how do these pathways interact with one another?

RQ3: What strategies, policy mechanisms and practices should actors utilize to better amplify NBCS within and across urban contexts?

To address these questions, I employed qualitative mixed methods, abductively analyzing key informant interviews and surrounding documents, through a comparative case study design of Vancouver, BC and Halifax, NS (as well as NBCS practitioners and initiatives that occupy inter- and trans-municipal roles). The development of two self-contained manuscripts from this study addresses the above research questions as follows:

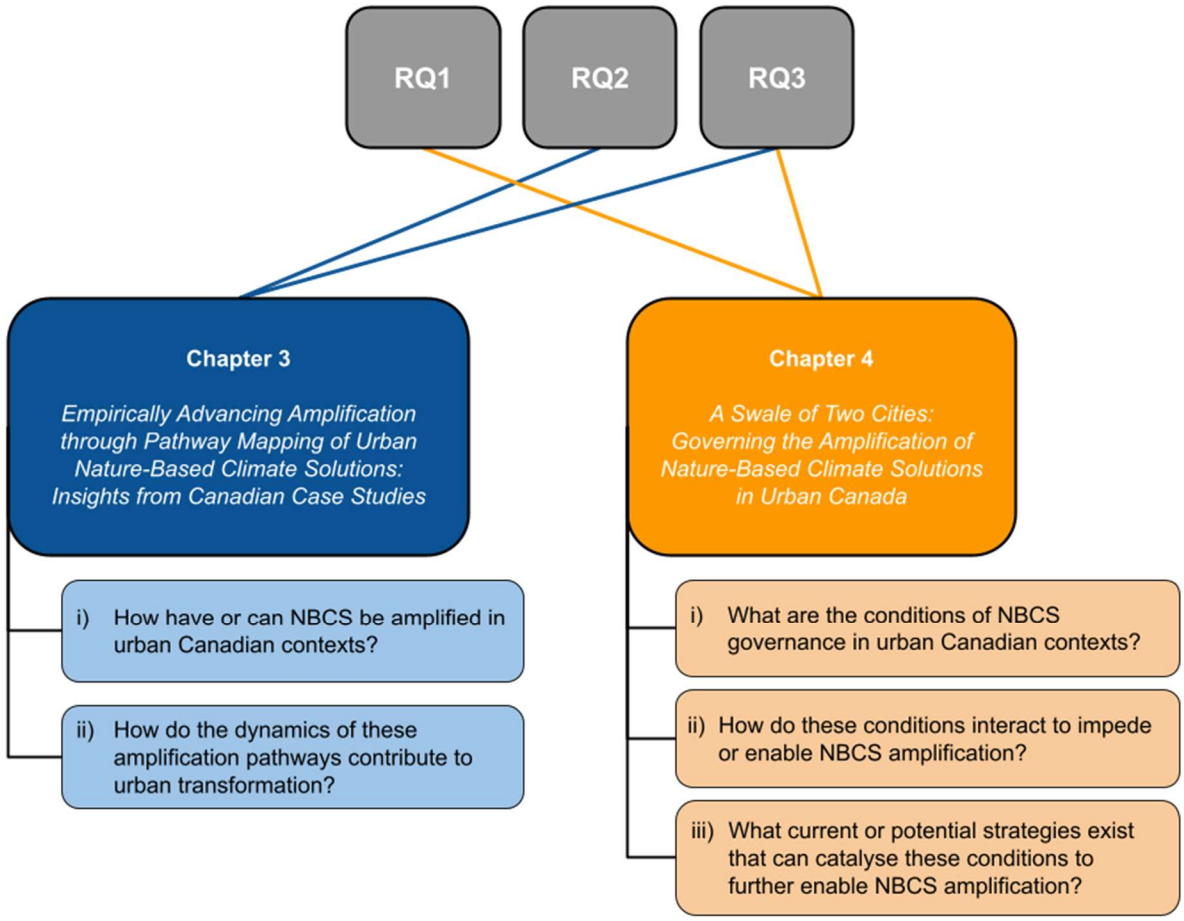


Figure 5.5. Research questions of study addressed by constituent manuscripts.

RQ2 is primarily addressed by Chapter 3, which maps and analyzes the amplification pathways of prominent urban NBCS initiatives across the case contexts. The pathway mapping of NBCS amplification for different initiatives allowed for the identification and analysis of how the impact of sustainability initiatives is increased along specific dimensions and modes across NBCS types, contexts and scales. Through this, common patterns emerged as to how and what type of amplification takes place. These emergent findings suggest that the amplification of sustainability initiatives such as NBCS develop over time as a non-linear, composite and non-uniform process occurring in multidimensional and recursive ways. Different combinations and developments of these initiatives demonstrated that amplification types occur simultaneously, sequentially and

regressively. Moments of simultaneous amplification could include those being of the same direction (i.e. stabilizing and speeding up both being within), or across different directions (i.e. within, out and/or beyond). Sequential amplification moments include amplification along one direction having been facilitated by amplification along another preceding amplification moment. De-amplification amplification described a decrease in the impact of an initiative. From this analysis, a new type of amplification is proposed and demonstrated, enriching, which describes increasing the initiative's impact through the diversity and quality of the co-benefits it provides. Together these findings suggest that the pathways of amplifying NBCS are neither uniform in how impact is progressively increased, nor in the kinds of benefits that are experienced, nor in how these impacts grow to challenges and change the social, institutional, technical and ecological dimensions of the urban structure.

RQ1 is primarily addressed by Chapter 4, which identifies the structural conditions of NBCS governance across the two case cities, and how these conditions interact to influence how these initiatives are amplified. Thematic analysis identified 24 prominent conditions of urban NBCS governance across 7 categories, which ranged from material, such as the characteristics of the specific site and surrounding built environment for NBCS projects, to relational, such as the perception of nature among local residents and practitioners. These conditions presented as interrelated and mutually reinforcing, producing processes and paradigms within their respective urban regimes. Several structural challenges emerged as the product of these conditions: competition in land use; insufficient valuation of (urban) nature; precarious capacity; limited trust and understanding of urban nature; limited internal and external collaborative governance; and limited mandates of central actors. In conversation with these barriers, current and aspirational practices and policies from a combination of existing literature and participant interviews enabled

us to identify several catalysts to these structural barriers. I combine existing interventions from literature and those developed from interview and document analysis to create context-specific recommendations for strategies that create opportunities for reconfiguring and realigning conditions that dissolve structural barriers. These catalysts contribute to both RQ1 and RQ3, and as such, will be discussed in further detail below. Comparing the governance of NBCS in Vancouver and Halifax also suggested that implementation and amplification of NBCS is sensitive to where it is situated in the organizational and larger governance structure. Where in the configuration of institutions and organizational units the NBCS initiative was centrally operated from emerged as a critical precondition that shapes the potential for amplification and pathways through which it occurred. This included departmental mandates, jurisdictions, legislation, expertise, operational capacities, and institutional proximity determining which NBCS types, land-use types, forms of collaboration, financial and informational resources, and knowledge systems could be mobilized. This created heterogeneity not just between urban contexts, but within them.

Given the more prescriptive position of RQ3, it is addressed by both Chapters 3 and 4. While both provide insight into strategies that can enhance urban NBCS amplification, particularly in the catalysts developed in Chapter 4, collating their contributions highlights particular insights regarding the collaboration and co-benefits of NBCS. Chapter 3 highlights how most amplification occurred collaboratively, both within and between organizations, and how initiatives can be transferred from one focal actor within a polycentric network to another or accumulate from several as they are amplified. Similarly, Chapter 4 highlights collaboration as a critical condition to the governance of NBCS and their amplification, particularly given the specific jurisdictions, operational processes, expertise, capacities and knowledge domains of individual departments or organizations. Given this, intermediary actors, such as trans-municipal organizations, research-to-

action units from post-secondary institutions, regional nonprofits and local enterprises, were critical in translating NBCS initiatives, resources, practices and insights across boundaries within and between urban contexts. Further, collaborating with local communities and Indigenous partners was pivotal in amplifying within and beyond, as it helped to embed the site into deeper values, community stewardship and biocultural practices, and cultivate political capital that influenced priorities. However, the ability to collaborate was limited by competing priorities of actors and constrained capacity for key staff and organizations. Chapter 3 findings demonstrate that NBCS initiatives don't uniformly provide the same diversity or quality of co-benefits across NBCS types or across their lifespan, and the suite and quality of these co-benefits can be amplified within the initiative and site. Chapter 4 highlights where in the organization (and larger governance structure) the NBCS initiative is situated can determine which benefits are prioritized, mandated and operable within their jurisdiction, capacities, and socio-ecological context. The translation of initiatives among actors (highlighted from Chapter 3) can thus change what priorities, mandates and jurisdictions they operate in.

Collaboration is critical to NBS amplification, as is often required to pool capacities and span institutional and physical contexts, but the conditions that determine actors' ability to collaborate need to be structurally improved to further this amplification. The co-benefits of urban NBCS are dynamic between types and through the maturation of the initiative, but which co-benefits are present are determined by which actors are in its implementation and the boundaries which they operate in. While adaptively reframing NBCS to align with existing priorities, or translating NBCS initiatives between actors can recalibrate the institutional boundaries in which they implemented to realize these co-benefits, these emerge as interstitial strategies compared to a changing of how urban nature is valued, prioritized, regulated and distributed in these regimes. I

raise these insights to distil this thesis toward a central claim: for the amplification of nature-based climate solutions to realize transformative impact, the structures and processes by which they are governed must be themselves transformed.

5.2. Contributions and recommendations

This thesis can be of use in advancing policy, practice, and further research. Chapter 3 provides contribution to scholarship surrounding socio-ecological sustainability transformations in applying amplification as an analytical framework, advancing its typology to include enriching, and the non-linear dynamics of how amplification occurs. Further research can develop enriching to explore specific pathways and impacts created by the change in co-benefits and how the combination of actors and co-benefits influences amplification pathways. Chapter 4 provides a contribution to urban and sustainability transitions governance scholarship, which advances understanding of NBCS context specificity to include where in the organizational and governance structure the initiative is situated frames how and by whom that initiative can be amplified. Further research could further explore the translating of NBCS initiatives among different actors, and further develop understanding on how catalytic interventions to the conditions producing structural amplification barriers occur across different configurations of NBCS placement in the governance structure. Both manuscripts support existing literature describing both NBCS and amplification as collaborative, inter-disciplinary, transdisciplinary, and inter-jurisdictional, political and place-based processes. Further, the non-linear dynamics of amplification pathways in Chapter 4 combined with the structural conditions and barriers of Chapter 3 present an opportunity for future research to further explore more mechanistic understandings of how the impact of sustainability initiatives fosters transformative change through changing the physical, social and institutional

landscapes of the urban regime (which is speculated on in Chapter 3 to a process of contextual reconfiguration).

As stated in the Introduction chapter and sections of manuscript chapters, Canadian NBCS remain an underexplored context in urban governance and sustainability transitions research. As both NBCS and the interrelated impacts they are promoted to address continue to grow, and the nature-climate governance complex of Canada continues to shift, it is a critical opportunity to examine these initiatives across Canada's diverse socio-institutional and socio-ecological contexts. Within this call, I specifically encourage future research to explore how Indigenous-led and co-produced NBCS initiatives are amplified, and the role this plays in Indigenous sustainable self-determination and a just transformation for Canada. While this is acknowledged as a limitation of this study, this recommendation for future research is done with two considerations: 1) the need for this research to be conducted with a reciprocal, relational and place-based ethic, and 2) that the capacity of Indigenous communities and organizations to lead and participate in this research must be strengthened. While the discourse surrounding the (un)constructive ambiguity, plurality and political work of NBCS language is something that is briefly explored in the literature reviews and interviews of this study, I recognize that this is substantive and growing line of NBCS research is not significantly explored in this study. Future research can examine the interrelation of these narratives and framings with how NBCS are amplified within and across different contexts and scales, particularly with regards to scaling up, scaling deep and enriching.

Contributions and recommendations to policy and practice are made in more detail in the manuscript chapters, as well as synthesized for more tailored non-scholarly publications. By examining amplification pathways alongside the structural conditions that determine them in Canadian contexts, this research provides both theoretical and practical contributions for

advancing urban NBCS, and their role in sustainability transformations. The recommendations developed throughout this thesis are intended to be as context specific and as place-based as the solutions they are for, rather than as universal or prescriptive. Arguably, NBCS stand unique among sustainability innovations in their ability to bridge and shape the deeper values and priorities embedded in how relationships are formed along socio-ecological and socio-institutional lines. It then stands necessary that these solutions are not metabolized, placated and misused by the same political power structures that gave rise to the same problems they are promoted to address. As stated in the Introduction chapter, nature is neither new nor separate to the urban. The opportunity presented at large then, one which inspired this thesis, is the enthusiasm, curiosity and capital that accompanies the exponential increase in popularity of 'working with nature' across all scales, contexts and from political incumbents to fringe actors. The task then, one which this thesis hopes to further, is leveraging this popularity to restructure the necessary political, institutional, and sociocultural paradigms that govern how we distribute, benefit from, steward, and relate to nature. This calls for a reconciling and rewiring of how different actors across scales and contexts collaborate towards a shared future, one which is resilient, just and inclusive of the more-than-human world.

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Appendix A – Ethics Documents

Recruitment email



Hello, [participant name]

My name is Kayne Boyall and I am a master's student working under the supervision of Dr. Sarah Burch (Department of Geography and Environmental Management, University of Waterloo).

I am conducting a **research study** that investigates the barriers and enablers of amplifying the impacts of nature-based climate solutions (NBCS) in Canadian cities, specifically focusing on Vancouver, BC and Halifax, NS. I am contacting you because of your involvement with the decision-making, management, funding, implementation, communication, coordination and/or maintenance of these initiatives. I aim to learn about how various collaborating actors in Halifax/Vancouver have worked together on these NBCS initiatives in their experimental or pilot stages, as well as their expansion and integration, and what factors have been involved in these processes.

I am currently inviting people to participate in this study. Participation in this study involves an in-person or virtual (Zoom) interview on your involvement, experience and perspective on these processes. There will be a list of guiding questions, but you will be free to shape the conversation with your perspective and share your expertise. The interview would take approximately an hour. I would like to interview you at your convenience between June 16th and 20th, 2025.

If you are interested in participating, please:

- Review the **attached information letter** with more details about the research study.
- Review, sign, and return the **attached consent form.**
- Fill out the **Microsoft bookings link HERE** and note whether you would prefer to meet in-person or on Zoom. To help accommodate scheduling, feel free to indicate multiple

time slots of availability, as this will assist in coordinating interview sessions without conflicts between participants.

I will then send a confirmation email and provide you with further information concerning logistics. **Please review, sign, and return the consent form before the interview**.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board.

If you need to adjust or cancel your interview, please email me at kboyall@uwaterloo.ca.

Sincerely,

Kayne Boyall, BSc (Env)
MSc student, Geography
Department of Geography and Environmental Management, University of Waterloo
kboyall@uwaterloo.ca

Letter of information

UNIVERSITY OF WATERLOO
FACULTY OF ENVIRONMENT
Department of Geography
and Environmental Management

Title of study: Exploring Amplification of Nature-Based Climate Solutions in Canadian Cities: A Comparative Case Study

Lead Investigator: Dr. Sarah Burch, Department of Geography and Environmental Management, University of Waterloo. Phone: +1 519 888 4567 Ext. 31932. Email: sarah.burch@uwaterloo.ca

Student researcher: Kayne Boyall, Department of Geography and Environmental Management, University of Waterloo. Email: kboyall@uwaterloo.ca

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To help you make an informed decision regarding your participation, this letter will explain what the study is about, the possible risks and benefits, and your rights as a research participant. If you do not understand something in the letter, please ask one of the investigators prior to consenting to the study.

What is the study about?

This study explores the factors that shape how nature-based climate solutions (NBCS) are expanded, integrated, and scaled in Canadian cities. As climate risks continue to intensify, NBCS offer an adaptable and co-beneficial approach to mitigation, adaptation, and resilience building. However, their implementation often remains limited to pilot projects. Understanding how these initiatives move beyond experimental stages into broader urban policies and practices is essential for enhancing their long-term and deep impact.

Through a comparative case study of Vancouver and Halifax, this research will examine the governance, social, economic, and ecological factors that shape how NBCS are implemented and amplified within and across Canadian cities. Through document analysis and stakeholder interviews, it will identify strategies to embed NBCS into urban policies and practices to amplify their impact. By gathering insights from individuals directly engaged in these processes—

including those involved in decision-making, funding, coordination, communication, and on-the-ground implementation—this study aims to build a well-rounded understanding of the opportunities and challenges associated with amplifying NBCS.

Your perspective and experience will help shed light on how different actors collaborate, navigate barriers, and identify pathways to grow NBCS within and across urban contexts. There are no right or wrong answers—this study values diverse perspectives and experiences to reflect the complexity of NBCS collaboration, implementation, and growth.

As a participant, you will receive a summary of the study's findings. Additionally, you will gain access to an adaptive toolkit developed from this research, designed to support decision-making for municipalities, NGOs, businesses, and governance networks.

What does participation involve?

Participation in this study is voluntary. It will involve an interview of approximately one hour in length to take place either virtually through Zoom, or in a mutually agreed upon location. You may decline to answer any of the interview questions at your comfortability. Further, you may decide to withdraw from this study at any time until the results of the study are published without any negative consequences by contacting the researcher via email or verbally.

With your permission, the interview will be audio recorded to ensure accuracy and support later transcription for analysis. If conducted virtually and you choose to leave your camera on, video will also be recorded, but it will not be used in the analysis. The video component will be deleted within seven business days, once the file has been converted into an audio-only format. After the interview has been completed, any quotes from the interview the researchers hope to use will be provided to you, with surrounding context.

This will provide an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish. Any quotes will be unattributed, where personal identifiers will be removed, and only attributed to a general description of your role and organization (e.g. "a senior employee at Halifax Regional Municipality expressed that...")

If referred by a colleague and you choose to participate, you may be asked about your role and your organization's involvement in the design, decision-making, implementation, funding, maintenance, or community engagement related to NBCS initiatives, as relevant to your position.

Some interviews may be conducted over an online platform, Zoom. Zoom has implemented technical, administrative, and physical safeguards to protect the information provided via the Services from loss, misuse, and unauthorized access, disclosure, alteration, or destruction. However, no Internet transmission is ever fully secure or error free.

Who may participate in the study?

You are eligible to participate in this study if you meet the following criteria:

1. You are employed by or affiliated with:
    - a municipal government in either Vancouver or Halifax, **OR**
    - a non-governmental organization, **OR**
    - a local business
2. You are/were involved in the decision-making, management, funding, implementation, communication, coordination or maintenance of NBCS in one of the case study cities.

Is participation in the study voluntary?

Your participation in the study is entirely voluntary. You may withdraw from the study at any time prior to the publication of results by contacting the researcher via email at kboyall@uwaterloo.ca or by informing the interviewer verbally at the time of the interview.

You may decline to answer any questions and may request to skip any question(s) at the time of the interview, or you may email the investigator in advance of the interview.

Participants retain the right to withdraw their information in part or in total from the project. Any direct quotations or references to your organization will be verified and confirmed with your consent before being publicly disclosed.

To ensure accuracy, transparency, and mutual understanding, the researcher will conduct a member checking process following the interview. This means giving you the opportunity to review, clarify, approve, modify, or withdraw any part of your interview data, including quotes, interpretations, and their attribution, that the researchers intend to use in publications or

presentations. This process applies to all participants, including those who may share lived experience or culturally informed knowledge, such as individuals from Indigenous backgrounds or Indigenous-led organizations. This ensures that any knowledge shared is represented respectfully, accurately, and in a way both researcher and participant are comfortable with.

Will I receive anything for participating in the study?

To thank you for your time and participation in the study, participants will receive an honorarium of $25.00 (CAD) in the form of a digital gift card, sent to your email after the conclusion of interviewing period. The gift card will be for a local green space or outdoor recreation provider, such as the Vancouver Board of Parks and Recreation, Nova Scotia Provincial Parks, or a comparable organization relevant to your region. The gift card will be sent to your email after the conclusion of the interviewing period. If you are not permitted to accept honoraria due to your position or institutional policy, or if you require an alternative arrangement, please let the researcher know at the time of the interview.

The amount received is taxable. It is your responsibility to report this amount for income tax purposes if required.

What are the possible benefits of the study?

Participation in this study may help you or your organization answer questions surrounding its policies and practices involved in NBCS, climate action, sustainability and community resilience.

Research results will be used to develop an adaptive toolkit for supporting decision-making for municipalities, NGOs, businesses, and governance networks, as well as academic and popular articles that may advance research-to-policy discussion on transformative climate and sustainability actions in Canadian cities.

What are the risks associated with this study?

There are no known or anticipated risks associated with participation in this study. If

you feel uncomfortable at any point, you are free to decline to answer a question, pause the conversation, or withdraw from the interview. See above for more details on voluntary participation.

Will my identity be known to others?

Your identity will be known to the researchers and to the individual who may have recommended you as a key informant, if applicable. While every effort will be made to maintain your confidentiality, complete anonymity cannot be guaranteed due to the detailed and contextual nature of the study.

Your name and exact job title will not appear in any thesis or report resulting from this study. With your consent, anonymized (i.e. any personal identifiers will be removed to protect your identity) quotations may be used attributed using a general description of your role (e.g., "a senior employee at Halifax Regional Municipality commented...").

How will data from this study be stored and accessed?

Interview data will be accessible only to the Lead Investigator and student researcher of the study.

All data collected during this study will be anonymized and retained for at least seven years in an encrypted digital folder. You may request removal of your data from the study at any time prior to publication by contacting the researcher at kboyall@uwaterloo.ca or the Lead Investigator at sarah.burch@uwaterloo.ca.

Who is funding this study?

This study is funded by the Social Science and Humanities Research Council of Canada (SSHRC).

Has the study received research clearance?

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB #47371). If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca.

Who should I contact if I have questions regarding my participation in the study?

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact the Lead Investigator, Dr.

Sarah Burch, at +1 519 888 4567 Ext. 31932 or by email at sarah.burch@uwaterloo.ca, or the student researcher, Kayne Boyall, at kboyall@uwaterloo.ca.

Sincerely,

Kayne Boyall, BSc (Env)

MSc student, Geography

Department of Geography and Environmental Management, University of Waterloo

kboyall@uwaterloo.ca

Written Consent Form



UNIVERSITY OF WATERLOO
FACULTY OF ENVIRONMENT
Department of Geography
and Environmental Management

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the letter of information about a research study being conducted by Kayne Boyall of the Department of Geography and Environmental Management at the University of Waterloo. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted. I am aware that I may withdraw from the study without penalty at any time prior to the publishing of results based on data from this research study by advising the researchers of this decision.

I am aware that my interview will be audio recorded to ensure an accurate recording of my responses and may be video recorded if the interview takes place over MS Teams or Zoom. At the beginning of the interview, the researcher will ask the questions listed on this page to confirm my continued consent to participate in the research study. I am aware that I have the choice to confirm my informed consent either by completing and signing the written consent form prior to the interview, or verbally at the start of the interview.

I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research, at my approval. While efforts will be made to protect my identity by omitting my name and exact job title, I understand that the researcher cannot guarantee total anonymity because of the specialized nature of the information being collected.

I understand that I may withdraw my consent to participate in this study at any time prior to or during the interview, and after the interview up until the point at which academic papers or other publications based on the data have been submitted for publication, without any penalty, by contacting the researcher. Once findings have been submitted for publication, it will no longer be possible to remove my data from those materials. To withdraw, I may contact the Lead Investigator at sarah.burch@uwaterloo.ca or the student researcher at kboyall@uwaterloo.ca.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB #47371). If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca. For all other questions, contact Kayne Boyall at kboyall@uwaterloo.ca.

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

☐Yes ☐No

I agree to have my interview audio recorded.

☐Yes ☐No

For online interviews only – I agree to have my interview video recorded.

☐Yes ☐No

I agree to the use of unattributed quotations in any thesis or publication that comes of this research.

☐Yes ☐No

I would like to have my organization's participation in this study acknowledged in the resulting thesis.

☐Yes ☐No

I would like to review the transcript of my interview.

☐Yes ☐No

Participant Name: _____
(Please print)

Participant Signature:

X _____

Date: _____

Verbal Consent



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Department of Geography
and Environmental Management

Participants will be sent a letter of information and written consent form prior to the interview. This verbal consent exists to confirm consent to participant if a completed written form was not received, or at the participant's preference. Bolded text indicates questions read at the outset of the interview.

Can you confirm that you received, read and understood the letter of information consent form?

Participant answers yes or no. Should the participant answer no, I will have a physical copy of the consent form and/or letter of information to read aloud prior to advancing. Key points of the study are listed on p. 2 for the participant to review, for me to read aloud during the verbal consent process, or as needed.

Do you have any questions relating to the consent form, or to the study?

Participant answers yes or no, and any outstanding questions are addressed before the interview begins.

Do you agree to participate in this study under the conditions outlined in the consent form?

Participant answers yes or no. If yes, the interview proceeds. If no, the interview is terminated with no penalty to the participant.

Unless you specifically ask to be named, any quotes used from this interview would be unattributed. Do you agree to have unattributed quotations used in any thesis or publication that comes out of this research?

Participant answers yes or no. If yes, the interview will proceed. If no, a note will be made that no direct quotes may be used from that transcript. If the participant asks to have their quotes attributed, a note will be made so that their transcript will not be anonymized.

Would you like to have your organization's participation in this study acknowledged in the resulting thesis?

Participant answers yes or no.

Would you like to review the transcript of your interview?

Participant answers yes or no. If yes, a note will be made to follow up with participant by email.

Do you agree to have your audio (and video if you choose to leave it on) recorded?

Participant answers yes or no.

By providing your consent, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities. Would you like to begin?

Key points of participation in this study, available at participant's request during consent process.

Key points of the study:

- This study explores how to amplify the impacts of nature-based climate solutions (NBCS) in Canadian cities through a comparative case study of Halifax and Vancouver.
- Your participation involves a one-time interview lasting approximately 60 minutes, conducted either in person or online via Zoom.
- I'll ask you about your professional experiences and perspectives related to NBCS governance, practice and implementation.
- Participation is entirely voluntary. You may decline to answer any question or end the interview at any time without any consequences.
- You may withdraw your data at any point before, during, or after the interview, up until the results are submitted for publication. To do so, you can contact me or the lead investigator, Sarah Burch.
- With your permission, the interview will be audio-recorded and transcribed. All responses will be anonymized. You will be offered the chance to receive and review the transcripts from today's interview.
- Any quotes, interpretations, and how I attribute them from this interview will be provided to you to review, amend, and approve or withdraw before their use in any publications.
- Only the Lead Investigator and the student researcher will have access to interview data, which will be anonymized and retained for at least seven years in an encrypted digital folder.
- As a thank-you, you will be offered a $25 digital gift card to a local greenspace or outdoor activity, unless you are unable to accept it.
- If you have any questions, you're welcome to ask now or at any point in the process by emailing myself or the Lead Investigator.

Letter of appreciation (by email)

UNIVERSITY OF WATERLOO
FACULTY OF ENVIRONMENT
Department of Geography
and Environmental Management

Hello, [Month XX], 2025

I would like to extend my sincere gratitude for your participation in the study on nature-based climate solutions (NBCS) in [City Name]. Your time, insights, and experiences have been invaluable to the success of this research. Your contribution will help further the understanding of how urban climate solutions are implemented and expanded, and we deeply appreciate your role in this important work.

(If the participant accepted remuneration)

As a token of appreciation for your time and effort, I am pleased to inform you that a $25.00 digital gift card has been sent to your provided email. Thank you again for your willingness to share your knowledge, which will have a lasting impact in climate action and sustainability. We are excited to share the findings in the near future.

If you have any questions or would like to receive updates on the progress of the study, please feel free to contact me at kboyall@uwaterloo.ca or the Lead Investigator at sarah.burch@uwaterloo,ca.

(If the participant declined/cannot accept remuneration)

Thank you for your willingness to share your knowledge, which will have a lasting impact on climate action and sustainability. We are excited to share our findings in the near future.

If you have any questions or would like to receive updates on the progress of the study, please feel free to contact me at kboyall@uwaterloo.ca or the Lead Investigator at sarah.burch@uwaterloo,ca.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB #47371). If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca.

Sincerely,

Kayne Boyall, BSc (Env)
MSc student, Geography
Department of Geography and Environmental Management, University of Waterloo
kboyall@uwaterloo.ca

Appendix B – Interview Guide

I. Greeting

Good morning/afternoon. My name is Kayne. Thank you so much for taking the time to meet with me today. Before we start with the interview questions, I would like to ask you a few questions to document your consent to participate in the research study. Did you have any questions or anything you wanted to discuss before getting started?

II. Verbal Consent

If a completed written consent form was not provided prior to the interview session, I would read through the verbal consent form (attached).

After participant has consented to participate in the study and to having the interview recorded, the audio recording will be started.

III. Questions

1. Nature-based climate solutions in practice
    - Could you tell me about your role at [organization]?
    - Can you tell me about the NBCS projects you've been involved with in [city]?
    - What does NBCS mean to you?
    - What was your role or involvement in these? How extensively were you involved, and for how long?
    - How does this/these project(s) compare to others you've worked on in your current (or past) role?

2. Perception of success and amplification
    - From your perspective, what makes an NBCS project 'successful' or impactful? How would you measure this?

    Open-ended

    - Can you describe if and how this NBCS initiative or project has changed, expanded, or evolved over time?

    Amplifying within

    - Have there been efforts to strengthen or sustain the NBCS initiative over time (e.g., maintaining funding, improving processes, institutional support)?
    - Have you noticed changes that have sped up its development or impact (e.g., streamlined permitting, stronger partnerships, increased public support)?

    Amplifying out

- Has the project increased its footprint in any way since its earlier stages?
- Have there been similar projects started in your area that draw directly from this initiative's success or model? Could you describe how those are connected or coordinated with your initiative?
- Have you seen similar projects emerge elsewhere that share ideas or inspiration
- from your work, even if not directly tied to it?
- Have any principles, tools, or lessons from your initiative been taken up more broadly or in other jurisdictions?

Amplifying beyond

- Has this initiative influenced or looped in policy, planning, or funding programs at higher levels (e.g., municipal, provincial)?
- How do you think this initiative has influenced priorities, urgency or values about climate action, nature, sustainability, or urban planning?

3. Barriers and Enablers
    - Who have been the most influential individuals, groups, or institutions in shaping NBCS in [city]? Would you describe these as expected?
    - How would you describe the collaboration and coordination among these groups and individuals?
    - Have there been any roadblocks to growing these NBCS projects from their initial phase that you could describe?
    - How do these compare to any experienced in the project's earlier, initial phases?
    - Can you think of and describe any specific actions, conditions, or triggers that have seemed to help NBCS project overcome these hurdles in increasing their impact?

4. Actors and collaboration
    - Who have been the most influential individuals, groups, or institutions in shaping NBCS in [city]?
    - As the projects you've worked on have grown and developed, what kind of actors have been involved?
    - Were there any actors that came on after it reached a certain point, or for particular tasks, phases, or stages of the project that you can describe?
    - How would you describe the collaboration and coordination among these groups and individuals?
    - Were there any surprising actors or relationships in this that have surprised you?

5. Indigenous community, perspectives and partnership
    - What has Indigenous engagement looked like in the NBCS projects you've been part of?
    - How did the trust and relationship with Indigenous partners evolve as the project grew and evolved?
    - How has working alongside Indigenous communities influenced how NBCS and their success is understood in the project?
    - What kinds of feedback from Indigenous communities have shaped the project, and how was that feedback received?
    - How did Indigenous perspectives challenge or enrich the original project vision?
    - How did you and Indigenous partners navigate some of the challenges in implementing and growing this project?
    - In what ways did Indigenous involvement shape the outcomes or impacts of the project?

6. Policy and Governance Recommendations

- How would you define success for this project? What are the metrics of that success?
- If another city wanted to implement NBCS, what do you think they could learn from [city]?
- If you had a magic wand that would change one thing to help grow NBCS impact and reach, what would it be?

7. Wrap-up and recommendations

- Is there anything we haven't discussed that you think is important to understanding how NBCS function and grow in your city?
- Are there any people or organizations you think I should speak with as part of this project?

III. **Conclusion**

Thank you again so much for your time. Could you confirm if you're able to accept the digital gift card as an honorarium for your time today?

Participant will declare if they are restricted from accepting due to the nature of their role.

If yes:

You'll be receiving the digital gift card at the end of the interview period. Could you confirm the email address to send that to?

If no:

Are there any considerations or alternatives in lieu of this?

This concludes the interview. Have a great rest of your day.

Audio/Video recording is stopped. End of interview

Appendix C – Sample Codebook

Primary code	Secondary code	Tertiary code
Amplification	Within	Speed up
		Stabilize
	Out	Grow
		Replicate
		Transfer
		Spread
	Beyond	Scale up
		Scale deep
Barriers / Enablers	Environmental	
	Financial	
	Operational	
	Institutional	
	Political	
	Cognitive	
	Systemic	
NBCS Scale	Watershed	
	Community	
	Neighborhood	
	Parcel	
Steppingstones		
NBCS co-benefits		
NBCS define		
NBCS success		
Magic wand		
Progression		
Pilot-amplify comparison		
Indigenous partnership		
Indigenous influence		
Quote		