August 2024

ENHANCING URBAN BIODIVERSITY WITH COMMUNITY MONITORING

Developing a Community Monitoring Program for Green Rainwater Infrastructure Planning

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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 organisations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability and climate action across the region.

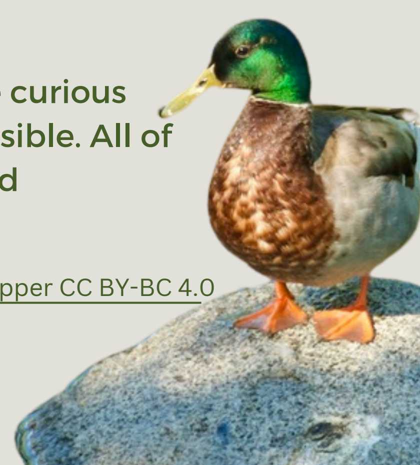
This project was conducted under the mentorship of Vancouver Board of Parks and Recreation & City of Vancouver staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of Vancouver Board of Parks and Recreation & City of Vancouver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

ACKNOWLEDGEMENTS

I, Clare Price, am an uninvited guest gratefully living and working on traditional, ancestral, unceded lands of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) Nations. I am grateful to learn from this land and its stewards, and am committed to integrating the principles of equity, anti-racism, and anti-colonialism in this work and others in the future. Any work concerning access to nature and stewardship of our non-human counterparts must seriously engage with colonial legacies of oppression and extraction, in Vancouver and beyond.

I want to thank my supervisors and the many staff in both departments for their mentorship and support over the duration of this project. Working alongside people who share thoughtful and courageous visions of socially just and ecologically balanced futures has been an educational and inspiring opportunity.

I also want to thank all of the observers on iNaturalist. Without the curious contributions of locals and visitors none of this work would be possible. All of the photos in this report were sourced from iNaturalist; species and photographers are noted for each.



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HOW TO READ THIS REPORT

These banners contain key objectives before each major section.

This is the Body Text.

The main text provides the bulk of information about the report objectives. You'll find details about the literature review, methods, and more, including summary tables and figures.

White Crowned Sparrow by @spottytowhee

These green squares contain:

- Key definitions
- Extra explanations or context tips to consider
- Links to external resources
- Other important content

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Executive Summary

Cities and nature, sometimes seen as incompatible, are finding better ways to coexist with the support of planners and communities. This report aims to provide methods for city staff to engage communities in monitoring urban biodiversity and better understand how nature interacts with urban greenspaces, particularly green rainwater infrastructure.

The report draws from research conducted between May and August 2024, including a jurisdictional scan, literature review, and staff workshop. Based on this research, it proposes ways to involve communities in collecting data on species around the city. Additionally, tools for identifying target species and designing monitoring programs were developed, considering species needs and staff capacity. This report provides a range of ideas, resources, and suggestions to support staff in engaging communities and gathering data on urban nature.

Introduction

Biodiversity is integral to a healthy city, a fact recognized by the City of Vancouver's Vancouver Plan (2022) and the Board of Parks and Recreation's Biodiversity Strategy (2016), and further established by groups like Biophilic Cities, the California Academy of Sciences, and Cities with Nature, among many others. Unfortunately, biodiversity loss is a growing concern globally, affecting both native and non-native species. In urban areas, it can signal degraded ecological function due to impacts of urbanization, including habitat fragmentation, pollution, the introduction of invasive species, and the heat island effect. Data on the drivers of urban biodiversity loss is often insufficient, especially at scales large enough to support effective ecological recovery; conversely, there is also limited data on the efficacy of different interventions. This data gap is a significant challenge for municipal governments striving to implement more data-driven planning.

Community monitoring offers a novel solution to the data paucity problem. Widespread community powered monitoring can contribute information at scale on ecosystems of all kinds across the city. Green rainwater infrastructure (GRI) is one strategy the City of Vancouver is using to bring nature back into the city, but the habitat value of GRI features remains under studied. Effective planning for connected corridors, essential for species movement and habitat connectivity and components of an ecological vision within the Vancouver Plan and VanPlay, relies on accurate knowledge of species locations, their use of naturalized areas, and their seasonal behaviors. With good research questions, effective project design, and consistent data management, community science can help provide information to city staff to support their ecological efforts.

Community Monitoring (or Community Science):
Community monitoring (or science), also known as participatory or citizen science, is a collaborative approach where the public participates in scientific research by contributing observations or analysis to support various studies. It is often used when extensive data collection is required, or to maintain ongoing records, such as species observations.

This report utilizes the term “community” instead of “citizen” to reflect a shift towards more inclusive language. 'Citizen' can inadvertently imply that to contribute to civic improvement or science, you must hold legal citizenship status.[1]

Project Purpose and Scope

This report was completed by a member of the 2024 Sustainability Scholars Cohort in fulfillment of a project co-developed by the Planning, Policy, and Environment and Engineering Green Infrastructure Implementation teams at Park Board and City of Vancouver.

The objective of the project is to determine best practices to measure changes in biodiversity and inform the design of green rainwater assets to enhance biodiversity. The following guiding questions helped steer the work:

- How can community monitoring be leveraged to improve efforts to monitor and support healthy species and habitats across Vancouver?
- What species are present in Green Rainwater Infrastructure sites?
- How does species richness change at sites over time?

In responding to the questions above, a small collection of resources and protocols were developed to be distributed to city staff and community partners. Their purpose is to produce replicable and vigorous species data that also supports community engagement and stewardship programs across the city. Section 3 of this report contains guidance about monitoring best practices, including information on frequency, key indicator species, leveraging digital community science platforms, and more.

The scope of the project included the following:

- conducting a policy scan and literature (academic and gray) review,
- designing and leading a staff workshop to obtain feedback on staff needs,
- compiling (or designing where appropriate) protocols and training documents to support community species monitoring in parks and green rainwater infrastructure assets,
- Informational meetings with external industry and/or government professionals.

Policy Context

The tables below provide a brief synopsis of the key plans and strategies City of Vancouver and Park Board have developed to support planning for stewardship and biodiversity across the city. Several have been phased out or consolidated but are included to demonstrate the longstanding commitment to considering urban nature in urban plans.

The following table features a summary of City and Park Board commitments related to urban nature that could benefit from community science.

Table 1. City of Vancouver's and Vancouver Board of Parks and Recreation's Commitments to Stewardship and Biodiversity.

Document	Commitment
Climate Change Adaptation Strategy (CCAS) (2012, updated 2024)	Focus on preserving nature and biodiversity and increasing resilience in the face of increasing climate change-related stressors through habitat enhancement, increased connectivity, and monitoring humans and nature (including environmental indicators).
Vancouver Plan (2022)	Big Idea # 3 is Climate Protection and Restored Ecosystems, creating more space for nature and protecting habitat to produce thriving ecosystems. Policy area #4, Ecology, also expands on the City's ecological vision, including increased connectivity, a resilient urban forest, increased access to nature, and naturalized City-owned public property.
Vancouver Bird Strategy (2015, updated 2020)	Focus on preserving bird habitat and diversity across Vancouver, especially in key biodiversity areas.
Greenest City Action Plan (2009-2020)	This was important early work seeking to establish Vancouver as "the greenest city in the world by 2020". Focus was mostly on expanding widespread access to nature and planting trees.

VanPlay Playbook (2019)	Extensive focus on the role of PB in developing a healthy city for people and nature. Specifically, “Move 3: Connectivity of parks and recreation experiences” and the chapter on nature as these name key elements such as connection to nature via stewardship, habitat connectivity, and ecosystem health. Action N.4.1 calls specifically for “monitoring, citizen science, and environmental education”.
Rain City Strategy (2019)	Extensive reference to biodiversity, strong focus on GI, which is an important source of new habitat production, conversion to wetland, and potentially small patch connectivity.
Urban Forest Strategy (2014, updated 2018)	Focus on enhanced habitat to support biodiversity, creating a resilience, diverse, accessible urban forest across public and private land.
Biodiversity Strategy (2016)	Key document in defining what support for biodiversity may look like parks, public, and private land across the city. Suggests expanding quantity and quality of ecological areas to support biodiversity and enhance access to nature. Suggests developing a city-wide monitoring plan.
Rewilding Vancouver from Sustaining to Flourishing: An Environmental Education and Stewardship Action Plan (2014)	Extensive focus on healthy co-existence, offering more access to nature for humans and granting nature access to the city.

Together, these plans describe robust commitments towards developing and maintaining a resilient, biodiverse urban ecosystem with thriving human-nature relationships. However, their advancement is hindered by a lack of information regarding species movements and conditions around the city, largely due to the considerable time and effort involved with species monitoring. Community science offers a potential solution because it generates verifiable information with less staff time and input, offering teams the ability to explore trends in species richness, habitat use, and connectivity across the city.

Methods

The methods to complete this project included a literature review and jurisdictional scan, staff and expert consultation, and research into ecological indicators, monitoring practices, and digital engagement in community science. The combination of primary and secondary sources, reflecting both local and global research and practices, supports a collection of protocols that will suit the needs of Vancouver's city staff members, residents, and green spaces.

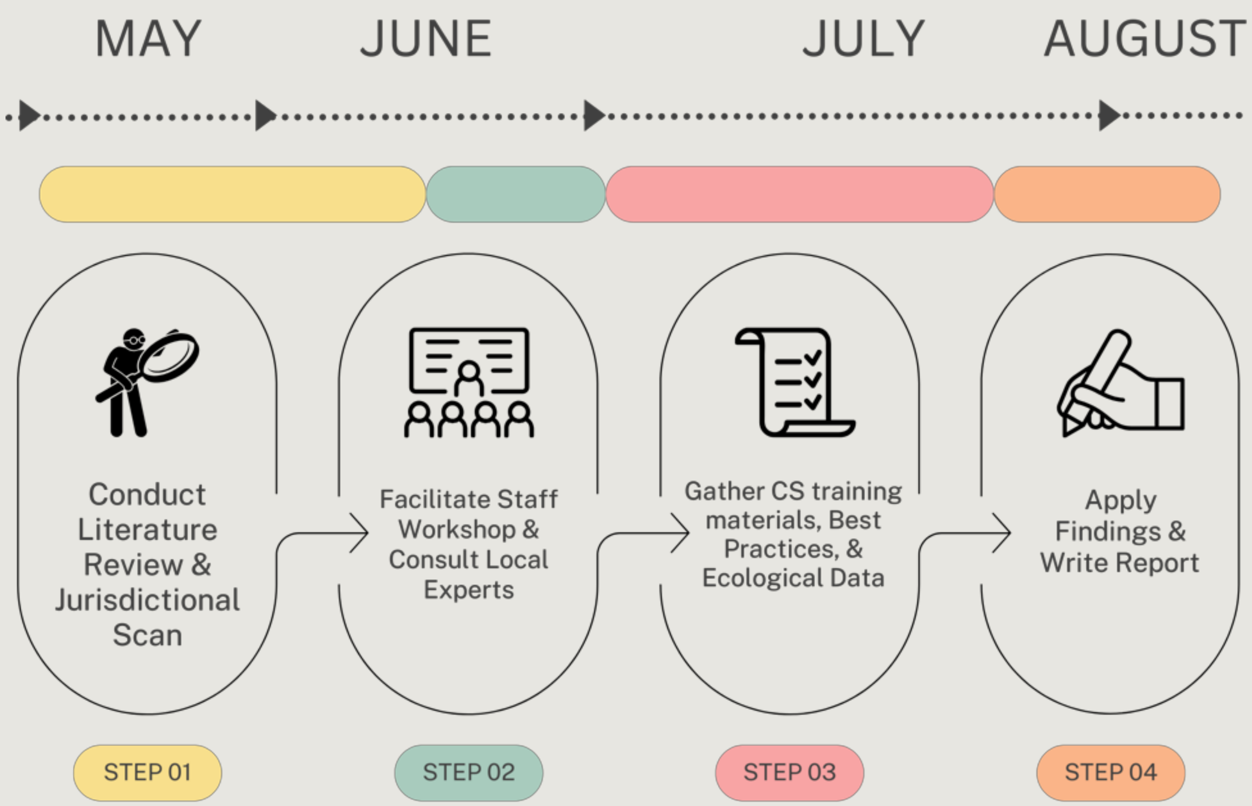

Figure 1. Sustainability Scholar Project Timeline, May to August 2024.

Expert and Staff Consultation (non-profit and government)

A workshop engaging city staff was conducted early in the research phase. The purpose was to solicit feedback on a preliminary protocol as well as staff needs and interests. Staff whose portfolio involves stewardship, community science or urban ecological data were invited to attend.

Beyond the workshop, informal interviews were conducted via email and video call with local stewardship coordinators or sustainability planners, which offered a deeper dive into experiences with community science organization and implementation.

Literature Review

The literature review covered scholarly research on community science applications for research and policy, including use cases, citizen engagement, and urban biodiversity. I included formal academic sources alongside gray literature (from governments, citizen groups, scientific organizations, and others). The merit of community science as scientific practice and a community and wellness building practice is explored below.

Best Practices Scan

To develop protocols that support staff in designing ongoing monitoring projects (through stewardship activities, annual bioblitzes, key indicator species monitoring, etc.) I searched for precedent among governments and natural history groups; resources and programming were largely sourced from the iNaturalist forums (California Academy of Sciences) and City of Surrey biodiversity and monitoring program, as well as inputs from work done by Birds Canada and other projects on the Canadian government's Citizen Science Portal.

Limitations

This research was limited primarily by the time allotted for completion. Over the course of outreach and research, several valuable directions and opportunities were identified but ultimately designated as out of scope, indicated below.

- Building a new data infrastructure for community science to be stored in at the city.
- Describing compatibilities between new community science and past academic or consultant data.

- Describing how to interpret species richness data to inform planting or infrastructure planning.
- Monitoring focused on hydrology, including quality, infiltration and movement of water.
- Designing protocols to capture oral histories or other more anecdotal data from community members. A shortcoming of this last component is that it excludes Indigenous oral histories and stewardship traditions; xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) Nations were not consulted as a part of this project, but in future work rights-holders should be engaged. This is further explored in Section 4: Opportunities for Future Work.

Barn Swallows by © Tobin Sparling CC BY-BC 4.0

Section 1: Background on Biodiversity and Community Science

In this section:

- Contextualizes why urban biodiversity matters.
- Explores key stressors facing urban biodiversity.
- Discusses the role of community science in understanding, preserving, and enhancing urban biodiversity.

Red-winged blackbird © Jodi Forster CC BY-BC 4.0

1.1 Biodiversity in Cities

Biodiversity is a general term to describe the variety of life on earth, including plants, animals, fungi, and microorganisms.

Urbanization threatens biodiversity through habitat loss, pollution, invasive species, and other stressors. Still, cities can host a surprising diversity of life. Urban green and blue spaces can provide diverse habitats for many species across parks, gardens, and waterways. Urban biodiversity contributes ecosystem services such as air and water purification, climate regulation, and pollination, which are vital for the well-being of city dwellers. Effective monitoring allows for the early detection of environmental changes and threats, enabling timely interventions to protect and enhance biodiversity. Monitoring can indicate the effectiveness of conservation, inform urban planning and development, and enhance the quality of life for urban residents by supporting the development of resilient green and blue spaces. These applications are of key interest for city staff and the focus of this report.

Ecology Terms to Know: [2]

Biodiversity is a broad term that encompasses the variety of life at all levels, including genetic diversity within species, species diversity within ecosystems, and ecosystem diversity across regions. It represents the total variability of life forms and their interactions. As a general term, there are many ways to measure and track biodiversity, though several key indicators are commonly used. These include species richness, abundance, and diversity.

Species Richness refers to the total number of different species present in a specific area or ecosystem. It is a simple count that does not consider the number of individuals of each species or the relative abundance of species. This will be what staff extract from community science data (with a few potential exceptions), and commonly used as a simple measure of biodiversity.

Alpha Biodiversity refers to biodiversity on a local scale and is another term for richness. To calculate count the number of different species in a particular area, as you would for richness. This term is often used to discuss changes in a single habitat over time, or two in a similar area at the same time.

Species Abundance describes the number of individuals of each species within an ecosystem. Unlike species richness, it provides information about the population size of each species and is a more complete and complex description of the community dynamics. Relative abundance is a term used to describe the evenness between different species.

Species Diversity combines species richness and species abundance, accounting for both the number of species and the evenness of their distribution. It reflects the variety within a community and how evenly individuals are spread across species. Usually described using an index, such as Shannon's Diversity Index.

A notable impact of urbanization is habitat fragmentation, a term to describe when formally large areas of habitat are separated into small, separated fragments by roads, houses, and other infrastructure. One way to combat this effect is by increasing connectivity through ecological corridors within urban areas that allow wildlife to move more freely and safely. Connectivity facilitates the movement of species between different habitat patches, ensuring access to resources, genetic exchange, and migration opportunities, which are essential for species survival and biodiversity conservation. Research has shown that even small, isolated habitat patches have strong benefits, despite historical beliefs that large, isolated protected areas were the only worthwhile use of conservation efforts. [3]

In urban areas, small habitats are often patches like green roofs, parks, street trees, river corridors, and wildlife crossings (which might be underpasses, viaducts, culverts, etc). Private land, though pivotal to regional connectivity, is often less emphasized in municipal connectivity planning due to the challenges of organizing monitoring and implementing change on private land. One exception would be the ability of municipalities to enforce small buffer zones next to key habitat (such as riparian area protections) and protections for large trees. Connected habitats support various species including birds, insects, mammals, and plants, allowing them to thrive even in highly developed areas. Urban connectivity also benefits people by providing vibrant green spaces that enhance quality of life by promoting recreation and nature connection.[4]

Metro Vancouver's "Connecting the Dots: Regional Green Infrastructure Network Resource Guide" (2015) was an early step in the ongoing process of developing a regional green infrastructure network. The report covers the many benefits offered by green infrastructure, including costs and considerations for natural and semi-natural options, like those in Figure 2, for improving the condition of urban environments for humans and species. With the implementation of a regional green infrastructure network, air and water can become cleaner, wildlife healthier, and quality of life improved for all.

Green Infrastructure vs. Green Rainwater Infrastructure

Green Infrastructure: Can refer to rainwater management, but also often used to describe a broad range of natural green assets that enhance ecosystems, as in the case of Metro Vancouver. Green rainwater infrastructure is a type of green infrastructure but does not describe all the components referenced in Metro's report.

Green Rainwater Infrastructure: In Vancouver, GRI refers to rainwater management that aim to recreate the natural water cycle via semi-natural and natural installations such as rain gardens, bioswales, permeable pavements, green roofs, and constructed wetlands.

Wetlands are particularly valuable habitats for biodiversity, supporting 40% of all plant and animal species at some point in their life or breeding cycles, despite occupying only 6% of the Earth's surface.[5] Green rainwater infrastructure is designed to "collect, filter, convey, and detain stormwater," thereby creating ponds or ephemeral wetlands through their function. As the Metro Vancouver region moves forward with their support of green infrastructure connectivity, monitoring species presence and ecological function at smaller scales will be crucial to developing a portfolio of adaptive assets bolstered by community support and engagement.

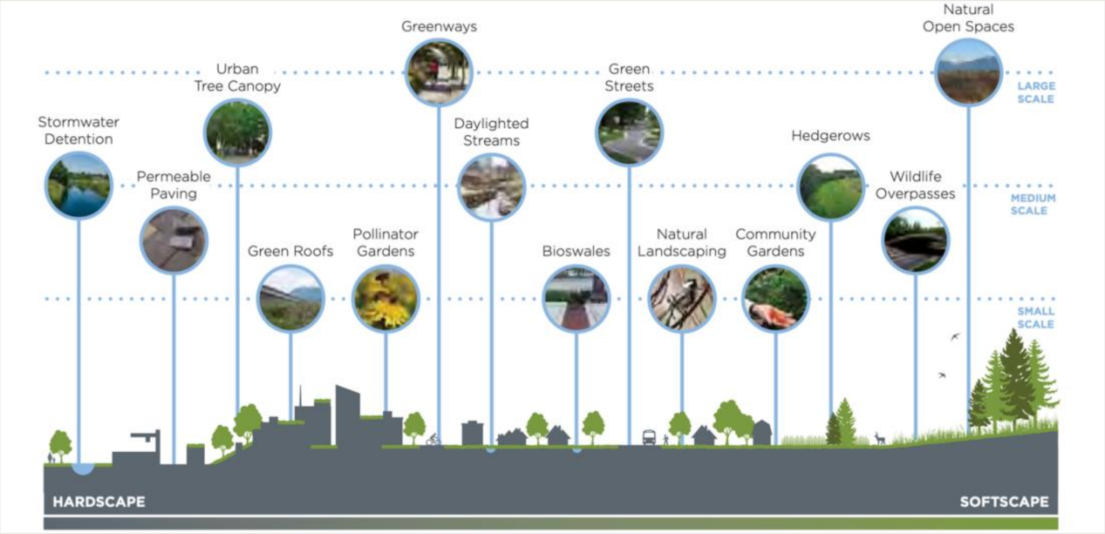

Figure 2. Figure from Metro Vancouver showing green rainwater infrastructure employed across urban landscapes, from hardscape to softscape.

1.2 Background on Community Science

Community science has been a popular activity for decades, if not centuries. The first Christmas Bird Count, a widely popular annual bioblitz organized by the Audubon Society, will celebrate its 125th anniversary in 2025. With the rise of digitalization and the spread of smart devices, community science platforms have become more accessible and widely used, catching the attention of researchers, governments, and conservation groups for their potential in providing extensive monitoring coverage.

Community science has been shown to support "large-scale data on species distribution and population abundance, species traits such as phenology, and ecosystem function variables such as primary and secondary productivity."[6]

Incredibly, community generated data accounts for 70% of animal records and 87% of bird records in the Global Biodiversity Information Facility (GBIF), an international data sharing platform.[7] Community monitoring projects are estimated to contribute $2.5 billion annually in in-kind value through volunteer efforts, further establishing their role as a mutually beneficial and highly valuable service.[8]

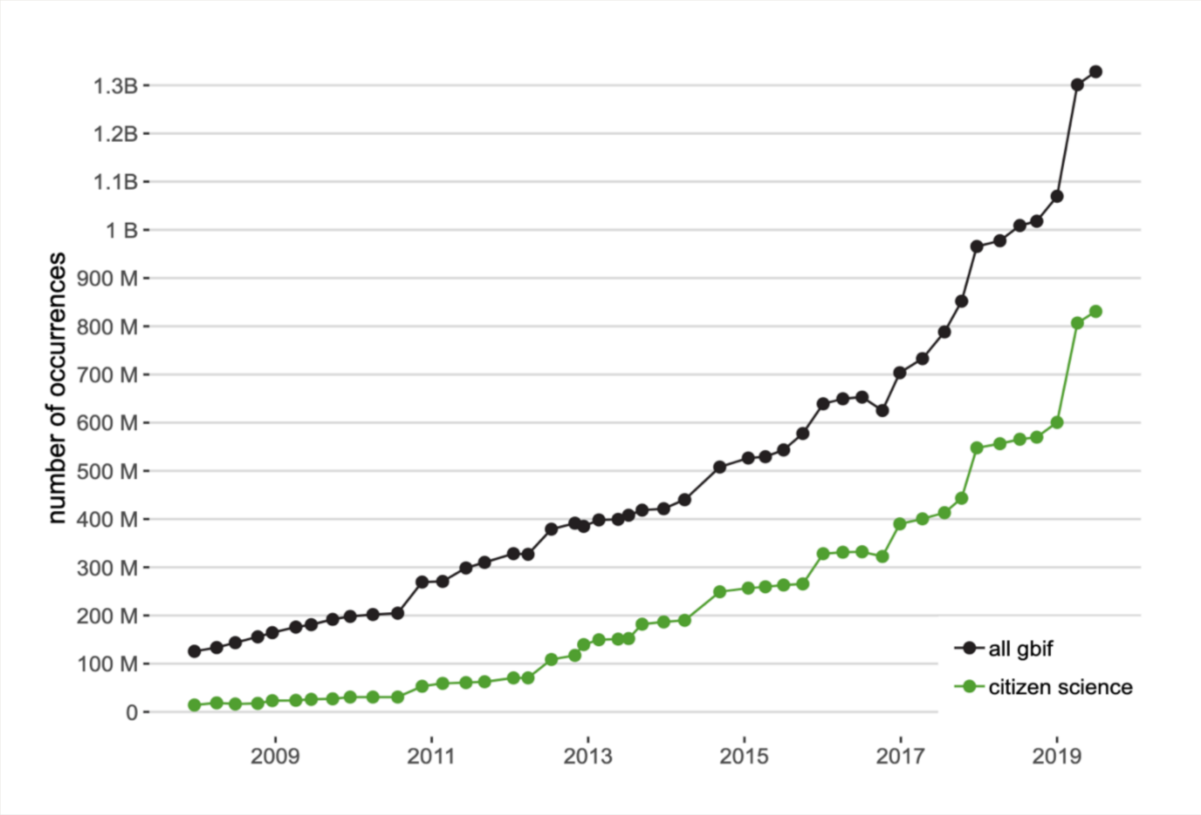

Figure 3. Graph showing overall contributed occurrences versus citizen contributed occurrences from 2008-2019. Retrieved from GBIF Blog, contributed by John Waller (2019) (https://data-blog.gbif.org/post/citizen-science-on-gbif-2019/)

Beyond biodiversity monitoring, community science apps are also commonly used to track pollution, noise, radiation, shoreline changes, waste, and a large variety of hazards and risks (such as landslides, earthquakes, wildfires, or floods).[9] The largest platforms for collecting data in North American are eBird and iNaturalist, hosting both open-source data as well as allowing for project integration. Platforms that serve as hubs to connect interested community members and projects are also increasingly popular, including Zooniverse and Scistarter.

Popular Community Science Platforms

<u>iNaturalist</u>

iNaturalist is a citizen science project by the California Academy of Sciences. Volunteers upload photos or sound recordings via a smartphone or web portal. The community helps identify these to the most specific taxonomic level possible. Once two users, or two-thirds of all identifiers on an observation, agree on the species, the observation is marked as 'research grade' and uploaded to the Global Biodiversity Information Facility.[10] If users are unsure of species identification, iNaturalist can suggest possibilities during upload. Participants can engage as observers, identifiers, or project leaders, contributing to the collective data for a specific area or engaging in targeted projects. One notable annual project is the City Nature Challenge, which invites urban residents worldwide to compete in recording the most observations over a four-day period. Bioblitzes, or intensive periods of biological observation conducted with the intention of recording all species found in a defined area, are often hosted on iNaturalist for its advantageous identification support and taxonomic organization.

eBird

eBird is one of the most comprehensive and widely used bird monitoring systems globally, with millions of observations submitted each year. Managed by the Cornell Lab for Ornithology, eBird is widely used to monitor populations and enable hobbyists to track their own observations. More rigorous observational standards and information requirements allows for some eBird data to be used to determine species diversity as well as richness.

Zooniverse and SciStarter

Zooniverse and SciStarter are two leading platforms for connecting interested individuals with community science opportunities.

Zooniverse offers a wide range of projects across various scientific fields, enabling volunteers to assist in analysis and classification, varying from identifying wildlife to analyzing astronomical images. SciStarter is also a project hub, connecting volunteers with thousands of initiatives worldwide and providing resources for both participants and project organizers. Both platforms democratize science by allowing the public to contribute to research and gain a deeper understanding of the scientific process.

Coastie and Chronolog

These are two community science-powered time series analysis projects, inviting visitors to selected sites to share photos so that policy makers and researchers can compare ecological and geological shifts over time.

The Coastie initiative is led by Parks Canada and the University of Windsor, adapting an earlier coastal monitoring project to suit the needs of Canadian users. Municipalities interested in getting new Coastie sites added are invited to contact the University of Windsor's Coastal Research Group.

Figure 4. A Coastie participant using one of the installed stands. From coastiecanada.ca.

Chronolog operates similarly, but not exclusively within federally owned parks; any location can host a Chronolog. The stands are often placed at culturally significant sites, natural features of interest, or unique areas within a city. Some more interesting examples include sites actively being restored, offering a unique opportunity to capture the re-integration of plants and animals across a landscape. Photos can be used to share updates with communities, generate time lapses, or integrate data into planning. The City of Nanaimo hosts 9 Chronologs, with 530+ contributions. A strength of this community science platform is the automation, requiring limited staff time during data collection, and well-organized information for staff interpretation.

Community science takes on many forms, as diverse as the communities that engage in it. Governments and academic institutions increasingly recognize the value of co-created solutions and seek opportunities to work with local stewards to understand places and their inhabitants better. Implementing just one of the community science solutions mentioned can be a first step in creating a set of tools that help generate data and promote community engagement focused on sustainability in Vancouver.

1.3 Opportunities for Using Community Monitoring Municipally

Community science is often applied for biodiversity monitoring, environmental risk monitoring, and to connect people with nature, with positive outcomes for wellbeing.[11] Understanding the specific landscape for community science and engagement in the region is key to designing well-tailored projects and planning for shortcomings.

Vancouver's public has demonstrated interest and ability to participate in community science. Table 2 shows statistics for regional engagement on iNaturalist, starting with a small, municipally organized bioblitz to record species found in the St. George Rainway and ending with observations for the province. Notably, Metro Vancouver achieved first place in the 2024 City Nature Challenge with over 14,000 observations gathered across the 4-day period, contributing to the 2.4 million observations generated by cities across the globe. Urban residents are excited about getting to know their environment and contributing to making it better, as demonstrated by the impressive scale of involvement.

Table 2. Regional iNaturalist Statistics at Various Scales, gathered July 18, 2024.

Area	Overall Observations (verifiable)	Overall Observers	Research Grade Observations	Total Species (Research Grade)
St. George Rainway Bioblitz (2022)	1,397	225	669	246
City Nature Challenge 2024	14,066	447	7,630	814
Vancouver, British Columbia	175,841	11,087	101,119	3,040
Greater Vancouver	756,628	23,523	466,443	5,522
British Columbia	3,971,676	56,513	2,354,895	13,689

Through crowdsourcing, community monitoring can generate data in volumes that government staff and institutional researchers would otherwise not be able to procure due to human resource constraints. Below are a few examples of government and non-governmental community monitoring programs:

Regional and Global Examples of Community Monitoring Programs

Whistler, Canada

Most community science programming in Whistler is organized by the Whistler Naturalists, supported by local government and other sponsors. This group conducts one of the longest standing and most successful annual bioblitzes in the region engaging participants in a range of programming across the year.

Surrey, Canada

A regional leader in integrating community monitoring into their Biodiversity Conservation Strategy and developing programming to support conservation priorities. Surrey participates in the City Nature Challenge, leads annual bioblitz events, and conducts more specific monitoring via their Surrey Natural Areas Partnership (SNAP) program, as well as references their Biodiversity Design Guidelines to support practitioners when seeking to support target species.

Edmonton, Canada

The Edmonton Area & Land Trust is a charity offering 5 opportunities to volunteers, split according to species of interest (Amphibians, Bats, Birds, Butterflies, or Field Ornithology). They have had such success in their programming that instead of accepting help on a rolling basis they offer a waitlist to volunteers.

Victoria, Australia

This government run program invites locals to engage as community scientist via iNaturalist on an casual basis as well as featuring projects to get involved with and features naturalist groups to join.

Wisconsin, USA

Waukesha Country Park System is one of only a couple governments with a well-established community science program, inviting site-adoptions and six monitoring streams for participants to choose from. Regular training and monitoring events are hosted, conducted by a staff conservation biologist. Wisconsin upholds its reputation with more programming from the Wisconsin Department of Natural Resources.

Similar regional groups that may offer specialist monitoring data include Nature Vancouver, the Nature Trust of BC, Stanley Park Ecological Society, and BC Nature (more can be found on NatureGuidesBC).

When staff at the City of Vancouver and the Board of Parks and Recreation were asked to share their visions for utilizing community monitoring in their work, the following themes emerged. While not suggestions were within scope of this report, they are included to represent staff perspectives on ley steps for adapting community monitoring to municipal needs an early stage of the research.[12] These insights are particularly valuable for understanding the inherent challenges of city work, including limited staffing and the need to design programs that engage diverse communities.

- **Overcoming Data Collection and Interpretation Challenges:**

  For community science to be effective, accessible tools and methods are key to engaging a wide range of participants, from tech-savvy individuals to those who prefer anecdotal or non-digital reporting.

  Protocols and toolkits should provide simple and clear guidance for staff and volunteers, ensuring consistent data collection and research design with tips on how to select the where/when/and which species.

- **Need for Clear Purpose and Research Objectives:**

  There have been mixed results from initiatives like the City Nature Challenge due to factors like staff capacity and not having a specific purpose for the data.

  Successful programs need clear research questions and well-outlined goals to justify staff involvement and ensure that the collected data meets the identified needs.

- **Known Data Gaps that Community Monitoring Could Help Address:**

  Staff expressed excitement around expanding efforts that monitor urban biodiversity, especially in specific wildlife areas like Still Creek, across daylighting projects, and in new GI projects. These efforts can provide critical data to support ecological planning and design. There are currently data gaps surrounding ecology on private land, which community science could help to fill by encouraging observation in backyards and other non-park or right of way areas.

- **Integrating Data into a Broader Accessible System:**

  There is potential to integrate citizen science data with other datasets to create a comprehensive information system, supporting more informed decision-making and planning. For instance, such a database could be used to identify priority areas where investment in GRI, turf conversion, stream daylighting, and other projects can most benefit ecological connectivity.

  Creating such a system would be a large undertaking and is beyond scope for this report but may be supported by the work that emerges from this report.

- **Frameworks are Needed for Sharing Local and Qualitative Knowledge:**

  Community mapping and other methods to capture qualitative local knowledge and historical context are needed.

  This objective is out of scope for the project, but this is referenced in Section 4.

- **Promoting Engagement:**

  Creating learning opportunities and fostering a culture of continuous observation and reporting across nature can enhance our citizen science efforts and engage a broader community base. Building monitoring into stewardship programming is a good way to begin this process.

There are many more examples of community monitoring programs and opportunities than mentioned above, often organized by naturalist groups, universities, or large nature conservancy organizations. Through engaging these groups and consulting staff to learn about common challenges and gather feedback, a community monitoring program can close an important knowledge gap on the influence municipally designed habitats (such as green rainwater infrastructure sites) on local biodiversity.[13]

Section 2: Guiding Principles and Best Practices

In this section:

- Introduces three methods for leveraging community monitoring: Existing Data Integration, Site adoption, and Custom projects.
- Discusses potential biases in community-generated data.
- Emphasizes the importance of careful project design, communication, and resources to effectively use community-contributed data.

Paddle-tailed Darner© Marcel CC BY-NC 4.0

2.1 Integrating Community Monitoring into Planning and Conservation

One key finding from this report is that existing stewardship programs, including the Seeding Stewardship Program, offer a potential opportunity for integrating community science. Volunteer programming is a great avenue to explore ways to share the tools and resources needed to make species observations at sites around the city.

I propose three monitoring methods to integrate community monitoring at various levels of engagement and staff involvement. Each approach is likely to be compatible within City of Vancouver and Parks Board volunteer programming and outreach communication with local communities, with varying staff input depending on the goals of the site. The remainder of this section introduces the methods and offers general guidelines for leveraging community monitoring. Section 3 gives tips for when to use each method, how to select target species, setting up community observers for success, and analyzing gathered data.

Integrating Existing Data

City Nature Challenge

This method refers to the act of using information generated by existing programs or campaigns, leveraging previous efforts to support ongoing projects or inform new ones. One example is the City Nature Challenge, organized in past years by Metro Vancouver and inclusive of all the boroughs. Feedback from the staff workshop indicated that this is the area least suited to near-term efforts and will be sparingly referenced in the remainder of the report. However, it is important to be aware of other community generated data projects and reference their work to compare sites, explore species movements/presence, and understand bigger patterns.

Site Adoption

This method is potentially well suited to integration within various volunteer programming, such as Seeding Stewardship. This approach would generally be used to gather information on which species are using smaller green rainwater infrastructure sites and other habitat patches that are not often casually monitored by iNaturalist users or in big community science projects. This model encourages residents to make a commitment to observing sites near their home, work, commute, or another regularly visited place. Staff will offer some training in the form of species guidelines, safety tips, and best practices but not facilitate site visits or reporting. iNaturalist will serve as the platform for reporting back to staff. Model programs for engaging volunteers include Adopt A Catch Basin and Green Streets.

Custom Projects

This method would include custom planned events like Bioblitzes. This approach generates more detailed data on species diversity and habitat conditions at a particular site, or even species abundance with special parameters. Though events like this require the most staff organization, it is a good compliment to the other two methods for the increased control over timing, participation, and methods. Staff would choose this route when more data is needed at a site than can be generated casually or by a few volunteers. Annual or bi-annual events are usually needed to establish baselines and monitor changes across a site.

2.2 Understanding Bias and Community Monitoring

It's important to recognize that community-generated data can reflect certain biases. Implementing a consistent protocol can help mitigate this issue. Balancing the tension between data quality and research design complexity is crucial for effectively using community-collected data. Clear goals and specific instructions on which species to observe can offer valuable insights into ecosystem health and guide targeted conservation efforts while minimizing persistent biases.

The following section outlines several common barriers to generating diverse and representative species information.

Overrepresentation of Charismatic Species (Preference Filter)

Observers on iNaturalist come from diverse cultural and educational backgrounds, bringing with them culturally specific preferences and taboos. Personal interests also influence which species individuals choose to observe. Generally, large body birds are overrepresented in community science, especially on platforms requiring verification images. A 2021 study investigating the overrepresentation of large-bodied birds found that the frequency of observations correlated directly with body size and commonness, highlighting the importance of project designers and data-users being aware of inherent biases and taking them into account. This distinction is critical when comparing programs that use more casual, unstructured methods to those with semi-structured or rigorous protocols, which may require formal training before submitting observations. In Vancouver, there is likely to be consistent bias towards larger, easily recognizable species like crows, great blue herons, and Canadian geese, which are the three most highly represented species on iNaturalist.[xiii] However, even for those projects that do take extra steps to narrow species of interest, people tend to report more recognizable and “interesting” species.

Within the Global Biodiversity Information Facility (GBIF) most community contributed observations are Aves (Birds, which are a class of Animalia), Animalia (not counting Aves, but including most living, moving things), Basidiomycota (Fungi), and Insecta (Insects), with a great deal fewer observations contributed across other classes. This is largely due to the influence of eBird and iNaturalist as well as another Swedish database, Artportalen, where there is a shared preference for bird research amongst both researchers and participants.

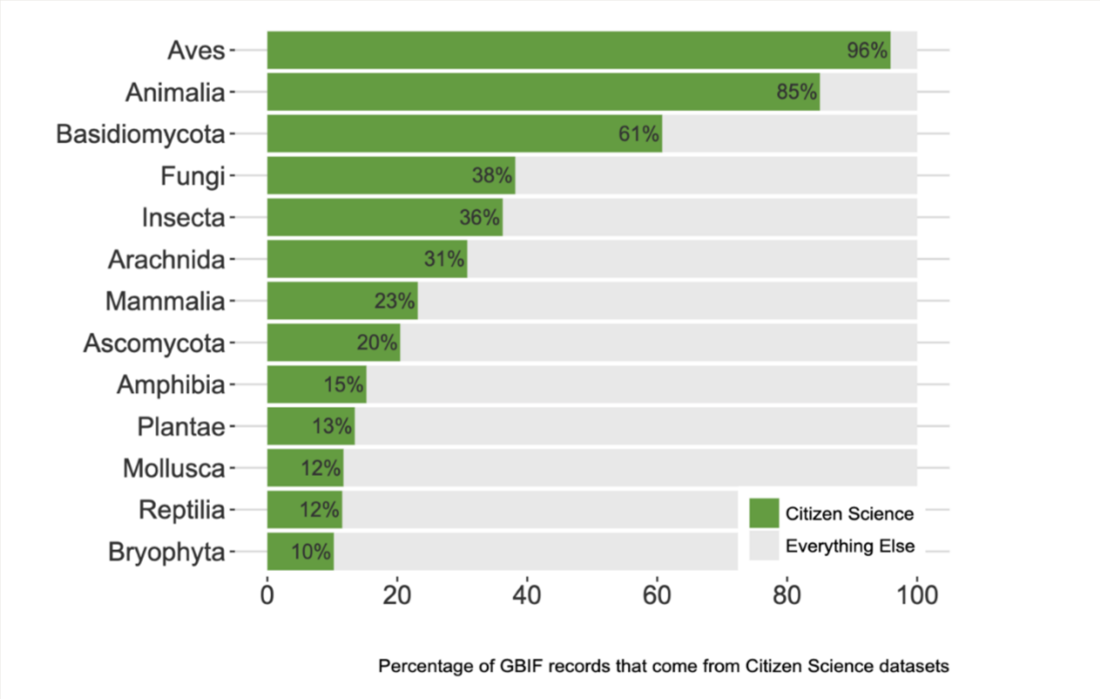

Figure 5. From John Waller (2019) on GBIF data blog (https://data-blog.gbif.org/post/citizen-science-on-gbif-2019/)

Narrow Representation (Seasonally, Spatially/Socially, Temporally)

The typical range of observation is insufficient to fully capture species preferences and presence. This limitation, discussed further in relation to the seasonal, spatial, and temporal effects of human activity, impacts the accuracy of community monitoring.

Seasonal

Participants often submit observations made during leisure time outdoors, which disproportionately occurs during warmer months. Bird observations typically occur during their most vocal periods, in the mornings during the nesting season (mid-March to late August), which further biases data towards spring and summer. While some organism groups, like most plants and insects, are less active or absent during winter, these seasonal preferences leave a gap in data for species that are non-migratory or active year-round.

Spatial/Social (Sampling and Participation Filter)

Studies show that community science observations tend to be concentrated in highly populated and accessible areas, spaces that attract observers for the purpose of viewing nature, and wealthier areas.[xiv] A study published in 2023 found a relationship between racially segregated housing zones and the density of bird biodiversity sampling, showing a significant under sampling in historically racialized communities.[14] These data gaps, influenced by access, preferences for specific landscapes, and a historical lack of access for disenfranchised communities, can perpetuate existing urban inequalities. This is significant because species data often play a central role in determining conservation priorities. It is crucial to consider the social, economic, and cultural factors influencing access to the outdoors and participation in data collection. This consideration helps to understand where data is generated, who is collecting it, and how these factors shape knowledge creation within the city.

Temporal (Detection Filter)

An American survey from 2022 indicated that most adults (58.8%) report spending less than an hour outdoors daily.[xv] Within this limited outdoor time, few people are likely to dedicate the entire duration to observing nature for iNaturalist, resulting in a narrow representation of species activity. Activity varies substantially across the week as well, with 37% more observations per day on weekends and 22% more unique users on those days.[xvi] Additionally, nocturnal and crepuscular species (active at night and twilight, respectively) are less likely to be recorded than diurnal species (active during the day) due to the mismatch between human and animal activity patterns.[xvii] Although some take time to document the natural world during commutes, lunch breaks, or days off, capturing a broader range of observations, timing is an important factor to consider when assessing species representation.

Observer Expertise (Detection Filter)

According to 2021 study investigating the first 11 years of iNaturalist's operations, "just 1% of the more than 1.7 million people with registered iNaturalist accounts uploaded more than 60% of the platform's observations," indicating the influence of active, dedicated naturalists who spend a great deal of time making observations. The study also investigated the preferences of observers, finding that the most active users were taxonomically specialized and preferred to make observations of the same species only twice before adding others within a particular group.[xviii] It seems that expert observers prioritize making diverse contributions within their preferred taxon, as opposed to casual incidental observations of all species they came across. However, the 10 most observed species comprise 4% of casual user's contributions (fewer than 5 observations total) and 3% of more seasoned users (five or more observations total), suggesting that users start with common species and specialize over time (quickly for professionals and slowly for hobbyists).[xix]

Below is a figure from Di Cecco et al., showing users with over 50 observations organized by their taxonomic tendencies; most generalist users were contributing data on plants, insects, and birds (first 3 groups from top down). Users who contributed data on lesser observed organism groups tended to be more specialized overall and less engaged with the more commonly observed taxon. The same was true within Insecta, with generalists mostly observing Lepidoptera, Odonata, and Hymenoptera (Butterflies and Moths; Dragonflies and Damselflies; Sawflies, Wasps, Bees, and Ants).[xx] As noted earlier, heavily observed species tend to be those that are conspicuous, easily recorded, or interesting to humans, leaving microscopic, timid, and "uninteresting" species behind. Some taxa requiring specialist knowledge include fish, amphibians, aquatic plants and invertebrates. Project design and data curation should be sensitive to which species are likely to show up in incidental records versus which may require more specialist design or expert input.

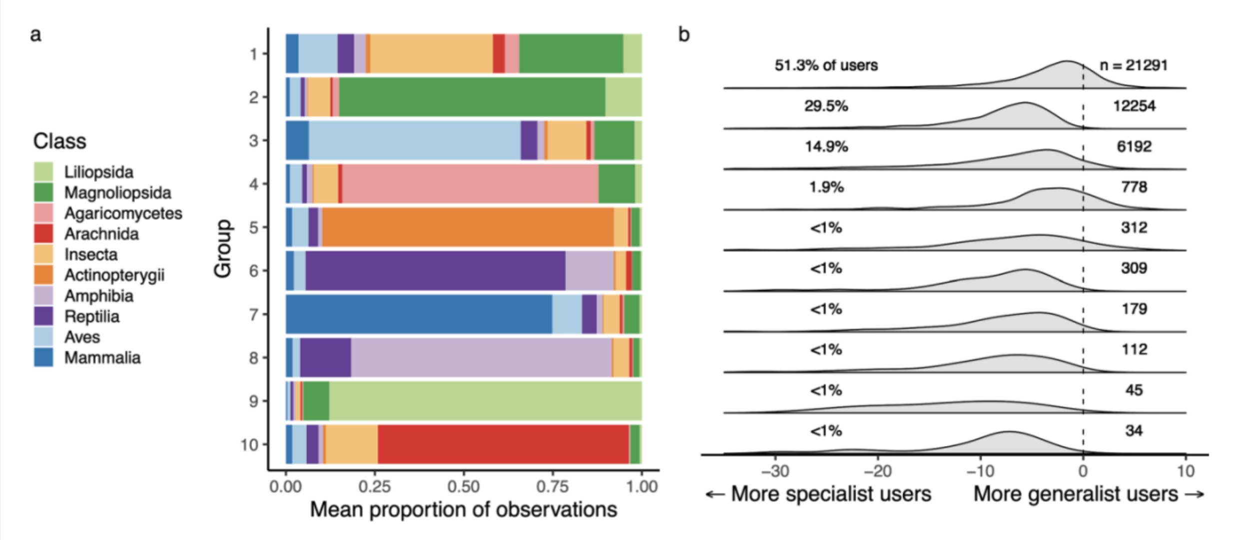

Figure 6. From Di Cecco et al. (2021) showing observations by user group and specialization.

When developing an urban monitoring program to track the impact of green rainwater infrastructure, it may not be possible to eliminate bias. Instead, bias is simply something for staff to be aware of and strive to minimize its impact where possible through intentional project design and data curation. As shown below in the figure from Carlen et al. (2024), the filter effect of human bias can be observed across species observations at several scales. The filters from this paper, including participation, detection, sampling, and preference, are indicated next to the biases they are related to.[15] While several key considerations are outlined above, not all biases are well-documented. Therefore, caution should be exercised when making conjectures from the data, especially regarding species abundance and community structure.

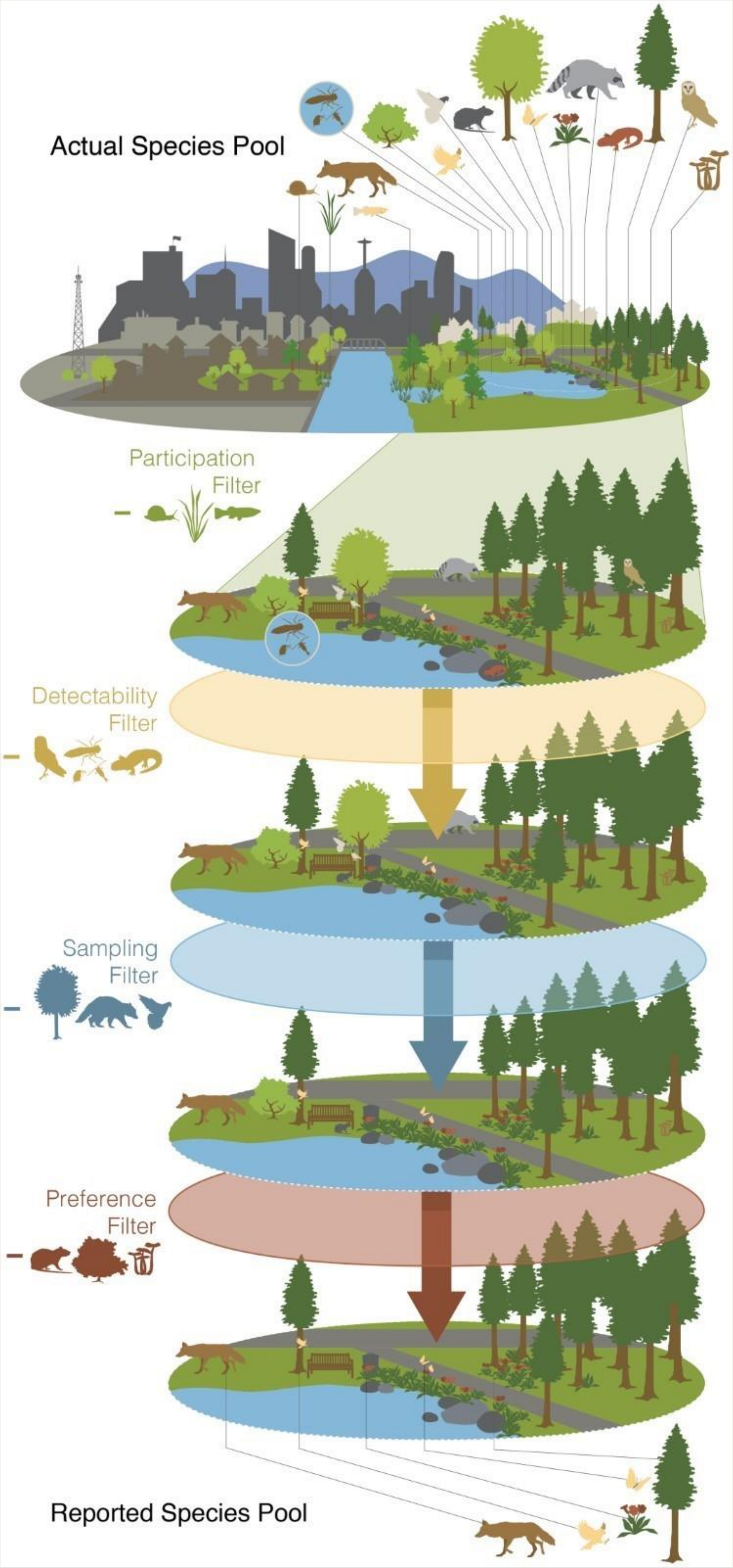

Figure 7. From Carlen et al. (2024) showing the filter effect of different biases, indicated in headers above where filters and bias overlap.

Mitigating Bias

One way to mitigate bias is to communicate with observers using clear objectives. A good general objective for a variety of projects may be the following:

> Your goal is to help record the variety of wild plants and animals in our area. By sharing your observations, you're helping city planners track changes in nature and protect local wildlife. Every observation you make is important!

Custom projects and site adoption will have more specific objectives, which need to be developed ahead of planning. One objective may be to track the presence of certain target species and provide community volunteers with resources to more easily identify such species. Resources for selecting target species and communicating to volunteers are included in section 3. One example of a project with more specific objectives is the 2022 St. George Rainway Bioblitz. Though staff didn't request special monitoring for specific species, since the goal was more to record total species richness at the site, the objectives conveyed specific measurable goals of the project and emphasized the role of participants in shaping the project, as well as specific design targets for staff; they can be read here.

Sharing objectives makes it clear to community members what the project seeks to accomplish. They are a good guide for both staff and community members when it comes to sites that are sparsely observed, like the St. George Rainway, where much more data is needed but collection can seem overwhelming. Sharing specific objectives can also ensure that community members understand the usefulness of their work. Staff can use the same language to report back to communities, referencing progress on objectives. Staff should actively review results and search for participant feedback to stay on top of sampling bias and correct where possible.

A few more specific strategies are suggested below, organized by biases discussed throughout Section 2.2

Overrepresentation of Charismatic Species: Develop projects that emphasize the importance of observing less noticeable species. Encourage volunteers to document target species, not just the most charismatic ones (though there may be overlap at times). Provide training on identifying and recording less prominent species, such as the Target Species ID Guide in this report.

Narrow Representation (Seasonal, Spatial/Social, Temporal):

- Seasonal: Design monitoring schedules that cover all seasons and target species life cycles a range of species activity profiles and manage human preference for recreating during warm months only.

- Spatial/Social: Promote participation across diverse neighborhoods, including underrepresented and historically marginalized areas, to reduce spatial biases. Consider partnerships with local community organizations to reach a broader audience.

- Temporal: Encourage observations during different times of day and week, including evenings and weekends, to capture a fuller picture of species activity, especially for nocturnal and crepuscular species.

- Observer Expertise: Provide training for volunteers to broaden their skills in identifying a wider range of species, including those that are less conspicuous or require specialized knowledge. Encourage more experienced observers to mentor newcomers or direct their efforts towards making identifications on iNaturalist, balancing data across taxonomic groups and improving observation quality.

2.3 Potential Incentives for Citizen Involvement

Understanding the diverse motivations behind why individuals engage in community science is key to designing effective programs. People volunteer for various reasons, such as the opportunity to learn new skills, contribute altruistically, socialize, pursue personal growth, or enhance their career prospects. Tailoring opportunities to address these motivations where possible can markedly increase participation. For example, emphasizing the educational value of a project may attract community members eager to learn, while highlighting social engagement aspects can appeal to those seeking connections.[16]

A study released this year by Park People highlights the profound benefits of stewardship activities, sharing that 97% of participants reported an increase in mental well-being and 98% felt a stronger connection to living things and the environment. However, the study also highlights that certain communities—particularly folks who are not cis-gendered women, BIPOC, and disabled individuals—are consistently less engaged and feel less connection to these activities. This suggests that there is potential for expanding stewardship benefits to these groups by exploring opportunities beyond traditional large urban parks (such as with the Site Adoption model introduced in Section 2.1) .[17]

Incentivizing participation can include both direct and indirect rewards. Providing certificates, badges, or small honorariums can recognize and motivate volunteers, especially those with expertise. The most vibrant programs tend to be comprised of expert amateurs and hobbyists, with input from professionals; the City of Surrey integrates this model by inviting professional biologists to engage with their bioblitzes, often separately (i.e. at a different time of day) from the public. A mixed group representing various experiences and expertise will more quickly provide “good” data by cutting down on training time and broadening the range of observations, ensuring more accurate and diverse data collection. Offering small honorariums for professional input is a valuable strategy. Collaborations with birding communities, existing stewardship groups, and natural history societies are likely to involve a mix of passionate, locally aware, and interested volunteers, but must make concerted efforts to better understand and include marginalized communities may fall short of integrating excluded communities as featured in the Park People study Competitions and challenges with prizes can further encourage active involvement. Across all programming, effective communication is essential; regularly updating participants on project progress, sharing success stories, and publicly acknowledging their contributions can boost motivation and retention.[18] Offering feedback opportunities (a simple survey is fine) allows participants to voice their experiences and interests, which can improve ongoing program engagement.[19]

A study from Australia found that after engaging in turtle monitoring projects, participants adopted more "turtle-friendly" behaviors, indicating a shift in attitudes towards conservation.[20] Respondents from the same study indicated that naturalized spaces with trails, wildlife, and native plants significantly enhanced their sense of nature connection and wellness, further supporting the findings of Park People (2024).

There is a myriad of options for creating an engaged, diverse community that supports monitoring. To summarize the points above, staff should consider the following:

- **Tailor Programs to Motivations**: Highlight opportunities that cater to various motivations, such as learning, socializing, and personal growth. Promoting opportunities through community centers may be one way to do this.
- **Acknowledge Diverse Needs**: Address the ongoing underrepresentation of certain communities by exploring inclusive and varied engagement opportunities.
- **Offer Direct Incentives**: Provide certificates, badges, or small prizes to recognize and motivate volunteers, particularly those with expertise. Some cities have a "Master Naturalist" distinction that could be a good incentive for some.
- **Recruit Experts**: Integrate professional biologists and experts into events to enhance data quality and engagement. Databases with current registries of professional biologists (R.P.Bios) are a good source of expertise, as well as natural history groups that have training requirements. Birds Canada's Marsh Monitoring program is one example that could either generate data for staff or provide informed participants. Engaging with universities to involve students is another potential source.
- **Promote Competitions**: Host small challenges or competitions with prizes to stimulate active involvement; for example, it could be an invitation to make observations on Earth Day or the International Day for Biological Diversity on social channels and newsletters. Engaging with (but not organizing or extensively promoting) City Nature Challenge, Great Backyard Bird Count, and others could give participants and understanding of the global relevance of their contributions.
- **Maintain Effective Communication**: Regularly update participants on project progress and share photos, highlights, and personal stories to encourage and celebrate engagement.

- **Seek and Incorporate Feedback on the Program**: Use surveys or other feedback tools to understand participant experiences and refine programming to suit interests and needs.
- **Balance Spaces**: Knowing that traditional green spaces (especially large parks) are a preferred space for engagement, focus on featuring diverse naturalized urban spaces to foster a stronger connection to nature in many types of spaces.

2.4 Staff Inputs

To support a community monitoring program (described in detail in Section 3), there are a few tasks for staff to assume, ranging from engaging observers to providing resources and analyzing incoming data. The time required for these tasks depends on the project's objectives, the most intensive being where staff are organizing custom monitoring events. In most cases, it is possible to avoid intense staff burden by slowly integrating monitoring and planning events as needed, and organizing resources to be as accessible as possible. Specific anticipated tasks are outlined below alongside representative icons.

Program Coordination and Data Curation: Designating a team member to oversee data entry and organize custom events, as well as liaise with partner groups and community members could be key to successful program development. Without designated staff support, application of data will be limited to one-off staff searches. I

Training and Support: In most cases, it is not necessary to develop new training documents, as so many have been created for the express purpose of supporting community scientists.[21] Making these available to interested community members, whether through volunteer onboarding or the public website, is key. These will include monitoring techniques, data collection methods, and safety protocols. There may need to be a staff member available to answer questions about organized events or provide training information.

Recruitment and Outreach: One important staff responsibility includes recruiting a diverse group of volunteers and managing outreach to underrepresented communities.

Communication Coordination: Staff should plan to deliver clear communication before and after events, in addition to developing a helpful web presence for interested volunteers. This could be included in an existing newsletter, social media, or community meetings. Public information sessions in advance of construction may be an interesting opportunity to invite community monitoring presence (before construction, during, after).

Volunteer Recognition: As discussed in section 2.3, a system that recognizes and celebrates volunteer contributions can maintain motivation and retention but requires staff time. This could also include opening mechanisms for feedback, seeking experiences from community members.

Legal and Safety Coordination: Whenever community members are invited to monitor or engage with nature and wildlife, there are special safety considerations. These concerns can mostly be mitigated with good resource availability but in some cases it may be necessary to check that liability insurance and consent forms are in place.

Evaluation and Reporting: Staff need to curate and evaluate data not only to extract information about species but also to report their findings back to communities. INaturalist provides helpful visual summaries of observations, which may reduce required staff time compiling graphics or statistics. Data evaluation can be time intensive, or not, depending on site objectives and if information is needed beyond presence/absence of target species.

Figure 8, on the next page, shows the monitoring methods alongside each of the potential staff inputs. Anticipated time required is expressed by icons representing low input (green), medium input (orange), and high input (red). This is an approximation, and subject to change depending on the specifics of each project.

Figure 8. Table showing anticipated staff inputs, discussed in Section 2.3, for each monitoring method. Staff inputs are organized by low (green), medium (orange), and high (red).

2.5 Potential Risks to Participants and Nature

Community monitoring plays a crucial role in gathering valuable environmental data, but it also carries potential risks for both participants and nature. One concern is that encouraging monitoring without supervision could unintentionally increase human traffic in sensitive habitats, potentially leading to habitat degradation, disturbance to wildlife, and trampling of vegetation. Additionally, participants might face physical risks if monitoring involves navigating difficult or hazardous terrain without proper training or guidance. In some cases, monitoring may place observers in contact with wildlife, where animal behaviors or even certain plants can pose physical risks to humans, or vice versa, if not handled properly. It can be difficult to ensure that participants are adequately prepared and informed about the environment and species they may encounter.

To mitigate these risks, community monitoring should be designed with careful consideration of the environment and participant safety, where possible. This could involve creating designated areas where monitoring activities are encouraged (a live map that encourages observation to gather new data), while limiting access to more sensitive regions to protect them from overuse. Such areas are likely to be better suited to more controlled events, such as facilitated bioblitzes or collaborations between staff and trained volunteers. If staff identify a likely risk, such as coyote presence or poisonous plants, a safety plan offering advice and treatment should be compiled and offered in advance.

Common Safety Concerns in Vancouver

Coyotes: Though coyotes are not native to Vancouver they have been thriving in the city for decades and can be observed during day or night. Humans and coyotes best coexist when communities understand their behaviors, outlined by Stanley Park Ecological Society as well as the City of Vancouver.

Toxic Plants: Toxic plants, whether they pose a risk through contact or ingestion are another important potential risk to participant safety. This resource on uncommonly known toxic plants will help ensure observers are keeping an eye out for unsafe plants known to be in the area.

Sick, Injured, or Dead Wildlife: Contact with sick, injured, or dead wildlife can be dangerous for humans as well as the animal. Offering a resource for what to do in the event of discovering an animal will help observers how to respond. The City of Vancouver has a webpage with numbers to call and other tips specifically for this purpose.

Considering strategies like pre-sampling assessments by staff or partner groups, having training requirements for certain events, and making resources on keeping humans and nature safe readily available can help manage impacts. Ensuring that participants are adequately prepared and informed about the risks and responsibilities of monitoring can also help reduce the likelihood of accidents or unintended environmental harm.

iNaturalist's "Obscured" Function

iNaturalist utilizes an "obscured" filter to hide specific location of particularly sensitive or endangered species. Staff should review this function to ensure that at-risk populations are not directly threatened by events (for example, populations of the Oregon Forestsnail have been found in the lower mainland and should not be disturbed). If a target species is especially sensitive, staff can provide instruction on how and when to use an obscured observation.

Oregon Forestsnail ©Derek @ my.tlahutum CC BY-NC 4.0

Section 3: Building a Monitoring Plan

In this section:

- Provides a guide for selecting target species.
- Discusses monitoring methods in depth.
- Gives tips on using iNaturalist and maximizing the value of collected data.

River Otter by © Marcel CC BY-NC

3.1 Selecting Monitoring Methods

The following section outlines recommendations for a combination of community monitoring methods focused on capturing species richness and habitat effectiveness at green rainwater infrastructure sites across the city. The methods include integrating existing data from observations around the city, site adoption, and planning custom events. Each of the components is discussed in more detail below. I also offer guidance on how to select appropriate target species. Consider the strengths and requirements of each method alongside the attributes of selected target species and choose the combination of strategies that best suits the site. A step-by-step tool has been developed to support this process, in Section 3.4, alongside a case study for Beaconsfield Park where a new GRI wetland is being constructed.

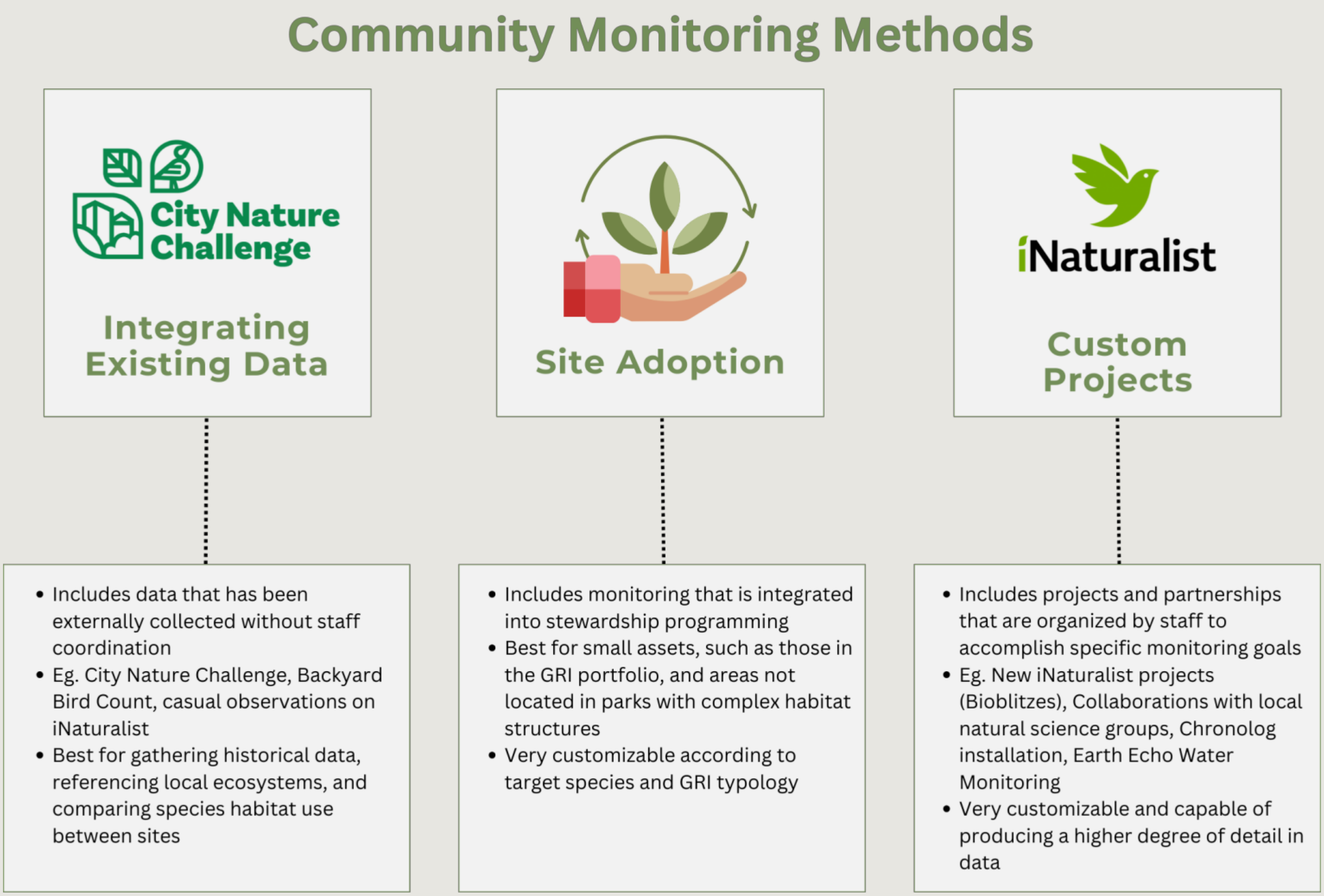

Figure 9. Overview of the three proposed monitoring methods.

Selecting Target Species

For green rainwater infrastructure development (as well as other ecosystem-based projects) staff may use target species to guide environmental design and measure ecological performance over time. Staff can use target species to guide their own general review of existing data and/or communicate to volunteers (in both site adoption and other custom projects) which species should guide their observations. If target species will be used, they should be developed in advance of selecting methods. If none are needed, skip ahead to the section titled "Integrating Existing Data" to start learning about methods. Otherwise, follow along to learn how to build a list according to specific site characteristics.

Species Classification Terms

Species are often classified into guilds according to how they benefit from or are harmed by urban habitat changes. They are also often classified according to their status as generalists or specialists. That distinction describes a continuum between being highly adaptable to many environmental conditions or having a limited tolerance to a small range of conditions with specific resource requirements, respectively.[22]

<u>Specialized species</u> are those that you might intend to attract when you build a specific type of new habitat, like a "wetland" or a "meadow". They are not likely to be observed hanging around the area already because they are very particular about their habitat needs. Hence, monitoring specialists can help you measure whether the site is successful at creating new functional habitat and inviting in species with less urban-adapted traits.

<u>General species</u> can thrive in a wide variety of environments, including urban ones. They are likely to already be using parks and other green spaces around the city, so can reasonably be expected as early and regular visitors to new habitats.

<u>Urban Adapters</u>

- Can thrive in urban environments by using human resources, though may not necessarily receive added benefit (unlike exploiters)
- Abundance of food and lack of urban predators contribute to their success
- Examples: American Robin, Anna's Hummingbird, Northern Flicker, Song Sparrow

<u>Urban Exploiters:</u>

- Benefit from associations with humans, usually generalist species that use food supplied by humans
- Well adapted to modified environments, can easily tolerate high levels of disturbance and often indicates an ecosystem that is degraded
- Examples: Glaucous Winged Gull, Northwestern Crow, European Starling, Raccoons, Eastern Gray Squirrels

<u>Urban Avoiders:</u>

- Sensitive, do not often enter urban habitats
- Have specific requirements for reproduction and foraging and prefer to avoid human disturbance
- May come as migratory visitors or to restored areas.
- Examples: American Dipper, Beard Lichen, Salamanders, Red Legged Frog, Western Painted Turtle, Western Sandpiper

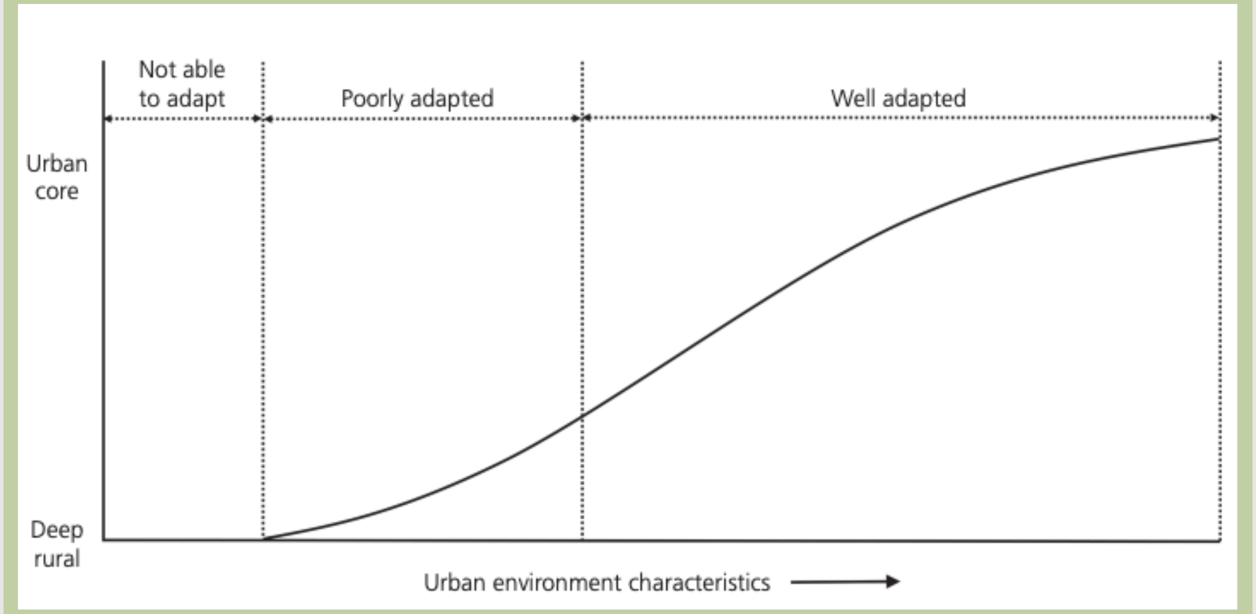

Figure 10. Urban avoiders would be found on the far left of this graph, with adapters and exploiters to the center and right. The classes are not mutually exclusive; the scale can vary from true urban avoiders that may never venture into the urban environments to adaptive avoiders that make strategic, minimal use of urban/suburban habitats, and adapters/obligates which rely heavily on an urban environment.

Indicator Species vs. Target Species

This report uses habitat specific species selections, called target species, to guide monitoring. It is common to see a similar objective accomplished with "key indicator species". The difference between the two terms is minimal but notable, discussed below.

Key Indicator species are used to infer information about ecosystem health and are chosen for their specific sensitivity to an environmental condition. They signal changes in the environment through presence, absence, and overall abundance.

Target species may be indicator species as well but are primarily selected for their importance to a conservation initiative. In this report, they are a range of species that can reasonably be expected to use new green rainwater infrastructure sites and have conservation, cultural, and/or ecological significance.

When starting the process of creating a species list for your project, consider things like:

- Can the species get to this site, considering the conditions in the surrounding area? What barriers or risks might they face along the way (think about how they physically move, how far they travel to forage each day, etc.)?
- Do the species on this list generally like to live near each other?
- Does this site provide the basic type of environment this species needs to forage, breed, shelter, and survive?
- Is there evidence of these organisms in the area ?
    - Great opportunity to use GBIF or iNaturalist to check your hunches!

Don't Know Where to Start? Don't Fret!

Section 3.3 of this report includes two custom made tools to guide staff through this process as well as a list of local databases and species guides with extensive information about what species live here, and where.

Using these guides can help you find the answers to some of the questions above. There are also many websites where you can find information about species' habitat preferences. If you don't know where to start, use a search engine! Using search terms like "*[species name] + [breeding]", or "[habitat type] + [Vancouver] + key species"* can help you start assembling an initial list of species to consider and learn more about.

The Target Species Guide and Visual Identification Sheet has been created to support staff in selecting a group of target species that capture project objectives and convey the range of habitat offerings created by the site. The target species list will be referenced while developing a monitoring plan, so take time to explore each step and select a group that captures a range of possibilities for the site (considering planting plans, uses, surrounding areas, and diverse organism groups). This list should balance expectations; including only aspirational, highly specialized species will result in a less engaging and rewarding observation experience for volunteers and a lack of data for staff. There are no “right” or “wrong” answers when it comes to choosing target species, only informed choices. Don’t worry too much about getting it perfect so much as spending the time to make sure you know what might be out there!

Target Species Selection Guide

Starting with the table below, following along with the steps to generate a target species list. The sheet, linked above, provides a space to characterize habitat offerings to be referenced throughout the process.

Step 1. Review Table 1 to start gathering a list of likely species for the site.

To start, scan the table below and note species known to use the typology in question. This is a good place to start thinking generally about what staff can expect to see observations of according to the habitat type.

This list is not exhaustive, but a starting place for selecting target species according to their potential use of GRI sites. Species can be added or removed based on site-specific conditions and design, and staff should look beyond this list in their planning.

Table 3. Potential species presence sorted by green infrastructure typology.

Species	Generalist/Specialist	Wetland (Red X indicates a requirement for trees)	Rain Garden and Bioretention	Rainwater Tree Trench
American Robin	Generalist	X	X	X
Anna’s Hummingbird	Generalist	X	X	
Glaucous-Winged Gull	Generalist	X		

Northern Flicker	Generalist	X	X	X
Northwestern Crow	Generalist	X	X	X
Song Sparrow	Generalist	X	X	X
Anise Swallowtail	Specialist (feeds on only certain plants, like fennel and parsley)	X	X	
Great Blue Heron	Generalist (though prefers wetlands)	X		
Little Brown Bat	Generalist (but can have roosting preferences and appreciates water sources)	X	X	
Pacific Tree Frog	Generalist (needs clean habitat, though)	X		
Cedar Waxwing	Generalist	X	X	
Mallard	Generalist	X		
Marsh Wren	Specialist (needs wetland)	X		
Western Bumblebee	Specialist	X	X	
Eight Spotted Skimmer	Generalist (only in and around wet areas or food sources)	X	X	
Blue-Eyed Darner	Generalist (only in and around wet areas or food sources)	X	X	
Pacific Forktail	Specialist	X	X	

Step 2. Review Local Species Trends and Similar Habitats

After reviewing the table above, identify local urban green spaces[1] with similar habitat features to the site. Examine observations on iNaturalist or the BC Species and Ecosystem Explorer[2] at that site and similar locations, using the space below to note commonly observed species, species at risk, and intriguing habitat users. Experiment with filters on iNaturalist by organism groups, conservation status, or timeline to narrow results. Note the locations of reference sites and where species are observed within them, using observation photos or GPS coordinates.[2]

Remember, target species lists should include a mix of generalist and specialist species—those likely to be found in suitable urban green spaces as well as those with specific needs that could be met by new habitats. Aim to select species representing a diverse range of preferences and requirements (not just insects or birds, but a combination). In the next step you will further sort by this classification, so just keep it in mind for now.

Step 3. Review notes from Steps 1 and 2 and compile a draft list of target species organized by "generalists" and "specialists".

Review findings from Steps 1 and 2 to create a draft of the target species list. Separate the list into generalists and specialists. See guiding questions and definitions below to support sorting.

Does this organism's presence reflect a positive shift in the local ecosystem? Is this a generalist species that quickly utilizes new habitats, or a more specialized user of habitats? Try to select a list of species that will indicate habitat improvement and uptake for both generalist and more specialist species, if the site allows. Some smaller or more disturbed sites, like tree trenches, are likely to only support generalists.

For example, after considering which types of habitats are created select a combination of eligible (e.g. suitable to the features of the site) species from the following groups.

- Pollinators
    - Indicate habitat creation and healthy plant communities
    - Any critter that carries pollen on their bodies as they move from plant to plant
    - Bees, butterflies, moths, and hummingbirds
- Birds
    - Indicate general habitat quality, food availability, and the overall health of ecosystems
    - Include songbirds, raptors, and waterbirds
- Aquatic Invertebrates
    - Indicate good water quality and low pollution
    - Caddis, mayflies, and dragonflies

- Amphibians
  - Indicate good water quality due to high sensitivity to pollutants and complex life cycles
  - Frogs, newts, and salamanders
- Small Mammals
  - Indicate habitat complexity, food availability, and space for escaping human disturbance
  - Beavers, bats, coast mole
- Soil Invertebrates
  - Indicate good soil health, nutrient cycling, and decomposition processes
  - Beetles, earthworms, and ants
- Invasive Species
  - Indicate an imbalance in the ecosystem; monitoring invasive species can drive mitigation and help native species move in
  - European starlings, invasive plants like English ivy and Himalayan blackberry

Table 4. Fillable table: Use this to brainstorm and sort relevant species at your site.

Generalists	Specialists	Invasives

Step 4. Using all the information above, compile the final target species list.

Keep total species to 10 to avoid overwhelming community volunteers and simplify tracking for staff. Species should be a mix of generalists and specialists to reflect the potential of the site in the long and short term, though not necessarily 50/50 if more of one or the other emerges from the research above. Organize them in the table below.

Table 5. Fillable table: Use this to further organize target species selections alongside key information.

Scientific Name	Common Name	Specialized or General Species?	Conservation Status	Observed locally? (Yes/No)

Step 5. Indicate the habitat needs, lifecycle/daily preferences, and any anticipated specialized monitoring requirements of selected target species.

This will provide helpful information when determining the right monitoring methods for the species list. Aligning monitoring efforts with life cycles and movements of target species ensures the most representative data of the site.

Habitat Features: Specific features within habitats that the species requires (e.g., tree cavities, water sources, vegetation types).

Life Cycle Habits: This includes breeding and nesting periods, feeding, migration, and times most active seasonally.

Breeding Season: Times of the year when the species is likely to be breeding or nesting.

Migration Patterns: Information on whether the species is migratory and, if so, when it is likely to be present in the area.

Active Periods: Times of the day or year when the species is most active. This information should be available in any guide featuring the target species.

For example:

- Nocturnal: Active primarily at night (e.g., owls, bats, many frogs and salamanders).
- Diurnal: Active during the day (e.g., most birds, butterflies, odonates, some frogs in wet conditions).
- Crepuscular: Active during twilight hours, such as dawn and dusk (e.g., deer, mosquitoes, moles).
- Matutinal: Active in the early morning (e.g., some species of bees).
- Vespertine: Active in the evening (e.g., moths, some birds).

Specialized Monitoring: If special expertise or unique capture methods are needed to identify this species make note below. For example, audio recordings (some bats and birds) and cover boards (reptiles and amphibians) are specialized methods, but expertise may come in handy for getting species ID on small insects or unique birds.

Table 6. Fillable table: use this to organize information on target species habitat and activity information before selecting monitoring methods.

Common Name	**Preferred Habitat Features**	**Life Cycle Habits**	**Active Periods**	**Requires Specialized Monitoring?**

Integrating Existing Data

Table 7. Key Strengths and Weaknesses of Integrating Existing Data method.

Key Strengths	Key Weaknesses
○ Lowest requirement of staff time ○ Ongoing source of data ○ Can be used for any GRI typology in any location if existing data is present	○ Least control over bias, therefore subject to high degree of observer preference

Program Coordination & Data Curation	Training & Support	Recruitment & Outreach	Communication Coordination	Volunteer Recognition	Legal & Safety Coordination	Evaluation & Reporting
high	low	moderate	low	low	moderate	high

All monitoring should begin with reviewing existing data, and in cases where there are limited resources (time, staff capacity, budget, etc) this could constitute the entirety of data collection for a site. In some cases, there may be extensive inputs of incidental data; for example, Hinge Park is a top observed location in Vancouver and has many new data entries a day.

For each site you want to know more about, take some time to explore what datasets already exist for the area or species you're interested in. Platforms like iNaturalist, GBIF, and BC Species and Ecosystem Explorer are great sources for information that is maintained independently and reliably. Groups such as Nature Vancouver, South Coast Conservation program, and Stanley Park Ecological Society (among others) have their own programs to collect data and support conservation, making them strong partners when looking to source data or support to future efforts. It is good to regularly scan new observations across the city to get a feel for which species are where. Email alerts for new species can be set up on iNaturalist, under “Places” on the bottom left-hand side, or on your profile, under “Following”.

Staff should set themselves up to access existing information by creating a profile on relevant websites and databases, conducting outreach towards groups with demonstrated experience and expertise in species monitoring, and becoming familiar with search functions on databases to find relevant data.

Data on the platforms mentioned above is contributed by iNaturalist users and government organizations, with considerable support from naturalist groups during annual events like the City Nature Challenge, Big Backyard Bioblitz, and Christmas Bird Count. One way to ensure consistent community monitoring is by building support for casual, incidental observers. Strategies for this are outlined below.

Supporting Casual Observers

Providing interested community members with tools for resource identification is another good way to support robust observations. Emphasize that the focus is on wild, not captive or planted, species. Observations of pets, gardens, farmed animals, and other domestic and introduced organisms are likely to appear, but can be reduced with resources to support more diverse observation. Staff can increase observation at a site (and regionally) with signage, like the one shown below at the Galiano ferry terminal. This is a very simple way to begin building a “culture” of biological observation and should be accompanied by resources like the ones above. A QR code to a landing page with more information will further support observers in making strong observations.

Figure 11. Sign on Galiano Island inviting iNaturalist observations from visitors.

See Section 3.2 *Accessing Data on iNaturalist* for more information about accessing and applying data found on iNaturalist.

Building a Webpage for Resources

Community monitoring begins by providing participants with information and resources. Creating a webpage that invites participation, offers tips, and links to training materials is a first step to engaging communities and automating engagement (which also helps to relieve some outreach on behalf of staff!).

Below are a few examples of strong webpages with a good mix of information and visual interest to inspire a local resource.

- Waukesha County, USA
- Surrey, BC
- Victoria, Australia
- Wisconsin, USA

Site Adoption

Table 8. Key Strengths and Weaknesses of Site Adoption method.

Key Strengths	Key Weaknesses
◦ Invites community members to engage closely with their local environment ◦ Produces consistent data inputs ◦ Potential for higher degree of detail and complexity than casual observations	◦ Requires staff oversight ◦ May be difficult to source volunteers across all GRI typologies and city neighborhoods ◦ Relies on reliability of volunteers

Program Coordination & Data Curation	Training & Support	Recruitment & Outreach	Communication Coordination	Volunteer Recognition	Legal & Safety Coordination	Evaluation & Reporting
	moderate	high	moderate	high	moderate	high

This method utilizes existing stewardship programs, such as Seeding Stewardship, to engage local volunteers with regular monitoring of sites around their home, school, work, and recreational spaces. The sites can be pre-determined and distributed by staff coordinating activities in stewardship groups, likely according to the proximity of the volunteer to the asset.

Sites are a good fit for this approach if they are small (2500 square feet up to 1 acre, or a half city block[23]), fragmented from larger parks (like Stanley Park, Pacific Spirit Park, Everett Crowley, or Queen Elizabeth) or small-scale typologies with simple habitat structures (like bioswales, bioretention bulges and cells, and rain gardens).

These smaller spaces and assets, which include most green rainwater infrastructure, can be effectively monitored by recruiting local volunteers to make consistent visits. This model can encourage monitoring micro habitat (tree wells, puddles, hollow stems, etc.) that is unlikely to be effectively monitored through unstructured, casual monitoring. Staff can choose to direct volunteers to pay special attention to target species or monitor more generally. For site adoption volunteers directed to monitor for target species, an info sheet should be compiled with general species ID information, like the one found at the end of the Target Species Guide, shown filled out using Beaconsfield in this case study. Beyond target species, site adoption volunteers can keep an eye out for invasives, such as Himalayan Blackberry, Yellow flag iris, Reed canary grass, English ivy, Morning glory, and Purple loosestrife.

Frequency and Duration

To capture seasonal changes, encourage volunteers to choose a place that they pass through regularly and can plan to stop at least on a bi-monthly (once every two months) basis.

The duration of visits can vary widely, depending on whether monitoring is general or for target species and the size of the site. The Maritime Northwest Citizen Science Monitoring Guide recommends determining time spent on a walking transect by taking the total length of the site in feet and dividing it by 10 (for minutes to spend at site).[24] This may be fast for beginner observers, but it is a good minimum time recommendation.

Participants should pay attention to all parts of the site, observing as many different habitat types as possible. For example, at a site like 63rd and Yukon observation should include around rocks, on the soils, in the trees, and on the plants. At simpler sites, like Richards St. , monitoring tree wells and activity in the trees is sufficient.

Figure 12. *63rd and Yukon (left) and Richards Street Tree Well. From Shannon Mendes.*

Custom Projects

Table 9. Key Strengths and Weaknesses of Custom Projects method.

Key Strengths	Key Weaknesses
○ *Great for gathering baseline data, engaging many community members, and monitoring at larger scales*	○ *Can be administratively complex* ○ *Takes a long time to organize and analyze* ○ *Requires the most staff time* ○ *Only produces data for a site at the time of the event*

Program Coordination & Data Curation	Training & Support	Recruitment & Outreach	Communication Coordination	Volunteer Recognition	Legal & Safety Coordination	Evaluation & Reporting
high	high	high	high	high	high	high

Large scale green rainwater infrastructure projects, like engineered wetlands, floodable spaces, multi-block blue-green system installations and stream daylighting, require more intensive monitoring due to their size and complexity.[25] Custom projects, namely staff organized bioblitzes but also externally managed community projects like Chronolog, offer detailed information about areas with historically limited data, unique species and ecosystems, or novel habitats. These events are a good choice when a project goal includes establishing a baseline for species richness, engaging a community in design, or surveying at a larger scale. The challenge of monitoring in large and/or diversely populated areas benefits from having many volunteers survey them at once, especially when many levels of expertise are engaged. Keep in mind the total number of custom projects across all sites; committing to planning several different bioblitz events a year is likely to quickly exhaust staff. Choose sites with high species potential and complex habitat structures that will benefit most from the effort required or organize these projects.

Frequency and Duration

Bioblitzes are typically conducted annually. Sometimes it may be more appropriate to select a bi-annual method, to capture seasonal variation. For example, a survey scheduled between March-August would represent peak activity for birds, pollinators, and plant growth but miss out on species that favor fall/winter conditions. Some local birds (migratory ducks) and mammals (such as beavers and otters) are more active in the cooler months, while other species breed during cold months in coastal environments (some salamanders and newts). A notable example of a potential green rainwater infrastructure target species that would benefit from winter monitoring is the Autumn Meadowhawk, a dragonfly with Species at Risk status in British Columbia that changes color during cooler months and becomes more observable. [26]

For green rainwater infrastructure, a great deal of habitat value comes from standing water, which fills during fall and winter months. Though summer is a good time for community participation and species sightings, staff might consider a fall or early spring event instead of a summer one if species attributes imply that those seasons are more likely to result in observations.

Frequency should also be chosen for the specific goals of the project; conducting a monitoring event a year before construction on a site starts, and a year after it is completed, for example. This could give a snapshot of information about how the habitat has changed and invite community members to experience the new space more intimately. If the project's primary objective is to encourage community engagement with the space, invite members in even if the site is not completed or reach maturation.

The duration of the event will also influence observations. An event that is a half day, whole day (12 hours), 24 hours, or even several days will have different outcomes. In person programming is typically only conducted over a half or whole day, any remaining time for observations conducted independently. If experts are invited, starting the day with a more detailed “blitz” and ending with public engagement is common.

For a reminder of common tools and approaches, see section 1.2 of this report.

Engaging Experienced Participants

Forming partnerships with research groups, ecological societies, or professional naturalists is a great way to rapidly enhance data quality from a community science event. In 2022, Stanley Park Ecological Society conducted a bioblitz in partnership with the Entomological Society of BC and the Biological Survey of Canada.[27] With 27 observers over a couple of hours, they obtained 135 research-grade species observations, representing 14% of all species recorded in the park to date, captured in just 2% of the total observations. Offering honorariums is common if invitations are extended to individual practitioners. A source of informed volunteers could be undergraduate biology classes or field courses, who often seek opportunities practical field experience, local nature clubs, or even a database for registered biology professionals.

Collection Projects

A collection project, mentioned here and elaborated upon in Section 3.2 *Leveraging iNaturalist for Monitoring*, is my recommended method for organizing custom projects on iNaturalist. Instead of requiring all members join a project to contribute, like traditional projects do, collection projects only require that organizers designate a place of interest and optionally add filtering criteria. It will then 'collect' eligible observations made in that shape file, regardless of whether observers attended an organized bioblitz or joined the project page. It is a great choice for more automated, broad data efforts where widespread participation is the focus.

3.2 Leveraging iNaturalist for Monitoring

iNaturalist, often called iNat, is one of the world's largest platforms for community science. Not only does it function as a human and AI powered social network for learning about nature, but as a crowdsourced identification tool and occurrence recording platform for hundreds of thousands of species. Engagement with the platform is already high in Vancouver, with more than 10,000 observers in the area. The app is free and easy to use, easing the burden on staff to educate users. This report features several user guides, selected from hundreds freely available online.

Knowing what iNaturalist is, and is not, enables users and planners to get the most out of it. Strengths of the platform include organizing species observations, supporting nature education, engaging communities, and presenting data accessibly. For staff to support observers and distill findings from the methods above, there are some important practices and terms to know, below.

General Use of iNaturalist

iNaturalist has an extensive library of training resources as well as a moderated forum. Below are a few essential resources to start with.

Getting Familiar with iNaturalist

Below is a collection of resources to support staff and observers with getting started on the platform and familiar with the different types of projects.

iNaturalist Getting Started Guide: A basic guide that explains how to create an account, make observations, and navigate the platform

iNat Help Forum (Knowledge Base): FAQs that cover a wide range of information about the platform and contributing to it.

Understanding and Managing Projects: An overview on to how to lead projects on the platform. Staff should start here to learn about their options with project design and pick up tips from the iNat team.

Video Tutorials: These are helpful for staff, but mostly oriented towards users; this would be a good page to share with volunteers, put on the website, or integrate into communications for a custom project.

User Resources for Improving Observations:

These will support new and improving observers. They would be useful across all three of the community monitoring methods.

Tips from the Nature Conservancy Canada:[28]

For Beginning Observers:

- Identify species that don't move, like trees and flowers.
- Look for slow-moving creatures, like slugs and snails.
- Help identify invasive species in your province so these can be mapped and tracked.
- Focus on one type of habitat each day: maybe a pond on one outing and a forest the next.

For Advanced Observers:

- Share observations from your taxonomic specialty.
- Document rarer and/or often-overlooked species, such as insects.
- Help identify invasive species in your area so these can be mapped and tracked. You can find examples of local invasive species here.
- Help less-experienced participants identify their observations. Select the "Identify" option in iNaturalist.

Photographing Insects

Photographing Plants

Photographing Mammals

Photographing Birds

Documenting Nature Without Damaging It

Documenting Invasive Species (and using iNaturalist in general), by the Invasive Species Council of BC

A resource from iNaturalist on how to make a "good" observation

A resource from BC Parks on species to start with and staying safe

Types of Observations

All observations on iNaturalist are contributed by users, who can delete their data at any time. Though the platform holds an extensive amount of information, it is not intended to store historical or important data indefinitely. For long term trend analysis check the Global Biodiversity Information Network, where research grade iNaturalist observations are exported weekly.

Types of Data Collection

There are three types of data collection, with the majority of iNaturalist observations being incidental (also called casual).[29]

Incidental data collection: an "incomplete" checklist of species in the area, collected while user's focus was on another task (walking, gardening, doing something outside of one's home). Most existing iNaturalist data will have been collected this way. Bioblitzes can be designed to use more controlled data collection (the following two types), but many participants are likely to use more of an attention-led strategy of selecting species to observe. The data validity gained through training participants to observe using a non-incidental method is not necessary for most community monitored science uses.

Stationary data collection: a more complete record of species in an area. The user's primary focus was species observation, and they know the exact time observation began and ended. Taken from a single, fixed location for the duration of observation. This could be one strategy proposed to site adoption volunteers, depending on the location of their site and whether they could remain in one spot for the duration of their time there. A disadvantage of this strategy is that it can negate smaller species, as scanning from one spot tends to advantage larger bodied birds.

Travelling data collection: similar to stationary collection but moving across a landscape on a transect. The user's primary focus was species observation (often only shore birds or another narrow subsect of local wildlife), they know the exact time observation began and ended and how far they travelled (usually more than 30m from starting point, without repeat sections). Many bioblitzes use this method, but without tracking of crossing back over one's path. Site adoption volunteers are also likely to use this method as they move across their site. This collection strategy is especially well suited to scanning for target species across a landscape.

Types of Projects

Collection Projects: This feature enables the creator to craft a project that will accept observations on a rolling basis, so long as they meet selected parameters. For instance, collection parameters include location, users, and taxa, in addition to data quality and time (none, all or some of these can be selected). Collection projects have the same user-friendly project page, and therefore data visualization tools. This project type is especially useful for gathering desired observations within a geographical location without requiring all observers to manually opt into contributing to a project, as is necessary for iNaturalist's "traditional" project. These save staff time without compromising data collection.

Another advantage of the collection feature is its ability to house data from all three of the monitoring methods. For instance, with a collection project filtered to include all green rainwater infrastructure sites, staff could monitor one project page for new data across all monitoring activity. Or, one collection project for all site adoption areas, one for large sites that will be monitored via a combination of methods, and so on. This degree of customization should be sufficient for any monitoring needs described in this report.

Resources for setting up a Collection Project

For more information on use cases, check out this article.

For a guide on how to set parameters, check out this article.

For a general guide on setting up a collection project, look here (the example given is a grassland project, but the same steps apply).

Traditional Projects: Differs from a collection project by having more customizable features on the admin side, allowing for more specificity and detailed projects. However, all users must manually select to join the project to contribute and upload their observations to the project page (no automatically sorted uploads). This requires that projects have considerable outreach and communication components. Traditional project creators must also have made 50 observations. These are unlikely to be used as often as collections, unless participation needs to be limited to members of a specific group or specific training is needed to participate. A notable advantage of traditional projects being used for custom projects is their ability to require certain fields be filled in, helpful where high quality control is desired.

Umbrella Projects: Enables comparing or collating a set of existing projects with an organized landing page to look through observations. Can organize collections over time at the same place, for example. This could be useful, but most focus is on present and future species data, not past.

Accessing Data on iNaturalist

An advantage of utilizing iNaturalist across all monitoring methods is the synergistic data organization and ease of access. Staff can go to the platform anytime to retrieve data, compare different sites and timelines, and review species observations as they are added. Below are a few tips for retrieving data on the platform more effectively.

Note: if a citation for data is needed, retrieve data from GBIF (can filter for iNaturalist contributions), as they will generate a citable DOI.

Searching for Places on iNaturalist

The default search for "Vancouver" in the location bar produces a map titled "Vancouver Marine Waters". To get to the pages showing data for Vancouver's municipal city boundary (with the addition of Pacific Spirit) use the URLs below or follow the step-by-step instructions.

Finding Vancouver, BC on iNaturalist

Each of the following iNaturalist links leads to a page for Vancouver, British Columbia (Municipality). Each has a slightly different strength and may be used according to staff preference or the needs of the task being performed. The appearance and navigation of the Explore page is overall most easily used for most tasks . The Places page gives a different view of observations and can be better for looking for trends in user preferences, overall species presence, and quickly filtering results. The Checklist page is mostly useful for filtering by taxon and reviewing the last observation of a species.

- Explore result for Vancouver, BC (Municipality)
- Places result for Vancouver, British Columbia (Municipality)
- Checklist result for Vancouver, British Columbia (Municipality)

Species observations for Vancouver can also be found on [GBIF](). This is a great place to go if a DOI citation is needed, or to only review research grade results.

Step-by-Step Instructions:

- Under the “Explore” tab, press “Filter”. In the “Place” box, in the bottom left-hand corner (you may have to select “More Filters”), type in “Vancouver”, and choose “Vancouver, British Columbia (municipality).

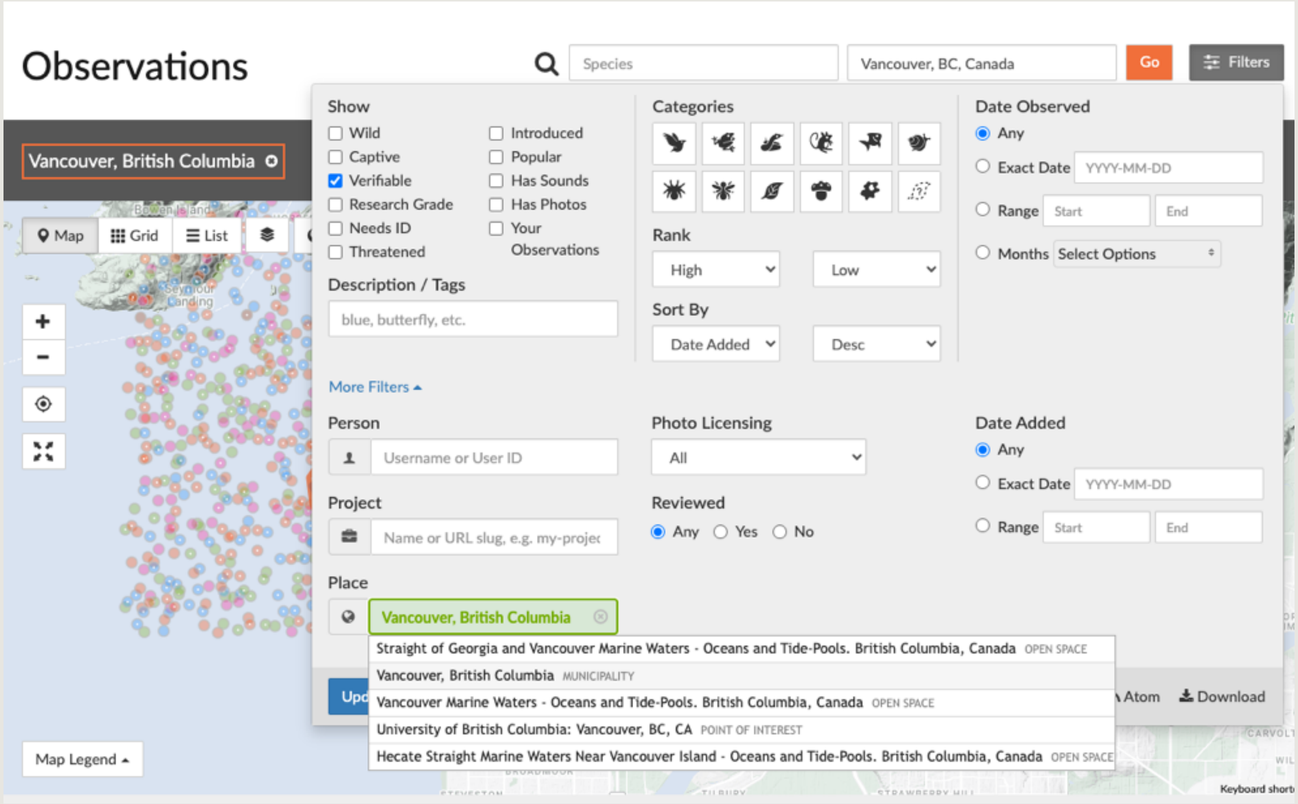

Figure 13. Screenshot showing where to filter for "place" on iNaturalist.

Downloading Data

Downloading data is relatively simple, both on project pages and in searches.

To download from a Collection Project, click "View All" to show all observations and use filter feature. Or, navigate to the “Observations” tab on the main page and click the "Export Observations" link. They get you to the same spot! You will be prompted to further filter results or download from GBIF if it is a large export, to avoid slogging down iNaturalist servers.

For traditional projects, it is the “Export Observations” button on the right side of the page. A ”download” button is in the bottom right of the filter box for all searches and will collect any information.

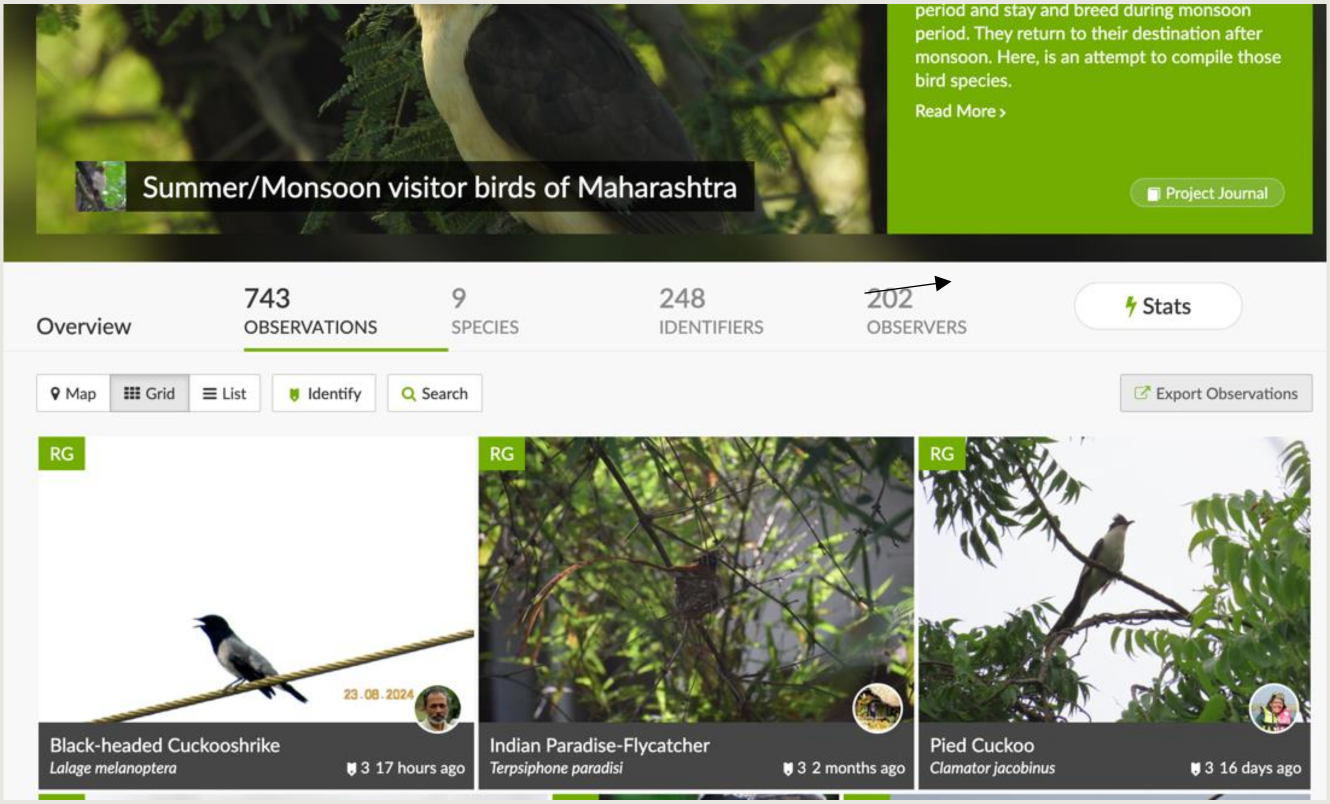

Figure 14. Screenshot showing where to download data on iNaturalist.

For more detailed download instructions, check out this resource from UCLA.

Filtering event details can offer organizers a wealth of information; try filtering by “native” species, "threatened” species, or detailed tags. Data can reveal information about how species are moving through the city, which species are utilizing which areas, species richness at different stages of observation, or invasive species progression. Key indicator species, a common point of monitoring focus, are discussed next.

3.3 Planning Guides for Staff

Below are several fillable sheets that were developed to support staff as they apply findings from this report and plan for monitoring at different sites around the city . The two sheets, titled “Target Species Selection Guide and Visual Identification Sheet” and “Community Monitoring Methods Planning Sheet” should be completed in the order they are listed. A case study example is included for Beaconsfield Park, a green rainwater infrastructure project in progress as of August 2024.

Target Species Selection Guide and Visual Identification Sheet.pdf

> This tool should be used to assess habitat offerings and make target species selections. The first part is a step-by-step guide to choosing a diverse and representative target species list. The second part is a sharable sheet with species identification information, to be shared with volunteers before they start making observations at the site.
>
> Case Study: Target Species Guide and Visual Identification Sheet Beaconsfield Case Study.pdf

Community Monitoring Methods Planning Sheet.pdf

> This tool will support staff as they consider which combination of methods will best suit their specific site objectives. Though all projects will have unique needs and considerations, a general guide on typologies and best suited methods is included. Staff should reference this document in tandem with Section 3.1 of the report to compile a monitoring plan.

Resources on Local Species and Ecosystems

Databases:

BC Conservation Data Center: This is another source for species occurrence data and information on biodiversity, compiled by a network of governmental and non-governmental programs around the US and Canada. Below are a few helpful links and tools from them.

BC Species and Ecosystems Explorer: A tool that can offer information about the species and ecological communities in BC, generate lists based on your chosen criteria, and support research on which species may occur in your area of interest. This is a great place to start before conducting surveys or reviewing monitoring

CDC iMap: This map offers occurrence data of red and blue listed species and could be helpful when determining target species and conservation priorities.

Local Species Guides:

Delta Naturalist's Species Identification Guides (Animals, Birds, Bugs, Butterflies/Moths, Damselflies/Dragonflies, Flowering Plants, Intertidal Life, Mushrooms, Woodland Plants, Garter Snakes)

Birds (of St. George Rainway and beyond) on iNaturalist

Common Birds of Vancouver by Bird Studies Canada

Animals of Lower Mainland on iNaturalist

Pacific Northwest Rainforest Trees on iNaturalist

Salamanders and Newts of the South Coast by Fraser Valley Conservancy

Profiles for local At-Risk Species by South Coast Conservation

ID Guide for Pollinators by Border Free Bees and EYA

Seasonal ID Guide for Birds by BirdsCanada

Section 4: Opportunities for Future Work

Developing a community monitoring program across City of Vancouver and Parks Board projects offers to generate current data about species, insight on the function of new habitat, and invite communities into the stewardship of natural areas in the city. As staff become more comfortable with community science programming, opportunities arise to enhance and continue building on these techniques. Future opportunities may include:

- **Encourage monitoring on private land**
    - Provide tools and suggestions to stewards of private land (renters and owners) for monitoring and enhancing biodiversity on their properties. This could include building capacity for landscaping with native plants and guidance for monitoring species in gardens and at feeders.
- **Enhance communication about community monitoring**
    - Engaging community members in monitoring begins with effective outreach. Building a website, creating marketing resources, engaging with new volunteers, and creating opportunities for people to learn how they can contribute to monitoring will be an ongoing effort. This could be integrated into the reporting process by creating a landing page where participants and those interested can learn more.
- **Developing a comprehensive species list for habitats around the city**
    - This could support staff by further classifying local species according to their habitat preferences, adaptability to urban environments, and conservation status. The key indicator species list developed for this report, ultimately included in the appendix, could be a starting place. The research by James (2018) on urban species adapted guilds could further support deciding on guild classification for key indicator species (a longer list that target species could be selected from).
    - Data on observations of different species could be tracked from monitoring data, informing goals and success of habitat indication.
- **More emphasis on alternative timing and methods in monitoring**

  - Including surveys at dawn, dusk, and nighttime and using audio monitoring (bird and bats).
  - This could come with partnerships with researchers, universities, or naturalist groups.
- **Explore opportunities to support qualitative and experiential community science**
  - Pamela Zevit (R.P.Bio), at the City of Surrey, suggested working on language integration to include traditional names for native species on iNaturalist.
  - This would require close collaboration with the host nations, xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh).
  - In addition to language, the idea of integrating more qualitative and experiential evidence, such as oral history, was mentioned at the workshop,
- **Form partnerships to support participation of equity-denied groups**
  - This could be with community centers, schools, or other outreach programs that engage equity-denied communities in science programming and other educational opportunities.
- **Invite libraries to engage in community monitoring training**
  - Here is a resource on libraries and community monitoring
- **Offer resources for more age groups and skill levels, such as school aged kids**
  - Seek is the kid friendly alternative to iNaturalist. Inviting schools and families to explore that platform could be a good supplement to custom projects and other engagement events.
  - Nature Conservancy Canada has developed worksheets for kids as well as some fun games for learning about community science.

Summary

This report explores the potential of community monitoring to engage locals, enhance data-driven planning, and gather information on how urban wildlife utilize green rainwater infrastructure. It includes an overview of the applications and benefits of community monitoring, along with an examination of modern tools and key considerations for their use. A set of methods is proposed and organized according to staff and site needs, with a particular focus on selecting and monitoring target species. This report should be used with the accompanying staff resources: the Target Species Guide and Visual Identification Sheet and the Community Monitoring Methods Planning Sheet.

The methods outlined are intended as a starting point and are expected to evolve with staff and participant feedback. Municipal use of community-gathered data is a developing field, requiring iterative design and a curious mindset when testing approaches. The monitoring methods are designed to balance achieving results with ease of implementation, though opportunities for expanding reach or adding complexity are discussed in Section 4.

The research, guides, and tips included above provide a foundation for designing and implementing a biodiversity monitoring program powered by community members. Understanding how wild species interact with municipally designed spaces is crucial to creating a green city that benefits all inhabitants. Regardless of the methods chosen and their implementation, the practices outlined in this report will empower staff and locals to engage more deeply with nature, contributing to the health and resilience of Vancouver's human and non-human communities.

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Appendices

Below are several resources that were not ultimately included in the body of the report but may be relevant for future work.

Appendix A: Full Links from this Report

The full web address of each of the links from this report are included below, organized by page number and listed in order of appearance.

Page 17

- https://www.inaturalist.org/projects/st-george-rainway-biodiversity
- https://www.inaturalist.org/projects/city-nature-challenge-2024-metro-vancouver-regional-district-mvrd
- https://www.inaturalist.org/observations?place_id=122697&subview=map
- https://www.inaturalist.org/places/greater-vancouver
- https://inaturalist.ca/observations?place_id=7085&subview=map

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- https://www.whistlernaturalists.ca/
- https://www.surrey.ca/renovating-building-development/land-planning-development/environmental-protection/biodiversity
- https://www.surrey.ca/renovating-building-development/land-planning-development/environmental-protection/biodiversity/design-guidelines
- https://www.ealt.ca/
- https://www.parks.vic.gov.au/get-into-nature/conservation-and-science/science-and-research/become-a-citizen-scientist
- https://www.waukeshacounty.gov/landandparks/park-system/ConservationintheParks/CitizenSciencePrograms/

Page 19

- https://wiatri.net/cbm/
- https://www.natureguidesbc.com/Links.html

Page 22

- https://vancouver.ca/files/cov/seeding-stewardship-program-overview.pdf

Page 23

- https://vancouver.ca/home-property-development/adopt-a-catch-basin.aspx
- https://vancouver.ca/home-property-development/green-streets-program.aspx

Page 33

- https://emeraldfoundation.ca/aef_awards/the-master-naturalist-program/#:~:text=The%20program%20has%20a%20learn,through%20stewardship%2C%20monitoring%2C%20naturalization%20and

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- https://stanleyparkecology.ca/wp-content/uploads/2021/07/Co-Existing-with-Coyotes-Poster.pdf
- https://vancouver.ca/parks-recreation-culture/urban-coyotes.aspx
- https://loonlake.ubc.ca/blog/3-toxic-plants-you-havent-heard-of-in-bc

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- https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-conservation/wildlife-health/what-to-do-if-you-find-sick-injured-or-dead-wildlife

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- https://inaturalist.ca/observations?place_id=122697&subview=map
- https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer

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- https://www.waukeshacounty.gov/landandparks/park-system/ConservationintheParks/CitizenSciencePrograms/
- https://www.surrey.ca/renovating-building-development/land-planning-development/environmental-protection/biodiversity/community-science

- https://www.parks.vic.gov.au/get-into-nature/conservation-and-science/science-and-research/become-a-citizen-scientist
- https://dnr.wisconsin.gov/topic/WildlifeHabitat/citizenMonitoring

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- https://bcnature.org/bc-nature-clubs/
- https://cab-bc.org/about-the-college/colleges-public-register/

Page 59

- https://inaturalist.freshdesk.com/en/support/solutions/folders/151000552105-
- https://inaturalist.freshdesk.com/en/support/solutions
- https://inaturalist.freshdesk.com/en/support/solutions/articles/151000176472
- https://inaturalist.freshdesk.com/en/support/solutions/folders/151000547795-

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- https://secure.natureconservancy.ca/site/DocServer/BioBlitz_2024_Photographing_insects_EN_finalized.pdf
- https://secure.natureconservancy.ca/site/DocServer/BioBlitz_2024_Photographing_plants_EN_finalized.pdf
- https://secure.natureconservancy.ca/site/DocServer/BioBlitz_2024_Photographing_mammals_EN_Finalized.pdf
- https://secure.natureconservancy.ca/site/DocServer/BioBlitz_2024_Photographing_Birds_EN_finalized.pdf
- https://secure.natureconservancy.ca/site/DocServer/BioBlitz_2024_Documenting_nature_without_damaging_it_EN_.pdf
- https://www.youtube.com/watch?v=eMoPHdLYgDY
- https://www.inaturalist.org/posts/15804-tips-for-making-great-observations
- https://eadn-wc02-5494031.nxedge.io/wp-content/uploads/2023/03/ID-guide.pdf

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- https://www.gbif.org/

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- https://inaturalist.freshdesk.com/en/support/solutions/articles/151000176246-common-collection-project-use-cases
- https://inaturalist.freshdesk.com/en/support/solutions/articles/151000176699-collection-project-observation-requirements-settings
- https://www.segrasslands.org/new-inat-project

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- https://inaturalist.ca/observations?place_id=122697&subview=map
- https://www.inaturalist.org/places/vancouver-british-columbia
- https://www.inaturalist.org/check_lists/850702-Vancouver--British-Columbia-Check-List?view=photo

Page 65

- https://gsmit.org/wp-content/uploads/2021/04/inaturalist_data_walkthrough.pdf

Page 66

- https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre
- https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer
- https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/known-locations-of-species-and-ecosystems-at-risk/cdc-imap-theme

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- https://deltanaturalists.org/nature-resources/
- https://www.inaturalist.org/guides/14821
- https://vancouver.ca/files/cov/map-guide-common-birds-of-vancouver.pdf
- https://www.inaturalist.org/guides/5005
- https://www.inaturalist.org/guides/10284
- https://fraservalleyconservancy.ca/wp-content/uploads/2018/03/Salamander-ID-hi-res.pdf
- https://sccp.ca/species-and-habitat
- https://borderfreebees.com/wp-content/uploads/2017/11/Common-Pollinators-of-British-Columbia-2nd-Edition.pdf

- https://naturecounts.ca/apps/checklist/index.jsp

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- https://scistarter.org/library-training
- https://secure.natureconservancy.ca/site/SPageNavigator/BioBlitz_2024/BB_2024_content.html?s_locale=en_CA&utm_source=eblast&utm_medium=email&utm_campaign=NAT_BIOBLITZ&utm_content=Autoresponder
- https://bootcamp.cvn.columbia.edu/blog/how-to-impact-your-community-with-citizen-science-even-if-youre-new-to-data-analysis/#1631676384590-4eea0a2e-41b4

Appendix B: Tips for Organizing a BioBlitz

Many guides have been compiled advising on methods and strategies for successful bioblitz planning. The questions I think would be most helpful for staff planning an event are below, along with guides and tips.

Guiding Questions for BioBlitz Planning:

  - What are my goals?
  - What are the most important outcomes? Is it engaging community, surveying the environment, or both?
    - More thorough surveys require more trained participants, more organization, and a longer running time. Usually, they engage experts and may even assign participants specific jobs based on their comfort and interest.
- How will I engage participants?
  - Promotion is a key element of a bioblitz. Partnerships, mentioned below, can ease the work of outreach. Otherwise, signage at the site and local community center and other public engagement strategies are likely to work well.
- How can I make this event more inclusive and accessible?
  - Do I have access to the proper resources?
    - Events may benefit from field guides, binoculars, bug nets, microscopes, Wi-Fi, etc.
  - Does a partnership make sense for this event?
    - Working with local naturalist groups to take advantage of their regular programming and volunteer base and share the logistical tasks can make regular bioblitz events more

achievable. This may also provide better access to local experts.

    - How will I report back to participants?
        - iNaturalist has a great landing page that makes reporting back key statistics and findings simple. Consider taking advantage of this and the “journal” feature to avoid writing lengthy reports. Collect participant emails to keep them up to date about future opportunities.
- Additional Planning Considerations:
    - Venue layout, licenses, extra parking, health and safety plan, first aid and emergency preparedness.
    - Healthy and safety includes any important information about potentially dangerous/toxic plants and insects, observing near the road, etc. Conduct a risk assessment to determine which types of risks participants may face and what staff could do to lessen them.

Appendix C: Regional Key Indicator Species

This section includes some helpful information about distinguishing between key indicator species and bioindicators. In the end, the language of the report was “target species,” chosen for the increased clarity with meaning and selection process over “key indicator species”. A list of species is also included, all relevant to the lower mainland.

At the time of this report, Vancouver does not have a formal list of key indicator species to be used for ecological planning. Key indicator species, or KIS, refers to species that can be used as proxies to indicate the ecological health of an ecosystem and suitability of habitat for groups of species. For example, bumble bees are commonly used as an indicator for other insects, as their presence implies the food and habitat availability required for many insects. The figure below provides a set of standards for selecting indicators. The rest of this section includes a list of species I selected based on these standards that may be appropriate for use as targets within certain green rainwater infrastructure sites and other habitat improvement projects around the city.

Good indicator ability	Provide measurable response (sensitive to the disturbance or stress but does not experience mortality or accummulate pollutants directly from their environment)
	Response reflects the whole population/community/ecosystem response
	Respond in proportion to the degree of contamination or degradation
Abundant and common	Adequate local population density (rare species are not optimal)
	Common, including distribution within area of question
	Relatively stable despite moderate climatic and environmental variability
Well-studied	Ecology and life history well understood
	Taxonomically well documented and stable
	Easy and cheap to survey
Economically/commercially important	Species already being harvested for other purposes
	Public interest in or awareness of the speces

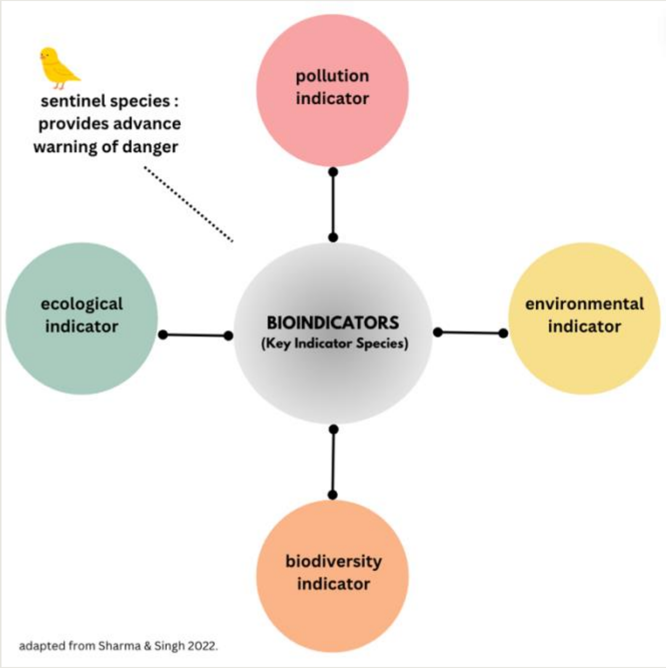
From. Holt & Miller (2010). Shared and important characteristics for key indicator species.

Bioindicators: These are species or groups of species used to monitor specific environmental conditions, detect pollution, or assess ecosystem health. Bioindicators are often chosen for their specific sensitivity to changes in their environment and can be used to qualitatively describe environmental change. They are often sub-classified according to the environmental characteristic they indicate for.

- Pollution – Indicates presence of pollutants
- Environmental – Indicates changes in environment (combined earth and life sciences, as well as habitat changes)
- Ecological – Indicates shifts in natural surroundings (species interactions)
- Biodiversity – Indicates changes in species composition and biodiversity

Key Indicator Species (KIS): These are species that reflect the overall health of an ecosystem. Their presence or behavior shows how well or poorly the environment is doing; often they are used to measure improvements in habitat. Key Indicator Species are a type of Bioindicator, chosen for the insight their presence provides about ecosystem health, but not all Bioindicators would be key indicator species (more chosen for sensitivity to environmental characteristics).

Sentinel Species: These species provide early warning of environmental changes or hazards, generally before other species begin to show signs of change. The “canary in a coal mine”.



Birds

Bald Eagle (*Haliaeetus leucocephalus*): [30]

- Indicator of ecosystem health and fish population levels
- Sensitive to environmental contaminants, such as heavy metals and pesticides
- Visual and audio monitoring

Great Blue Heron (*Ardea herodias*):[31]

- Indicator of wetland health
- Reflects the quality of aquatic ecosystems and the availability of prey species
- Visual and audio monitoring

Western Screech-Owl (*Megascops kennicottii*):[32]

- Indicator of urban forest health
- Sensitive to habitat fragmentation and changes in forest composition

- Visual and audio monitoring; highly nocturnal, so may require specialized monitoring

Fish

Pacific Salmon (*Oncorhynchus spp.*):[33]

- Indicator of freshwater and marine ecosystem health
- Reflects changes in water quality, habitat availability, and climate conditions
- Visual surveys and stream surveys

Three-spined Stickleback (*Gasterosteus aculeatus*):[34]

- Indicator of freshwater ecosystem health
- Sensitive to pollution and changes in water quality, though very tolerant to severe hypoxia (low oxygen) and variable salinity; they are likely to be an early fish species to re-appear (indicating improvements) or conversely signal extremely poor quality with their disappearance
- Visual Surveys

Coastal Cutthroat Trout (*Oncorhynchus clarkii*):[35]

- Indicator of intact stream and estuarine ecosystems with clean water and healthy riparian zones
- Needs diverse, complex habitats and cold, clean water for all life stages
- Visual and stream surveys; only likely to appear in minimally disturbed areas.

Amphibians

Northern Red-legged Frog (*Rana aurora*): [36]

- Indicator of wetland and riparian health
- Sensitive to changes in water quality and habitat degradation
- Visual Surveys for individuals or egg clusters

Western Long Toed Salamander (*Ambystoma macrodactylum*):

- Indicator of wetland and riparian health; live in fish free areas
- Sensitive to changes in water quality, environmental toxins, and habitat loss/fragmentation
- Visual Surveys and Cover Board monitoring in early spring[37]

Western Toad (*Anaxyrus boreas*):[38]

- Indicator of strong wetland and upland ecosystem health
- Reflects changes in moisture regimes and habitat availability
- Visual and Audio surveys

Invertebrates

Banana Slug (*Ariolimax columbianus*)

- Banana Slugs are sensitive to habitat quality and moisture levels
- Presence can indicate the health of forest floor ecosystems, particularly in relation to moisture, organic matter, and habitat integrity
- Visual Surveys

Butterflies (e.g., Western Tiger Swallowtail, *Papilio rutulus*):[39]

- Indicator of terrestrial ecosystem health
- Reflect changes in plant diversity and habitat quality, strong preference for healthy riparian habitat along streams and rivers
- Visual Surveys

Odonates (Dragonflies and Damselflies, e.g. Blue-eyed Darner, Common Green Darner, Eight-Spotted Skimmer)

- Indicator of terrestrial ecosystem and wetland health, sensitive to pollution and habitat loss
- Reflect changes in plant diversity and habitat quality, strong preference for healthy riparian habitat along streams and rivers
- Visual Surveys

Lichen

Old Man's Beard (*Usnea spp.*):[40]

- Indicator of air quality
- Sensitive to air pollution, particularly sulfur dioxide and nitrogen oxides
- Visual Surveys

Mammals

River Otter (*Lontra canadensis*):

- Indicator of freshwater and coastal ecosystem health
- Reflects the quality of aquatic habitats and the availability of prey species

- Visual Survey

Beaver (*Castor canadensis*.):

- Sensitive to disturbance, pollution, habitat degradation, and altered hydrology due to urbanization
- Reflects the quality of aquatic habitats
- Visual Survey

Coast Mole (*Scapanus orarius*):

- Indicator of soil health and ecosystem productivity
- Sensitive to soil compaction, pollution, and habitat disturbance
- Burrow Surveys, Visual Surveys

Little Brown Bat (*Myotis lucifugus*):

- Indicator of insect population dynamics and ecosystem health
- Sensitive to habitat loss, pesticides, and White-nose Syndrome
- Acoustic Surveys, Roost Counts, Visual Survey

Sliver-haired Bat (*Lasionycteris noctivagans*):

- Indicator of forest health and insect population control
- Sensitive to deforestation, pesticides, and climate change
- Acoustic Surveys, Roost Counts, Visual Survey

Muskrat (Ondatra zibethicus):

- Indicator of wetland health and water quality
- Sensitive to water pollution, wetland drainage, and habitat alteration
- Visual Surveys

Endnotes

[1] Ellwood, E. R., Pauly, G. B., Ahn, J., Golembiewski, K., Higgins, L. M., Ordeñana, M. A., & Von Konrat, M. (2023). Citizen science needs a name change. *Trends in Ecology & Evolution*, *38*(6), 485-489.
[2] https://www.khanacademy.org/science/ap-biology/ecology-ap/biodiversity/a/community-structure
[3] Wintle, B. A., Kujala, H., Whitehead, A., Cameron, A., Veloz, S., Kukkala, A., ... & Bekessy, S. A. (2019). Global synthesis of conservation studies reveals the importance of small habitat patches for biodiversity. *Proceedings of the National Academy of Sciences*, *116*(3), 909-914; Lindenmayer, D. (2019). Small patches make critical contributions to biodiversity conservation. *Proceedings of the National Academy of Sciences*, *116*(3), 717-719.
[4] https://metrovancouver.org/services/regional-planning/Documents/connecting-the-dots.pdf
[5] https://citieswithnature.org/wetlands-nurturing-communities-and-sustaining-urban-life/
[6] Ibid.
[7] Theobald, E. J., Ettinger, A. K., Burgess, H. K., DeBey, L. B., Schmidt, N. R., Froehlich, H. E., ... & Parrish, J. K. (2015). Global change and local solutions: Tapping the unrealized potential of citizen science for biodiversity research. *Biological Conservation*, *181*, 236-244.
[8] Ibid.
[9] Hognogi, G. G., Meltzer, M., Alexandrescu, F., & Ştefănescu, L. (2023). The role of citizen science mobile apps in facilitating a contemporary digital agora. *Humanities and Social Sciences Communications*, *10*(1), 1-16.
[10] Callaghan, C. T., Poore, A. G., Hofmann, M., Roberts, C. J., & Pereira, H. M. (2021). Large-bodied birds are over-represented in unstructured citizen science data. *Scientific reports*, *11*(1), 19073.
[11] Hognogi, G. G., Meltzer, M., Alexandrescu, F., & Ştefănescu, L. (2023). The role of citizen science mobile apps in facilitating a contemporary digital agora. *Humanities and Social Sciences Communications*, *10*(1), 1-16.
[12] These themes were derived from conversations with staff during the workshop organized by the scholar to fulfill the project objectives.
[13] https://summit.sfu.ca/_flysystem/fedora/sfu_migrate/19683/etd20491.pdf
[14] Referred to in the study as 'historical redlining,' which is not used here due to limited familiarity with the term in Canadian context. From Ellis-Soto, D., Chapman, M., & Locke, D. H. (2023). Historical redlining is associated with increasing geographical disparities in bird biodiversity sampling in the United States. *Nature Human Behaviour*, *7*(11), 1869-1877.
[15] See Carlen, E. J., Estien, C. O., Caspi, T., Perkins, D., Goldstein, B. R., Kreling, S. E., ... & Schell, C. J. (2024). A framework for contextualizing social-ecological biases in contributory science data. People and Nature, 6(2), 377-390 for more on how filters are related to bias and can skew observation data in cities.
[16] West, S. E., & Pateman, R. M. (2016). Recruiting and retaining participants in citizen science: What can be learned from the volunteering literature. *Citizen science: Theory and practice*.
[17] https://parkpeople.ca/blog/seeding-nature-connections-the-proven-benefits-of-park-stewardship-in-diverse-city-spaces
[18] https://www.citizenscience.gov/toolkit/howto/step5/#
[19] West, S. E., & Pateman, R. M. (2016). Recruiting and retaining participants in citizen science: What can be learned from the volunteering literature? *Citizen science: Theory and practice*.
[20] Santori, C., Keith, R. J., Whittington, C. M., Thompson, M. B., Van Dyke, J. U., & Spencer, R. J. (2021). Changes in participant behaviour and attitudes are associated with knowledge and skills gained by using a turtle conservation citizen science app. *People and Nature*, *3*(1), 66-76.
[21] For example, eBird, iNaturalist, https://participatorysciences.org/, https://www.citizenscience.gov/, https://scistarter.org/, along with most large naturalist groups. More links for specific protocols and educational tools are throughout this report.
[22] James, P. (2018). The biology of urban environments. Oxford University Press.

[23] https://addisonparks.org/wp-content/uploads/2017/02/5.-Classification-of-Parks.pdf

[24] https://www.xerces.org/sites/default/files/2018-05/17-011_01_MaritimeNorthwestCSMG_May2016_web.pdf
[25] https://vancouver.ca/files/cov/one-water-gri-typologies.pdf
[26] https://www.sccp.ca/species-habitat/autumn-meadowhawk
[27] https://inaturalist.ca/projects/stanley-park-bioblitz-fall-2022?tab=stats
[28]https://secure.natureconservancy.ca/site/SPageNavigator/BioBlitz_2024/BB_2024_content.html?s_locale=en_CA&utm_source=eblast&utm_medium=email&utm_campaign=NAT_BIOBLITZ&utm_content=Autoresponder#faq
[29] https://support.ebird.org/en/support/solutions/articles/48000950859-guide-to-ebird-protocols
[30] Elliott, J. E., Wilson, L. K., & Wakeford, B. (2005). Polybrominated diphenyl ether trends in eggs of marine and freshwater birds from British Columbia, Canada, 1979-2002. Environmental Science & Technology, 39(15), 5584-5591.
[31] Butler, R. W. (1995). The patient predator: foraging and population ecology of the Great Blue Heron (Ardea herodias) in British Columbia. Canadian Wildlife Service Occasional Paper.
[32] Cannings, R. J., T. Angell, P. Pyle, and M. A. Patten (2020). Western Screech-Owl (Megascops kennicottii), version 1.0. In Birds of the World (P. G. Rodewald, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.wesowl1.01
[33] Quinn, T. P. (2018). The Behavior and Ecology of Pacific Salmon and Trout. University of Washington Press.
[34] Santos, E. M., Ruivo, R., Trade, L., & Leid, L. G. (2013). The use of the stickleback as a sentinel and model species in environmental genomics. Comparative Biochemistry and Physiology Part D: Genomics and Proteomics, 8(4), 313-323.
[35] McPhail, J. D. (2007). The Freshwater Fishes of British Columbia. University of Alberta Press.
[36] https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/plans/mp_northern_red_legged_frog_e_final.pdf
[37] https://8trees.ca/cs-coverboard-project/
[38] https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/mp-western-toad-e-proposed.pdf
[39] https://linnet.geog.ubc.ca/efauna/Atlas/Atlas.aspx?sciname=Papilio%20rutulus
[40] Richardson, D. H. S. (1992). Pollution monitoring with lichens. Natural History Museum Publications, London.