Classifying and Mapping Urban Green Interventions to Support Biodiversity and Connectivity in Vancouver

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August 2023

Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of Vancouver Board of Parks and Recreation staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of Vancouver Board of Parks and Recreation or the University of British Columbia.

Acknowledgements

I humbly acknowledge that the work for this project took place on the unceded ancestral lands of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), Stó:lō and Səl̓ílwətaʔ/Selilwitulh (Tsleil- Waututh) Nations.

I would like to thank **Jo Fitzgibbons** and **Francisca Olaya Nieto** for the amazing contribution, feedback, and support throughout this project.

Cover photo by Vanessa Amorocho (View from Queen Elizabeth Park).

All of the images in this report were taken by the author unless otherwise mentioned.

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Executive Summary

Project Context

Vancouver is determined to reshape its relationship with nature, increasing the proportion of naturalized areas, fostering ecological connectivity and diversifying habitats for wildlife. A key challenge to achieving these goals is understanding the spatial distribution and functions of the existing green network. This report identifies key observations in current green network spatial data and proposes a habitat classification system building on previous work done for the city of Vancouver. The classification system serves as a tool to guide area-specific greening opportunities and develop efficient, equitable and environmentally sound spatial prioritization strategies to enhance the green network. With this classification system, the Park Board can better plan, align and direct future efforts to increase natural elements across the city, leveraging benefits for wildlife and the community.

Findings

The proposed habitat classification system captures all existing and potential green space typologies irrespective of their size because even the smallest green areas can contribute to the city's ecological health and serve different biodiversity groups. The classification system includes various habitat types in the city of Vancouver, ranging from large natural forests in parks to small green infrastructure assets in street right of ways. A map was created to depict the different typologies of urban habitats and how they interact spatially. As for spatial data management, there is a need for an integrated spatial data strategy across the Park Board and City teams to establish clear team roles, collection guidelines, data resolutions, and updating periods of ecological data in the city. The City and Park Board currently lack a consistent method for defining and spatially measuring naturalized areas in the city. Similarly, the mapping of natural ecosystems from Metro Vancouver SEI differs from the Park Board's definition of natural and naturally managed areas in their spatial extent and attribute specificity. The ecological data can be further enhanced by mapping missing landscaped habitats such as green roofs, community gardens and garden plazas.

Greening Opportunities

Recommended greening opportunities include partnering with the School Board to build green roofs and green walls and increase canopy in school premises; using utility and railway corridors to establish naturalized mobility connectors with abundant tree, shrub and green infrastructure (GI) assets and require environmental stewardship in public/private vacant lots.

Introduction

With the growing consequences of climate change experienced in cities, Vancouver is determined to preserve biodiversity and enhance its ecological health. The early history of colonization and urban development in Vancouver resulted in the destruction of almost all of the original natural ecosystems in the city. Coastal wetlands and tidal marshes were infilled, the majority of streams were buried, old-growth forests were cleared, and wildlife species disappeared due to minimal environmental regulation[1]. Today, development pressures will continue to rise as Vancouver estimates a population growth of 170,000 new residents by 2050 (City of Vancouver, 2022), posing a major risk for natural space loss in the future.

Vancouver has recognized the need for a paradigm shift to reconcile with nature and welcome it in the city as it continues to strive toward reconciliation, carbon neutrality, equity and climate resiliency. Ninety-nine percent (99%) of Vancouver residents live within a 10-minute walk of a park or green space. However, although most people have access to a park in Vancouver, not all of our parks support biodiversity or provide access to meaningful experiences in nature. Vancouver's ecological vision moves beyond just increasing green space for people; it reflects the urge to *reshape* the city's relationship with nature and biodiversity by increasing the proportion of naturalized areas and their connectivity, supporting healthy ecological processes and providing habitat for wildlife.

In order to enhance ecological health and connectivity, we must first develop a baseline understanding of what we have and how it works. Understanding the spatial distribution and functions of the existing green network can help us to develop efficient, equitable and environmentally sound spatial prioritization strategies. This report identifies key observations in current green network spatial data management practices and proposes a habitat classification system building on previous work done for the city of Vancouver. The proposed habitat classification system also serves as a tool to identify spatial data gaps and provide recommendations on potential green interventions that will enhance the city's green network by using specific neighbourhood examples. With this classification system, the Park Board can better plan, align and direct future efforts to increase natural elements in the city, leveraging benefits for wildlife and the community.

[1] See Vancouver Plan (2022) for more information on Vancouver's history.

The objectives of this report are:

- Synthesize and classify existing types of space available with existing and potential green spaces in the city in a habitat classification system.
- Identify spatial gaps where there is insufficient spatial data on green interventions.
- Learn how different partners manage spatial data in the city, including collection, analysis, organization and updating.

Background

What is Biodiversity?

The Convention of Biological Diversity defines biodiversity as "the **variability** among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (United Nations, 1992). Stemming from this definition, biodiversity is not only concerned with species richness and abundance but also with the **ecological interactions** among organisms (e.g., predation, symbiosis and competition) and with the habitats they occupy (e.g., nitrogen fixation, gas exchange and decomposition) creating the wide diversity of ecosystems that we observe.

"Biodiversity" is more than just the variety of species in a place. It also includes the ways those species interact with each other and the habitats they occupy.

Biodiversity is, in and of itself, a *complex adaptive system* emerging from ecological interactions occurring at multiple spatial and temporal scales but also from species' ability to adapt to change over time (Levin, 2000, 2005). The ecological interactions at the local scale are different from those at the landscape and global scales (i.e., alpha, beta and gamma biodiversity). Similarly, biodiversity can vary through time at a fixed spatial location, for example, during the removal of natural spaces in cities changing the original species mix (Levin, 2005). Contributing to this complexity is the fact that species are capable of evolutionary change when new stressors are introduced, creating new pathways for ecological interactions and biodiversity assemblages in a specific area (Levin, 2000, 2005).

In other words, biodiversity is constantly changing and evolving. Decisions we make about land use and green space can impact ecosystems in unpredictable and surprising ways. Cities are striving to bring “nature” back, and to do so successfully, city staff and policy-makers will need to understand the complexity nested in nature and the rewilding of urban spaces.

Why Do We Need Biodiverse Cities?

How policymakers define and measure urban biodiversity is important in the realms of planning, sustainability and conservation. Urban biodiversity refers to the variety of organisms, their interactions and the multiplicity of habitats in and around dense human settlements. Some definitions incorporate the social and built components, moving on to a more holistic social-ecological point of view (Pickett et al., 2016). This report defines urban biodiversity as the variability of all living organisms, their interactions and all-natural, semi-natural and culturally modified green spaces interspersed in a human settlement.

Urban biodiversity is the variability of all living organisms, their interactions and all-natural, semi-natural and culturally modified green spaces embedded in a dense human settlement.

Together, green spaces form the green network of the city, comprising open natural spaces, streams and creeks, beaches, shorelines, parks, community gardens and natural gardens, street trees, green infrastructure, ponds and lakes, green roofs and green walls that can occur in multiple land uses of public, private or mixed type. These spaces work together to support the ecological health of the city and provide social, environmental and economic benefits. Having a robust, connected network of green spaces is essential to support urban biodiversity.

We need biodiverse cities in order to adapt to climate change and overall live enjoyable, healthy lives. Biodiversity supports an ecosystem's capacity to provide services and goods to people, such as climate regulation, water and air purification, pollination and pest control, among others.

Most of the food we eat is pollinated by insects, which in turn depend on certain flowers and habitats to survive. Our food system is most resilient when it contains multiple different pollinator species who are able to pollinate our food - that way, if a disease, predator, or other stress suddenly threatens to extinct one species, we still have many

others around that can pollinate our food. This is just one example that demonstrates how biodiversity is necessary for human well-being.

Moreover, biodiversity provides an opportunity for disconnecting from the urban fringe to experience nature, observe wildlife, enhance mental and physical health and foster spirituality, learning and inspiration. Loss of biodiversity in cities would impact the provision of NCPs over time and decrease the quality of life (Cardinale et al., 2012).

Strategies for Enhancing Urban Biodiversity

Cities have a significant role in biodiversity protection as they continue to grow significantly in the following decades, with an additional 2.5 billion people moving into urban areas by 2050 (United Nations, 2018). Despite the permanent land use changes from development, cities can contribute to biodiversity conservation with effective urban green space planning and management.

For cities hoping to restore and conserve nature, a necessary first step involves identifying what habitat already exists and what kinds of habitats offer the best opportunities for coexisting with biodiversity. We can refer to these interdependent habitat areas in a city as a "green network."

A **green network** is the combination of natural and semi-natural areas in a city that support the environment and ecosystems, as well as open areas for conviviality and wellness. A green network includes important habitat areas for the many non-human beings we share the city with.

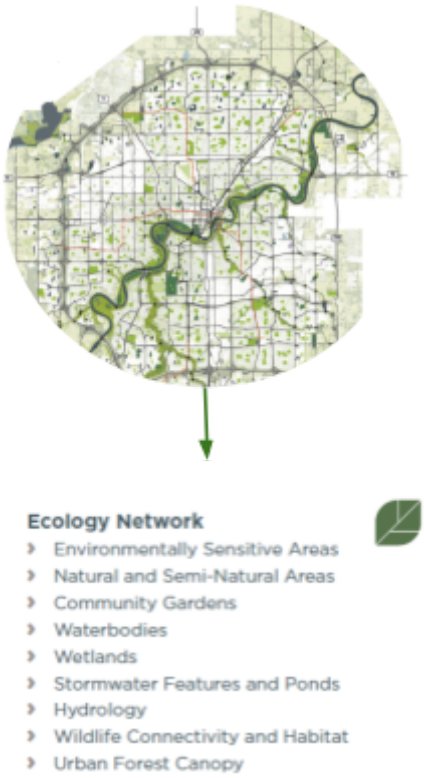
After first defining and mapping the green network, a city can identify priority areas for biodiversity conservation and areas that are underserved or lack access to nature. Once the green network has been mapped and priority areas defined, cities can start proposing green interventions to enhance urban biodiversity, taking advantage of multiple land use types available in the urban matrix.

Depending on the quality of the urban landscape or the degree to which it has been developed, green interventions could fall into either of these two categories: land sparing and/or land sharing. **Land sparing** refers to strategies that spare natural habitat space and limit the extent of urban development, resulting in more compact and higher-density developments. These include preserving remnant natural patches, maintaining riparian corridors, increasing parkland and dedicating land for large GI assets. **Land sharing** refers to interspersing green spaces with urban areas, largely used in cities where the natural landscape has been highly developed (McDonald et al., 2023). Land-sharing alternatives include green roofs and facades, street and private trees, green plazas and smaller GI assets. Many cities opt for using both types of strategies to achieve the largest benefits for biodiversity.

Edmonton: Breathe

Green Network Strategy (2017)

Edmonton's green network integrates the ecological network, celebration network[2] and wellness network[3], having a holistic and functional approach. Specifically, for the enhancement of the ecological network, Edmonton proposes:

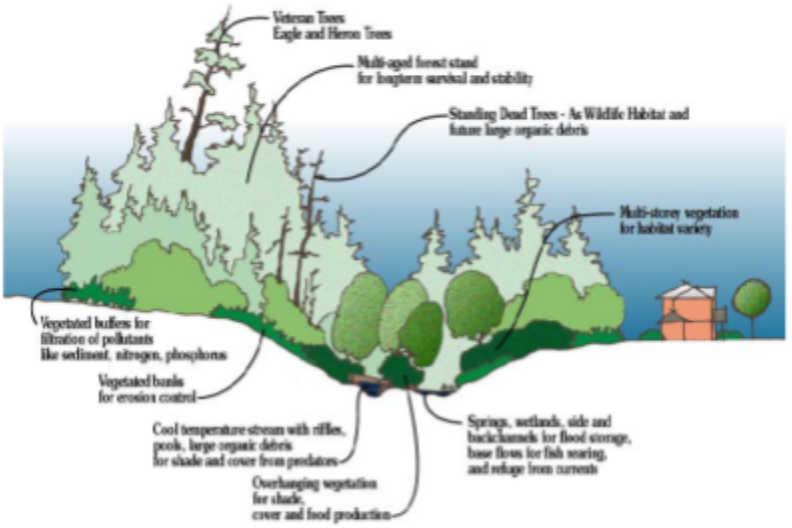


- Connecting core biodiversity areas with corridors such as greenways or co-located with linear infrastructure (e.g., utilities, pipelines, rail corridors).
- Add more constructed wetlands into new and existing urban developments.
- Enhance and restore smaller open spaces (e.g., pocket parks, vacant lots, road islands, bioswales) or green infrastructure (e.g., bioswales) that act as critical habitats and stopovers for wildlife.
- Protect or restore habitat quality in municipal cemeteries and golf courses acting as critical habitat, and provide incentives for private cemeteries and golf courses to follow municipal recommendations for habitat protection and restoration.

[2] Vibrant community gathering areas - civic plazas, festival and event areas cultural and historic landscapes, pedestrian oriented streets.
[3] Open spaces highly supportive of physical and mental wellbeing - parks with exercise stations, biking and walking trails, and sport areas.

Surrey: Green Infrastructure Network (GIN, 2011)

Surrey's GIN uses the U.S. National Vegetation Classification (USNVC) to classify and quantify all natural and semi-natural vegetation across the city. The main components of the GIN are hubs (large natural and semi-natural areas), sites (small natural and semi-natural areas), potential corridors and the urban matrix. GIN does not explicitly include small-scale green spaces such as green rainwater infrastructure but identities this as an opportunity. Some green interventions recommendations are:



Example of a Stream Corridor for Connectivity providing a wide range of vegetation structure and habitat possibilities. Obtained from Surrey's GIN.

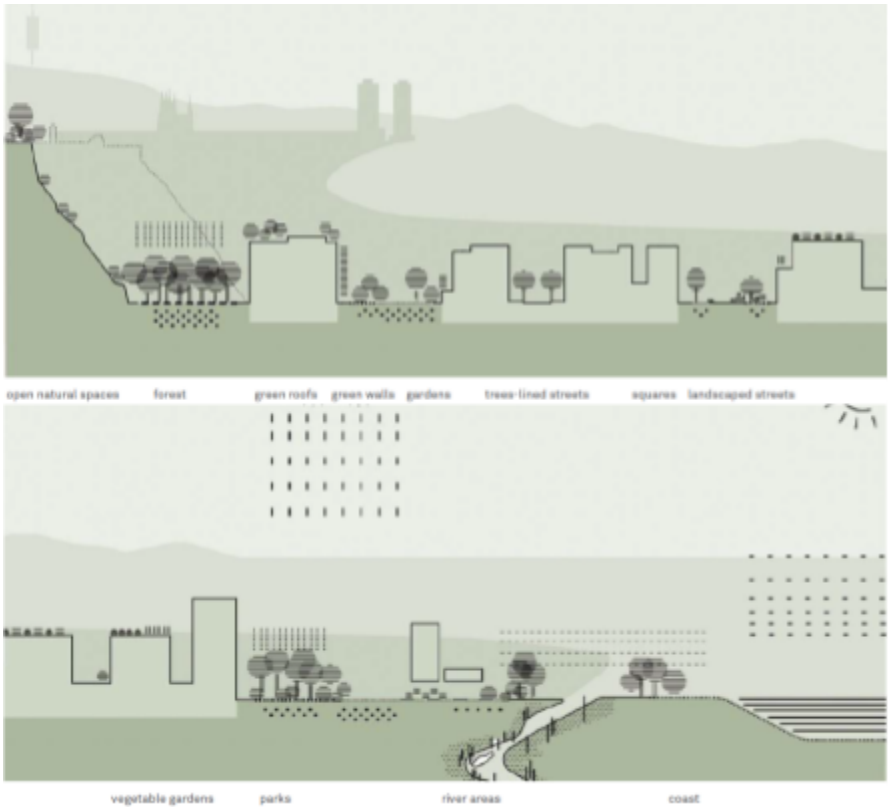
- Have at least one effective corridor between hubs that follow utility right of ways, watercourses, riparian areas, steep slopes, floodplains, wetlands and forests. They should minimize road crossings.
- Complement core hubs and sites with smaller green spaces and neighbourhood trees that provide stepping stones and increase the quality of the urban matrix.
- Enhance urban backyard habitats in areas with limited opportunities for establishing dedicated corridors for wildlife movement.

Barcelona: Green Infrastructure and Biodiversity Plan (2020)

Barcelona's vision is to become a city where nature and urbanity converge and enhance each other. The city plans to model their green network on the basis of connectivity and re-naturalization using urban green corridors and varying kinds and sizes of opportunity areas ranging from natural to man-made green infrastructure. Some actions include:

Images Obtained from Barcelona Green Infrastructure and Biodiversity Plan

- Convert under-used small green spaces in public streets to low maintenance areas.
- Create more greenery in decks, rooftops, walls, courtyards and inner block areas.
- Create green spaces in temporarily unused plots in the form of short-term gardens ensuring they incorporate facilities for people to enjoy.
- Increase vegetation and street furniture in urban plazas, including short-term gardens, especially in underserved areas.



Type of spaces that make up Barcelona's green network - *Obtained from Barcelona's biodiversity plan*

Overall, using the wide range of available strategies to enhance biodiversity, cities can contribute to biodiversity conservation in significant ways. The various shapes, infrastructure heterogeneity, and connectivity corridors can increase habitat diversity for local or transient species, provide stopover habitat for migratory species, stimulate genetic diversity and support pre-adaptation to climate change (Spotswood et al., 2021).

Biodiversity Policy Context in Vancouver

Vancouver has developed multiple city planning documents and programs addressing specific matters of environmental action and sustainability. Important milestones achieved over the past twenty years include a Green Rezoning Policy in 2011 (requiring all new developments to adopt LEED standards), an Ecodensity program in 2008 to adopt more sustainable planning processes and a Community Climate Change Plan in 2005 to reduce carbon emissions[4].

In 2011, the Greenest City Action Plan (GCAP) paved the way to a greener city by guiding actions toward zero carbon emissions, zero waste and healthy ecosystems. The GCAP addressed biodiversity through the lens of increasing access to nature for all Vancouver residents and set important priority areas related to the conservation and expansion of urban canopy and parkland within city boundaries. The GCAP wrapped up in 2020, having progressed in multiple priority areas, but more importantly, it informed policymakers on the fronts that needed to be tackled more aggressively to achieve a sustainable, healthy and just city.

Building on successes from the GCAP, Vancouver is currently working with a wide range of plans and strategies that contribute to biodiversity conservation from multiple directions. Together, these policies present opportunities for achieving co-benefits that support biodiversity conservation and enhance the green network of the city.

Vancouver Plan (2022):

VanPlan, recently approved in July 2022, is the land use strategy that guides the long-term growth of the city of Vancouver. VanPlan uses a composite overlay spatial analysis defining six key city building blocks and layers with the purpose of implementing a holistic perspective when defining future land use directions and ensuring coordination between different subject matters. One of the key city-building layers is Ecology, defined in this plan as the system of existing, enhanced and future habitat areas, corridors and blue-green networks that enhance ecosystem function and biodiversity and allow residents to connect with nature. Vancouver Plan highlights its vision of a city that reshapes its relationship with nature and restores its ecological health in the realms of land use planning and implementation.

Climate Emergency Action Plan (CEAP) (2021):

This is Vancouver's current climate change action plan that continues the work done by the GCAP. The CEAP establishes bold targets to reduce carbon pollution by 50% by 2030 and to

[4] Visit City of Vancouver website to read more about work done before the GCAP

become carbon neutral by 2050. The plan also sets an interim target to remove 5,000 tonnes of CO2/year beyond the current baseline of 16,000 tonnes of CO2/year by 2050 within city boundaries. The City staff recognizes that this effort is not enough to cover the carbon sequestration share recommended by the United Nations to limit warming to 1.5 °C; however, reaching the desired carbon sequestration level is not feasible within city boundaries, and it will depend on the elicitation of supporting projects outside city boundaries. The CEAP conceives Natural Climate Solutions (NCS) as a big move towards achieving interim carbon sequestration targets and emphasizes on the urgent need to increase tree canopy citywide to 30% from the current 23% by 2050.

VanPlay (2019):

VanPlay is the Parks and Recreation Services Master Plan that sets a 100-year vision, a 25-year outlook and a 10-year implementation plan for all public lands managed by the Vancouver Board of Parks and Recreation. Important assets included in this plan are all public parks and beaches, street trees, botanical gardens, conservatories and large recreational areas such as golf courses. VanPlay puts biodiversity at the forefront through 3 nature-related strategic goals: create a green network (Goal 6), restore wild spaces (Goal 6) and protect existing parks and spaces (Goal 2). The Playbook, which is VanPlay's implementation plan, establishes 5 nature-related specific approaches for action, each of them with tangible actions, programs and policies directed to protect, enhance and nurture natural spaces and urban canopy through connectivity and naturalization.

Rain City Strategy (2019)

The Rain City Strategy is a long-term roadmap for evolving rainwater management practices through green rainwater infrastructure (GRI). By mimicking the natural water cycle, GRI will reduce the costs of stormwater management in the city while also contributing to other essential city-building processes, such as creating enhanced habitats that support biodiversity. It calls for expanding the green area that receives and treats rainwater runoff, and so it presents an opportunity to join efforts to expand green and blue systems that support biodiversity across all sorts of land use types in the city.

Urban Forestry Strategy (2018)

The Urban Forestry Strategy provides a foundation for how Vancouver manages the urban forest. It sets directions to protect, plant and manage and monitor trees on public and private lands across the city guided by the principles of equity and resiliency. It also updates canopy

cover trends, suggesting that while canopy cover in public lands is growing, private property is declining. Biodiversity protection is central to this strategy as it aims to increase canopy cover and reduce the loss of native trees within the city.

Biodiversity Strategy (2016)

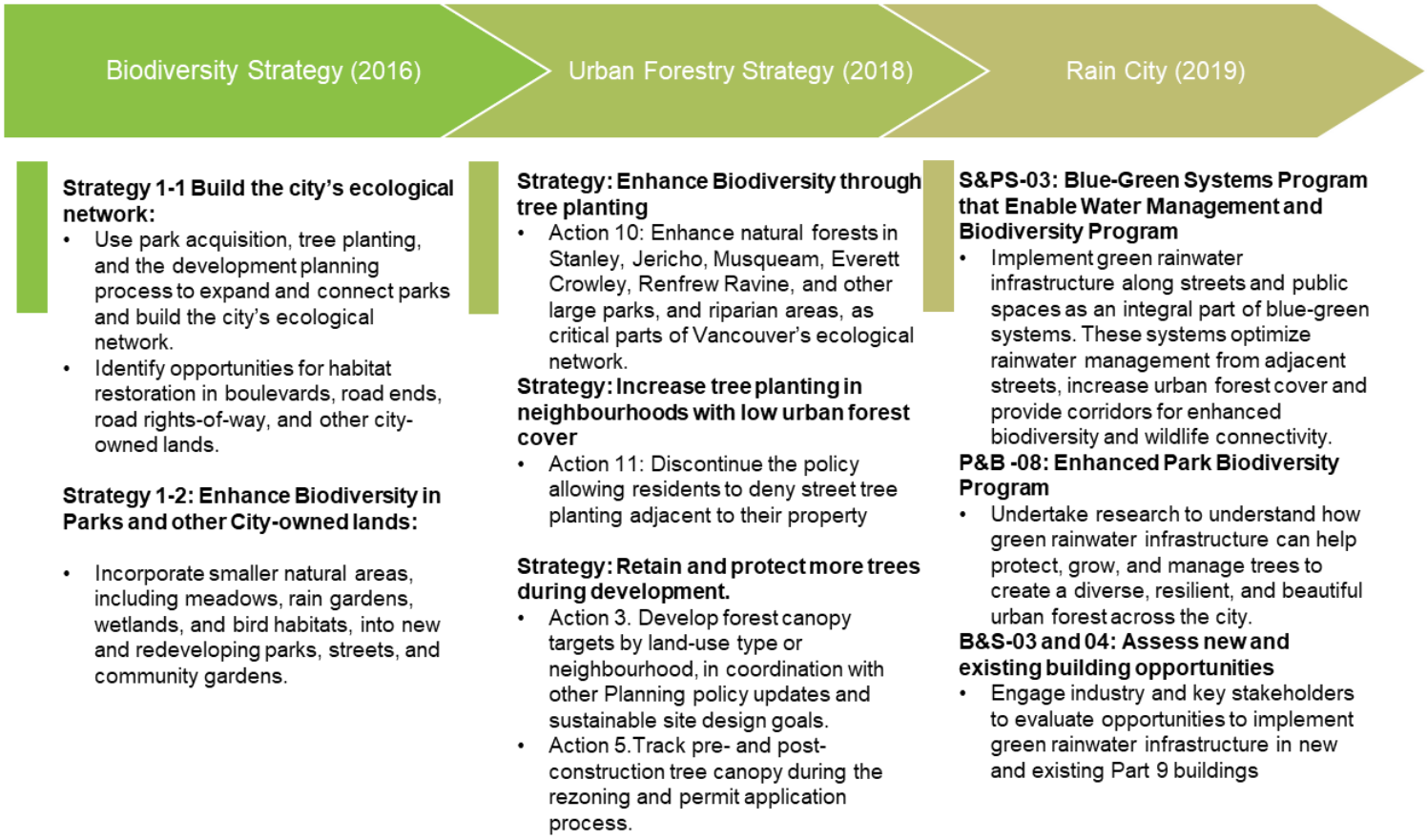
Adopted by the Board of Parks and Recreation Services, this strategy provides a foundation for protecting and restoring natural areas, species and ecological processes. This strategy defines priority habitats, priority species and biodiversity hotspots for the City of Vancouver, finding Stanley Park, Spanish Banks, Everett Crowley Park, Musqueam Marsh, Musqueam Park and Jericho Park as areas of environmental significance. It also sets targets for restoring an additional 25 ha of natural areas of the existing 847 hectares in parks by 2020, which has now been met. Great attention is given to the use of park acquisition, tree planting and inclusion of smaller natural habitats like pollinator meadows, rain gardens and wetlands in redeveloping parks, community gardens, boulevards, street ends and street right of ways.

Summary of Policies

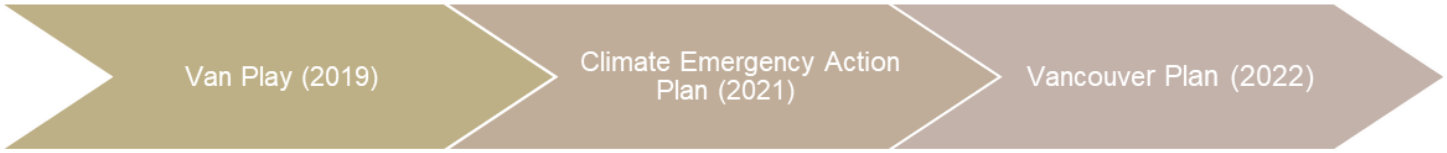
Combined, all these plans and strategies **agree** on the following strategic goals:

- Increase the quantity (hectares) of naturalized areas in the city, including both foreshore and inshore habitats.
- Support a variety of habitats in parks, such as wetlands, salt marshes, pollinator meadows, riparian areas and rain gardens.
- Enhance the ecological connectivity of green spaces and natural areas by identifying opportunities for habitat creation in a variety of land use types.
- Increase access to natural areas for all Vancouver residents.
- Increase urban canopy cover, especially in neighbourhoods with low percentages.
- Expand the use of green infrastructure for stormwater management that connects parks, shorelines and supports biodiversity.
- Leverage sustainable food systems with biodiversity.
- Support biodiversity through awareness campaigns, stewardship and data monitoring.

Figure 1. Most relevant policies related to biodiversity across city plans and strategies.



Continuation of **Figure 1**



N.1 Protect and enhance the integrity of foreshores, waterways and beaches

- Identify marine conservation zones to protect and enhance delicate shoreline ecosystems

N.2 Protect Vancouver's freshwater resources through ecological restoration, green infrastructure, and water conservation.

- Identify, acknowledge, uncover and connect freshwater features, and historic streams

N.3 Nurture, protect and connect the city's ecological network and natural areas

- Identify locations for habitat corridors based on urban wildlife movement, bird flyways, biodiversity hotspots, hidden streams and green infrastructure gaps.
- Provide access to a naturally managed area of at least 0.2 ha within a 10-minute walk of all residents.

6. 01. Retaining and Enhancing Nature Climate Solutions on Private Lands.

- Strengthen tree retention during redevelopment. Consider a comprehensive update of the Protection of Trees Bylaw
- Explore other regulatory tools that support healthy trees such as setbacks.

6.02. Enhance Nature Climate Solutions efforts on public land.

- Increase canopy cover from 23% to 30% by 2050
- Continue expanding Naturally Managed Areas and improve management techniques
- Planting trees in neighborhoods with historical tree deficits to increase tree canopy and reduce urban heat island effects.
- Developing blue-green systems to manage water, contribute to the urban forest and biodiversity, and enhance active transportation routes

Sets 4 strategic land-use directions related to biodiversity

Embed ecosystems in Planning: Support the health of Vancouver's ecosystems as an integral part of planning, urban design, and city building.

- Establish a whole systems approach to land use planning, that incorporates the protection, restoration and maintenance of key ecological features and areas.

Make space for nature: Identify, rehabilitate and connect ecological systems in Vancouver.

- Identify new and enhance existing biodiversity hotspots and corridors and environmental regeneration areas

Protect nature: protect ecosystems and manage growth around them

- Establish appropriate environmental setbacks that limit development around important water bodies

Provide access to nature: Increase and ensure equitable access to nature

- Support the intensification of the greenway network, towards car-free to car-light corridors

Methodology

I followed a general research approach that consisted of 5 stages (Figure 2). In the following subsections, I explain these stages in more detail.

Figure 2. General research approach.

Read & Review

We conducted four semi-structured interviews with city staff from the GIS, Environment and Green Infrastructure working teams (Table 1). The interviews lasted between 50 to 60 minutes and were done online via Microsoft Teams. The questions explored two themes: 1) the significance of the green network, biodiversity and connectivity concepts in their agendas and functional roles, and 2) the types of spatial data they use and how these data are created, stored and maintained. I analyzed interview transcripts and summarized key themes emerging from open-ended questions.

Table 1. Interviewees listed by department and name.

Working Team/Department	**Participants**
Green Infrastructure Implementation (CoV)	Julie McManus (Senior GI Project Manager)

	Ben Watson (Engineering Assistant)
GIS and Data Team (Park Board)	CJ Schouten (GIS supervisor) Eliana Macdonald (Data and GIS lead)
Urban Forestry - Parks Operations (Park Board)	Reg Eddy (Urban Forestry Planner)
Vancouver Plan Implementation - Real Estate, Environment and Facilities Management (CoV)	Angela Danyluk (Senior Environmental Specialist)

In parallel, I performed a targeted policy review of multiple CoV and Park Board official strategies and plans within the environmental and sustainability realms, giving special attention to areas about the green network, natural areas conservation and urban forestry. I recorded specific strategies and policies related to biodiversity and grouped them into "Pathways of Action" categories following inductive qualitative coding (See Appendix A). I also took note of available maps, habitat inventories and ecological spatial data layers referenced in these documents to gather all available information and to start visualizing where there could be opportunities for collaboration on the biodiversity agenda.

Compile & Document Data

Using GIS software, I compiled all data layers shared by staff that contained relevant information to the green network and took note of the layers I could not access due to confidentiality issues. During this stage, I identified what nature elements were mapped in the city, at what specific attribute and spatial resolutions, and how these were calculated. I found five mapping sources for green spaces in the city of Vancouver, as I explain in Figure 3. More specific information on the layers accessed and reviewed can be found in Appendix B: Spatial Data Inventory.

Figure 3. Major sources of ecological spatial information for the city of Vancouver.

Some of the layers provided by these sources have overlapping typologies, meaning that similar natural features were mapped using different calculation methodologies and attribute categories. I give examples of some but not all overlaps identified during the data collection and documentation in Table 1. I prioritized layers that depicted a finer spatial resolution over layers that seemed more coarse and layers with more specific attributes over ones with little information to create the final maps. Generally, I observed that layers used with the Biodiversity Strategy and the SEI seemed to have coarser spatial features than the ones from the Turf and Horticulture Areas Inventory. Potential reasons for this difference could be the scale of analysis; while the natural area and sensitive ecosystems were done at the city and regional level, the mapping of turf and horticulture areas was done at the park and golf course level and meant to

inform a more granular scale of site management, compared to the broader ecological network planning being done at the city and regional scale.

There was great attribute variability between layers showing similar features belonging to different sources. However, I was able to review how each similar category was calculated and to find similarities that allowed me to merge the attributes of the overlapping features from all sources.

Table 2. Major overlaps found during data collection and mapping solution description.

Map Component	Sources	Specific overlapping layers	Overlay Order for visual representation in Map A	Description
Forests and shrublands	Biodiversity Strategy	2010 Natural Vegetation Mapping	2 (Bottom)	This layer shows remnant natural areas city-wide but in a coarser spatial resolution. However, it contains specific attribute information related to vegetation class and subclass that are relevant to describe the habitat type. I set this layer at the bottom, and it will show where Naturalized Horticulture Beds are not present.
	Turf and Horticulture Booklet	2016 Naturalized Horticulture Beds	1 (Top)	This layer intends to map the remnant natural vegetation in golf courses and parks. It is more up to date and with finer spatial resolution, so I gave preference to this layer to show natural areas in parks and golf courses by setting it at the top. However, it does not contain vegetation class and subclass attribute-specific information.
	Urban Forestry	2018 Forest Stand Polygons	Not used	Even though this layer is the most up-to-date, it does not contain the appropriate spatial coverage (it was done only in major parks and hubs) and attribute resolutions (does not contain vegetation classes and subclasses), so I did not use it.
Herbaceous and Turf areas	Biodiversity Strategy	2010 Natural Vegetation Mapping - specific polygons classified as	2 (Bottom)	This layer mapped graminoid vegetation city-wide and these areas overlapped with highly maintained sport turfs from the turf maintenance layer. I set this layer at the bottom as it is not clear whether all mapped areas

		"herbaceous"		within this layer are natural or not. It will show where turf areas are not present.
	Turf and Horticulture Booklet	Turf maintenance layer	1 (Top)	I gave priority to this layer because it is the most updated source that maps turf areas in parks and golf courses. Has different maintenance degrees, therefore, more attribute resolution.

Reclassification & Habitat Classification System

I propose a habitat classification system building on previous work done for the city of Vancouver, where I continue to use important naming conventions already in use for green spaces in the City. In general, I propose classification categories that came directly from available spatial data layers and on fewer occasions, I had to perform queries to create new layers based on existing data to get the category of interest; this process is called "reclassification." One example of this corresponds to naturalized areas in the city, which I had to compute from the turf_maintainance layer by selecting entries that had more than a 50% value in the Naturalized field from the attribute table.

Additionally, I conducted a brief literature review of documents from other cities and papers discussing topics about urban green mapping and green network strategies (See "Strategies for Enhancing Urban Biodiversity" section in the Introduction). From these sources, I extracted ideas for categories of green in the urban landscape and with varying degrees of land use modification and densities. Reading what other cities have been mapping allowed me to enrich the classification scheme by proposing new names for existing layers or ideas for additional green space categories that have not been mapped but that form part of the green network in the city, such as green roofs, green facades and community gardens.

Limitations and Data Assumptions

Outdated datasets may not accurately reflect on-the-ground realities

Most of the proposed categories for the classification system were based on existing natural spaces classifications from the 2012 SEI done for Metro Vancouver and the 2010 Vegetation Mapping Layer for the CoV. Given that these sources of data are over a decade old, the classification system could include definitions of habitats that are no longer present for Vancouver or have been altered. In this case, there is an opportunity to review the proposed categories once a thorough, updated version of SEI is released.

Inconsistent interpretation and definitions of "natural," "naturalized" and "non-natural" areas

Even though the classification system intends to provide a differentiation between "natural" and "non-natural" green areas, these terms are not clearly and consistently defined in the source documents and data sets, and it was often difficult to differentiate them based on spatial data alone. Without a consistent, agreed definition for these terms, staff interpretation and measurement of these areas may vary with perspective, making it difficult to track progress in the long term. Additionally, I identified inconsistent definitions and naming keys used for similar green spaces and typologies. For example, "herbaceous areas" coming from the 2010 natural vegetation layer overlapped significantly with "turf areas" with varying degrees of maintenance from the Vancouver parks. In that case, I assumed that all grass areas belonged to turfs, which I allocated to non-natural spaces; however, that could be a source of error as some of those areas could be remnant herbaceous natural areas that existed originally in the city. Often, spatial information comes from different consultants, levels of government or city groups. Because there is not a very clear definition of natural and non-natural green spaces across the many layers found in the city, as well as a standardized naming convention, there is the risk that this error continues to happen in the future if not changed. City and Park Board staff can address this problem by identifying organization-wide definitions and service standards for these areas, as has been done for Green Rainwater Infrastructure (GRI).

Varying scales of data make it challenging to represent nuance in a single city-wide map

The scale of urban green spaces that support biodiversity varies extensively depending on the land use type and history of land use change. The classification system contains all possible size scales of urban habitats. Despite the multiple benefits of having a scale-comprehensive approach, some spatial visualization limitations arise. For example, smaller natural elements are too small to visualize in maps the size of the city of Vancouver. For this reason, performing an overlay and connectivity analysis using the proposed classification system is best suited at a neighbourhood scale (1:10.000) so that you can visually identify all green space elements relevant to an urban context. For analyses city-wide level (1:60.000), small nature features become less visually apparent, and large hubs dominate. City scale analyses would be best carried out with coarser urban habitat classification categories.

The utility of the classification system is dependent on input data quality, completeness and accuracy

Effective implementation of this classification system will be dependent on having good quality spatial data with proper attributes and spatial resolution, posing a constraint for situations where data is not collected with these conditions due to external factors such as funding and time constraints. The classification system would only be effective when spatial data in Vancouver continues to be collected at the appropriate quality through time with minimum required resources allocated.

Classification System

The proposed classification system provides a comprehensive list of categories for habitat types that form the green network of the city of Vancouver. As the city continues to enhance and create new spaces for biodiversity, this system will help in setting standards and effectively map and plan for spaces for nature. The categories were defined so that they capture all existing and potential green space typologies irrespective of their size because even the smallest green areas can contribute to the overall city's ecological health and serve different biodiversity groups, and so granularity is an added value of the proposed system. For this reason, the classification system includes elements at different scales, for example, large natural forests in parks as well as small bioretention swales in street right of ways. For natural and semi-natural areas, I used the U.S. National Vegetation Classification (USNVC) because it is the system currently adopted by the BC Conservation Data Centre. For green spaces that have been culturally modified, I largely adopted categories and naming conventions already used in existing spatial data and proposed a few additional categories, such as garden plazas, community gardens, private gardens and lawns, green facades and green roofs.

Table 2 introduces the classification system organized by degree of naturalness and by land use type where each green space (category) can occur. It also documents information about spatial layer sources when existing or states the need for mapping when non-existent, the reclassification processing description, and the data steward team for each category.

Figure 4 depicts map A with the green network for Vancouver using the proposed classification system. Categories not displayed are the ones not mapped or without the proper spatial representation.

Table 3. Proposed habitat classification system for the green network of Vancouver.

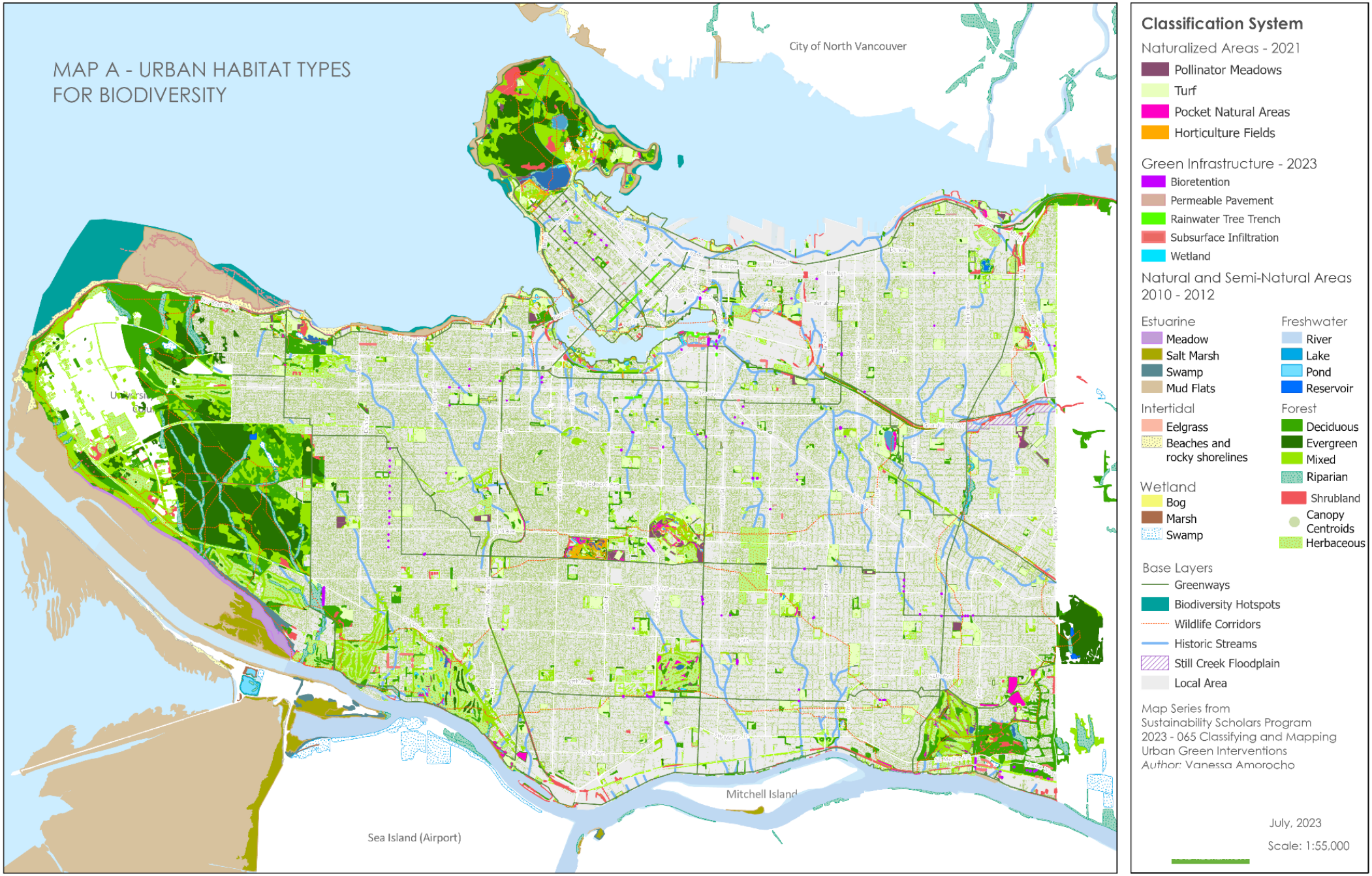
Type	Land Use	**Categories**	Short Description	Source	Spatial Layer
Natural and Semi-Natural (Not modified or slightly modified by human activity - original ecosystem functions have not been altered)	Biodiversity Hotspots in Vancouver (Usually large green terrestrial parks)	Forest (evergreen, deciduous, mixed)	Areas with Natural Forest (trees with crowns overlapping and generally forming 60-100% cover) and split into their leaf phenology types.	Biodiversity strategy	2010_vegetation_mapping
		Shrubland (evergreen, deciduous, mixed)	Vegetation generally dominated by woody vines - shrubs generally greater than 0.5 m tall with individuals or clumps.	Biodiversity strategy	2010_vegetation_mapping
		Herbaceous	Areas where herbs (graminoids, forbs and ferns) are dominant, usually more than 25% cover. Natural herbaceous areas are not present in Vancouver. They correspond to mowed turfs in parks and naturally managed areas such as pollinator meadows.	Biodiversity strategy	2010_vegetation_mapping
	Aquatic Freshwater	Stream	Represents historical streams within city boundaries, many of which have been paved over or piped. Of these, only 5 creeks have been daylighted.	Biodiversity strategy	olstreamexisting.shp
		Riparian Forest	Vegetation adjacent to water bodies (lentic and lotic) up to 30 metres	Metro Vancouver	Sensitive Ecosystem Inventory
		Swamp	Type of wetland formed by standing or gently moving water. Can occur seasonally or persist for long periods of time. Distinguished by the presence of trees or tall shrubs	Metro Vancouver	Sensitive Ecosystem Inventory (SEI)
		Bog	Type of wetland as defined by the Sensitive Ecosystem Inventory (2013). Wetland dominated by Sphagnum peat mosses, which soak up large quantities of water and create acidic conditions	Metro Vancouver	Sensitive Ecosystem Inventory (SEI)
		Marsh	Type of wetland that is shallowly flooded (permanently or periodically) by slow-moving water and is rich in nutrients. As defined by the SEI (2013)	Metro Vancouver	Sensitive Ecosystem Inventory (SEI)

		Vernal / Natural Ponds	Small, shallow wetlands that lack permanent inlet or outlet streams and often dry out in the summer.	Turf and Horticulture Booklet	Ponds and Water Features (This layer mixes natural vs artificial water bodies)
		Lakes	Naturally occurring, static bodies of open water greater than 2m deep and generally greater than 8 ha, with little to no floating vegetation; deeper water than a pond.	Metro Vancouver and Turf and Horticulture Booklet	SEI and PondsAndWaterFeatures.shp
	Intertidal Areas - Saltwater or brackish	Estuarine Marshes	Intertidal ecosystems that are flooded diurnally. These marshes occur in the middle to upper tidal zones of estuaries where saltwater influences predominate and are dominated by emergent herbs, grasses, or low shrubs. [1]	Metro Vancouver	Sensitive Ecosystem Inventory (SEI)
		Tidal flat or mudflat	Coastal wetland formed in intertidal areas where sediments have been deposited by tides or waves	Metro Vancouver	Sensitive Ecosystem Inventory (SEI)
		Estuarine meadow	Occur in the high intertidal and supratidal zones of estuaries, where tidal flooding occurs less frequently than daily and is tempered by freshwater mixing. Species composition is relatively diverse, typically with a mix of graminoids and forbs	Metro Vancouver	Sensitive Ecosystem Inventory (SEI)
		Beaches and bedrocks	Well- to sparsely-vegetated or non-vegetated beaches and shorelines.	Metro Vancouver	Sensitive Ecosystem Inventory (SEI)
Agricultural	Agricultural	Community Gardens/ vegetable gardens	Edible vegetable gardens or community gardens	Turf and Horticulture Booklet	Not mapped as polygon layers. The horticulture beds layer contains a few vegetable beds polygons but only in VanDusen Botanical garden and Fraserview golf course.
Cultural Landscape (green spaces in modified landscape with the	Open fields (Parks, Golf courses, cemeteries, botanical gardens)	Turf & Grass	Horticultural mowed and maintained herbaceous vegetation (grass) in parks of all sizes.	Turf and Horticulture Booklet	Turf.shp
		Pollinator Meadows	Naturally managed areas for pollinators in parks and golf courses. Simulates natural herbaceous vegetation.	Turf and Horticulture Booklet	Obtained from Turf_Maintainance.shp polygons that had an entry for the "Pilot_mowing"

intention to mimic original ecosystem functions or bring nature to highly dense areas)					attribute field. Older meadows were obtained from the existing meadows.shp layer
		Pocket Natural Areas	Small remnant woodland and native plantings in parks and golf courses. Includes native areas in Golf Courses and Naturalised Areas from the Horticulture Fields layers. Could be an important habitat for local species with lower mobility or act as stepping stones.	Turf and Horticulture Booklet	Merge of horticulture_beds.shp (with values bigger than 50 in the "Naturalized" field from the attribute table) and Golf_course_Native_Areas. shp
		Horticulture Fields	Includes rose beds, shrubs species mix for landscaping and shrubs for ornamental purposes (in city parks) - Areas with some degree of maintenance	Turf and Horticulture Booklet	Layer obtained from horticulture_beds.shp after removing naturalised areas.
	Street, right of way/ street ends	Greenways	Network of land containing linear elements (tree-lined streets, bikeways and pathways) that are planned, designed and managed for multiple purposes, including spaces for recreation, urban wildlife movement, rainwater management and aesthetics.	Transportation planning team, City of Vancouver	Greenways.shp
		Pollinator Meadows	Naturally managed areas for pollinators in streets	Turf and Horticulture Booklet	Obtained from Turf_Maintainance.shp polygons that had an entry for the "Pilot_mowing" attribute field. Older meadows were obtained from the existing meadows.shp layer
		Urban trees (street trees)	Canopy centroids from the Lidar survey in 2018	Vancouver Parks Operations, Urban Forestry Strategy	Canopy centroids layer updated in 2018
		Garden Plazas	Small Urban Areas where street furniture and gardens are placed on top of paved streets. Roads are decommissioned for non-motorized uses	Undefined	Not mapped

		Rainwater Tree trenches	Green infrastructure type consisting of lined trees placed in cell trenches that allow root growth and manage stormwater	CoV Green Infrastructure Division	2023 GI Assets
		Bioretention	Green infrastructure that uses biotic components to retain water - it includes swales and rain gardens	CoV Green Infrastructure Division	2023 GI Assets
		Infiltration trench	Type of green infrastructure as defined by the GI team within the COV	CoV Green Infrastructure Division	2023 GI Assets
		Permeable pavement	Type of green infrastructure as defined by the GI team within the COV	CoV Green Infrastructure Division	2023 GI Assets
	Freshwater	Reservoirs and Ponds	Artificial water bodies of any area and size. Includes small ponds. Non-chlorinated, non-recreational.	Turf and Horticulture Booklet	Ponds and Water Features. This layer mixes natural vs artificial water bodies
		Constructed Wetland	Engineering structures for rainwater management	CoV Green Infrastructure Division	2023 GI Assets
	Private Property Lots (Single family homes, duplexes, strata and multifamily and large buildings, including private schools)	Gardens and Lawns	Lawns and gardens around the perimeter of private property lots.	Undefined	Not mapped
		Private Trees	Trees around the perimeter of private property lot - include front and backyard trees	Vancouver Parks Operations, Urban Forestry Strategy	Canopy centroids layer updated in 2018
		Green Roofs	Vegetated rooftops in buildings - includes all types of green roofs	Undefined	Not mapped as a polygon (there is a point layer)
		Green walls/green facades	Vegetated exterior walls or facades of buildings	Undefined	Not mapped

Figure 4. Map A: urban habitat types using the classification system.



Gap Analysis - Example for Renfrew Collingwood Neighbourhood

In the following section, I provide an example of how the classification system can be used to conduct a gap analysis in a specific area by the Park Board. The workflow I propose can work for similar analyses in other areas of the city. It can also be adapted to analyze a single spatial typology (e.g., pollinator meadows) or use the comprehensive list of urban green space categories.

Step 1. Understand existing green spaces and interventions in the area of interest

Looking at the region of interest, observe what types of green spaces exist, how they are distributed and what is missing. In Renfrew Collingwood, there are potential overflow water pathways (from historic streams), one lake, and riparian habitats along Still Creek, Trout Lake and Renfrew Ravine Park. Multiple potential wildlife corridors (dashed orange line) and greenways (dashed green line) are intersecting the area. There are large patches of pollinator meadows in Falaise Park and a few assets of green infrastructure in Beaconsfield and Clark Parks, but no record of rainwater tree trenches. There is evidence of poor tree canopy cover in large parcel lots and along major streets like Kingsway St and Commercial Drive. Local and Neighbourhood Parks seem to be mostly areas for turf and grass but few natural stands of forests.

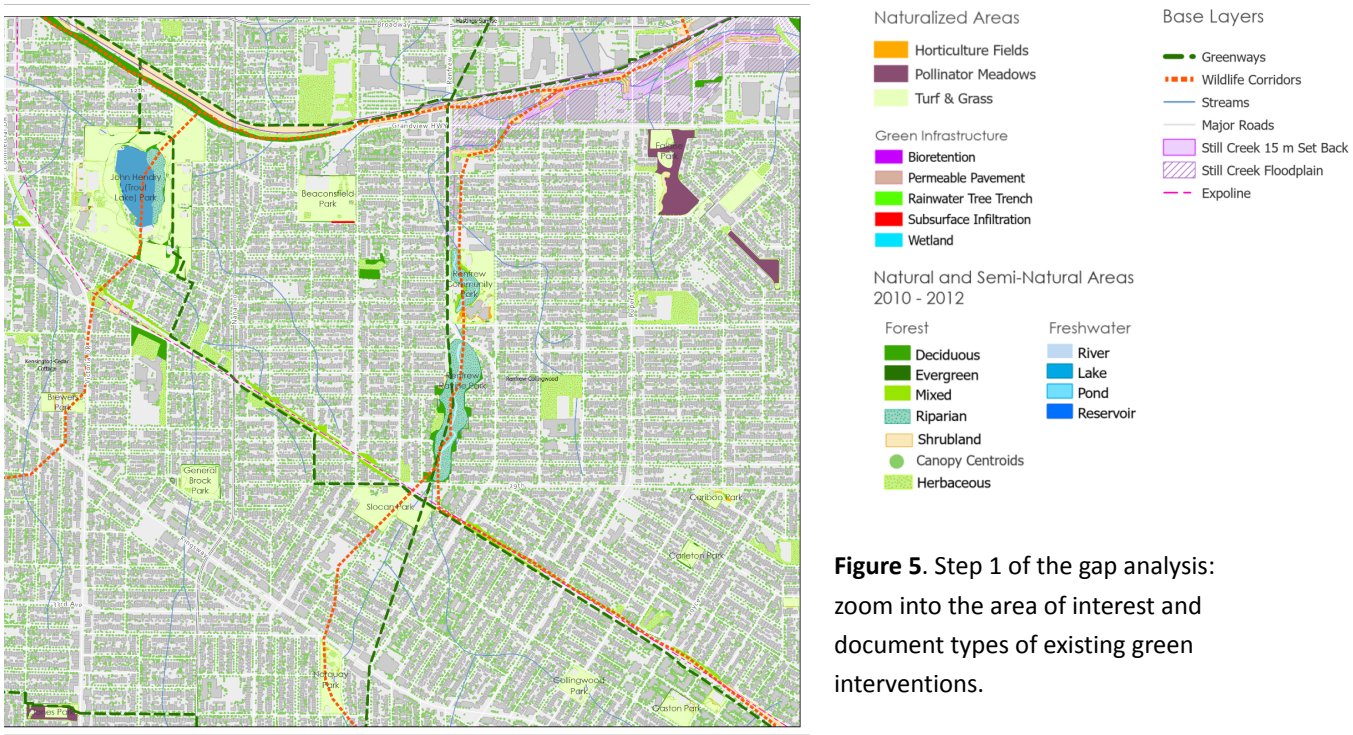


Figure 5. Step 1 of the gap analysis: zoom into the area of interest and document types of existing green interventions.

Step 2. Bring relevant performance indicator spatial data

Overlay relevant performance indicator data layers to identify areas with pressing social and environmental needs. For example, VanPlay's Equity Initiative Zones showcase historically underserved zones where at least 2 to 3 inequity indicators overlap. The indicators measure park access gaps, demand for low-barrier recreation, and urban canopy gaps. For the Renfrew Collingwood neighbourhood, there are priority Equity Initiative Zones in the eastern part of the neighbourhood and along Kingsway Street. Other performance indicator layers include urban heat index, flood risk, population density, and air quality index, among others.

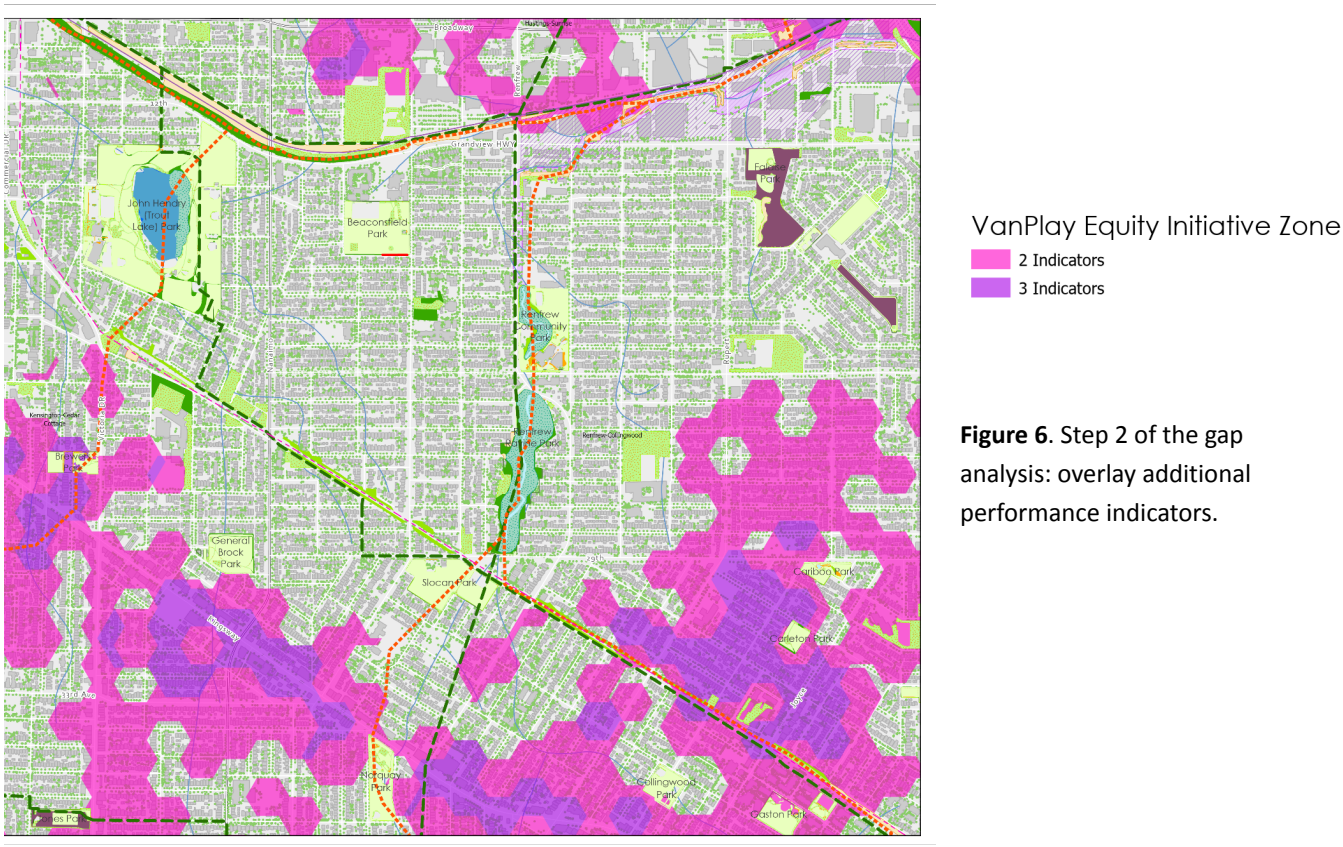


Figure 6. Step 2 of the gap analysis: overlay additional performance indicators.

Step 3. Create a buffer connecting larger and smaller natural areas and parks in low-performance hotspots

Draw a line that connects large natural areas (usually destination parks) with smaller local and neighbourhood parks in areas with low social and environmental performance indicator results. John Hendry (Trout Lake) Park, Renfrew Ravine and Everett Crowley Park (in the south) are biodiversity hubs and local and neighbourhood parks can function as stepping stones for

wildlife. Use the potential wildlife corridors and greenways to further guide where the line should be drawn and, if possible, intersect areas that are low on existing green interventions and habitat types. Make a buffer of 50 metres on each side to define areas with high value for green interventions.

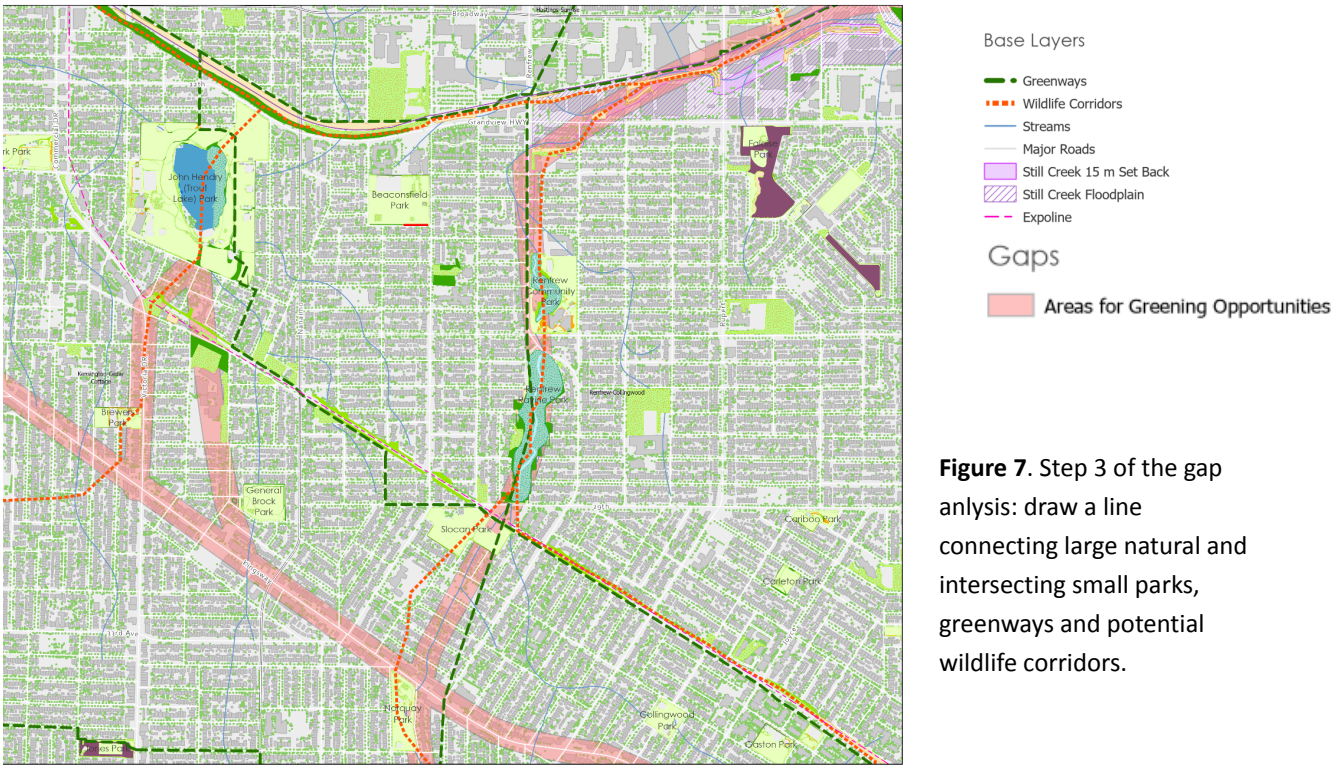


Figure 7. Step 3 of the gap anlysis: draw a line connecting large natural and intersecting small parks, greenways and potential wildlife corridors.

Recommendations

Spatial Data Management

1. **Establish a standardized definition for natural and naturally managed areas in Vancouver**

   There is a significant need to establish a standardized, organization-wide definition and associated service standards for naturally managed (naturalized) and Remnant Natural Areas in the city of Vancouver. Currently, the Park Board maps naturalized areas as a combination of 4 different layers: Golf course native areas, naturalized horticulture beds, pollinator meadows and golf course forests. Remnant natural areas in parks were mostly obtained from Metro Vancouver in the SEI inventory and the 2010 Vancouver vegetation mapping layer. However, many of these features overlapped and had different definitions for similar green spaces. These areas are essential for monitoring the green network's ecological health and connectivity. Standardizing spatial features and providing specific definitions for natural and naturally managed area types, and making sure to differentiate these from maintained green spaces (grade A, B, and C turfs), will help in streamlining and leveraging collaboration across levels of government and city groups. For a positive example of how this has been done before, staff can look to the City's Green Infrastructure division which has worked to articulate a clear, concise definition of green rainwater infrastructure with associated asset types and service standards.

2. **Create a Data Strategy to set priorities and remove barriers to collaboration**

   Develop a GIS Data Strategy to set goals, objectives and actions for ecological data management. The data strategy should align with strategic directions from VanPlay (2019) and Vancouver Plan (2022) and define roles and responsibilities across CoV and Park Board teams, such as Green Infrastructure Implementation, Planning, Policy and Environment, and Urban Forestry. It should also indicate what ecological data is to be collected, how it should be collected (for example, defining a key or dictionary for how to name layer attributes and the format as in table, point, line, polygon or raster), and how often it should be updated. In interviews, the GIS team shared that their role is largely "reactive" and not "proactive", implying their work is mostly to facilitate the use, management and sustainment of spatial data that arrives in different formats and definitions from multiple consultants or city staff teams. In other words, different staff

teams collect different data sets according to their own immediate needs, with little coordination across teams and potential data uses. This lack of coordination can result in redundancies and inefficiencies (e.g. excessive staff time spent collecting identical data for different purposes) as well as confusion (e.g. when these similar environmental features are described, labelled and maintained inconsistently across teams). There is a significant opportunity to identify priority areas and organize spatial data management in a strategy, allowing consultants and staff to collect, maintain and update ecological data proactively, efficiently and in a collaborative way.

3. **Map missing ecological assets of the green network**

   Many green assets exist in reality that had no associated spatial dataset to include in the map. The green network map and classification system can be improved if these data sets were to be created and included. As the urban fringe continues to expand, it is essential to understand and keep track of all spaces that support the urban ecological matrix by using GIS and spatial analysis tools. Map these elements in the appropriate feature format (Point, line, polygon) to better represent and quantify their benefit to the ecological network). Some relevant urban green spaces without spatial information are:

- Green Roofs: There is a point data layer available, but a polygon is needed.
- Community gardens or Food forests: There is a point data layer available, but a polygon layer is needed.
- Urban or pop-up Plazas: A point layer would work fine with suitable attributes that provide additional information, such as the number of garden boxes, but not strictly necessary. Just having spatial information that points to their location will assist in assessing connectivity.
- Large areas of grass and gardens in private lots: Assess the value of mapping front and backyard lawns and gardens of large private properties.
- Known locations of wildlife habitat sites and features like eagle nests, salmon spawning sites, heron colonies, beehives, bat boxes, and swallow bird boxes.

Greening Opportunities

The previous section showed an example of how the green network map can be used to establish priority areas for restoration and enhancement of 1. existing biodiversity hotspots and habitat hubs and 2. enhancing existing and or adding new corridors that connect biodiversity hotspots, taking advantage of local, neighbourhood and community parks to work as stepping stones. In this section, I will provide recommendations on specific green interventions that can work spatially to support the green network by taking advantage of different land use types in these priority areas.

1. Use available space in schools and large developments to aid connectivity

In the habitat maps created, schools and large housing developments stand out for being large open space areas with deficient tree canopy cover and with large yards and building footprints. Many of these buildings are located in close proximity to important biodiversity hotspots or are intersected by potential wildlife corridors and potential overflow pathways or old streams (See figure 9). City staff had already identified in the Climate Emergency Action Plan the exceptional case of schools, stating that many lie within hotspots around the city where the urban heat island effect and lack of shade are pronounced.

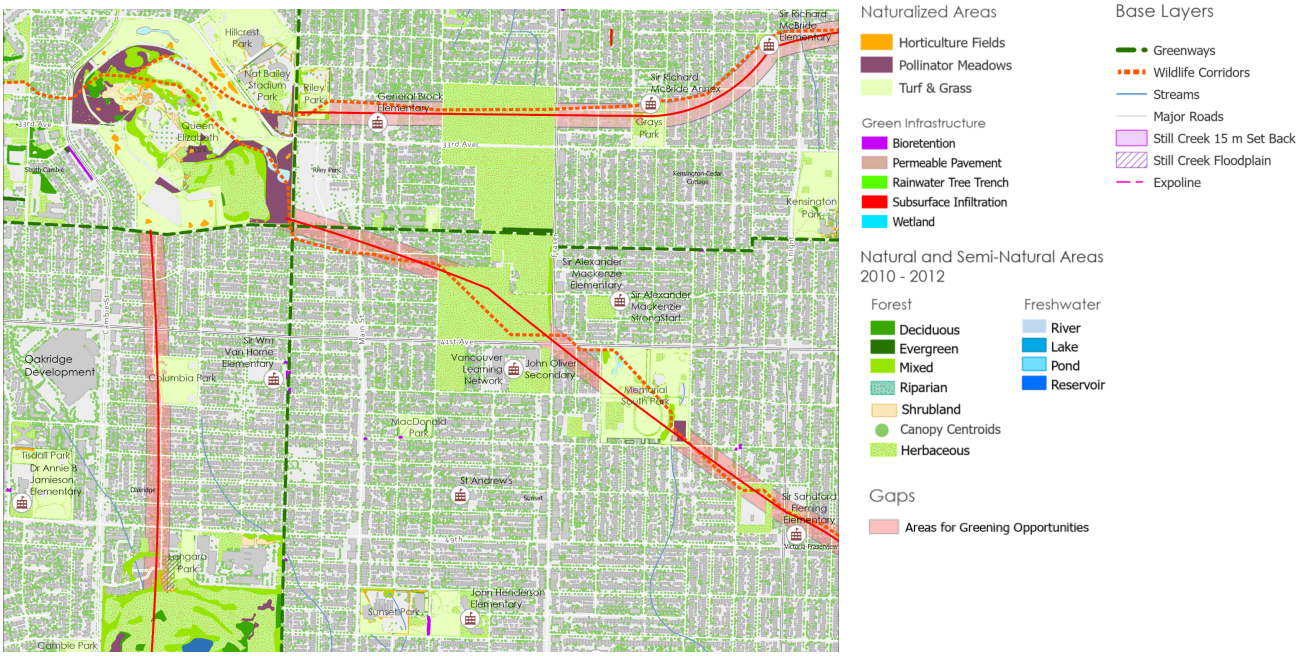


Figure 8. Location of schools along potential opportunity areas (light red areas and wildlife corridors) and large housing developments such as Oakridge development in proximity to large biodiversity hotspots (Queen Elizabeth Park and Langara Park).

The Park Board and the City could partner with the Vancouver School Board to support the establishment of green interventions in school yards and buildings. Such interventions could support access to nature as well as educational and hands-on learning opportunities for students. For example, rain gardens could support curriculum related to the water cycle, pollinator gardens can provide opportunities for students to explore insect ecology, and gardens can help students learn about local food systems and plant life cycles. Some of the interventions that would work very well in these spaces are:

- Green roofs
- Green walls
- Rain gardens
- Pollinator meadows
- Increasing forest canopy in the vicinity of recreational yards
- Community gardens and food forests

2. Use space adjacent to railways to increase natural areas in the city

Environmentally focused staff (e.g. with Park Board or REFM) can collaborate with Transportation focused staff to explore the viability of enhancing natural spaces around the Skytrain transportation network. These spaces have a great potential to become part of the city-wide greenway network (as is already the case for some areas of the city) or other types of green mobility connectors when there is less available space for separate bike and pedestrian pathways. Future efforts should integrate Parsons (2021) proposed classification system of mobility connectors by pathway role, capacity, widths and slope characteristics and how these can be applied to adjacent railway space across the city (See Appendix C). Combining railway space with different classes of mobility connectors represents a low-hanging fruit opportunity to move efficiently while providing space for biodiversity and increasing access to nature. Green interventions that could work well in these spaces include:

- Adding more canopy trees: Increase canopy cover of native trees and shrubs when soil and space conditions are suitable for naturalization, or use of horticultural fields in areas with less space. Deciduous tree species help provide shade during summer and light during winter, while conifers may provide added urban cooling value (Eyster and Beckage, 2022)
- Blue and green systems: where these railways align with overflow pathways, there is an opportunity to include interconnected blue and green systems for stormwater

management that mimic the natural flow of water while also providing benefits for wildlife and water quality.

Figure 9. Areas adjacent to the expo line Skytrain with low canopy cover. This area can be enhanced by adding more interspaced deciduous trees.

3. Leverage the use of vacant lots or reclaim land

Often, cities can have land that is underutilized or on hold for development for long periods of time. One example is the Little Mountain development that was demolished and cleared in November 2009; to this date, it remains an open lot. Other examples could include street ends and underutilized auxiliary laneways. There is an opportunity to convert these spaces into temporary functional green space, even if they will eventually be used for development. In the years that these patches exist, they have the potential to enhance urban greenery, provide stopovers for biodiversity, help in soil stabilization and provide a host of other ecosystem services (Gaw & Richards, 2021; McDonald et al., 2023). City staff could review current zoning and development bylaws to incentivize or require environmental stewardship or temporary

public benefit spaces by landowners, developers or organizations during the extended periods of time these lots remain vacant.

Connected to this idea, there is also the reclaiming of land in areas where, if designated for a natural space, they will have the potential for supporting multiple economic, social and environmental benefits. As the Park Board is currently working on a parkland acquisition strategy, given all the existing and competing pressures for land, analyzing whether a parcel of land that becomes available is in a zone where there are multiple needs unattended can help leverage approval for purchase and investment for greening opportunities. Even though planning tools like the Equity Initiative Zones already address the idea of multi-layered benefits, I proposed adding more factors to define priority areas for investment such as:

- Potential to increase ecological connectivity, for example, if the land is located where a greenway would connect two large destination parks or biodiversity hubs.
- Areas with high urban heat.
- Areas with poor air quality in regard to air pollutants (PM2.5) and noise.
- Areas with historic streams and high flood risk.
- High-density neighbourhoods.

Figure 10. Example of an underutilized street with an opportunity to increase biodiversity. Photo taken in 45th and Chester Street, Vancouver, BC.

Conclusion

Urban biodiversity conservation is imperative for supporting vital ecosystem functions and services in cities, as well as for advancing Vancouver's principles of equity, resilience and reconciliation. As the city continues to densify and land use pressures arise, having strong foundations and systems set in place to manage, enhance and monitor the ecological integrity of Vancouver's green network will prevent biodiversity loss and ensure equitable access to nature in the future. The Park Board is leading progress towards this end by protecting existing biodiversity hotspots and bringing nature back, taking advantage of the different types of spaces in the urban landscape. With consistent collaboration across teams, a standardized ecological data strategy, and by conducting spatial prioritization of green interventions, the Park Board can nurture, protect and connect urban biodiversity efficiently and effectively for years to come.

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Appendices

Appendix A: Strategies Related to Biodiversity (Full list)

Table 4. Specific strategies and actions related to urban biodiversity dimensions (area, habitat diversity, connectivity, stressors and ISWM) across all city planning documents.

Expand Area and Habitat Diversity	**Van Play (2019)** - **N.1.1**.Identify marine conservation zones to protect and enhance delicate shoreline ecosystems - **N.1.3** Create a thriving intertidal zone that supports a biodiverse habitat while protecting the parks and sea wall recreation trail - **N.3.3** Enhance habitat value for pollinators, insects, and birds by improving the soil nutrients and surrounding ecologies with horticultural methods and species selection - **N.5.2**. Increase tree canopy cover in the Equity Initiative Zones, to provide more access to nature, supply increased shade, and reduce the urban heat island effect. - **P.3.2** Acquire new park land that reflects the Strategic Bold Moves and Approaches for Action related to nature such as increasing the proportion of naturalised areas in the parks system and expanding the variety of ecosystem in all park typologies. **Biodiversity Strategy (2016)** - **S.2.1.7** Incorporate smaller natural areas, including meadows, rain gardens, wetlands, and bird habitats, into new and redeveloping parks, streets, and community gardens. - **S.2.1.8** Create wildflower meadows for bees and other pollinators in parks, streets, the cemetery, and golf courses. - **S.1.2.** Identify opportunities for habitat restoration in boulevards, road ends, road right-of ways, and other city-owned lands.I - **11.**Restore native forests in Stanley, Jericho Beach, Musqueam, Renfrew Ravine, Everett Crowley and other large parks. - **13.**Update tree selection, tree density, and maintenance guidelines to increase the value of the urban forest for birds and other species. **Vancouver Plan (2022)** - **4.2.3.** Identify new and enhance existing biodiversity hotspots and corridors and environmental regeneration areas. - **4.2.4** Retain and grow a healthy and resilient urban forest, using City land use planning tools to provide more space for permeability, quality soil and increased tree canopy across the city. - **Direction 4.2: Make Spaces for Nature** Establish a healthy, city-wide ecological network through transforming road space, parkland acquisition, naturalization of parks, and other City-owned public property. Increase the urban forest canopy and expand the blue green network. - **Direction 4.3. Protect Nature 4.3.6.** Strengthen policies and regulations to protect and create natural assets on private

	property, with requirements and consideration for restoration, to increase biodiversity city-wide and connectivity within natural systems. **Rain City (2019)** - **P&B-07. Enhanced Urban Forest Program**.Undertake research to understand how green rainwater infrastructure can help protect, grow, and manage trees to create a diverse, resilient, and beautiful urban forest across the city. - **B&S-06 Resilient Roofs Program** Examine policy and program options for resilient, blue-green roofs (and variations therein) for new and existing buildings, integrating learnings from "Research and Innovation. - **P&B-10 Multi-stakeholder Land Acquisition for Rainwater Management and Park Use in Key Watershed Areas**. Contribute to a reduction in paved surfaces and associated rainwater runoff as well as provide a location for the management of rainwater and park amenity space through land acquisition across the city. - **S&PS-03: Blue-Green Systems Program**. Implement green rainwater infrastructure along streets and public spaces as an integral part of blue-green systems - **S&PS-05. Laneway Rehabilitation & Retrofit Program.** Undertake research to assess the opportunities, barriers, lessons learned and financial tools and mechanisms for retrofitting laneways to enable them to manage rainwater runoff and potentially adjacent private properties. - **P&B 12 Protect and Enhance Beaches and Waterfront Program** Work in partnership with Indigenous Peoples, other levels of government and stakeholders to protect and enhance the city's beaches and waterfront through improvements to rainwater quality and reduction of combined sewer overflows into waterways. Seek opportunities to implement green rainwater infrastructure to enhance recreational uses of beaches and the waterfront, improve aquatic habitat for fish and wildlife and help mitigate and adapt to impacts associated with climate change. **CEAP (2019)** - **6.01: Retaining and Enhancing NCS on Private Lands.** The Protection of Trees Bylaw is currently being reviewed for pilot changes in conjunction with the City Manager's Internal Development - **6.02: Enhance NCS efforts on public land.** Planting trees in neighbourhoods with historical tree deficits to increase tree canopy and reduce urban heat island effects. Developing blue-green systems to manage water, contribute to the urban forest and biodiversity, and enhance active transportation routes. - **6.03 Enhance sequestration through implementation of NCS pilot projects within the city.** There are a number of capital projects in the planning stages that could be advanced with a strong sequestration focus. Salt marshes and wetlands are known to offer some of the largest potential for NCS.

	Urban Forestry Strategy (2018) - **Strategy: Enhance biodiversity through tree planting.** Action 12. Enhance natural forests in Stanley, Jericho, Musqueam, Everett Crowley, Renfrew Ravine, and other large parks, and riparian areas, as critical parts of Vancouver's ecological network. Action 13. Plant trees to enhance bird and pollinator populations, including expanded use of native trees in park and street tree planting - **Strategy: Increase street and park tree diversity.** Action 14. Update tree selection guidelines to reflect the City's goals for climate adaptation, rainwater management, food production, biodiversity, and reconciliation. - **Strategy: Manage natural forests to increase resilience and enhance biodiversity.** Action 29. Enhance forest ecosystem components in parks such as understorey vegetation to support birds and other biodiversity. -
Increase Connectivity	**Van Play (2019)** - **N.3.1** Continue to enhance, nurture and connect existing natural areas to address impacts of threats like community use, carrying capacity, climate change, and invasive species - **N.3.5.** Identify locations for habitat corridors based on urban wildlife movement, bird flyways, biodiversity hotspots, hidden streams and green infrastructure gaps. - **N.3.6.** Provide access to a naturally managed area of at least 0.2 ha within a 10 minute walk of all residents. **Biodiversity Strategy (2016)** - **S.1.1** Use park acquisition, tree planting, and the development planning process to expand and connect parks and build the city's ecological network. - **19**. Use the Green Streets program and greenway design to support pollinator and bird habitat and improve connectivity between parks and natural areas. - **20.** Assess where street rights-of-way can be used to better support biodiversity, including restoring the shoreline of the Fraser River at road ends or better connecting adjacent parks. **Van Plan (2022)** - **Direction 4.4: Provide Access to Nature. 4.4.2** Support the intensification of the greenway network, towards car-free to car-light corridors that connect people to natural areas in sustainable ways. - **4.2 Make Space for Nature 4.2.2** Ensure natural areas support the health of Vancouver's water systems and are integrated within the ecological network. - **4.4.4.** Ensure the ecological network integrates with food

	production and harvest spaces **Rain City (2019)** - **P&B-06.Create a Green Network that will Connect our Parks, Waterfront and Recreation Areas.** Work citywide to implement a layered GRI, human and ecological network to help achieve VanPlay Goal #6 to create a green network to connect parks, waterfronts and recreation spaces **Urban Forestry** - **Strategy: Increase tree planting in neighbourhoods with low urban forest cover.** Action 8. Increase street tree planting in the Downtown Eastside, Marpole, False Creek Flats, and other priority neighbourhoods with below average urban forest cover.
Remove Stressors	**Van Play (2019)** - **N.3.2** Establish an integrated approach to managing established and emerging invasive species in parks **Biodiversity Strategy (2016)** - **9.** Develop a city-wide Invasive Species Action Plan, and control priority invasive species in parks. **Van Plan (2022)** - **Direction 4.3 Protect Nature. 4.3.1.** Establish appropriate environmental setbacks that limit development around important water bodies. - **Protect Nature 4.3.3.** Establish land use designations and development permit requirements for Ecologically Sensitive Zones to protect and enhance ecological functions. **Urban Forestry Strategy (2018)** - Soil availability, conditions of soil to support native trees are hard to find. Action 30. Control invasive species that degrade forest ecosystems.
ISWM (Integrated stormwater management)	**Van Play (2019)** - **N.2.1** Identify, acknowledge, uncover and connect freshwater features, and historic streams, to both help manage and filter stormwater and increase their visibility. - **N.2.3** Establish principles and a decision-making framework to determine appropriate locations to incorporate green infrastructure, like bioswales and wetlands, in parks to create wetland habitat, improve water quality, manage stormwater and reduce the need for irrigation **Biodiversity Strategy (2016)** - **14.** Use the city-wide Rainwater Management Plan to prioritize enhanced stormwater management activities in ecologically important catchments.

	Van Plan (2022) - **10.2.1 Manage Water on boulevards, sidewalks, and streets** Reallocate parts of the public right-of-way (e.g., streets and sidewalk areas) to expand the breadth and scale of nature-based assets such as green rainwater infrastructure. - **10.2.2** Develop a city-wide blue-green network of connected park-like streets that manage rainwater, support climate adaptation and biodiversity, and create public space opportunities. - **10.3.1** Develop land acquisition plans and design guidelines to create room for natural buffers, green rainwater infrastructure, and water-adaptive public spaces. **Urban Forestry Strategy (2018)** - **Strategy: Plant trees to support green infrastructure and reduce climate change impacts.** Action 19. Increase canopy cover in conjunction with green infrastructure initiatives to improve rainfall interception and infiltration.

Appendix B: Spatial Data Inventory

Data	Access to Data?	Source	Format	Description	Relevant Field Names	Last Updated
Urban Canopy	Yes	Urban Forestry Parks Board	LAS- Laser	Surface Cover for the City. Measure canopy cover percentage and area Map and assess the distribution and condition of native forests	Point data was classified as 1. Unclassified 2. Bare-earth and low grass 3. Low vegetation (<2m) 4. High Vegetation (>2m) 5. Water 6. Buildings 7. Other 8. Noise	2022
Forest Stand (2018)	Yes	Urban Forestry Parks Board	Polygon	Measure canopy cover percentage and area Map and assess the distribution and condition of native forests	Data only contains the name. No other info	2018
Forest Stand (2023)	No	Urban Forestry Parks Board	Polygon	Measure canopy cover percentage and area Map and assess the distribution and condition of native forests	Type, dominant species, invasive species, soil properties.	2023
Street trees	Yes	Urban Forestry	Points	Locate trees in public streets and record allometrics and species	Tree species, height range, diameter at breast height (dbh), neighbourhood, plant area, block ID	2017
Canopy Centroids	Yes	Urban Forestry/ Developed by Diamond Head Consulting	Points	Represent the canopy centroids of all pixel detected vegetation in vancouver. Include canopy centroids in private and public property	Tree leaf phenology	
Biodiversity Hotspots	Yes	Biodiversity Strategy	Polygon	Layer created for Vancouver's biodiversity strategy	Data only has Name and Hectares Column. But the Name column contains biodiversity hotspots that represent different habitat types - shoreline, lake, lagoon, pond,	2016

					corridor, ravine, wetland, forest, botanical garden, creek, marsh, golf course,	
Wildlife Corridors	Yes	Biodiversity Strategy	Line	Describes potential wildlife corridors	Split lines by Function “Key” (Function has classification key that is not explained in data metadata)	2016
GI Assets (Public Sites)	Yes	GI team COV	Polygon	Describe conditions of GI assets in streets right of ways and include some assets in parks (Hinge park, Crown/Musqueam st).	Typology (tree trenches, bioretention, permeable pavement, subsurface infiltration), sub-type (bioswale, bioretention bulge, bioretention cell), %impervious surface, % drainage area, land_use and local area	2022 - ongoing
GI Assets (Private Sites)	No	GI team COV	Polygon	Describe and classify GI assets in private properties	Not accessible	Unknown
Sensitive Ecosystem Inventory (SEI)	Yes	Metro Vancouver	Polygon	Contains all sensitive ecosystems in priority areas - subtidal, intertidal, forest, shrubland, herbaceous, wetlands	All field names as defined by the SEI dictionary - Search for related appendix	2010-2012
Golf Courses	Yes	GI team COV	Polygon	Total surface area of golf courses in vancouver	Name(golf course), Type (Private/Public)	2018
Golf Course Forested Area	Yes	Turf and Horticulture Booklet	Polygon	Boundaries of forested areas within golf courses	Golf Course name	2016
Golf Course Native Areas	Yes	Turf and Horticulture Booklet	Polygon	Unmaintained grass and woodland remnant areas (including riparian zones). Not irrigated.	Golf Course name	2016
Meadows	Yes	Turf and Horticulture Booklet	Polygon	Unmaintained grass areas in parks. Cut at four to six inches in height. Non-irrigated.	Location, Asset ID	2016
Naturalised Horticulture Beds	Yes	Turf and Horticulture Booklet	Polygon	Remnant woodland and native plantings (including riparian zones).	Horticulture type (annual beds, perennial beds, roses, naturalized, shrub and regular maintenance, vegetable beds), and location	2016

Ponds and Water Features	Yes	Turf and Horticulture Booklet	Polygon	Living Body of Water. Non-chlorinated. Non-recreational	Name, Category, park location, natural condition categorization	2016
Turf Maintenance	Yes	Turf and Horticulture Booklet	Polygon	From the Turf and Horticulture Booklet - includes areas for Turf that are managed naturally in Parks and Golf Courses	Type (Grade A, B and C), Location_Description, Usage	2016
Vegetation Mapping 2010	Yes	Biodiversity Strategy	Polygon	Maps Vancouver vegetation and categorizes them into Evergreen, Deciduous, Mixed, Shrub, Sparse Vegetation, Grass and Wetland)	Similar to the GIN strategy from Surrey, provides Subclass, Modifier, Submodified and degree of naturalness to each forest patch	2010

Appendix C: Parson's Proposed Mobility Classification System (2021)

	Pathway Role	Type of Use / Accessibility	Capacity	Trail Width	Surfacing	Slope
Class A: AAA Greenways	Provides urban connections to important destinations throughout the city.	Walking Jogging Cycling Roller Blading Stroller Wheelchair	High	3 to 5 mts	Asphalt Concrete	Optimum 2-3% Maximum: 8%
Class B: Passive Pathways	Provides an opportunity for passive park circulation.	Walking Jogging Cycling Roller Blading Stroller Wheelchair	Low to Moderate	1.5 to 3 mts	Asphalt Unit Pavers Concrete	Optimum 2-5% Maximum: 8%
Class C: Connector Pathways	Short distance paths that provide connection to facilities and/or passive pathways and greenways.	Walking Stroller Wheelchair	Low to Moderate	1.5 to 2 mts	Asphalt Gravel Unit Pavers Concrete	Optimum 2-5% Maximum: 8%
Class D: Nature Trails	Pathways that provide connection to natural settings (i.e. forests)	Walking Jogging Cycling	Low	1 to 3 mts	Gravel Mulch Compacted Earth	Optimum 2-10% Maximum: 30%
Class E: Informal Trails	Pathways that act as desire lines for a shorter navigated route.	Walking Jogging Cycling	Low	.5 to 2 mts	Grass Compacted Earth	Maximum: 8%