Designing a Citizen Science Protocol for Monitoring Mini Forests in the Fraser Estuary

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Image: City of Richmond, 2023

Disclaimer

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

Territorial Acknowledgment

The author acknowledges that the work for this project took place on the unceded ancestral lands of the Musqueam, Squamish, Tsleil-Waututh, and other Coast Salish Nations. The author acknowledges that the work presented describes a protocol for community monitoring and stewardship of stolen land across Turtle Island. The author encourages those engaging with this work to acknowledge, respect, and meaningfully engage the First Nations, Inuit and Metis peoples on whose land they carry out this work.

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Executive Summary

In 2023, through the National Mini Forest Pilot and Living Cities Canada Fund initiatives, Green Communities Canada provided funding to plant 16 new mini forests across Canada in partnership with local community organizations. Mini forests, otherwise known as Miyawaki forests, are a novel approach to urban greening. These densely planted forests are typically the size of a tennis court and grow into a mature forest in only 15-20 years. Benefits include increasing local canopy cover and biodiversity, restoring habitat, and improving stormwater infiltration. To determine the benefits of Canadian mini forests and encourage wider implementation, systematic monitoring of mini forests is needed. A monitoring protocol incorporating citizen science is proposed, following global precedents.

Citizen science, or community science, is an established research method which involves volunteers from the local community conducting research to meet a larger goal. Two strands of citizen science (CS) have been distinguished; participatory citizen science and democratic citizen science. Participatory citizen science widens the geographic scope of scientific research, asking many volunteers to collect and contribute data to a central database to be analyzed by professional scientists. These projects are known as contributory projects. In contrast, democratic citizen science democratizes the field of science, involving volunteers in defining the research question and developing the research methods. These projects can be collaborative or co-created projects. Citizen science has been used by organizations around the world to monitor the growth, health, and impact of mini forests. IVN Natuureducatie in the Netherlands partners with local schools to monitor their mini forests, while Earthwatch in the United Kingdom provides supply kits and uses accessible language to encourage prospective volunteers to participate. Thus far in Canada, few groups have had capacity to undertake a full monitoring protocol despite resources being offered by Green Communities Canada and their partner organizations.

Following a literature review, eight interviews with subject matter experts and community-based organizations, and a workshop with 25 Canadian mini forest practitioners, a prototype of a monitoring protocol has been developed. This monitoring protocol proposes five areas of research:

(1) Tree Health & Growth
(2) Flood Management
(3) Soil Health
(4) Biodiversity, and
(5) Human Interaction

However, to actualize a successful and meaningful mini forest monitoring protocol in Canada, the following three priorities must first be met:

(1) identifying an open access means to receive and store the data collected,
(2) Identify a central group to analyze data, develop policy outcomes, and evaluate the programme for successes and weaknesses, and
(3) Work with the central group, the Canadian Mini Forest Community of Practice, and other stakeholders to define research objectives. Review the proposed protocols to ensure alignment with the research objectives.

Introduction

Mini forests, also called Miyawaki forests or tiny forests, are a novel approach to urban greening that is gaining popularity across Canada. The afforestation method is used internationally to increase local canopy cover, biodiversity, and stormwater absorption. The Tiny Forest concept, based on the Miyawaki planting method developed by Japanese ecologist Dr. Akira Miyawaki in the 1970s, encourages planting dense, multi-layered mini forests in areas as small as a tennis court (Bruns et al., 2019). The resulting mini forest is multi-layered, with plants representing the canopy, sub-canopy, understory and groundcovers of a mature forest. Based on the principles of ecological succession, the method plants native vegetation species closely together. This encourages competition, improves ecosystem resiliency, and increases the growth rate, resulting in a mature forest in as little as 15-20 years (Miyawaki, 1999).

In 2023, through the National Mini Forest Pilot and Living Cities Canada Fund initiatives of Green Communities Canada, 16 new mini forests have been planted across Canada, including one in the Terra Nova Rural Park in the City of Richmond, British Columbia (Fitzpatrick, 2023). This mini forest, collaboratively led by the City of Richmond and the Garden City Conservation Society, was planted on Earth Day (April 22) 2023 and later expanded in the fall of 2023 (Garden City Conservation Society, n.d.). In time and together with other mini forests in Richmond, it is expected that this mini forest will contribute to the health and conservation of the Fraser River Estuary by increasing canopy cover and biodiversity, stabilizing soils, restoring habitat, and enhancing water quality and stormwater infiltration.

However, systematic monitoring and collection of relevant data is needed to better understand the ecological impacts of these mini forests on the wider estuary ecosystem. Moreover, with few longitudinal studies assessing the benefits of mini forests, and none in Canada, there is a gap in the research supporting the claims of the Miyawaki method. Monitoring these mini forests for environmental and social benefits could lead to a wider uptake of the method by local governments, community-based organizations, and other groups across Canada. With over 40 mini forests planted across Canada in the past 3 years and more to come in 2024 and beyond, there is a need to standardize mini forest monitoring and make it accessible for all community groups to undertake – regardless of budget, funding, volunteer capacity, ages, or abilities. Following the example of other contexts like the United Kingdom, Europe, and Australia, a citizen science or community-based monitoring protocol is proposed to facilitate mini forest monitoring in Richmond, BC, and across Canada.

Methods

To develop a monitoring protocol for Canadian mini forests, this research began with a literature review of citizen science including the best practices, principles, benefits, and challenges of citizen science. Alongside this literature review, a review of academic and grey literature concerning global mini forest monitoring practices and findings was conducted. This review grounded the research in an understanding of best practices, research focus areas, and challenges with citizen-led mini forest monitoring.

To supplement the literature review, eight interviews were conducted with Miyawaki mini forest experts, professional ecologists, researchers overseeing citizen science mini forest monitoring, and community-based organizations involved in the 2023 National Mini Forest Pilot. The semi-structured interviews focused on a range of topics, depending on the background and expertise of the interviewee. Topics included current mini forest monitoring practices in Canada; current global citizen science mini forest monitoring practices; the development and implementation of citizen science mini forest monitoring protocols and their associated successes and challenges; soil health monitoring using citizen science; and the specific data metrics or impacts most meaningful to monitor in Canadian mini forests. Given the project focus on the mini forest in Terra Nova Rural Park in Richmond, BC, an in-person site visit was completed at this location. Accompanied by the project partners, City of Richmond and the Garden City Conservation Society, the site visit grounded the research in the monitoring needs and hopes for the Richmond mini forest.

Together, the literature review, expert interviews, and site visit contributed to the development of a citizen science protocol prototype based on four main areas of focus for data collection and monitoring: (1) tree growth and mortality, (2) soil health, (3) flood management, and (4) biodiversity. As a final step in the research methodology and to ensure the citizen science protocol was developed collaboratively, a workshop was held on July 18th, 2024. The objective was to present the prototype protocol and early research findings to the Canadian mini forest community of practice, hosted by Green Communities Canada. This workshop was a valuable opportunity for discussion with and feedback from 25 individuals involved in planting mini forests across Canada, including representation from the Garden City Conservation Society, based in Richmond. Emerging from this workshop, a fifth area of focus for data collection and monitoring was added to the protocol: (5) human interaction. Other comments, concerns, and suggestions were incorporated into the final report and monitoring protocols as well. Following citizen science best practices around collaborative project development, this approach resulted in a final protocol which better reflects the needs, interests, and capacity of the groups who will be utilizing the protocol to monitor their mini forests. As emphasized by Richter et al. (2018), an understanding of prospective stakeholders is key to developing capacity and ensuring the ongoing success and momentum of a citizen science project (p. 281).

The Concept, Practice & Principles of Citizen Science

Image: City of Richmond, 2023

Citizen science, community science, or participatory science is an umbrella term which encapsulates the myriad ways non-professional scientists, community members, school children, or otherwise regular *citizens* contribute to science research (Conrad & Hilchey, 2010; Carlen et al., 2024).[1] Citizen science (CS) is not a new approach to scientific research; rather some large-scale projects have been ongoing for decades, like the Christmas Bird Count which began in 1900 and continues to engage thousands of citizens across the Americas annually (National Audubon Society, n.d.). However, it wasn't until the 1990s and early 2000s that CS projects began to surge in popularity, as public awareness increased around the human impacts on natural ecosystems combined with concerns around government monitoring of those ecosystems, stemming from cuts in funding and doubts surrounding government staff bias and expertise. Between 1988 and 1992, new CS water monitoring programs tripled (Conrad & Hilchey, 2010). This surge in popularity has continued to present day, aided by the integration of the internet into everyday life, allowing for increased project visibility and accessibility via social media (Bonney et al., 2014; Williams et al., 2018).

Citizen science has made important contributions to our current understanding of the natural environment, including the effects of climate change and the impacts of land use changes on ecological processes (Bonney et al., 2014; Dickinson et al., 2010). Perhaps the most influential model of CS to date is the long-term monitoring of species across large geographic scales (Dickinson et al., 2010). Whether through direct collaboration with scientists to gather species-specific data or simply using online apps like eBird and iNaturalist to document sightings in their local area, CS has become an important tool for biodiversity research and is proving to be a particularly effective method for identifying rare organisms, invasive species, and disappearing native species (Cornwall, 2024; Dickinson et al., 2010).

Strands & Typologies of Citizen Science

There are two broad strands of citizen science which differ in their understanding of the purpose and potential contributions of CS to the field of science. These two strands are *participatory citizen science* and *democratic citizen science*. The two strands of citizen science can succinctly be defined and differentiated as "citizens as data collectors" (participatory) vs. "citizens as scientists" (democratic) (Conrad & Hichey, 2010).

The first strand, participatory citizen science (also known as instrumental citizen science), sees CS as a tool or method for research collaboration where people contribute observations and collected data towards a larger science project conducted by professional researchers (Eitzel et al., 2017). Subscribers of the participatory view see the key benefit of CS as its ability to increase the reach and scale of scientific research. Dickinson et al. (2010) note that CS "is perhaps the only practical way to achieve the geographic reach required to document ecological patterns and address ecological

[1] While the term citizen science (CS) is used throughout this report to refer to this research approach, other terms like community science have been proposed as a more inclusive alternative, as the word "citizen" implies that participants must be registered citizens in the places where they are engaged in CS.

questions at scales relevant to species range shifts, patterns of migration, spread of infectious disease, broad-scale population trends, and impacts of environmental processes like landscape and climate change" (p. 166).

The second strand, democratic citizen science, emphasizes the role of CS in the democratization of science. This conception emphasizes the opportunity CS offers for restoring public trust in science and re-orienting scientific research towards environmental issues (Eitzel et al., 2017). Whether intentional or not, science and scientific research can often be elitist – from research priorities being defined by institutional funding to research findings being communicated in scholarly journals behind a paywall, current science research is not accessible to all ages, abilities, or socio-economic classes. This elitism betrays the responsibility science has to society, and advocates of the democratic strand conceive CS as an opportunity to reconnect science to society through community engagement.

Citizen science projects are categorized into three major typologies: (1) *co-created*, (2) *collaborative*, and (3) *contributory*. The first two typologies, co-created and collaborative, offer participants the opportunity to assist in determining the research objectives or methods, and tend to include a broader range of participants with different identities, livelihoods, experiences and knowledge. These typologies fall within the purview of the democratic strand, while the third typology, contributory, remains under the conventional participatory strand. Most large-scale citizen science projects are contributory projects, such as eBird and iNaturalist (Carlen et al., 2024).

Ten Principles of Citizen Science

Given the rapid expansion of citizen science projects and monitoring programs, the European Citizen Science Association developed ten principles underlining best practices in citizen science (Robinson et al., 2018). These principles were developed to guide governments, decision-makers, researchers and project leaders when funding or developing CS projects. They offer a means to unify CS projects, creating cohesion with a commonly defined purpose while simultaneously supporting the creative, independent, and bottom-up nature of CS:

Principle #1: Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding.
Citizens may act as contributors, collaborators, or as project leader and have a meaningful role in the project.
Principle #2: Citizen science projects have a genuine science outcome.
For example, answering a research question or informing conservation action, management decisions, or environmental policy
Principle #3: Both the professional scientists and the citizen scientists benefit from taking part.
Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to

scientific evidence, for example, to address local, national and international issues, and through that, the potential to influence policy.

Principle #4: Citizen scientists may, if they wish, participate in multiple stages of the scientific process.

This may include developing the research question, designing the method, gathering and analysing data, and communicating the results.

Principle #5: Citizen scientists receive feedback from the project.

For example, how their data are being used and what the research, policy or societal outcomes are.

Principle #6: Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.

However, unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratisation of science.

Principle #7: Citizen science project data and metadata are made publicly available and where possible; results are published in an open-access format.

Data sharing may occur during or after the project, unless there are security or privacy concerns that prevent this.

Principle #8: Citizen scientists are acknowledged in project results and publications.

Principle #9: Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.

Principle #10: The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data-sharing agreements, confidentiality, attribution and the environmental impact of any activities.

(European Citizen Science Association, 2015)

Image: Little Forests Kingston, 2023

Implementing the Ten Principles: Benefits and Challenges

ECSA's 10 principles of citizen science offer a roadmap of best practice in developing and administering a successful, inclusive, mutually beneficial and rewarding citizen science programme. These 10 principles capture and highlight some of the benefits of incorporating citizen science into a larger research project. However, not all citizen science programmes can – or choose to – incorporate all 10 principles. Despite potentially improving the citizen science program, the 10 principles can be challenging to implement in practice. The following section describes in greater detail each of the principles and uses each principle to illustrate a benefit or challenge associated with citizen science.

Principle #1: Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding.

CHALLENGE

- While not a unique challenge to citizen science, engaging communities which have historically been underrepresented in science (such as minorities, people with disabilities, and people with low incomes) continues to be a challenge for citizen science.
- As noted by Peltola & Arpin (2018), most citizen science participants are well educated (p. 370) while Carlen et al. (2024) find that data collected as part of contributory citizen science projects in the United States and the United Kingdom are overwhelmingly gathered by white, wealthy community members. They also find that as wealth decreases, so too, does participation in contributory citizen science projects (p. 378).
- This can have a material impact on the data gathered by citizen scientists, as the data collected tends to correlate with where participants live, feel safe, or have access to (Cornwall, 2024). Geographic areas that marginalized groups live in or access regularly, and/or where environmental contamination has occurred, are often underrepresented in citizen science data. (Carlen et al., 2024). If the data is used to inform decision-making, as emphasized in Principle #2, this risks recreating racial and socio-economic biases within resulting policies (Cornwall, 2024).
- Inclusion is a key tenet of citizen science, not only emphasized in the ECSA Ten Principles but central to the democratic definition of citizen science. Given this importance, citizen science projects must find ways to engage people with diverse levels of privilege, education, socio-economic status, and specialization to fully realize this principle (Peltola & Arpin, 2018).
- Some options to improve diversity and inclusion in citizen science are:
    - Offering a range of participation opportunities, particularly with regards to the amount of time and prerequisite skills needed to participate
    - New and diverse approaches to recruitment and project publicity
    - Translating project materials

- Developing the project in partnership with the community, to ensure project activities and community priorities are aligned (Robinson et al., 2018, p. 11)

Principle #2: Citizen science projects have a genuine science outcome.

BENEFIT

- Distinguishing citizen science from pure education or community outreach is the fact that citizen science results in scientific outcomes that can be utilized to inform research publications or policy (Robinson et al., 2018).
- Bonney et al. (2014) note that while citizen science projects should have an authentic scientific objective, their outcomes can be more than scientific. In fact, citizen science projects can help to realize significant social outcomes.
- In one example, researchers worked with nonliterate individuals in the Congo to document environmental impacts from poaching and illegal logging, utilizing their smartphones to capture data. In another example, residents of a poor neighbourhood were empowered to collect air-quality data and health indicators to document how air pollution was affecting their health (p. 1437).
- These projects demonstrate the potential empowerment citizen science can offer people from all socio-economic, cultural and educational backgrounds to address issues in their communities (Bonney et al., 2014).

Principle #3: Both the professional scientists and the citizen scientists benefit from taking part.

BENEFIT

- Participants are motivated by a range of diverse benefits, and long-term project success relies on citizen science benefiting all involved.
- Conrad & Hilchey (2010) note the myriad benefits of citizen science include:
    - environmental democracy,
    - scientific literacy,
    - social capital,
    - citizen inclusion in local issues,
    - benefits to government,
    - benefits to ecosystems being monitored
    - democratization of science, and
    - the encouragement of more sustainable communities (pp. 279-280).
- Carlen et al. (2024) go further, describing the proven benefits of citizen science as: greater personal agency and political participation…a connection to civic and legal forums that provide legitimacy to public input, a sense of advocacy for environmental action… increased accountability and industrial compliance with regulatory agencies and a strengthened sense of community belonging and care of the local environment.” (p. 378).

Principle #4: Citizen scientists may, if they wish, participate in multiple stages of the scientific process.

BENEFIT

- While the dominant typology of citizen science projects is 'contributory', more benefits – including greater breadth of participant backgrounds – come when the community is more deeply involved in the project creation, through a 'collaborative' or 'co-created' method.
- Increasing inclusion in project development or other stages of the research process can lead to a greater sense of ownership over research outcomes (Robinson et al., 2018) and increased volunteer involvement in research that serves the community needs and interests (Bonney et al., 2014).

Principle #5: Citizen scientists receive feedback from the project.

CHALLENGE

- A lack of volunteer interest and difficulty recruiting participants is a significant challenge for citizen science projects. However, volunteer dropout can be mitigated by positively reinforcing participation by recognizing volunteer efforts (Conrad & Hilchey, 2010). Feedback justifies the volunteers' time spent on the project, motivating continued participation (Segal et al., 2015).
- Sharing the research findings with participants can motivate further participation by demonstrating how their efforts have affected scientific or societal change.
- Feedback offers an opportunity for scientists to provide a deeper explanation of the research and findings, creating a connection between the citizen scientists and researchers (Robinson et al., 2018).

Principle #6: Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.

CHALLENGE

- All data, whether collected by citizens or professional scientists, has some degree of error or variation. In many cases, the citizen-collected data is of equal quality to that collected by professional scientists (Bonney et al., 2014; Robinson et al., 2018).
- While training can be an important tool for reducing error or bias, there is no evidence that personalized training is any more effective at reducing data error than volunteers who have taught themselves the protocols (Dickinson et al., 2010).
- Although scientists may be concerned about the quality of data collected through citizen science, this concern is unfounded, as the data quality is comparable to that collected through professional science. Yet, there is a genuine challenge with contributory projects focused on biodiversity monitoring having a large discrepancy between the actual species in an area and those reported (Carlen et al., 2024). Additionally, some areas may be more

difficult for people to access than other areas (such as cliff faces or swamplands), limiting species observations in these less accessible spaces.

- When there are no prerequisites or minimum effort required to participate, multiple filters – including a participant filter, detectability filter and sampling filter – can result in an over-reporting of rare species and an under-reporting of common species a participant may find less interesting (Carlen et al., 2024; Dickinson et al., 2010).
- Conrad & Hilchey (2010) note that data fragmentation and a lack of participant objectivity can foster mistrust of citizen-collected data.
- However, training and data validation by professional researchers can mitigate this (pp. 281-282). Citizen science project leaders thus have a responsibility to measure and report the quality of citizen-collected data (Robinson et al., 2018).

Principle #7: Citizen science project data and metadata are made publicly available and where possible, results are published in an open-access format.

CHALLENGE

- While Principle #7 is accepted by the citizen science community, there is a long way to go for citizen science to become truly open science.
- Most citizen science projects do not give participants direct access to the data set collected, and it can be years between participant data collection and the publication of results (Robinson et al., 2018).
- Most citizen science projects work independently, and their data sets may not be known or made available to decision makers (Bonney et al., 2014). This can pose a challenge for translating the citizen-collected data into policy outcomes, as advocated for in Principle #2.

Principle #8: Citizen scientists are acknowledged in project results and publications.

NEUTRAL

- It is important for the contributions of participants in citizen science projects to be recognized in all project outputs, including academic publications, presentations, or other events.
- A thank you statement covering all volunteers should be sufficient; however, acknowledging the extraordinary contributions of individual participants may sometimes be recommended (Robinson et al., 2018).

Principle #9: Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.

NEUTRAL

- Evaluation of citizen science programmes is strongly encouraged, as some outcomes from citizen-collected data may not initially be identified or reported. Additionally, lessons can be garnered from reflection on successful and unsuccessful aspects of each project or programme (Robinson et al., 2018).

Principle #10: The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data-sharing agreements, confidentiality, attribution and the environmental impact of any activities.

NEUTRAL

- Whenever volunteers are involved, a careful consideration of their health, well-being, and individual rights is required. Citizen science project leaders should maintain an awareness of the power balance between volunteers and other project stakeholders (Robinson et al., 2018).

Image: Little Forests Kingston, 2023

Summary of Recommendations

Based on the literature and primary research, the following are recommendations for citizen science monitoring of mini forests in Canada.

(1) Where possible, provide opportunities for volunteers and the broader Canadian mini forest community to co-create or collaborate on developing the monitoring protocols or on any changes to the protocols.
(2) Offer a range of participation modes and avenues, to include people with diverse skills, educational backgrounds, capacities, interests, and time available. Scaffold participation by engaging many volunteers for certain activities (e.g. species observations) but only a select group of committed volunteers for more rigorous monitoring protocols (e.g. tree growth).
(3) Consider how best to engage potential volunteers in the local community, especially for project publicity and volunteer recruitment (e.g. neighbourhood flyers, directed social media posts, or notices on signs near the mini forest itself).
(4) Consider if the local community necessitates translation of project materials, including recruitment materials.
(5) Meet the community where they are at (i.e. in terms of skill level, interests, etc.).
(6) Validate data or offer training to ensure the quality of citizen-collected data when it comes to biodiversity monitoring, as the reported species may not reflect actual species due to unconscious filtering. Additionally, include in any final reporting that species observations may be limited to more accessible parts of the site. For example, there could be overreporting of edge species in a mini forest and underreporting of species within the dense centre of a mature mini forest.
(7) Make data available to volunteers and policy makers directly, where possible.
(8) Provide volunteers with feedback, either directly or indirectly (via policy changes, impact reports, etc.) to motivate continued and sustained participation.

Incorporating the first of these recommendations into a Canadian mini forest monitoring protocol will help to democratize science, encouraging continued participation while creating a "more just, equitable and inclusive practice of data collection" (Carlen et al., 2024). Keeping in mind the needs, interests and capacities of the end user while developing the protocol (by incorporating recommendations #2-5) will lead to greater participation. For participation to be meaningful, a community must be interested enough to participate and must benefit in some way from participation. Without a sense of meaning, where the citizen science protocols are not adjusted to suit their interests or concerns, potential volunteers may choose not to participate at all (Peltola & Arpin, 2018). Similarly, protocols that are too rigid or demanding can reduce the number of volunteers who are able or willing to participate (Dickinson et al., 2010). Incorporating computers, smartphones, and web-based applications into a monitoring protocol is an effective means to engaging groups with limited literacy or education, and facilitating wider inclusion (Peltola & Arpin, 2018).

Current Global Practices of Mini Forest Citizen Science Monitoring

Image: City of Richmond, 2023

Citizen science has been used to monitor mini forests around the world since at least the mid-2010s. Mini forests require significant community participation for their planting, and so naturally, community-based stewardship, maintenance, and monitoring is encouraged. Two of the primary groups practicing citizen science monitoring for mini forests are IVN Natuureducatie in the Netherlands and Earthwatch in the UK.

IVN Natuureducatie, Netherlands

The Dutch environmental non-profit was the first group to plant a tiny forest in Europe, planting two in the small town of Zaanstad just outside of Amsterdam in 2015 (Ottburg et al., 2017). In partnership with Wageningen University, IVN utilized citizen science to monitor their mini forests – one planted using the formal Miyawaki method and the other planted with an adapted method incorporating fruit trees and shrubs. In addition to monitoring the two mini forests, the 12 citizen scientists also monitored two reference plots planted directly adjacent to each mini forest, in order to compare results. Volunteers were divided into six pairs and asked to monitor monthly for a year, from January to December of 2017, taking soil samples (to be analyzed by professional soil scientists) and monitoring tree and shrub growth, soil fauna, and presence of songbirds. The volunteers were trained by the university researchers and IVN experts, who also contributed to the monitoring throughout the year. While tree growth was ultimately not mapped because the timeframe did not result in significant growth or mortality, the citizen science project did demonstrate a significant increase in biodiversity within the mini forests compared to the reference plots. As well, the soil was shown to have similar levels of bacteria and fungi as mature forests (ibid., p. 16).

Despite the positive findings, the researchers encountered some difficulty with regards to citizen science. Given the level of monitoring intensity, only two of the six citizen scientist groups monitored monthly. One of the groups almost never participated. While IVN does not speculate on reasons for this lack of continued and sustained enthusiasm, in developing their final citizen science protocol for other mini forests in the Netherlands, they have adjusted their approach. Perhaps in response to these challenges, IVN has increased the pool of volunteers engaged in citizen science efforts to ensure monthly monitoring can be sustained. As such, each mini forest they plant is now adopted by a local school to use as an outdoor classroom and to monitor the growth, significantly increasing the pool of volunteers by including school children (IVN Natuureducatie, n.d.). They also have allowed for other monitoring protocols (beyond soil samples, soil fauna, biodiversity and bird monitoring) to be incorporated, depending on the volunteers' interests and expertise. For training, the group notes: "training by giving courses, walking together during the study, and guidance and assistance by species experts is therefore important" (Ottburg et al., 2017, p. 35). Since 2015, IVN has planted over 200 Tiny Forests and engaged over 10,000 school children, nearly 700 teachers and over 900 residents in the planting, maintenance, and monitoring of their mini forests (IVN Natuureducatie, n.d.).

Earthwatch UK, United Kingdom

Earthwatch UK utilizes simple citizen science monitoring surveys to engage the participation of both citizens and school children in their Tiny Forest programme (Cardenas et al., 2022). The monitoring protocol is focused on five main areas of research: (1) biodiversity – monitoring pollinators, butterflies, and ground dwellers; (2) carbon sequestration – calculated based on tree growth and species; (3) thermal comfort – monitored using a weather station and individual subjective reports; (4) flood management – monitoring the soil compaction, texture, colour and infiltration rate; and (5) social impact – participants and volunteers complete personal experience questionnaires related to feelings of nature connectedness (Earthwatch Institute, 2023). The Earthwatch approach to citizen science is largely contributory, with citizens providing large amounts of data which is then used by researchers on staff to answer research questions at a national and international scale (Earthwatch Institute, n.d.-a).

What is notable about the Earthwatch approach to citizen science is the low barrier to access. The data can be entered directly to an online portal site for each Tiny Forest, or volunteers can complete the monitoring surveys by hand using provided tracking sheets (Cardenas et al., 2022; Earthwatch Institute, n.d.-b). Monitoring kits with all the necessary equipment are provided to any group interested in regular mini forest monitoring, along with in-person training (S. Cowling, personal communication, July 3, 2024). Even the language used to describe the monitoring protocol is intentionally selected to invite volunteers who may otherwise not participate in science by naming their monitoring events "discovery days".

Earthwatch evaluates and adjusts their protocols on an annual basis, keeping the metrics the same but adding layers or changing the wording to make the protocol clearer (S. Cowling, personal communication, July 3, 2024). They work to ensure the protocols are standardized and interoperable, aligning with other national monitoring efforts, so their data can be utilized towards national research objectives. Driving their protocol development and evaluation are wider research objectives. They routinely ask themselves what the objective of this data collection is and whether/how the data collected can lead to achieving that bigger impact.

Canada: Early Monitoring

Monitoring of Canadian mini forests has been limited, despite resources and templates offered by Green Communities Canada (GCC) through their online mini forest training course (see Green Communities Canada, 2024). The available monitoring resources offer instructions for gathering baseline data of the mini forest site (prior to planting), setting up a monitoring plot, and monitoring tree health and mortality, biodiversity, and human interactions with the mini forest (including presence of litter and other incivilities). A template maintenance and monitoring plan allows groups to outline the seasonal activities to be conducted by volunteers.

Despite limited uptake by Canadian mini forest practitioners, one group has utilized these resources, beginning their mini forest monitoring journey in early June 2024. The

Toronto Region Conservation Authority (TRCA) have developed and signed a monitoring agreement with a local community association – a highly-dedicated group of local volunteers – and are utilizing the GCC template to define the seasonality and frequency of monitoring activities (E. Weyman, personal communication, June 26, 2024). In addition to the monitoring protocols set out in the GCC materials, TRCA is also monitoring for invasive species. To kick off the monitoring, TRCA "in-sourced" experts to conduct a 3-hour in-person on-site training session with the volunteer group. This enabled the TRCA experts to walk through each monitoring protocol with the volunteers, so they would feel comfortable continuing to monitor on their own into the future.

Not all community organizations in Canada have access to experts to conduct this level of training, and that may be a barrier to the uptake of mini forest monitoring in Canada. Likewise, the data collected by the TRCA mini forest volunteers is sent to TRCA staff to analyze. Again, this capacity for analysis is unique to TRCA in the community groups engaged in implementing Canadian mini forests, and that could be another barrier to monitoring uptake.

Other Canadian community groups are doing some level of monitoring, however not to the extent recommended in the GCC materials. Little Forests Kingston works with academics from Queen's University to conduct soil sampling and analysis (J. Cowan, personal communication, July 2, 2024). In Richmond, BC, a small team of volunteers (n=4) from Garden City Conservation Society (GCCS) are also doing high-level observational monitoring at their Terra Nova Rural Park mini forest sites (S. MacGougan, personal communication, June 28, 2024). This monitoring consists of checking for invasive species, making observational assessments of the mini forests' growth, and letting the City of Richmond know when the forest requires watering. GCCS has also engaged a team of experts to conduct a bird diversity study of the mini forest. While these groups would be interested in more rigorous monitoring, there are barriers to doing so including data analysis, volunteer capacity, and funding.

Image: Green Venture, 2023

Summary of Recommendations

(1) Provide in-person, on-site training by local experts or academics to citizen science volunteers, to empower them and create a sense of familiarity with the monitoring protocols.
   a. Explore partnerships with local universities, research teams, experts, or other institutions to offer this training.
   b. Consider creating a Thinkific course to offer this training, utilizing videos to demonstrate each monitoring protocol. Include closed captioning and other techniques to improve accessibility and provide this training in both official languages, English and French.

(2) Increase the pool of volunteers and scaffold participation, as in Recommendation #2 of the previous section. Explore partnerships with local schools or other established community groups to increase the number of volunteers.
   a. Explore following the IVN Natuureducatie model by having local schools "adopt" the mini forest to use as an outdoor classroom and use monitoring as an educational opportunity.

(3) Focus on reducing barriers to access by offering diverse ways to participate in citizen science monitoring.
   a. Include different modes of participation (e.g. QR codes, paper tracking sheets to be completed by-hand, etc.) to suit a diversity of people of all ages and abilities.

(4) Define the research objectives – what this research hopes to achieve in terms of policy, science, or social objectives. Ensure the data being collected serves the specific research objective.
   a. As in Recommendation #1 of the previous section, engage the local community, volunteers, or Canadian mini forest community of practice in determining and defining the objectives of the research.

Developing a Canadian Mini Forest Citizen Science Monitoring Protocol

Image: City of Richmond, 2023

Considering the literature review, review of global practices, and expert interviews, four key areas of research were identified for inclusion in a Canadian mini forest citizen science monitoring protocol. These four areas are: (1) tree growth & mortality, (2) flood management, (3) soil health, and (4) biodiversity. These four areas were selected for not only their importance in determining the health of the mini forest, but also for the relative ease and approachability of the citizen science monitoring which would be used to test these areas.

The expert interviews offered many valuable insights which helped to inform and develop the monitoring protocol. These insights influenced various factors, including: the set-up of the monitoring protocol (recommending a monitoring strip instead of a monitoring plot, utilizing iNaturalist); the tests suggested to measure the four research areas (soil biodiversity counts, qualitative biodiversity monitoring instead of quantitative, wire test for compaction); and ways to avoid challenges other groups have faced (not using tree tags, placing a stake next to tiles for ground dweller monitoring or suggesting an alternate method, monitoring a control site or outside the mini forest). Some important suggestions regarding volunteer engagement included: ensuring that the time and training required was not prohibitive and that volunteers understood what made a Miyawaki mini forest different from a natural forest or conventional tree planting, to ensure they maintain the forests' integrity during monitoring. Lastly, some recommendations for future work should there be the budget available included: annual soil sampling to be sent to professional soil researchers to determine the soil chemistry, bacteria presence, overall health, and carbon storage.

Prototype Canadian Monitoring Protocol

The below table summarizes the tests to be included in the monitoring protocol, organized by area of research. See the Appendix for the complete protocol with instructions and tracking sheets.

Area of Focus	Monitoring	Description	Tools Needed	Scope	Time Needed
Tree Growth & Mortality	Tree Height	Measure the tallest point of the tree	• Tape measure • Sturdy pole • Tape	Every tree within monitoring strip	1 hour
	Stem diameter	Measure the diameter of the tree stem at 10cm & 130cm	• Digital calipers or ruler • String • Tape measure		
	Mortality	Observe & record any dead plants to estimate mortality	N/A	Any plant with no obvious signs of growth	
	Overall forest growth	Photograph forest	• Camera • Stake or marker	Entire forest	5 mins

Flood Management	Soil wetness	Simple observation of soil saturation according to reference photos	N/A	Monitoring strip & outside mini forest	5 mins
	Infiltration rate	Measure soil infiltration rate using metal ring or pipe inserted in soil	• Metal ring, pipe or can • Waterproof marker • Ruler or tape measure • Wood block & hammer or rubber mallet • Water • Timer	3 locations within monitoring strip & 3 locations outside mini forest	1.5 hours
Soil Health	Soil Texture	Determine soil texture using texture flow chart	• Water • Water dropper • Texture flow chart	3 locations within monitoring strip & 3 locations outside mini forest	1 hour
	Soil Colour	Determine soil colour using Munsell colour chart	• Munsell colour chart		
	Soil compaction	Insert stiff wire into soil and measure depth inserted before wire bends	• Wire flag or marker • Permanent marker • Ruler		
	Mulch Depth	Measure depth of mulch and organic matter on top of soil	• Ruler	3 locations within monitoring strip	15 mins
Biodiversity	Ground dwellers	Observe & record (photograph) ground dwellers spotted during timed count or under tiles	• Phone • Access to iNaturalist • Timer (timed count) • Shovel (timed count) • 3x Tiles (tile method) • 3x Stakes (tile method) • Permanent marker (tile method)	Monitoring strip *or* 3 tiles within monitoring strip	20 mins (timed count) *or* 15 mins (tile method)

	Plants	Observe & record (photograph) any new plants growing	• Camera • Access to iNaturalist • Species Identification Guidebook (optional)	Monitoring strip	30 mins
	Creatures	Observe & record (photograph) any pollinators, butterflies, birds, mammals or other creatures (time d count)	• Camera • Timer • Access to iNaturalist • Species Identification Guidebook (optional)	Monitoring strip	30 mins (timed count)

After presenting this protocol prototype to the participants of the Canadian Mini Forest Community of Practice in July 2024 (n=25), a fifth area of research focus was added to the protocol. Monitoring for human interaction was added due to the overwhelming expression of interest by the meeting participants to better understand the social implications of mini forests. The below table summarizes the fifth area of research focus:

Area of Focus	Monitoring	Description	Tools Needed	Scope	Time Needed
Human Interaction	Incivilities	Observe & record any incivilities (litter, dog mess, graffiti, etc.)	N/A	Entire forest	15 mins
	Human Engagement	Observe & record any human interactions or engagement with the mini forest during a timed count	• Timer	Entire forest	30 mins (timed count)

As proposed, a monitoring session would require approximately 6 hours of volunteer time, based on 1 volunteer. With 2 or more volunteers, the monitoring session could likely take less time. Some protocols, such as the biodiversity and human interaction timed counts, could take place concurrently by 2 or more volunteers, reducing the overall monitoring time needed. Likewise, tests which require multiple samples or testing locations (e.g. soil health tests, infiltration rate text) could happen concurrently, reducing the time needed for that protocol. The minimum number of monitoring sessions recommended is once per year, although more monitoring is strongly encouraged. The mini forest community of practice confirmed this time requirement to be reasonable, feasible, and within their group's capacity during the focus group session.

Implementing the Ten Principles: Challenges and Opportunities for Canadian Mini Forest Citizen Science

When it comes to developing a citizen science protocol for monitoring Canadian mini forests, including the Richmond mini forests, there are some significant challenges to overcome to realize the ten ECSA principles in practice. Of the 10 principles, Principles #2, #5, and #7 are particularly difficult to realize given the current context of Canadian mini forests.

> **Principle #2:** Citizen science projects have a genuine science outcome.
> **Principle #5:** Citizen scientists receive feedback from the project.
> **Principle #7:** Citizen science project data and metadata are made publicly available and where possible, results are published in an open-access format.

Realizing these principles requires a central body, organization, or group committed to hosting an open access repository of the citizen-collected data, coordinating research questions and objectives, analyzing the data to answer those objectives, and translating the data into concise policy reports or academic publications to achieve scientific or societal outcomes (Bonney et al., 2014). This centre would also evaluate the citizen science programme, adjusting methods and protocols as necessary, meeting Principle #9: Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.

There are opportunities on the horizon for overcoming this challenge. By utilizing Network of Nature's ArcGIS map of Canadian mini forests to log citizen-collected data, there may be an avenue for an open access repository of the data. However, an improvement in user experience would be required to reduce barriers to access and increase ease of use. Additionally, with a National Mini Forest Coalition currently in the early stages of development, there may be capacity and interest within that group to take on the data analysis and outcome development. Regardless of whether these opportunities manifest, the priority should be addressing these challenges prior to sharing the citizen science protocol prototype with community groups or volunteers.

Priorities to Actualize a Canadian Mini Forest Citizen Science Monitoring Protocol

To implement a citizen science monitoring protocol for Canadian mini forests, there are a few key priorities which must be met in the short-, medium-, and long-term to ensure a successful and meaningful programme. They are presented in order of importance.

Short-term Priorities

(1) Identify an open access means to receive and store the data, such as the Network of Nature ArcGIS mini forest map.
   a. If using the Network of Nature ArcGIS map:
      i. Improve the user experience of the map, making data entry accessible to users (i.e. does not need to be submitted to Network of Nature to be entered on the map).
      ii. Design the monitoring data entry areas to mirror the citizen science tracking sheets to create an intuitive, easy experience for users.

(2) Identify a central group or organization to analyze data, develop policy and research outcomes, and evaluate the programme for successes and weaknesses.
   a. This group does not need to be a monolith, and there is potential for certain groups or organizations to take responsibility and ownership of only certain aspects of the data (i.e. soil health), publishing results and evaluating the research method for that specific area only.
      i. However, there should be a central group working cross-Canada for each area of research.

(3) Once a central group is identified, work with the Mini Forest Community of Practice and other Canadian stakeholders to determine the research objectives.
   a. Review all protocol tracking sheets and instructions to ensure the data collected and methods used serves these larger objectives or goals.

Medium-term Priorities

(4) Once these foundational pieces are addressed, graphically design the protocol tracking sheets to make them more engaging.

(5) Determine how best to organize and input the biodiversity data into iNaturalist. This could include creating a place or project in iNaturalist using the defined boundaries of the mini forest, as presently suggested.
   a. The central group or organization may wish to meet with members of the iNaturalist team to determine the best approach.

(6) Determine the reading level of the protocols and adjust wording as needed to ensure legibility for all ages and abilities (at maximum, aim for a sixth-grade level of comprehension).

(7) Translate protocols and project recruitment materials to better invite the involvement of marginalized or immigrant communities.

a. Suggested languages for Richmond, B.C. are French, Mandarin, and Vietnamese.
b. For Indigenous communities, provide these monitoring protocols in the appropriate Indigenous language.

Long-term Priorities

(8) Create a guide on developing and maintaining stewardship committees for monitoring and maintain mini forests, with recommendations for local community groups to utilize.
(9) Involve subject matter experts for each area of research focus (i.e. ecologist, soil scientist, hydrologist) to review each protocol.
(10) Develop a free Thinkific course which includes videos explaining how to conduct each protocol, step-by-step, in both official languages (English and French).
  a. In addition to demonstrating how to conduct the protocols, explore the possibility of including how-to videos for data analysis.
  b. Explore the possibility of engaging subject matter experts to appear in videos conducting each protocol, step-by-step.
(11) If budget permits, conduct annual soil sampling at each Canadian mini forest site and work with a Canadian soil research institute (e.g. Vineland Research and Innovation, etc.) to measure the health of the soil, including chemical composition and carbon storage.
(12) Engage an academic partner to carry out longitudinal studies of Canadian mini forests, publishing academic research results using citizen-collected data.

Image: City of Richmond, 2023

Resources

Bonney, R., Shirk, J. L., Phillips, T. B., Wiggins, A., Ballard, H. L., Miller-Rushing, A. J., & Parrish, J. K. (2014). Next Steps for Citizen Science. *Science*, *343*(6178), 1436–1437. https://doi.org/10.1126/science.1251554

Bruns, M., Bleichrodt, D., Laine, E., Van Toor, K., Dieho, W., Postma, L., & De Groot, M. (2019). *Handbook: Tiny Forest Planting Method.* IVN Natuureducatie. https://www.greenflagaward.org/media/2136/tf_handbook_2019_english_0.pdf

Cárdenas, M., Pudifoot, B., Narraway, C., Pilat, C., Beumer, V., & Hayhow, D. (2022). *Nature-based Solutions Building Urban Resilience for People and the Environment: Tiny Forest as a case study*. https://doi.org/10.5281/zenodo.7053895

Carlen, E. J., Estien, C. O., Caspi, T., Perkins, D., Goldstein, B. R., Kreling, S. E. S., Hentati, Y., Williams, T. D., Stanton, L. A., Des Roches, S., Johnson, R. F., Young, A. N., Cooper, C. B., & Schell, C. J. (2024). A framework for contextualizing social-ecological biases in contributory science data. *People and Nature*, *6*(2), 377–390. https://doi.org/10.1002/pan3.10592

Conrad, C. C., & Hilchey, K. G. (2011). A review of citizen science and community-based environmental monitoring: Issues and opportunities. *Environmental Monitoring and Assessment*, *176*(1), 273–291. https://doi.org/10.1007/s10661-010-1582-5

Cornwall, W. (2024, March 20). *Social inequities can skew our view of the natural world*. https://www.anthropocenemagazine.org/2024/03/social-inequities-and-citizen-science-can-skew-our-view-of-the-natural-world/, https://www.anthropocenemagazine.org/2024/03/social-inequities-and-citizen-science-can-skew-our-view-of-the-natural-world/

Dickinson, J. L., Zuckerberg, B., & Bonter, D. N. (2010). Citizen Science as an Ecological Research Tool: Challenges and Benefits. *Annual Review of Ecology, Evolution, and Systematics*, *41*(Volume 41, 2010), 149–172. https://doi.org/10.1146/annurev-ecolsys-102209-144636

Earthwatch Institute. (2023). *Tiny Forest Monitoring Report 2023*. https://tinyforest.earthwatch.org.uk/images/documents/Tiny-Forest-Monitoring-Report-2023.pdf

Earthwatch Institute. (N.d.). *Tiny Forest Research.* Retrieved July 29, 2024, from https://tinyforest.earthwatch.org.uk/tiny-forest-research. Referenced as n.d.-a.

Earthwatch Institute. (N.d.). *Tiny Forest Resources.* Retrieved July 29, 2024, from https://tinyforest.earthwatch.org.uk/resources#data-sheets. Referenced as n.d.-b.

Eitzel, M., Cappadonna, J., Santos-Lang, C., Duerr, R., West, S. E., Virapongse, A., Kyba, C., Bowser, A., Cooper, C., Sforzi, A., Metcalfe, A., Harris, E., Thiel, M., Haklay, M., Ponciano, L., Roche, J., Ceccaroni, L., Shilling, F., Dorler, D., … Jiang, Q. (2017). Citizen Science Terminology Matters: Exploring Key Terms. *Citizen Science: Theory and Practice*, 1–20.

European Citizen Science Association. (2015). Ten Principles of Citizen Science. *ECSA*. Berlin. http://doi.org/10.17605/OSF.IO/XPR2N

Fitzpatrick, T. (2023, April 26). Network of Nature and Green Communities Canada launch National Mini Forest Pilot program in Richmond, B.C. *Canadian Geographic*. https://canadiangeographic.ca/articles/network-of-nature-launches-the-national-mini-forest-pilot-program-in-richmond-b-c/

Garden City Conservation Society. (N.d.). *Miyawaki Forest.* Retrieved July 29, 2024, from https://gardencityconservation.ca/miyawaki-forest/

Green Communities Canada. (2024). *Mini Forest Training* [Thinkific Online Course]. https://green-communities-canada.thinkific.com/courses/mini-forest-training.

Guerrini, C. J., Majumder, M. A., Lewellyn, M. J., & McGuire, A. L. (2018). Citizen science, public policy. *Science*, *361*(6398), 134–136. https://doi.org/10.1126/science.aar8379

IVN Natuureducatie. (N.d.). *What are the effects of a Tiny Forest.* Retrieved July 29, 2024, from https://www.ivn.nl/aanbod/tiny-forest/effects-tiny-forest/

Miyawaki, A. (1999). Creative Ecology: Restoration of Native Forests by Native Trees. *Plant Biotechnology*, *16*(1), 15–25. https://doi.org/10.5511/plantbiotechnology.16.15

National Audobon Society. (N.d.). *History of the Christmas Bird Count.* Retrieved July 29, 2024 from https://www.audubon.org/community-science/christmas-bird-count/history-christmas-bird-count

Ottburg, F., Lammertsma, D., Bloem, J., Dimmers, W., Jansman, H., & Wegman, R. M. A. (2018). *Tiny Forest Zaanstad: Citizen science and determining biodiversity in Tiny Forest Zaanstad*. https://doi.org/10.18174/446911

Peltola, T., & Arpin, I. (2018). Science for everybody?: Bridging the socio-economic gap in urban biodiversity monitoring. In S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel, & A. Bonn (Eds.), *Citizen Science* (pp. 367–380). UCL Press. https://www.jstor.org/stable/j.ctv550cf2.32

Richter, A., Dörler, D., Hecker, S., Heigl, F., Pettibone, L., Sanz, F. S., Vohland, K., & Bonn, A. (2018). Capacity building in citizen science. In S. Hecker, A. Bonn, M. Haklay, A. Bowser, Z. Makuch, & J. Vogel (Eds.), *Citizen Science* (pp. 269–283). UCL Press. https://www.jstor.org/stable/j.ctv550cf2.26

Robinson, L. D., Cawthray, J. L., West, S. E., Bonn, A., & Ansine, J. (2018). Ten principles of citizen science. In A. Bonn, S. Hecker, M. Haklay, A. Bowser, Z. Makuch, & J. Vogel (Eds.), *Citizen Science* (pp. 27–40). UCL Press. https://www.jstor.org/stable/j.ctv550cf2.9

Segal, A., Simpson, R. J., Homsy, V., & Hartswood, M. (2015). Improving Productivity in Citizen Science through Controlled Intervention. In *Proceedings of the 24th International Conference on World Wide Web,* 331-337. Geneva: ACM.

Vohland, K., Land-zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R., & Wagenknecht, K. (Eds.). (2021). *The Science of Citizen Science*. Springer Nature. https://doi.org/10.1007/978-3-030-58278-4

Williams, J., Chapman, C., Leibovici, D. G., Loïs, G., Matheus, A., Oggioni, A., Schade, S., See, L., & van Genuchten, P. P. L. (2018). Maximising the impact and reuse of citizen science data. In S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel, & A. Bonn (Eds.), *Citizen Science: Innovation in Open Science, Society and Policy* (pp. 321–336). UCL Press. http://www.jstor.org/stable/j.ctv550cf2.29

Protocol Resources

Tree Growth & Mortality

Earthwatch Institute. (N.d.). *Carbon Storage.* Retrieved July 29, 2024, from: https://tinyforest.earthwatch.org.uk/images/resources/Carbon-Capture-Tree-size-MG.pdf

Guelph Urban Forest Friends. (N.d.). *How to measure a tree.* Retrieved July 29, 2024 from: https://guffguelph.ca/how-to-measure-a-tree/#:~:text=Wrap%20your%20string%20around%20the,circumference%20by%20pi%20(3.14).

Protocol Diagram Icons:

Freepik. *Small Fruit Tree Growing on Earth free icon* [Icon]. www.flaticon.com

Freepik. *Tree With Thin Branches Covered by Leaves free icon [*Icon]. www.flaticon.com

Unicornlabs. *Person free icon* [Icon]. www.flaticon.com

Flood Management

Australian Wine Research Institute. (2010). *Vineyard Activity Guides: Measuring the infiltration rate of water into soil using the ring infiltrometer method.* Retrieved July 29, 2024, from: https://www.awri.com.au/wp-content/uploads/v_activity_infiltration_rate.pdf.

Earthwatch Institute. (N.d.). *Flood Management: Infiltration Rate & Moisture.* Retrieved July 29, 2024 from: https://tinyforest.earthwatch.org.uk/images/resources/Flood-Management-Infiltration-MG.pdf.

Geography Teacher. (2020, April 30). *How to measure infiltration rate* [Video]. YouTube. https://www.youtube.com/watch?v=3PSroyhfXDM.

Minnesota Pollution Control Agency. (2023). *Determining soil infiltration rates.* Minnesota Stormwater Manual. Retrieved July 29, 2024, from: https://stormwater.pca.state.mn.us/index.php/Determining_soil_infiltration_rates.

Murray Local Land Services. (2012, May 23). *How to measure infiltration* [Video]. YouTube. https://www.youtube.com/watch?v=PItDMA-6840.

Natural Resources Conservation Science. (2008). *Soil Quality Indicators.* United States Department of Agriculture. Retrieved July 29, 2024, from: https://www.nrcs.usda.gov/sites/default/files/2022-10/Infiltration.pdf.

TSU Extension. (2018, November 14). *Soil Health – Measuring soil infiltration rate* [Video]. YouTube. https://www.youtube.com/watch?v=9KSdTFHA_E4.

Vidacycle. (2020). *Infiltration Rate.* Retrieved July 29, 2024, from https://soils.vidacycle.com/soil-tests/1-3-infiltration-rate/.

Vidacycle. (2020). *Soil testing: how to measure infiltration rate effectively.* Retrieved July 29, 2024 from https://soils.vidacycle.com/blog/soil-testing-how-to-measure-infiltration-rate-effectively/.

Protocol Diagram Icons:

Freepik. *Stopwatch free icon* [Icon]. www.flaticon.com

Freepik. *Timer free icon* [Icon]. www.flaticon.com

Protocol Images (in order of appearance on tracking sheet):

Irvine, K. (2024, January 19). *Dusty dry greenhouse soil at the end of autumn EdibleBackyard. NZ* [Image]. Kath Irvine's Edible Backyard. https://www.ediblebackyard.co.nz/how-to-rehydrate-dry-soil/#:~:text=Set%20up%20the%20sprinkler.,a%20cloudy%20or%20drizzly%20day.

13Imagery. (2015, May 5). *Hands holding soil* [Image]. Shutterstock. https://www.shutterstock.com/image-photo/hands-holding-soil-275200676

Steiner, J. M. (2019, October 1). *Jamestown water pooled in yard* [Image]. The Jamestown Sun. https://www.jamestownsun.com/weather/flood-potential-saturated-soil-in-the-fall-could-lead-to-spring-flooding.

Andrew. (2015, April 10). *Flooding Soil Run Off* [Image]. Planet Permaculture. https://planetpermaculture.wordpress.com/tag/run-off/.

Soil Health

Earthwatch Institute. (N.d.). *Flood Management: Soil Compaction, Texture & Colour.* Retrieved July 29, 2024 from:

https://tinyforest.earthwatch.org.uk/images/resources/Flood-Management-Soil-classification-MG.pdf.

Ministry of Agriculture Food & Rural Affairs. (2012). *Tools for Soil Diagnostics.* Government of Ontario. Retrieved July 29, 2024 from: https://www.omafra.gov.on.ca/CropOp/en/general_agronomics/soil_management/tool-for-soil-diagnostics.html.

Natural Resources Conservation Science. (2022). *Guide to Texture by Feel.* United States Department of Agriculture. Retrieved July 29, 2024, from: https://www.nrcs.usda.gov/sites/default/files/2022-11/texture-by-feel.pdf

Natural Resources Conservation Science. (N.d.). *Soil Health.* United States Department of Agriculture. Retrieved July 29, 2024 from: https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health.

Natural Resources Conservation Science. (N.d.). *Soil Health Assessment.* United States Department of Agriculture. Retrieved July 29, 2024 from: https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health/soil-health-assessment.

Natural Resources Conservation Science. (2015). *Soil Quality Indicators.* United States Department of Agriculture. Retrieved July 29, 2024, from: https://www.nrcs.usda.gov/sites/default/files/2022-10/indicator_sheet_guide_sheet.pdf

Ontario Federation of Agriculture, Government of Ontario, & Government of Canada. (2004). Scheduling: Knowing When & How Much to Irrigate. In *Best Management Practices: Irrigation Management* (pp. 24-47). Retrieved July 29, 2024 from: https://bmpbooks.com/publications/irrigation-management/scheduling-knowing-when-and-how-much-to-irrigate/.

Yergeau, S., Raabe, C., & Murphy, S. (2020). *Cooperative Extension Fact Sheet FS1313: Assessing and Addressing Soil Compaction in Your Yard.* Rutgers New Jersey Agricultural Experiment Station. Retrieved July 29, 2024 from:

https://njaes.rutgers.edu/fs1313/#:~:text=Hold%20the%20wire%20at%20the,good%20condition%20(OCSCD%202012).

Protocol Diagram Icons:

BSD. *Plant free icon* [Icon]. www.flaticon.com

Biodiversity

Earthwatch Institute. (N.d.). *Ground Dwellers.* Retrieved July 29, 2024 from: https://tinyforest.earthwatch.org.uk/images/resources/Biodiversity-Ground-Dwellers-MG.pdf

Karbassioon, A., & Stanley, D. A. (2023). Exploring relationships between time of day and pollinator activity in the context of pesticide use. Basic and Applied Ecology, 72, 74–81. https://doi.org/10.1016/j.baae.2023.06.001.

Human Interaction

Benton, J.S., Anderson, J., Pulis, M., Cotterill, S., Hunter, R.F. and French, D.P. 2020. Method for Observing pHysical Activity and Wellbeing (MOHAWk): validation of an observation tool to assess physical activity and other wellbeing behaviours in urban spaces. Cities & Health, pp.1-15.

Devisscher, T. (2021). *Greenspace Observation Field Sheets* [Class handout]. UFOR200: Urban Forests & Well-being. University of British Columbia. Vancouver, BC

Appendix: Canadian Mini Forest Citizen Science Monitoring Protocol Prototype

Image: City of Richmond, 2023

Mini Forest Citizen Science Monitoring Guide

If you are reading this guide, you deserve a big THANK YOU for participating in monitoring Canadian mini forests. The work you are about to do is important! It can help us understand the benefits of mini forests for the soil, trees, plants, animals, and humans.

Mini forests, or Miyawaki forests, are a new and exciting way to green our cities and towns. They involve planting many native species in a very small area to encourage competition and increase the growth rate, giving us a mature forest in only a few decades. There are many potential benefits associated with mini forests, like increasing tree canopy cover and urban biodiversity, but data is needed to demonstrate these benefits in Canada. By monitoring these mini forests, you are contributing to a data set that could be utilized to understand the benefits of mini forests, demonstrate their value, and potentially encourage more mini forest plantings across Canada.

Because mini forests have many plants in such a small area, there is big potential for improved biodiversity. But this density also means mini forests can look a little messy and unkept for the first few years of their lives. The mini forests are not meant to look like other green spaces you might be familiar with. They are not meant to be tidy, landscaped, or controlled. They are intended to mimic a natural ecosystem, and so as you monitor these mini forests, keep in mind that it's okay if they look messy! There might be new plants that start to grow. You may see many new insects and creatures. You might observe some natural processes, like plants dying or leaves littering the ground. These are all (mostly) good things, indicating a healthy and functioning ecosystem.

Establishing a Monitoring Strip

A monitoring strip is a 1-metre-wide strip of your mini forest running across your mini forest. It can run lengthwise or widthwise. A monitoring plot is another option, involving a 1-metre radius circle near the center of your mini forest. Monitoring strips are recommended to use because there is the potential to monitor for differences in the growth and health of your mini forest on the edge compared to the middle. It is important to use markers, stakes, or flags to visually identify the monitoring strip and be able to easily locate it into the future.

<u>Equipment Needed</u>

- Measuring tape or metre stick
- Stakes, flags, or other markers
- String

<u>Steps</u>

1. Use a metre stick or measuring tape to measure a 1-metre distance across your mini forest.

2. Stick a flag, stake, or other marker on either side of the measured metre distance.
3. Run a string from each marker in a straight line to the opposite edge of the mini forest and stick a flag, stake, or other marker in the ground on the opposite side.
4. You should now have 4 flags, stakes or markers in the ground: 2 on each edge of the mini forest with a 1-metre distance between each pair.
5. Stick flags, stakes, or other markers into the ground along each string. Remove the string to not interfere with the growth of the mini forest.
6. You now have a demarcated monitoring strip in your mini forest!

Mapping the Species in your Monitoring Strip

To assist with future tree growth and health monitoring, it is important to identify and number all the trees within your monitoring strip. As well, to assist with future biodiversity monitoring, it can be helpful to identify all the other plants within your monitoring strip, to help identify any new species growing in your monitoring strip.

To create a reference map of your monitoring strip, diagram and number each tree and plant within your monitoring strip immediately after you establish the strip. This could be done using a simple drawing, or by stitching together aerial photos of your monitoring strip to create a reference map. Regardless of the method you choose, number each tree clearly on the reference map and provide a separate guide or index key identifying the tree species. You can identify the species of the other plants, as well. It is most important to identify and number the trees, so prioritize creating that reference map before you begin mapping the other plant species.

Tagging each tree is another option. However, tags can easily fall off trees or cause issues as the tree grows by choking the tree. If you choose to use tags instead of a reference map, be mindful over the years as your mini forest grows to adjust the location of the tags and ensure they are not causing harm to the tree.

Using iNaturalist

The biodiversity monitoring protocols rely on the online social network, iNaturalist, to document and record observations of species in the mini forest. iNaturalist is a helpful tool because it is open access, encourages collaboration, has helpful checks and balances for species identification, and is widely used. The mobile application makes iNaturalist accessible to most people in most regions of Canada. For those who don't have a smartphone, iNaturalist can be used on a desktop or laptop computer as well. You can take photos using a camera, load them onto the computer, and upload them manually onto iNaturalist. Note that this method is more time-consuming than using iNaturalist on a smartphone.

The iNaturalist website has extensive reference articles and video tutorials to make using the website and documenting observations easier to understand. It is recommended to familiarize yourself with how to use iNaturalist by exploring their Help section and watching their video tutorials. It may be helpful to spend a few weeks using iNaturalist to document species, insects, animals, and plants around your neighbourhood for a few weeks prior to starting the biodiversity monitoring of your mini forest. This will ensure you are familiar with iNaturalist before you begin.

Before you begin monitoring the biodiversity of your mini forest, you must add your mini forest as a “place” in iNaturalist. This can help filter species observations for only those within the boundaries of your mini forest. For more details on creating a place in iNaturalist, click here. **To create a place, you need to have already logged 50 observations on iNaturalist,** which could be achieved in 1-2 weeks of observations around your neighbourhood. Once you have created a place, you can then create a project for your mini forest in iNaturalist. For more details on creating and managing a project in iNaturalist, click here.

Tree Growth & Mortality Monitoring Instructions

Tree health – including growth rate and survival – is important to monitor to understand the success of the mini forest method. These metrics can be useful to estimate the amount of carbon dioxide being captured and stored by the mini forest.

Equipment

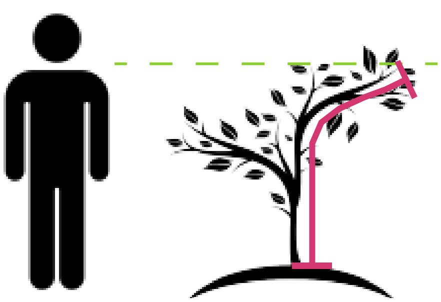
- Tape measure
- Sturdy pole, ideally extendable (optional, if applicable)
- Tape (if applicable)
- Digital callipers or ruler
- String (if applicable)
- Camera or phone
- Stake or marker (optional)

Recommended Timing & Frequency

Frequency:	Annual or bi-annual
Timing:	It is recommended to conduct this test at the same time every year to be able to compare results. If conducting the test once a year, Fall is recommended. If you are monitoring twice per year, Spring and Fall are recommended.

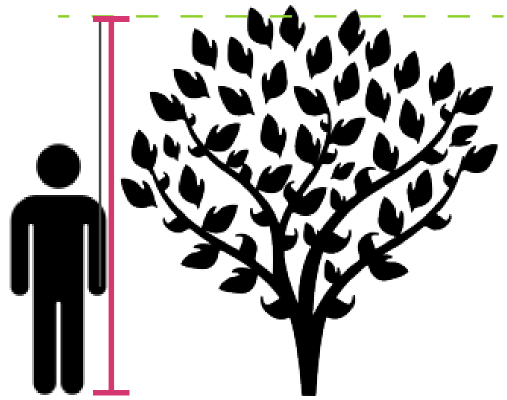
Tree Height

1. Record the tree number and species on the tracking sheet.
2. Look at the tree and find the tallest point.



If the tree is within standing height:

3. Measure along the stem from the tip of the tallest point down to the soil. Be sure to follow any bends of the stem. If necessary, clear mulch or dead leaves from the base of your tree to measure to the soil.
4. Record this measurement on your tracking sheet. Put any mulch or debris you cleared back around the base of the tree.



If the tree is within the height of your sturdy pole:

5. Tape the tip (0cm) of the tape measure to the top end of your sturdy pole. Make sure the measuring tape is attached to the pole by taping at other points along the pole's length, if necessary.
6. Extend the top of the pole to the tallest point of the tree and run the measuring tape to the soil. If necessary, clear mulch or dead leaves from the base of your tree to measure to the soil.
7. Record this measurement on your tracking sheet. Put any mulch or debris you cleared back around the base of the tree.

If the tree is taller than the pole:

8. Record the maximum height of your pole by extending the pole as high as possible and measure to the soil. Record this measurement as "taller than X cm or inches".

<u>Stem Diameter</u>

For trees with multiple stems, select the stem that is in the middle in terms of thickness – not the thickest stem, but not the thinnest either.

1. If necessary, clear mulch or dead leaves from the base of your tree so you can see the soil. Measure 10cm from the soil or base of your tree.
2. If using digital callipers, check that they are set to zero before beginning. Place the prongs on either side of the tree stem and hold the callipers flat. Record the diameter displayed on the callipers' digital display (in mm) on your tracking sheet.
3. If using a ruler, line up your ruler at the 10cm mark and measure the stem diameter. Record this number (in mm) on your tracking sheet.

If your stem diameter is greater than 100mm:

4. Repeat this test at 130cm by measuring from the soil or base of the tree. Record the stem diameter (in mm) on your tracking sheet.

<u>Mortality</u>

1. As you monitor the tree growth in height and diameter, make note of any observations regarding the tree's health, including noting any signs of distress or disease.
2. If there are no obvious signs of growth, assess if the tree is dead. You can do this by scraping away a bit of bark with your fingernail. If it is green underneath the bark, the tree is alive. If it is dry and brown underneath the bark, the tree is dead. Do not measure the height or diameter of any dead trees.

3. After you finish measuring all trees within your monitoring strip or plot, estimate the mortality rate (e.g. 3 of 30 trees are dead, so estimating a 10% mortality rate). Record this percentage on your tracking sheet.

<u>Overall Forest Growth</u>

1. On your first monitoring session, determine a suitable location for taking pictures of the forest. This could be one spot with a good overall view or multiple spots (on each side of the mini forest). Mark your photo location with a stake or other marker, or by saving the GPS location on your phone or mapping application.
2. Each monitoring session, including the first one, take a photo of the forest from this location. These photos will help visualize the overall forest growth over time.
3. ***(Optional)*** If desired, take a photo of the forest from this location after each major storm or period of inclement weather.

Tree Growth & Mortality Monitoring Sheet

Mini Forest Site Name: ________________________ Date: ____________________________

Time Started: ________________________________ Time Completed: __________________

	Tree Number	**Tree Species**	**Tree Height** *(cm)*	**Stem Diameter at 10cm from the base** *(mm)*	**Stem Diameter at 130cm from the base** *(mm)*	**Notes on tree health (disease, distress, mortality)**
Example #1	*#1*	*Douglas Fir*	*70cm*	*70mm*	*n/a*	*Some yellowing leaves*
Example #1	*#2*	*Douglas Fir*				*Tree is dead*
Monitoring Strip or Plot						

Estimated Mortality Rate (%): ______________________________

Flood Management Monitoring Instructions

The infiltration rate is the amount of water that can be absorbed by the soil compared to how much is run-off. It can be impacted by the soil type, composition, and compaction. This test will help monitor and assess whether your mini forest is improving water infiltration and reducing the risk of flooding.

Equipment

- Metal ring, pipe or can
- Waterproof marker
- Ruler
- Wood block and hammer or rubber mallet
- Water
- Timer

Recommended Timing & Frequency

Frequency: Annual

Timing: It is recommended to conduct this test at the same time every year to be able to compare results. It is best to conduct the test in Summer or early Fall, as the ground can be saturated with seasonal rainfall in the Winter or Spring.

Soil Wetness Observation

1. In your monitoring strip or plot, have a close look at the soil. This may require you to move mulch, grass, or dead leaves out of the way so you can see the soil. If you must clear away this top layer to see the soil, clear an area that is 1 sq. ft.
2. Based on the reference photos in the tracking sheet, estimate the soil wetness. This estimation should be representative of the whole monitoring strip or plot, so choose what best fits with the soil you can see.
3. Repeat steps 1-2 for the soil outside of the mini forest and record your estimation on the tracking sheet.

Water Infiltration Rate Test:

The infiltration ring can be a metal ring, pipe, or even a metal can! As long as whatever you use is open on both sides and made of a durable material, it should work for this test.

Getting Started

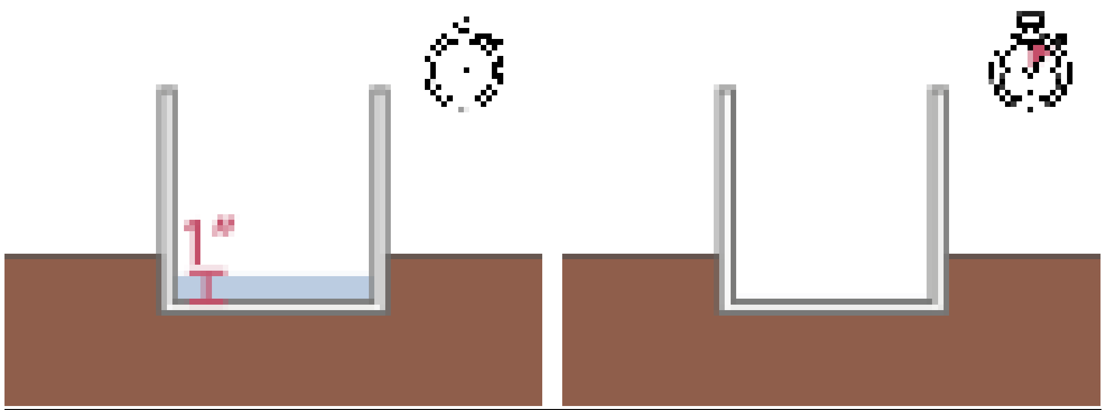
1. On the outside of the ring, use your ruler to mark a line 5cm (or 2”) from the bottom of the infiltration ring. This is how deep you want to hammer the ring into the soil.
2. Locate a suitable area of soil within the mini forest monitoring strip or plot that is free of any noticeable roots, cracks, or bore holes.
3. Place the wood block on top of the metal infiltration ring and use the hammer or rubber mallet to insert the infiltration ring into the soil. The wood block allows you to

keep your hands away from the ring while you hammer it into the ground. Your infiltration ring should now be buried 5cm (or 2”) into the soil.

4. Pat the soil on the inside of the infiltration ring to close any gaps around the inside edge of the ring. The soil should be right up against the metal ring.
5. This YouTube video offers a visual step-by-step guide for inserting your infiltration ring.

Conduct the Infiltration Rate Test

6. Insert your ruler into the infiltration ring. Get your timer ready!
7. Pour 2.5cm (or 1”) of water into the infiltration ring and start your timer.
8. Stop the timer when all the water has just been absorbed and the surface of the soil is glistening. Record the time to the nearest half minute under “Infiltration Rate 1”.
9. Repeat steps 6-8. Record this second time to the nearest half minute under “Infiltration Rate 2”. **This is a better indication of your soil’s infiltration rate, because it is less affected by recent weather.**
10. Repeat this test in 2 other locations **within** your monitoring strip or plot. You can then calculate an average infiltration time for within the mini forest.
11. Repeat this test in 3 locations **outside** of the mini forest. You can then calculate an average infiltration time for outside of the mini forest.
12. Calculate the infiltration rate for each test site and an average for both within and outside the mini forest.



Flood Management Monitoring Sheet

Flood management monitoring & observations are to be done both within the mini forest monitoring strip or plot and outside of the mini forest.

Mini Forest Site Name: ____________________________ Date: _________________________________

Time Started: _____________________________________ Time Completed: _____________________

Season: ☐ Spring ☐ Summer ☐ Fall

Weather: ☐ Sunny ☐ Partly Cloudy ☐ Overcast ☐ Light Rain ☐ Heavy Rain ☐ Inclement Weather

Soil Wetness:

Soil within the mini forest is:

DRY
No wetness
☐

WET
Soil looks healthy
☐

SATURATED
Small puddles
☐

RUN-OFF
Large puddles; soil is soaked
☐

Soil outside the mini forest is:

DRY
No wetness
☐

WET
Soil looks healthy
☐

SATURATED
Small puddles
☐

RUN-OFF
Large puddles; soil is soaked
☐

Water Infiltration Rate:

	Location	**Infiltration Time 1** *(m:s)*	**Infiltration Time 2** *(m:s)*	**Infiltration Rate** *(inches absorbed/hour)* Infiltration rate = 60 / minutes taken for 1" to be absorbed	**Average Infiltration Time** *(use infiltration time 2 for all locations)* Average = TestSite1_IT2+ TestSite2_IT2+ TestSite3_IT2 / 3	**Average Infiltration Rate** *(inches absorbed/hour)* Infiltration rate = 60 / minutes taken for 1" to be absorbed
Example	*Test Site*	*6:00*	*7:30*	*8"/hour*	*7:00*	*8.6"/hour*
Within Mini Forest	Test Site #1					
	Test Site #2					
	Test Site #3					
Outside Mini Forest	Test Site #1					
	Test Site #2					
	Test Site #3					

Soil Health Monitoring Instructions

Did you know that soil is a living ecosystem, teeming with life, containing billions of organisms which break down organic matter and release essential nutrients? Did you know that healthy soil sustains healthy plants, forests, and ecosystems above ground? While soil health cannot be measured directly, there are different indicators of healthy soil, including the soil's structure or texture, level of compaction, and presence of earthworms and ground dwellers. Over time, monitoring for these indicators can help us understand whether mini forests affect the soil health.

<u>Equipment</u>

- Water
- Water dropper
- Munsell Colour Charts – available for download and print or for purchase
- Ruler
- Wire flag or wire marker
- Permanent marker

<u>Recommended Timing & Frequency</u>

Frequency: Annual

Timing: It is recommended to conduct this test at the same time every year to be able to compare results. There is no recommended seasonal timing for this monitoring protocol.

<u>Soil Texture</u>

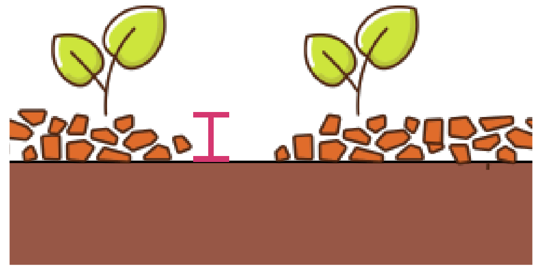
1. Take a small sample of soil into your hand and follow the instructions on the Soil Texture Flow Chart in the tracking sheet to determine the soil texture. Record your assessment of the soil texture in the tracking sheet.
2. Repeat using 2 different soil samples from different areas within the monitoring strip or plot for a total of 3 soil sample tests within the mini forest. Repeat for 3 areas outside of the mini forest.

<u>Soil Colour</u>

1. Take a small sample of soil into your hand and use your Munsell Colour Charts to determine the soil's colour by placing the soil directly onto the printed chart and finding the closest match.
2. Repeat using 2 different soil samples from different areas within the monitoring strip or plot for a total of 3 soil sample tests within the mini forest. Repeat for 3 areas outside of the mini forest.

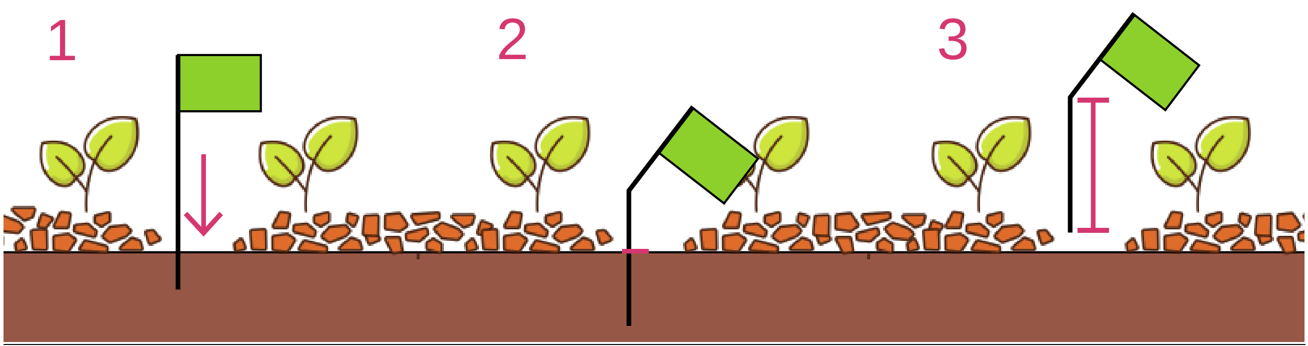
Mulch Depth

1. Clear a small amount of mulch out of the way using one or two fingers until you can see the soil.
2. Place your ruler to the soil and measure the depth of the mulch. Record the measured depth on the tracking sheet.
3. Repeat steps 1-2 in 2 different areas within the monitoring strip or plot for a total of 3 compaction tests within the mini forest.



Soil Compaction

1. Using your wire flag or wire marker, push the wire gently and smoothly into the soil until the wire starts to bend.
2. Mark the wire with your marker and remove it from the soil. Measure the depth the wire was inserted into the soil using your ruler. Record this depth on your tracking sheet.
3. Repeat in 2 different areas within the monitoring strip or plot for a total of 3 compaction tests within the mini forest. Repeat for 3 areas outside of the mini forest.



Soil Health Monitoring Sheet

Soil heath monitoring is to be done both within the mini forest monitoring strip or plot and outside of the mini forest.

Mini Forest Site Name: ___________________________ Date: ________________________________

Time Started: ____________________________________ Time Completed: ____________________

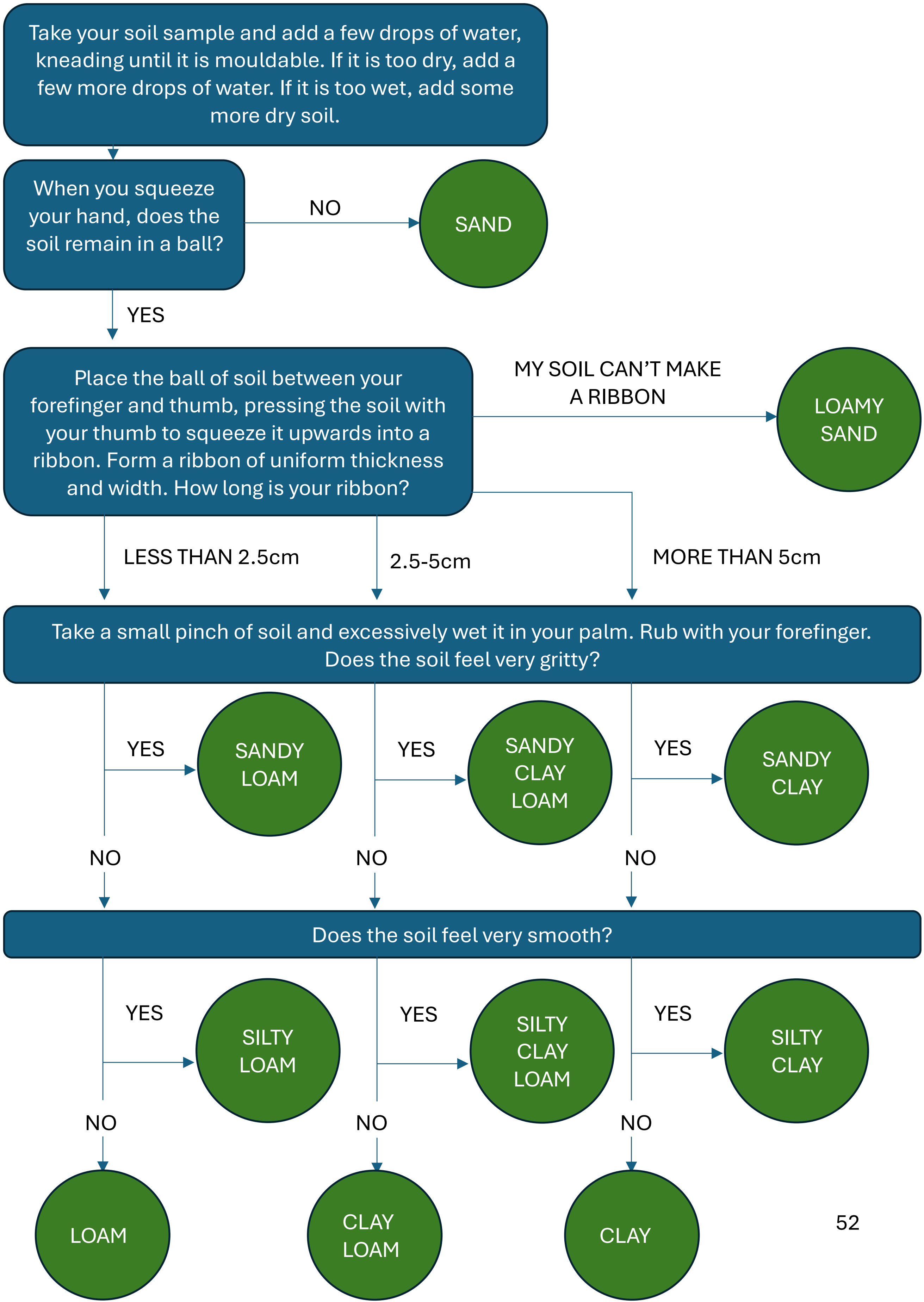
Season: ☐ Spring ☐ Summer ☐ Fall

Weather: ☐ Sunny ☐ Partly Cloudy ☐ Overcast ☐ Light Rain ☐ Heavy Rain ☐ Inclement Weather

<table>
<tr><th></th><th>Soil Sample</th><th>Description of Test Site</th><th>Soil Texture</th><th>Soil Colour</th><th>Mulch Depth (in inches)</th><th>Wire Insertion Depth (in inches)

A wire inserted to a depth of 12” or more indicates good soil; 4-12” indicates fair soil; and less than 4” indicates poor, compacted soil.</th></tr>
<tr><td>Example</td><td>Soil Sample 1</td><td>Approximately 2m from north edge of mini forest in the middle of the monitoring strip</td><td>Loamy Sand</td><td>7.5YR 4/6</td><td>3”</td><td>8”</td></tr>
<tr><td rowspan="3">Within Mini Forest</td><td>Soil Sample 1</td><td></td><td></td><td></td><td></td><td rowspan="3"></td></tr>
<tr><td>Soil Sample 2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Soil Sample 3</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Outside Mini Forest</td><td>Soil Sample 1</td><td></td><td></td><td></td><td rowspan="3">N/A</td><td rowspan="3"></td></tr>
<tr><td>Soil Sample 2</td><td></td><td></td><td></td></tr>
<tr><td>Soil Sample 3</td><td></td><td></td><td></td></tr>
</table>

Soil Texture Flow Chart



Biodiversity Monitoring Protocol

Biodiversity refers to the variety of living things present in an ecosystem. It is very important for the health and wellbeing of an ecosystem, and for a healthy planet. Monitoring for biodiversity – in plant life, insects and ground dwellers, animals, pollinators, and other creatures – helps us understand how a mini forest supports life in its many forms.

Equipment

- Camera
- Timer
- Access to the site's iNaturalist project (via smartphone or computer)
  - *Consult the monitoring guide for further details on using iNaturalist*
- Species identification guidebook (optional)
- Shovel (Ground Dwellers - timed count method only)
- 3x Tiles (Ground Dwellers - tile method only)
- 3x Stakes, Markers or Flags (Ground Dwellers - tile method only)
- Paint or permanent marker (Ground Dwellers - tile method only)

Recommended Timing & Frequency

Frequency: As often as possible! At least annual. To encourage more frequent monitoring, it is recommended to include a QR code on signage at the site, linking directly to the site's iNaturalist project, as well as simple instructions. This can empower passers-by to participate in monitoring biodiversity, increasing the number and frequency of observations.

Timing: If only monitoring annually, it is recommended to monitor at the same time every year to be able to compare results. Summer is highly recommended. Note that some animals and insects may be more active at certain times of day (i.e. birds in the morning, pollinators in the afternoon, bats at night).

Plants

1. Moving from one end of the monitoring strip or plot, take a picture of any new plants growing that were not originally planted and upload the picture to the iNaturalist project for your mini forest, including your best guess for identifying the species.
2. This test can also help you monitor for invasive species. If you identify an invasive species growing in your mini forest, notify the community group, municipality, or other organization involved in planting and maintaining the mini forest. Determine the best course of action with that group for removing the invasive species, consulting experts or government officials if necessary.

Pollinators, Birds, and Other Creatures

1. Select a spot near the middle of your monitoring strip or plot, or near most of the flowering plants. Make yourself comfortable – it is important you can remain as still as possible during this test.
2. Set your timer for 30 minutes. Observe and record any pollinators, birds, or other creatures you see during this time.
3. Take a picture of any pollinator, bird or creature you observe and upload the picture to the iNaturalist project for your mini forest, including your best guess for identifying the species.

Ground Dwellers

If using the timed count method:

1. In your monitoring strip or plot, have a close look at the soil. This may require you to move mulch, grass, or dead leaves out of the way so you can see the soil. If you must clear away this top layer to see the soil, clear an area that is 1 sq. ft.
2. Set your timer for 20 minutes. Observe and record any ground dwellers you see in the soil during this time. Feel free to do some lifting or moving, or even use your shovel to dig, to gain better access to ground dwellers.
3. Take a picture of any ground dweller you observe and upload the picture to the iNaturalist project for your mini forest, including your best guess for identifying the species.

If using the tile method:

1. **(First monitoring session only)** Place 3 tiles on the soil in 3 different areas of your monitoring strip or plot. This may require you to move mulch, grass, or dead leaves out of the way so you can see the soil.
2. Place a stake, marker, or flag next to the tile so you can easily find it in future monitoring sessions, as they can sometimes be buried under mulch, leaf litter, or other organic matter.
3. Number each tile using paint or a permanent marker.
4. Lift each monitoring tile and quickly take a picture of the ground dwellers underneath and on the underside of the tile (if applicable). Upload zoomed-in photos of each ground dweller to the iNaturalist project for your mini forest, including your best guess for identifying the species.
5. Return the monitoring tile to the same exact location. Each monitoring tile should only be lifted once per day. If necessary, clear any mulch or debris from where the tile was sitting on the ground, so the tile is in direct contact with the soil.

Human Interactions Monitoring Instructions

Access to green space can offer humans many health, well-being, and social benefits, including a connection to nature. Monitoring how humans interact with mini forests can help us understand the benefits these unique green spaces offer to the individual and the community. Part of monitoring human interaction is not only looking for signs of positive interactions, but negative interactions as well: garbage, vandalism, graffiti, etc.

NOTE: *It is especially important when conducting this monitoring protocol to be respectful of the rights (for instance, to privacy) of the people you are observing. While you should avoid standing out, you should be open and honest with anyone curious about what you are doing and why – even if that means missing recording some individuals interacting with the mini forest.*

Equipment

- Timer

Recommended Timing & Frequency

Frequency: As often as possible! At least annual

Timing: This test can be conducted at any time. However, note that there are more popular times for people to visit and interact with green spaces (i.e. weekends, lunch hour or after school/work, Spring, Summer or early Fall, etc.) If only monitoring once a year, it is strongly recommended to monitor on a summer weekend in the middle of the day (between 11am-4pm) during good weather, to maximize your observation potential.

Incivilities

1. Slowly and mindfully walk around the full perimeter of your mini forest. Pay extra attention to any installed features (i.e. around benches, signs, fencing). If your mini forest has any paths, gathering spaces, or points of access, slowly walk through those as well.
2. Record any incivilities observed on your tracking sheet.
    a. *Incivilities are any harms, destruction, or vandalism to the mini forest that seem to be caused by humans, including litter, graffiti, broken branches, etc.*

Human Engagement

1. Choose a comfortable location outside of the mini forest, but where you have an optimal view of all or most of the mini forest.
    a. *Sitting within the mini forest for this test could scare off or otherwise discourage potential engagement or interactions.*
2. Set your timer for 30 minutes.

3. Observe and record every person who passes by the mini forest. Make notes of whether they observe, enter, or engage with the mini forest or its features on your tracking sheet.
    a. *Engaging with the mini forest could mean utilizing any features (i.e. benches), conducting monitoring or maintenance, touching plants, etc.*

Human Interaction Monitoring Sheet

Mini Forest Site Name: ____________________________ Date: _________________________________

Season: ☐ Spring ☐ Summer ☐ Fall

Day of the Week: ☐ Weekday (Monday to Friday) ☐ Weekend (Saturday or Sunday) ☐ Holiday

Weather: ☐ Sunny ☐ Partly Cloudy ☐ Overcast ☐ Light Rain ☐ Heavy Rain ☐ Inclement Weather

Incivilities (select all observed):

☐ Litter ☐ Graffiti ☐ Broken Glass ☐ Dog Mess ☐ Broken or Damaged Features

☐ Other:

____

Human Engagement:

Time Started: ______________________________________ Time Completed: _____________________

Person	**Age Group** *Child 0-12* *Teen 12-17* *Adult 18-65* *Elder >65*	**Observe Mini Forest** *Yes – 1* *No – 0*	**Read Signs** *Yes – 1* *No – 0*	**Enter Mini Forest** *Yes – 1* *No – 0*	**Engage with Mini Forest** *Yes – 1* *No – 0*	**Notes on Engagement**
Ex. #1	*Teen*	*1*	*0*	*1*	*1*	*Person walked through mini forest path and rested on the bench at the middle of the mini forest*
1						
2						
3						
4						
5						
6						
7						
8						
9						